Species Status Assessment

for the

CANADA LYNX *(Lynx canadensis)*

Contiguous United States Distinct Population Segment

Photo by Keith Williams

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U.S. Fish and Wildlife Service
Regions 1, 3, 5 and 6

* This SSA report was written by the Canada Lynx Species Status Assessment Team (Lynx SSA Team), which consists of a Core Team of Service biologists who work on lynx issues across the DPS range and an SSA Framework Implementation Team of Service and U.S. Geological Survey staff who have developed and advanced the SSA framework. Core Team members also participate on the Interagency Lynx Biology Team (ILBT) and contributed to the recently-revised Lynx Conservation Assessment and Strategy (LCAS; ILBT 2013, entire).

NOTE ABOUT THIS DRAFT DOCUMENT, DECEMBER 2016

This is a preliminary draft document of the U.S. Fish and Wildlife Service. This draft species status assessment report has not undergone peer review, and it should not be cited or referenced as an agency document. At this time it is intended for the sole purpose of soliciting scientific reviews from expert peer reviewers, from State and Federal partners with expert knowledge of the species and its habitat, and from internal reviewers by Department of Interior staff. The document is not intended to solicit public comment. This document will be revised after this scientific review. This document does not predetermine any future agency decision under the Endangered Species Act. For more information contact Jim_Zelenak@fws.gov.

Table of Contents

Executive Summary

<u>Background</u>

This report presents the results of a species status assessment (SSA) conducted for the contiguous United States (U.S.) distinct population segment (DPS) of Canada lynx (*Lynx canadensis*). The DPS was listed in 2000 as threatened under the Endangered Species Act (ESA) because of the inadequacy, at that time, of existing regulatory mechanisms on Federal lands. The SSA will provide the scientific basis for the statutorily required 5-year status review for this listed species and other decisions the U.S. Fish and Wildlife Service (Service) is required to make in accordance with the ESA. The SSA provides an evaluation of the current and possible future conditions for lynx in the six geographic units within the DPS that currently support or recently supported resident lynx populations. The units are distributed across the northern contiguous U.S. from Maine to Washington and south along the Rocky Mountains to western Colorado (Figure 1).

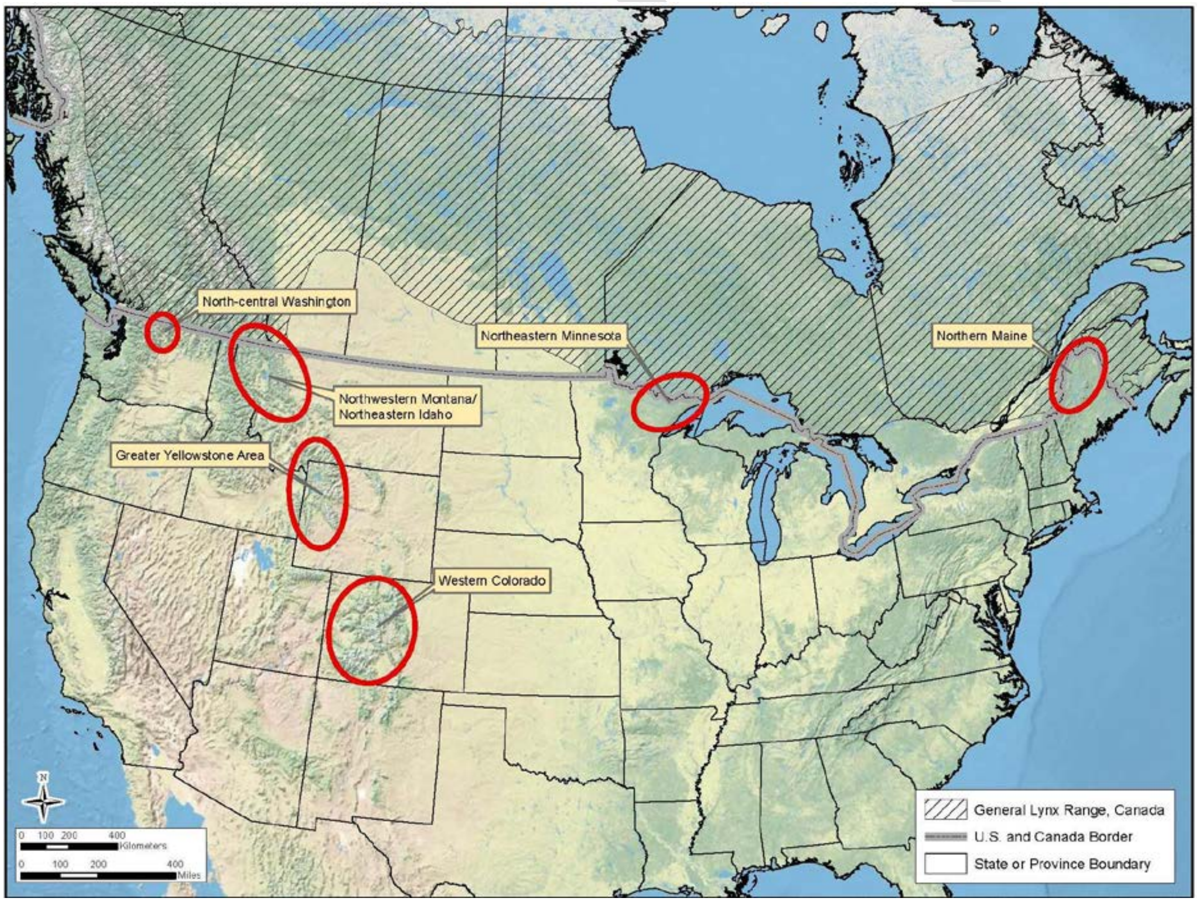


Figure 1. Six geographic units within the range of the contiguous U.S. distinct population segment of Canada lynx (*Lynx canadensis*).

These units encompass the geographic areas in the contiguous U.S. with the strongest historical and/or recent evidence of an ability to support persistent resident lynx populations and, combined, they represent approximately the southern two percent of the species' entire breeding range (98 percent occurs in Canada and Alaska). The units are relatively isolated from each other, but four of the six units are directly adjacent to lynx populations and habitats in Canada. Although lynx are regularly or occasionally documented in other parts of the northern contiguous U.S., usually peripheral to the SSA geographic units, the ability of these peripheral areas to support persistent resident lynx populations remains questionable. Lynx may occur in such areas as small and ephemeral breeding populations or as occasional dispersing or transient individuals. The locations and sizes of the SSA geographic units are summarized in Table 1.

Table 1. Canada Lynx SSA Geographic Units.

Unit No.	Unit Name and Location	Unit Size (km^2)
Unit 1	Northern Maine	28,909
Unit 2	Northeastern Minnesota	21,101
Unit 3	Northwestern Montana/Northeastern Idaho	26,997
Unit 4	North-central Washington	5,176
Unit 5	Greater Yellowstone Area	23,687
Unit 6	Western Colorado	25,294

This report represents the Service's evaluation of the best available scientific information, including the formally-elicited professional judgments and opinions of recognized lynx experts. Based on this information, we: (1) describe the ecological requirements and population dynamics of the species; (2) evaluate the historical and current condition of lynx populations in the DPS, including the six geographic units, and the factors that appear to have influenced them; and (3) assess the future viability of the DPS in the near term (through the year 2025), mid-term (through 2050), and through the end of this century in terms of the conservation biology principles of resiliency, redundancy, and representation (the "3 Rs").

The lynx is a habitat and prey specialist that requires dense boreal and subalpine forests having long winters with deep, fluffy snow and abundant snowshoe hares, which typically comprise >90 percent of the lynx's year-round diet. The lynx has evolved morphological adaptions (long legs and large paws) that allow it to efficiently travel and capture hares in snow conditions that are difficult for most other terrestrial hare predators (e.g., bobcats, coyotes). These characteristics provide lynx with a seasonal (4-5 months in most of the DPS) competitive advantage over other hare predators and allow them to occupy habitats that are unavailable to some of their competitors.

The DPS occurs at the southernmost margin of the species' range and of the environmental thresholds of snow quality, depth, and persistence; hare density; and boreal forest conditions that lynx require. Because of this, lynx habitats and, thus, lynx are naturally less abundant and more patchily distributed in the DPS than in the core of the species' range in Canada and Alaska. Maintaining connectivity between the DPS and lynx populations in Canada is thought to be important, but whether the demographic and/or genetic health of DPS populations depends on intermittent immigration of lynx from Canada and, if so, to what extent remain uncertain.

Research and surveys undertaken since the DPS was proposed for listing in 1998 have significantly improved our knowledge of the distribution, habitats, and population dynamics of lynx in the contiguous U.S. For example, analysis of historical records in the U.S. and Canada indicated that many lynx records in the contiguous U.S. coincided with intermittent "irruptions" (mass dispersal events) of lynx from Canada into the northern U.S. when hare populations in Canada underwent cyclic declines (every 8-11 years). During these irruptions, large numbers of lynx occurred temporarily in (and disappeared quickly from) areas that we now believe are naturally incapable of supporting resident populations.

Additionally, although we knew resident lynx occurred in Maine, we lacked information on the historical and recent distribution and quality of lynx habitat. We now know that forest regeneration after large-scale clear-cutting in the 1970s and 1980s has contributed substantially to the current broad distribution of high-quality habitat in northern Maine, which currently supports the largest resident lynx population in the DPS. Similarly, we were uncertain if Minnesota supported a resident breeding population, but we now know that a persistent population occupies the northeastern corner of the state. Research and monitoring also suggest that lynx and habitats in the western U.S. are naturally less abundant and more patchily distributed than was thought at the time of listing, and lynx may have been extirpated recently from several areas thought to have previously supported small resident populations (e.g., the Kettle Mountains in northeastern Washington, the Garnet Mountains in western Montana, and the Greater Yellowstone Area of southwestern Montana and northwestern Wyoming). We also know that recent extensive wildfires in north-central Washington have temporarily reduced the amount of high-quality lynx habitat and have probably caused a decline in lynx numbers there. Finally, as a result of the release of 218 Canadian and Alaskan lynx from 1999 to 2006 and the subsequent survival and reproduction of some of these lynx and their offspring, resident lynx currently occupy parts of western Colorado.

<u>SSA Framework</u>

The framework for conducting an SSA takes into consideration the life history and ecological requirements of the species to understand how the species maintains itself over time. Therefore, we evaluated the ecological requirements of individual lynx and populations and the current and possible future conditions for resident lynx populations in each geographical unit to assess the viability of the DPS. The SSA uses the conservation biology principles of resiliency, redundancy, and representation as the framework for assessing current and future conditions. Resiliency describes the ability of the species to withstand stochasticity, redundancy describes the ability of the species to withstand catastrophic events, and representation describes the ability of the species to adapt over time to long-term changes in the environment. The 3 Rs can be influenced by any number of factors. For lynx, the factors evaluated in this SSA include: (1) the original factor for which the DPS was listed as threatened (the inadequacy of existing Federal regulatory mechanisms at the time of listing); (2) the factors considered by the Interagency Lynx Biology Team (ILBT) to have the potential to exert population-level effects on the DPS (climate change, vegetation management, wildland fire management, and habitat loss and fragmentation); and (3) other factors that could influence the continued ability of particular geographic units to support resident lynx.

Uncertainties and Assumptions

Several primary sources of uncertainty had to be accounted for in our analysis, including the dearth of empirical data on lynx population sizes, trends, and other important demographic parameters in the DPS; the influence of immigration of lynx from Canada on the persistence of DPS populations; the effectiveness of habitat management efforts; and the effects of competition on lynx populations. We lack similar demographic information for snowshoe hares throughout much of the DPS. Additionally, consistent methods to monitor hare and lynx habitats have not been implemented throughout most of the DPS. And importantly, given the emerging role of climate change as a stressor, uncertainties about the rate and extent of projected future declines in snow quality, depth, and persistence, and in the northward and upslope retraction of boreal, subalpine, and montane forests constrain our ability to precisely predict effects on lynx and snowshoe hare populations and habitats, including to what degree these changes may affect interactions between lynx and their competitors.

To account for these uncertainties in our analysis, we identified a number of critical assumptions based on the literature and input provided by the lynx experts we consulted. We treated the following assumptions as constants in the analysis.

- We assume that, in general, habitat quality, hare densities, and lynx numbers are naturally lower and hares noncyclic or weakly cyclic at the southern margin of the lynx's range, including the DPS, than in the core of the species' range in Canada and Alaska.

- We assume that as a consequence of generally lower habitat quality and hare densities, only some places within the DPS range are capable of supporting persistent resident lynx populations, while others may naturally support resident lynx only ephemerally, and yet other areas are naturally incapable of supporting resident lynx despite boreal-forest-like vegetation and the presence of some hares.

- We assume that lynx populations in the DPS occur as the southern extensions of larger, cross-border populations or as relatively isolated subpopulations of the larger Canadian populations.

- We assume that lynx exhibit a "mainland-island" metapopulation structure in which DPS populations function as "islands" that receive periodic input from "mainland" Canada populations.

- We assume that connectivity with larger lynx populations in Canada is important, and that periodic immigration of lynx into the DPS from Canada contributes to the persistence of DPS populations, although the extent to which the demographic and genetic health of DPS populations depends on immigration remains uncertain.

- We assume that lynx in the DPS require specific snow conditions (deep, “fluffy,” and persistent) to express a competitive advantage over bobcats and other terrestrial hare predators, and that in the absence or loss of these conditions, lynx will be displaced by other hare predators.

- We assume that the lynx, as a boreal forest- and snow-reliant predator that relies heavily on a single, similarly-specialized prey species, and whose habitats are influenced by climate-mediated disturbance factors (e.g., wildfire, forest insects, wind/ice storms, etc.), is highly sensitive and broadly exposed to the impacts of climate change and has limited adaptive capacity to respond to it. Therefore, we assume lynx populations in the DPS are vulnerable to the projected impacts of continued climate warming.

- We assume that lynx conservation measures and habitat management guidance adopted by the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM) via formally amended or revised management plans have had a positive influence on DPS lynx populations that occur on Federal lands and will continue to do so as long as those measures and guidance are implemented.

- We assume that the DPS could be delisted in the future and that some of the current protections afforded by the ESA could be lost and/or relaxed. However, we assume conditions for delisting would include requirements and incentives to continue to conserve lynx and its habitats and to try to assure persistence of resident lynx populations in those places that can support them in the DPS range.

For purposes of the SSA, we forecast potential future conditions for lynx in the DPS through year 2100. Beyond that time frame, uncertainty regarding the potential impacts of climate change and other potential stressors to lynx populations in the DPS becomes so great as to preclude meaningful analysis or projections of viability.

Current Conditions

The current distribution of resident lynx in the contiguous U.S. is likely somewhat smaller than the historical distribution because of the potential loss of small populations in several places (e.g., northern New Hampshire, perhaps the Adirondack Mountains of northern New York, Isle Royale in Lake Superior, the Kettle Mountains of northeastern Washington, and, more recently, the Greater Yellowstone Area of Southwestern Montana and northwestern Wyoming, and perhaps the Garnet Mountains in western Montana). However, based on verified historical records, we lack compelling evidence that the current distribution and relative abundance of resident lynx in the DPS range are substantially diminished from historical conditions, and resident populations continue to persist in the geographic areas with the strongest historical evidence of an ability to support them. Nonetheless, in many parts of the DPS range habitat features (forest distribution and structure, hare densities, and snow conditions) appear to exist at or just above thresholds thought necessary to support persistent lynx populations.

Resiliency – The apparent long-term (historical and current) persistence of resident lynx populations in at least four of the six geographic units (Units 1-4) and the absence of reliable information indicating that the current distribution and relative abundance of resident lynx are substantially reduced from historical conditions suggest adequate historical and recent levels of resiliency among lynx populations in the DPS. Among these units, lynx in Maine appear to have recently demonstrated resiliency by responding positively to substantial anthropogenic increases in the amount and distribution of high-quality foraging habitat. Conversely, the current absence of resident lynx in the Garnet Mountains of Unit 3 (a small and somewhat isolated mountain range at the southern periphery of Unit 3) may suggest a recent decline in resiliency in this part of the unit. The persistence of lynx in north-central Washington (Unit 4) despite the substantial recent wildfire-mediated loss of habitat suggests resiliency in that population. However, the post-fire increase in home range size and likely decrease in lynx numbers may indicate the population in Unit 4 is currently less resilient (less able to persist if additional or similar habitat losses occur) than it was previously. Among the other two geographic units, the current absence of resident lynx in the GYA (Unit 5) despite the large proportion of lands in conservation status (e.g., national parks and designated wilderness areas) may indicate the naturally lower level of resiliency expected among small and relatively more isolated populations. In western Colorado (Unit 6), the absence of resident lynx for much of the past century may indicate historically inadequate resiliency in this unit. However, the recent persistence of resident lynx in this unit following the 1999-2006 introduction of 218 Canadian and Alaskan lynx suggests recent resiliency thus far. We conclude that the DPS as a whole currently demonstrates adequate resiliency despite the possibility that resiliency may have declined recently in several geographic units.

Redundancy – The current broad distribution of resident lynx populations in large, geographically discrete areas makes the DPS invulnerable to extirpation caused by a single catastrophic event. The DPS range currently spans the northern contiguous states from Maine to Washington and south along the Rocky Mountains to southwestern Colorado. Resident breeding lynx populations currently occupy five of the six geographic units (all but the GYA; Figure 1). Of the five occupied units, four are larger than 20,000 km^2 (7,722 mi^2), and the other (North-central Washington) is over 5,000 km^2 (1,931 mi^2) (Table 1). We find that no single catastrophic event could result in the functional extirpation (loss of the ability to support resident lynx populations) of the entire DPS or of any of the individual geographic units that currently support resident populations. Because we lack evidence that persistent lynx populations have been lost from any other large geographic areas in the contiguous U.S., it also seems that redundancy in the DPS has not been meaningfully diminished from historical levels. We conclude that the DPS currently demonstrates adequate redundancy to preclude the possibility of extirpation via catastrophic event.

Representation – The high rates of dispersal and gene flow and, therefore, generally low levels of genetic differentiation across most of the lynx's range, including the DPS, suggest the absences of current threats to the genetic health of lynx populations in the DPS. Although hybridization with bobcats has been documented in Maine and Minnesota, it is not considered a substantial current threat to the DPS. Similarly, although some small populations may have become extirpated recently, resident lynx in the DPS remain broadly distributed across the range of ecological settings that seems to have supported them historically in the contiguous U.S., suggesting relative maintenance of the breadth of diversity of ecological settings occupied within the DPS range. Because there are no indications of significant loss of or current threats to the genetic health or adaptive capacity of lynx populations in the DPS, and the current level of representation does not appear to indicate a decrease from historical conditions, we find that the DPS currently displays an adequate level of representation.

Future Conditions

We and the lynx experts we consulted expect that the number of resident lynx and the distributions of resident populations in the DPS range will decline through the end of the century largely as a result of projected continued climate warming and associated impacts, which are likely to exacerbate the potential adverse effects of other factors (e.g., forest management, competition from other hare predators). Continued warming is expected to cause a northward and upslope retraction of the boreal forest and snow conditions that lynx need, resulting in smaller, more fragmented, and increasingly isolated patches of habitat and a reduced probability of persistence for all resident populations in the DPS range. We expect that resident populations will persist through mid-century in all five of the geographic units that currently support them (albeit in reduced numbers and distributions), but that lynx may be functionally extirpated (loss of the ability to support persistent resident populations) from two or three of the units by the end of the century.

The western geographic units (units 3 through 6) may be more likely to support resident lynx longer than units 1 and 2 under projected climate change scenarios given the higher percentage of land managed specifically for lynx conservation and their greater topographic potential to facilitate the upward elevational shift in in lynx habitats projected by climate models. Nonetheless, we are unaware of any management actions that can be expected to abate the projected long-term retreat of boreal forests and diminished snow conditions expected under continued climate warming. Further, climate-induced frequency and intensity of wildfires and forest insect outbreaks are expected to increase, particularly in the western portion of the DPS, although we do not anticipate such events alone to cause the permanent loss of breeding lynx populations in any geographic unit. In Minnesota and Maine (units 1 and 2), suitable boreal forest and snow conditions are projected to decline more severely than in the western units, and in some climate modeling scenarios they could disappear completely from these units by the end of the century. Over the next 15-20 years, lynx habitat conditions in Maine are also likely to decline significantly from current historically high and anthropogenically influenced levels as private forest management practices, particularly a shift away from landscape-level clearcutting, result in forest succession detrimental to snowshoe hare and lynx needs.

Resiliency – We expect resident lynx populations in all geographic units that currently support them to be smaller and more fragmented and isolated in the future, and each geographic unit and the DPS as a whole will, therefore be less resilient in the future. We anticipate that resiliency will likely be adequate to foster persistence of resident lynx in most units through mid-century but that it will be substantially diminished after that time, with resulting extirpation of resident populations from two to three (of five) units by the end of the century. Projected climate warming is expected to exert the greatest influence on the resiliency of individual populations, and thus continued presence of resident lynx in each geographic unit, although uncertainty remains regarding the timing, extent, and biological consequences of such impacts. As vegetation and snow conditions become less favorable, competitors (e.g., bobcats) are likely to outcompete and displace lynx. This in turn will reduce lynx abundance and density within populations, making populations more susceptible (i.e., less resilient) to stochastic events.

Redundancy – Although redundancy in the DPS will decline with the projected loss of populations from two or three geographic units by the end of the century, our evaluation suggests that none of individual geographic units that currently support resident lynx are vulnerable to extirpation from a single catastrophic event. Given that, we conclude that the DPS as a whole is not vulnerable to extirpation from a catastrophic event. We recognize that a sequence of discrete but spatially-clustered catastrophic events in lynx habitats over a short time could increase the potential for functional extirpation in one or more of the individual geographic units (especially the possibility of additional large wildfires in north-central Washington), thereby reducing redundancy within the DPS. However, as long as resident lynx remain geographically well-distributed in one or more units within the DPS (and we expect populations to persist in two or three of five units by the end of the century), extirpation of the DPS from a single catastrophic event is very unlikely.

Representation – Although some lynx populations in the DPS units are demographically isolated from each other and the level of interaction between others is uncertain, there seems to be little risk of significant genetic drift. This is because of the currently observed and expected future high level of gene flow across most of the lynx's continental range, the species' well-documented dispersal capability, and the current and likely future connectivity and absence of significant barriers to dispersal between Canada and most DPS geographic units. Based on these factors and expert input, we find that is there is no indication that the relatively low level of genetic diversity currently observed among lynx populations is likely to reduce DPS viability in the future and no indication that future gene flow is likely to be substantially reduced. This information suggests the current and likely future relative genetic health of the DPS. How the potential loss of resident lynx from one or more geographic units may affect representation within the DPS in terms of ecological diversity is uncertain. The loss of resident lynx from any of the geographic units could result in the loss of behavioral and potential future genetic adaptations to the climate-mediated changes now occurring and likely to continue into the future at the southern edge of the lynx range. Such potential adaptability to diminished snow conditions, increasingly patchy and isolated boreal forests, and reduced hare abundance may be important to the taxon as a whole faced with a rapidly changing climate.

DPS-wide Synthesis

We and the lynx experts we consulted expect that resident lynx populations are likely to continue to persist, albeit in reduced numbers and distributions, in all five geographic units that currently support them through mid-century, but that functional extirpation is likely in two to three of those units by the end of the century, driven largely by projected continued climate warming. Because resident lynx in many parts of the DPS persist in areas that appear naturally to barely meet thresholds for hare densities and habitat quality and distribution, relatively small declines in these features could result in loss of the ability to support resident populations over large areas. Because of this, we believe that future lynx habitats and resident populations throughout the DPS range are likely to be smaller and more fragmented, and geographic units that are already relatively isolated from other lynx populations are likely to become even more isolated in the future. Uncertainty increases at mid- to late-century regarding the timing and extent of various stressors that will affect lynx and hare habitat and snow regimes, especially those related to climate change. However, review of the best available science in concert with input from lynx experts suggests that the probability of the persistence of resident breeding populations will decline in all geographic units, with the negative DPS-wide trajectory continuing to the end of the century, and (with no evidence to the contrary) beyond that time frame.

Because resident lynx populations in all geographic units that currently support them are expected to be smaller and more fragmented and isolated in the future, each geographic unit and the DPS as a whole will be less resilient in the future. Our analyses and expert input suggest that resiliency will likely be adequate to foster persistence of resident lynx through mid-century in most of the five geographic units that currently support them. However, we believe it is very unlikely that resident lynx populations will persist through the end of this century in all of the geographic units that currently support them. That is, we believe that resiliency will be substantially diminished because of reduced population sizes and distributions throughout the DPS, with resulting extirpation of resident populations from two to three (of five) units more likely than not by the end of the century.

We conclude that the functional extirpation of resident lynx populations from one or more geographic unit would demonstrate a loss of resiliency, reduced redundancy, and, possibly, reduced representation within the DPS. The probability of losses in resiliency, redundancy, and representation puts the Canada lynx DPS at increasing risk of extirpation through the end of this century.

Chapter 1: Introduction

The U.S. Fish and Wildlife Service (Service) designated lynx in the contiguous U.S. as a distinct population segment (DPS) and listed it as threatened under the Endangered Species Act of 1973, as amended (ESA) in 2000 (65 FR 16052-16086). On May 8, 2014, the United States District Court for the District of Montana ordered the Service to complete recovery planning for the lynx DPS (U.S. District Court MT 2014a, p. 8). On June 25, 2014, the same court ordered the Service to complete a recovery plan by January 15, 2018 "…unless the Service finds that such a plan will not promote the conservation of the [lynx]" (U.S. District Court MT 2014b, p. 2). Thus, we conducted this SSA (version 1.0) to summarize the best available information on the current status and likely future viability of the DPS. This SSA will inform a determination by Service decision makers of whether (1) the DPS continues to warrant protection under the ESA and (2) a recovery plan is needed to guide conservation and recovery of the lynx DPS.

1.1 Background

The Canada lynx is a North American wild cat that is most strongly associated with northern-latitude boreal forests (taiga) of Canada and Alaska (McCord and Cardoza 1982, p. 729; Agee 2000, pp. 39-41; Aubry *et al*. 2000, pp. 373-374; Mowat *et al*. 2000, p. 272). It is a prey specialist and relies almost exclusively on adequate populations of its primary prey, the snowshoe hare (*Lepus americanus*), to support survival, reproduction, recruitment, and, therefore, population persistence (Ruggiero *et al*. 2000a, p. 110; Mowat *et al*. 2000, p. 270; Steury and Murray 2004, pp. 128, 136-138; USFWS 2005, p. 2; Interagency Lynx Biology Team [ILBT] 2013, pp. 30-34; 79 FR 54808-54809). Lynx survival and distribution is also influenced by snow conditions. It is generally restricted to areas that receive deep, powdery, and persistent snow that allows lynx, with their proportionately longer limbs and very large feet, to outcompete other terrestrial hare predators that are less efficient in such conditions (McCord and Cardoza 1982, pp. 748-749; Quinn and Parker 1987, p. 684; Buskirk *et al*. 2000a, pp. 89-94; Buskirk *et al*. 2000b, pp. 400-401; Ruggiero *et al*. 2000b, pp. 445–449; Hoving 2001, p. 75; Hoving *et al*. 2005, p. 744-749; Carroll 2007, entire; Gonzalez *et al*. 2007, entire; ILBT 2013, pp. 25-26; 79 FR 54809).

Lynx are generally considered secure, widespread, abundant, and distributed throughout most of their historical ranges in Canada and Alaska, which, combined, account for roughly 98 percent of the species' distribution. Lynx are distributed across approximately 5.5 million km^2 (2.1 million mi^2) in Canada (Environment Canada 2014, p. 2) and 534,454 km^2 (206,354 mi^2) in Alaska (University of Alaska Center for Conservation Science 2016, entire; Reimer 2016, *pers. comm.*). The southern peripheries of the boreal forest and the distributions of snowshoe hares and lynx extend into the northern contiguous U.S. (Bittner and Rongstad 1982, p. 146; McCord and Cardoza 1982, p. 729; Agee 2000, pp. 39-41; Aubry *et al*. 2000, pp. 379-382; Hodges 2000a, pp. 163-173; McKelvey *et al*. 2000a, pp. 242-253), where the six geographic units evaluated in this SSA represent the remaining 2 percent of the species' breeding distribution (approximately 131,168 km^2 [50,644 mi^2]; see Figure 1 and Table 2, below). Lynx populations in the DPS (as well as some others on the margin of the range in southern Canadian provinces) seem to function as peripheral subpopulations (islands) of a larger (mainland) metapopulation centered in north-central Canada (McKelvey *et al*. 2000b, p. 25; 68 FR 40077; also see 2.2 below). The demographic and genetic health and persistence of DPS populations are thought to be influenced by connectivity with, and immigration of lynx from, larger populations in Canada (McKelvey *et al.* 2000b, pp. 21, 33; Schwartz *et al.* 2002, entire; 78 FR 59434, 59447; 79 FR 54815).

Lynx were documented historically in 24 of the Lower 48 States (McKelvey *et al.* 2000a, pp. 207-232), but records in many places are associated with cyclic "irruptions" of large numbers of lynx dispersing from southern Canada during the decline phase of 8- to 11-year snowshoe hare population cycles. Many of these occurrences were in anomalous habitats, and lynx were unable to persist and establish populations in most of these areas (Gunderson 1978, entire; Thiel 1987, entire; McKelvey *et al.* 2000a, pp. 242, 253; Aubry 2006, pp. 1-2; ILBT 2013, p. 23; see also section 2.3.2, below). Habitats capable of supporting persistent resident lynx populations in the contiguous U.S. occur over a much smaller geographic area that includes parts of the Northeast (primarily northern Maine), western Great Lakes (northeastern Minnesota), Rocky Mountains (northern Idaho, northwestern Montana; perhaps also parts of northeastern Washington, the Greater Yellowstone Area (GYA) of southwestern Montana and northwestern Wyoming, and parts of western Colorado), and the eastern Cascade Mountains of northern Washington (68 FR 40077-40080; USFWS 2005, p. 3; 79 FR 54806-54807; Lynx SSA Team 2016, pp. 6-7). Although uncertainty remains regarding the historical distribution of resident lynx in the contiguous U.S., and small breeding populations may have been lost from some places, neither broad-scale breeding range contraction nor substantial changes in population status in the contiguous U.S. has been documented based on verified occurrence data (68 FR 40099; 72 FR 1187; 79 FR 54798, 54815; McKelvey *in* Lynx SSA Team 2016, p. 11; also see section 2.3.2, below).

The Service designated lynx in the contiguous U.S. as a DPS and listed it as threatened under the ESA in 14 states in 2000 because of the inadequacy, at that time, of existing regulatory mechanisms on Federal lands (65 FR 16052). In 2003, in response to a court memorandum opinion on the 2000 listing rule, the Service reaffirmed its determination of the lynx DPS and its status as threatened under the ESA (68 FR 40076). The Service completed a recovery outline in 2005 (UUSFWS 2005, entire), designated critical habitat for the DPS in 2006 (71 FR 66008) and, in 2007, again in response to a court order, clarified its determinations of "significant portion of the range" and that all lynx in the contiguous U.S. constitute a single DPS (72 FR 1186). Also in 2007, the Service announced that it would initiate a 5-year status review of the DPS (72 FR 19549). The Service revised the critical habitat designation for the DPS in 2009 (74 FR 8616) and 2014 (79 FR 54782) and, concurrent with the latter, rescinded the state-based definition of the DPS boundary to formally extend ESA protection to lynx "where found" in the contiguous U.S., including New Mexico and other states that were not included in the original DPS range (79 FR 54804). The Service reinitiated the 5-year status review in 2015 (USFWS 2015, entire), and that review will be informed by this SSA report. On September 7, 2016, the U.S. District Court for the District of Montana remanded the 2014 critical habitat designation to the Service for further consideration (U.S. District Court MT 2016, entire).

The six geographic units evaluated in this SSA encompass all areas of the contiguous U.S. that currently support or are believed to have recently supported persistent resident lynx populations (Figure 1, above). Five of the six geographic units were designated as "Core Areas" in the Recovery Outline (USFWS 2005, pp. 4-6, 21, 23), and western Colorado was designated a "Provisional Core Area" (USFWS 2005, pp. 6, 21, 23). With the exception of western Colorado, these units also encompass and closely mirror the areas the Service designated as critical habitat in 2014 (79 FR 54782). Some areas adjacent to but outside these geographic units are known or suspected to intermittently support lynx home ranges and occasional reproduction. Uncertainty remains as to whether resident lynx populations occurred historically in other areas not encompassed by the geographic units evaluated here.

The six geographic units include Federal, private, State, and Tribal lands. The amounts in each ownership vary among the units, with private lands predominating in Maine, a mix of ownerships in Minnesota, and Federal lands predominating in the western units (Table 2).

Table 2. Lynx SSA Unit Sizes and Percent Ownership.

			Land Ownership/Management (Percent)[2]						
			Federal[3]				Private	State	Tribal
Unit[1]	Unit Size (km^2)	Percent of SSA Area	All Federal	USFS	NPS	BLM			
1	28,909	22.0	1.2	0	1.2	0	90.4	7.3	0.9
2	21,101	16.1	47.4	44.9	2.5	0.01	15.5	36.2	1.0
3	26,997	20.6	84.3	69.3	13.6	1.5	8.0	4.1	3.5
4	5,176	3.9	91.5	84.6	6.7	0.1	0.3	8.2	0
5	23,687	18.1	97.6	79.7	16.7	1.1	2.2	0.3	0
6	25,294	19.3	90.1	85.2	1.8	3.1	9.3	0.6	0
All Units	131,164	100	63.8	55.6	7.1	1.1	26.3	8.8	1.1

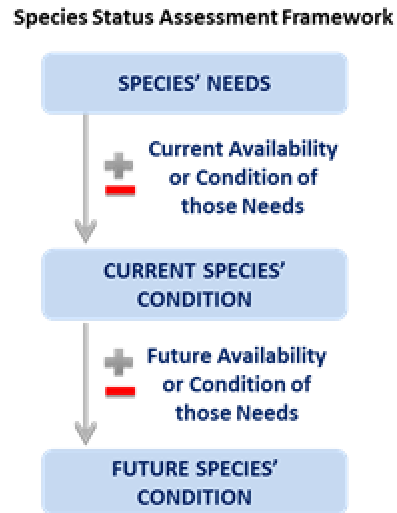
[1] Unit 1 - Northern Maine; Unit 2 - Northeastern Minnesota, Unit 3 - Northwestern Montana/ Northeastern Idaho, Unit 4 - North-central Washington, Unit 5 - the Greater Yellowstone Area (Southwestern Montana/Northwestern Wyoming), Unit 6 - Western Colorado.

[2] Unit sizes and ownership for units 1-5 are those calculated for the areas designated in 2014 as lynx critical habitat, including some Tribal, State and private lands that met the criteria for critical habitat but which were excluded from the designation in accordance with section 4(b)(2) of the Endangered Species Act. Unit 6 size and ownership were calculated by the Service's Western Colorado Field Office in coordination with Colorado Parks and Wildlife based on telemetry data from radio-marked lynx.

[3] USFS = U.S. Forest Service; NPS = National Park Service; BLM = Bureau of Land Management.

1.2 SSA Framework and Report

The Service is engaged in a number of efforts to improve the implementation of the ESA (see http://www.fws.gov/endangered/improving_ESA/). As part of this effort, our Endangered Species Program has developed the Species Status Assessment (SSA) Framework to guide how we assess the best scientific and commercial data available when evaluating the biological status of species. In conducting an SSA, we take into consideration the life history and ecological requirements of the species to understand how the species maintains itself over time (captured under the broad heading of "species needs"); the current condition of the species at the individual, population, and range-wide levels in terms of meeting those needs; and the likely changes in the environment that may influence the species' future condition and, thus, the viability of the species.



The SSA Framework defines viability as a description of the ability of a species to sustain populations in the wild beyond a biologically meaningful time frame[1]. Throughout the assessment, the SSA uses the conservation biology principles of resiliency, redundancy, and representation (collectively known as the "3 Rs") as a lens to evaluate the current and future condition of the species. Briefly, resiliency describes the ability of the species to withstand stochastic events; redundancy describes the ability of the species to withstand catastrophic events; and representation describes the ability of the species to adapt over time to long-term changes in the environment. As a result, the SSA characterizes a species' ability to sustain populations in the wild over time based on the best scientific understanding of current and future abundance and distribution within the species' ecological settings. Importantly, the SSA neither results in, nor predetermines, any decisions (e.g., listing status, critical habitat designations, section 7 consultation requirements, etc.) by the Service under the ESA. Instead the SSA provides the biological basis to inform these decisions. The SSA is a dynamic document and should be periodically revised as new scientific information becomes available.

The Species Status Assessment Report (SSA Report) is a summary of the information assembled, reviewed, and assessed by the Service and is based on the best scientific and commercial data available at the time of the assessment. Completed SSA Reports and supporting material can be found at the collaborative repository of the National Park Service and the USFWS called "ServCat" at the following IP address: *http://www.fws.gov/Refuges/NaturalResourcePC/IandM/serviceCatalog.html*.

1.3 Analytical Approach and Methods

We used the SSA Framework (October 2015, version 3.3) described above to evaluate the current status of resident lynx in the contiguous U.S. as well as the likelihood that the geographic areas supporting resident lynx in the DPS would continue to do so in the near term and at mid- and end-of-century (years 2025, 2050, and 2100). We framed our evaluation in terms of the 3 Rs using conceptual modeling (Figures 2-5) based on available published

[1] Viability is not a specific state, but rather a continuous measure of the likelihood that the species will sustain populations in the wild over time. USFWS. 2015. Species Status Assessment Framework. Version 3.3. October 2015.

literature, other information on the historical and current status of and threats to lynx in the DPS and, where empirical data are lacking, on formally-elicited expert opinion and best professional judgment (Lynx SSA Team 2016, entire).

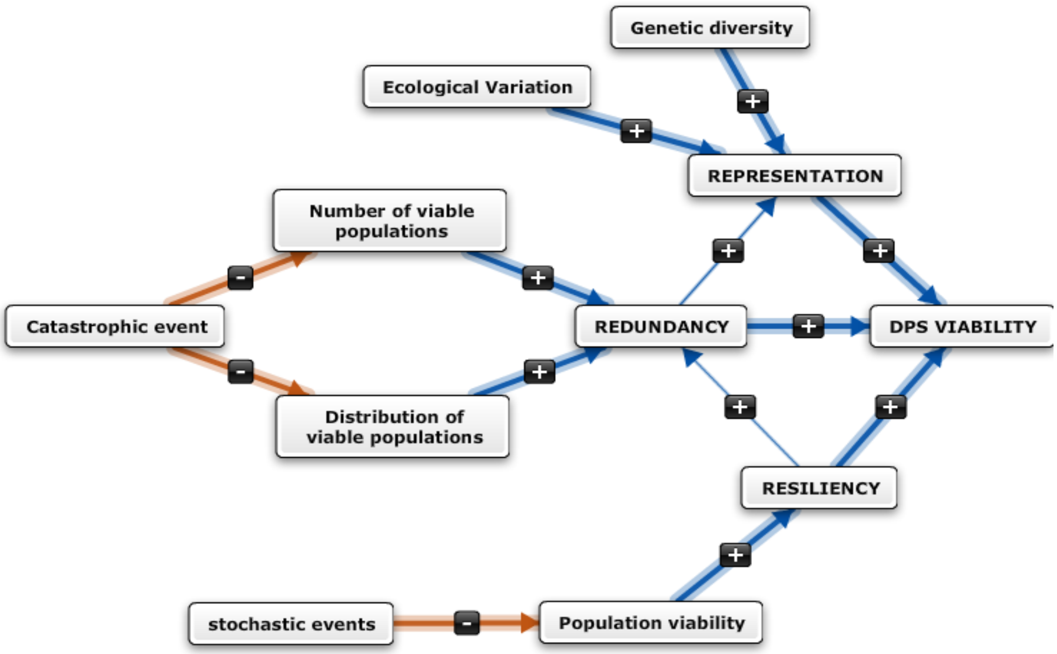


Figure 2. Conceptual model of the factors thought to influence the 3 Rs as they pertain to lynx viability.

We applied the definitions from the SSA Framework for the principles of redundancy, representation, and resiliency, provided in section 1.2, to Canada lynx as described below. We evaluated redundancy and representation at the scale of the DPS as a whole, and resiliency at the scale of lynx populations within each of the six geographic units.

To evaluate **redundancy** for the lynx DPS, we considered the current and likely future geographic distributions of resident breeding populations and whether the DPS is currently vulnerable to extirpation from a catastrophic event or would be vulnerable in the future. We consider catastrophic events to be relatively discrete in both time and geographic extent (e.g., wildfires, storms, floods, volcanic eruptions, etc.) and, therefore, we do not consider anthropogenic climate warming as a catastrophic event (see below). Figure 3 shows examples of relationships among factors that may influence redundancy within the lynx DPS.

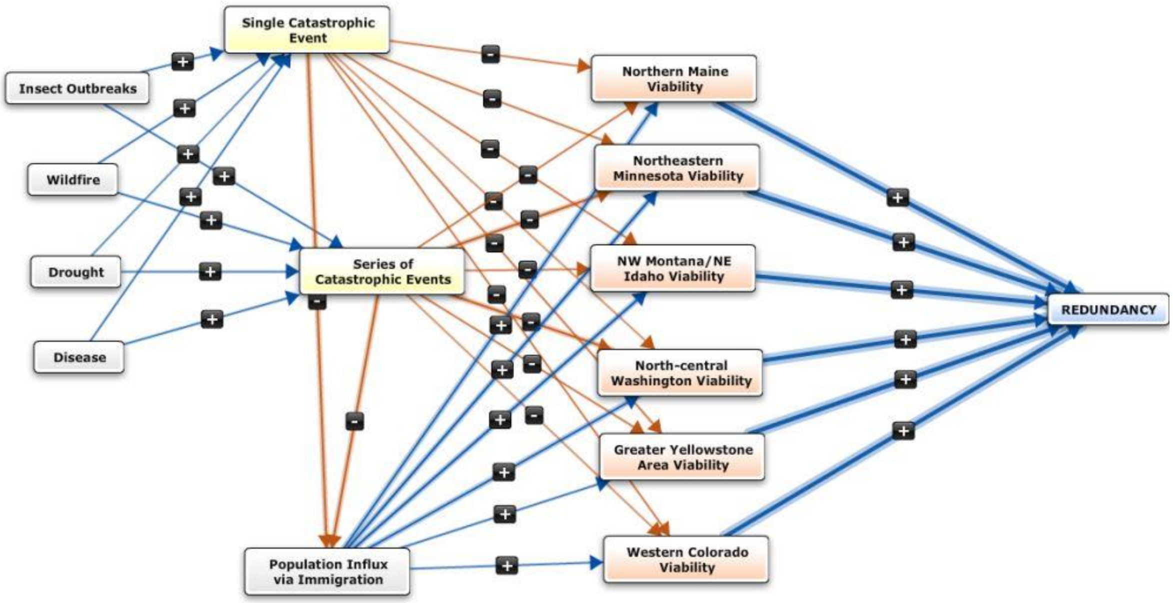


Figure 3. Conceptual model of factors thought to influence redundancy within the lynx DPS.

To evaluate **representation** for the lynx DPS, we considered measures of genetic diversity and heterozygosity, the current and likely future ecological diversity of geographic areas occupied by resident breeding populations, and the documented dispersal capabilities of the species, as shown in Figure 4 below.

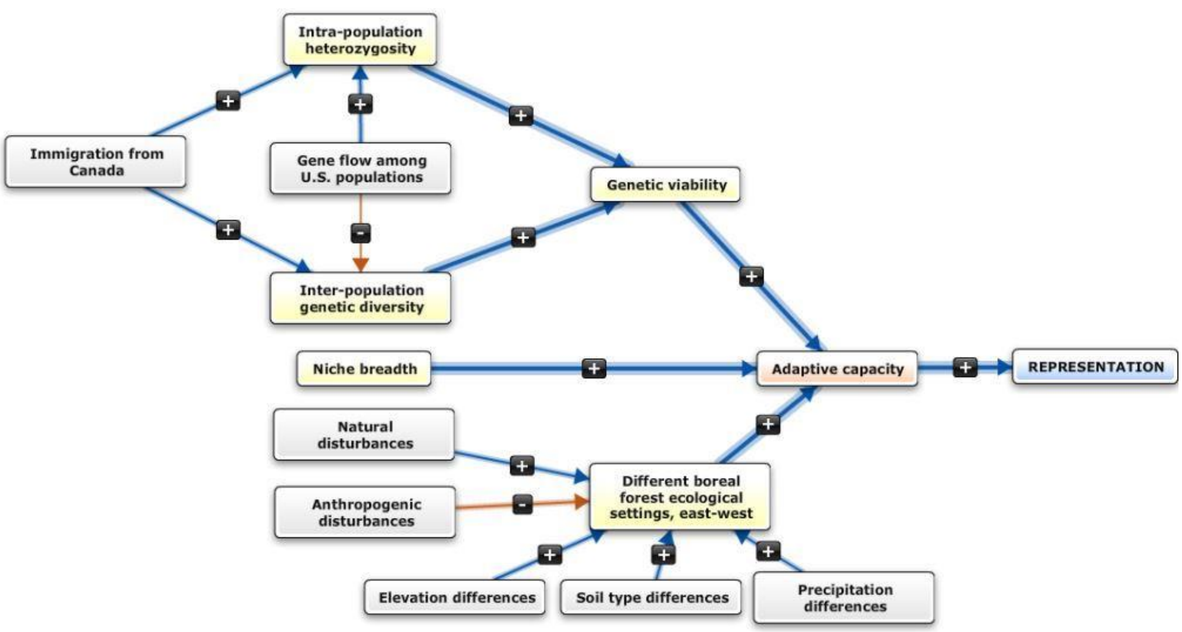


Figure 4. Conceptual model of factors thought to influence representation within the lynx DPS.

Because we lack reliable estimates of population sizes and trends, growth rates, and other long-term demographic data for most populations in the DPS, our evaluation of the **resiliency** of lynx populations in the DPS was based largely on consideration of recent status updates and formally-elicited expert opinion regarding the likelihood that DPS populations will remain viable into the future. The relationships among factors that influence DPS resiliency are shown in Figure 5 below.

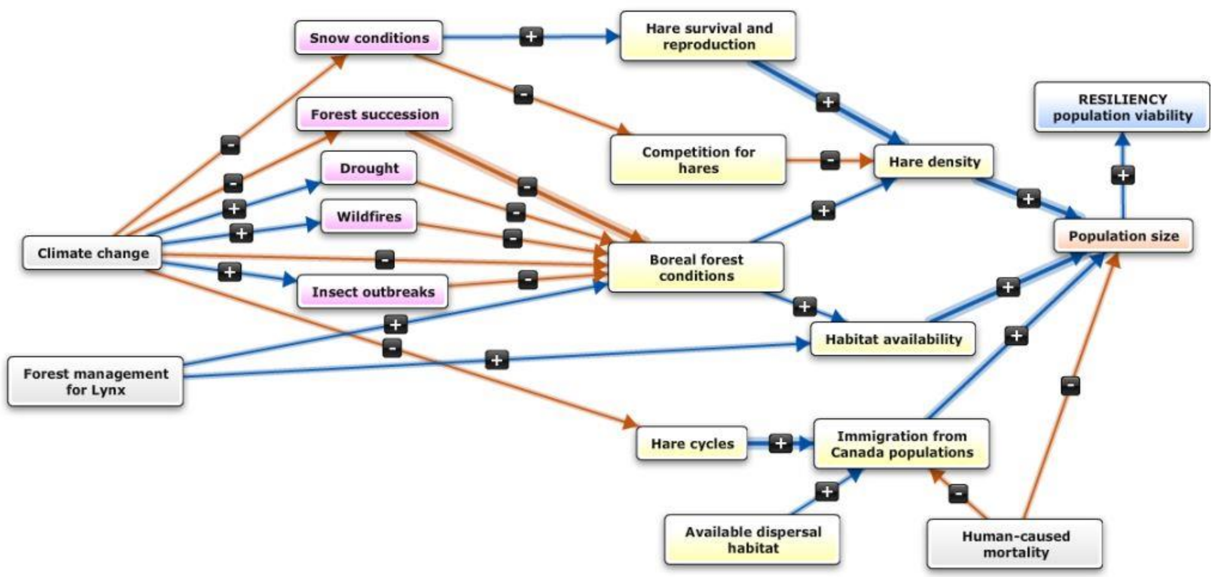


Figure 5. Conceptual model of factors thought to influence the resiliency of lynx populations within the DPS.

We elicited expert input on the probabilities that resident lynx populations will persist in each geographic unit because we lack reliable estimates of the sizes and trends of lynx populations in the DPS and because existing demographic data are inadequate to construct empirical models to project population sizes, trends, and viability into the future. In Chapter 5, we present summaries of experts' predictions regarding the probability of lynx persistence in each geographic unit; the factors they thought would most likely influence those probabilities; and the sources of uncertainty that influenced their confidence in their predictions. We then present our evaluation of the scientific literature regarding how certain anthropogenic factors may influence future conditions for resident lynx in each geographic unit. The factors we consider for each geographic unit include regulatory mechanisms (the factor for which the DPS was originally listed under the ESA) and the anthropogenic influences identified by the Interagency Lynx Biology Team (ILBT) as the most likely to have population-level impacts to lynx in the DPS (climate change, vegetation management, wildland fire management, and habitat loss/fragmentation; ILBT 2013, pp. 68-78). Other factors were also evaluated for some geographic units if the SSA Core Team member most familiar with that unit felt those factors could pose meaningful, even if less likely, risks to the unit's continued ability to support resident lynx. After considering all of the above, we present our conclusions regarding the future conditions for resident lynx in each geographic unit and we discuss the extent to which our conclusions agree with or differ from the projections provided by the lynx expert panel we consulted and, if they differed, why.

Implicit in our evaluation of the future for lynx in the contiguous U.S. is our recognition and consideration of a future in which the DPS is not listed under the ESA. However, given the DPS's listing history and the ESA's requirements for delisting, we do not evaluate the unlikely hypothetical future in which the DPS is not listed and all protections and conservation efforts disappear. Rather, we assume that although some protections could be relaxed (e.g., less stringent analyses of Federal project-related impacts, potential for some states to reinstitute limited trapping/hunting harvest), that conditions for delisting would include requirements and incentives to continue to conserve lynx and its habitats and to assure persistence of resident lynx populations in those places that can support them on Federal, State and Tribal lands (perhaps some private lands as well). Our evaluation, therefore, considers the possibility of the future relaxing of some lynx conservation measures and efforts, but not the complete absence of all protections for lynx.

Additionally, we do not to define and evaluate specific and explicit climate change/ greenhouse gas emissions scenarios or attempt to quantify differences in DPS viability or the persistence of resident lynx populations in individual geographic units based on differences in the rate and extent of potential impacts associated with projected continued climate warming. This is because of the limited resolution and inherent uncertainty of available climate models and the inadequacy of existing demographic data for projecting lynx populations in the DPS over time, including their potential responses to a range of climate-mediated potential future habitat conditions. Therefore, this SSA does not constitute or include a formal climate change vulnerability assessment (Glick *et al*., editors, 2011, entire) for the lynx DPS. Instead, underlying our evaluation in this SSA is the recognition that the lynx, as a broadly-distributed boreal forest- and snow-reliant predator that relies heavily on a single, similarly-specialized prey species, and whose habitats are influenced by climate-mediated disturbance factors (e.g., wildfire, forest insects, wind/ice storms, etc.), is likely highly sensitive and broadly exposed to the impacts of climate change and has limited adaptive capacity to respond to it. Therefore, we (along with the experts we consulted and the ILBT) consider lynx populations in the DPS vulnerable to the projected impacts of continued climate warming. While we recognize that the pace and extent of impacts would be expected to differ under specific emissions or modeling scenarios, the limitations described above preclude us from quantifying those differences and their potential influence on the probabilities that resident lynx will persist in the DPS or in individual geographic units. Finally, in our analyses we do not consider anthropogenic climate warming a catastrophic effect because it is not temporally- and spatially-discrete; characteristics of events traditionally considered catastrophic (e.g., wildfires, floods, storms, volcanic eruptions, etc.). Rather, we consider climate warming as an ongoing, pervasive, and cumulative stressor of lynx and their habitats, particularly at the southern margin of the species' distribution, including all geographic areas of the DPS.

Chapter 2: Lynx Ecology

In this chapter, we describe the physical characteristics, taxonomy, and genetics of the Canada lynx, its life history and population dynamics, and its taxon-wide and DPS distributions. We rely heavily on recent summaries of this information provided in the revised *Canada Lynx Conservation Assessment and Strategy* (LCAS; ILBT 2013, entire), the Service's recent proposed (2013) and final (2014) rules to revise the designation of critical habitat for the DPS (78 FR 59430-59474; 79 FR 54782-54846), and the results of an October 2015 lynx expert elicitation workshop (Lynx SSA Team 2016, entire). We also provide a summary of the pertinent ecological requirements of lynx at the individual, population, and DPS levels. These ecological requirements form the basis of our analyses conducted in Chapters 3 through 5.

2.1 Species Taxonomy, Description, and Genetics

The Canada lynx (order Carnivora; family Felidae) is one of four species within the genus *Lynx* (Kerr 1792), which also includes the bobcat (*L. rufus*, Schreber 1777), the Eurasian lynx (*L. lynx*, Linnaeus 1758), and the Iberian or Spanish lynx (*L. pardinus*, Temminck 1827). There are three recognized subspecies of Canada lynx: *Lynx canadensis canadensis* (Kerr 1792), *L. c. mollipilosus* ("Arctic lynx," Stone 1900), and *L. c. subsolanus* ("Newfoundland lynx," Bangs 1897) (Integrated Taxonomic Information System online database, *http://www.itis.gov*, retrieved April 14, 2016).

The Canada lynx is a medium-sized cat with long legs and large, well-furred paws. In winter, the lynx's fur is dense and has a grizzled appearance with a grayish-brown mix of buff or pale brown fur on the back, and a grayish-white or buff-white fur on the belly, legs, and feet. In summer, its fur is more reddish to gray-brown (McCord and Cardoza 1982, p. 730). It has long tufts of black hairs extending from the tips of its ears, a short, completely black-tipped tail, and often a distinct dish-like facial ruff of pale hairs tipped black. Lynx generally measure 75 to 90 cm (30 to 35 in) long and weigh 6 to 14 kg (14 to 31 lb) (Quinn and Parker 1987, Table 1; Moen *et al.* 2010a, Figure 2; Maine Department of Inland Fisheries and Wildlife 2012, unpublished data), and males are 13-25 percent larger than females (Mowat *et al.* 2000, p. 267). The lynx's large feet and long legs make it highly adapted for traversing and hunting in deep, powdery snow, where its low foot-loading (weight per surface area of foot) is thought to provide a competitive advantage (Buskirk *et al.* 2000a, p. 90; 2000b, p. 400; ILBT 2013, pp. 26, 36, 81) over other terrestrial predators of snowshoe hares, the lynx's primary prey. In southern Canada and the northern contiguous U.S., where the southern edge of the lynx range overlaps the northern edge of the bobcat range, the two species are easily confused because of their similar size and appearance. However, the lynx's longer ear-tufts, larger feet, and black-tipped tail distinguish it from the bobcat, which has shorter ear tufts, small feet, and white on the underside of the tail. Bobcats are much more common and abundant than lynx in most of the contiguous U.S.

Overall, genetics research suggests high gene flow across most of the continental range of lynx, likely because of high dispersal rates, large dispersal distances, and the absence of significant barriers to genetic interchange throughout much of the lynx range, including the DPS (Schwartz *in* Lynx SSA Team 2016, pp. 11-12). Genetic evidence also indicates interactions between lynx populations even where physical barriers appear most likely to restrict gene flow. For example, although *L. c. subsolanus* on Newfoundland Island is genetically (Row *et al.* 2012, pp. 1262-1266; Koen *et al.* 2015, p. 528) and morphologically (Khidas *et al.* 2013, pp. 597-601) distinct from mainland lynx (*L. c. canadensis*), there is evidence of genetic exchange between the two areas, indicating that some lynx are able to cross the 15-60 km-wide (9-37 mi) Strait of Belle Isle that separates them (Koen *et al.* 2015, p. 527). Similarly, despite some differences in functional genetic markers (unique alleles) in lynx south versus north of the St. Lawrence Seaway/River in eastern Canada, which suggest the potential for evolutionarily significant differences in those areas, recent analyses reveal genetic exchange among lynx on either side, indicating that some lynx successfully navigate this barrier (Koen *et al.* 2015, pp. 524-528; Bowman *in* Lynx SSA Team 2016, p. 12-13).

Schwartz *et al.* (2003, entire) documented reduced genetic variation (lower mean number of alleles per population and lower expected heterozygosity) among peripheral lynx populations compared to populations in the core of the lynx geographical range in Canada and Alaska. While recognizing that small changes in genetic variation can lead to large changes in population fitness, the authors noted that the differences between core and peripheral populations in their study were small enough to suggest a lack of significant population subdivision (i.e., no indication of genetic isolation, substantial genetic drift, or potential genetic ''bottlenecks'' among DPS populations; Schwartz *et al.* 2003, p. 1814; 79 FR 54793). This finding is consistent with their earlier work, which documented high levels of gene flow (the highest yet documented for any carnivore) between core and peripheral lynx populations despite large separation distances (Schwartz *et al.* 2002, entire). Their results did not suggest that reduced genetic variation among peripheral populations was because of human disturbance (i.e., habitat loss/ fragmentation on the southern periphery of the geographic range; Schwartz *et al.* 2003, p. 1814), but they did imply that the persistence of lynx populations in the contiguous U.S. depends on dispersal from larger (core) populations (Schwartz *et al.* 2002, p. 522).

Currently, there is no indication that the levels of connectivity and gene flow between lynx populations in the DPS and those in the core of the lynx's range are inadequate to maintain the genetic health of DPS populations. Given the connectivity of most DPS units with lynx populations and habitats in Canada, the noted dispersal capabilities of lynx, evidence of dispersal in both directions across the Canada-U.S. border (Aubry *et al.* 2000, pp. 386-387; Squires *et al.* 2006a, p. 38; Moen *et al.* 2010b, pp. ii, 17, 19; Vashon *et al.* 2012, p. 22), and the small number of immigrants thought necessary to maintain genetic variability in peripheral populations (McKelvey *et al.* 2000b, pp. 23-24), genetic isolation, biologically meaningful genetic drift, or potential genetic ''bottlenecks'' appear unlikely among most DPS populations in the future (79 FR 54793).

Within the contiguous U.S., minor genetic sub-structuring has been documented among lynx subpopulations in western Montana (Schwartz *in* Lynx SSA Team 2016, p. 12 and Appendix 5).

Genetic diversity may be somewhat greater among lynx in western Colorado than elsewhere in the DPS range because of the broad geographic distribution of the source populations that contributed to the lynx releases in Colorado (45 lynx from Quebec, four from Manitoba, 91 from British Columbia, 48 from The Yukon Territory, and 30 from Alaska). Additionally, lynx-bobcat hybridization has been documented in Minnesota, Maine and New Brunswick (Schwartz *et al.* 2004, entire; Homyack *et al.* 2008, entire), where male bobcats bred with female lynx to produce fertile offspring with lynx-like ear tufts, intermediate foot-size, and bobcat-like fur (ILBT 2013, p. 35). In Minnesota from 2000 to 2015, DNA analyses documented 13 distinct hybrid individuals (Moen and Catton *in* Lynx SSA Team 2016, pp. 13, 19); no hybrids have been documented in the western portion of the lynx's range (Schwartz *in* Lynx SSA Team 2016, p. 12).

2.2 Life History and Population Dynamics

All aspects of lynx life history are inextricably tied to its primary prey, the snowshoe hare (Figure 6). Snowshoe hares comprise a majority of the lynx diet throughout its range (Nellis *et al.* 1972, pp. 323–325; Brand *et al.* 1976, pp. 422–425; Koehler 1990, p. 848; Apps 2000, pp. 358–359, 363; Aubry *et al.* 2000, pp. 375–378; Mowat *et al.* 2000, pp. 267–268; von Kienast 2003, pp. 37–38; Squires *et al.* 2004a, p. 15, Table 8, Olson 2015, pp. 60-69), and hare abundance is the major driver of lynx population dynamics. Lynx den site selection, litter sizes, pregnancy, as well as recruitment, survival (kitten, subadult and adult) and dispersal rates, and population age structure, home range sizes, density, and distribution are all strongly influenced by hare abundance (Koehler and Aubry 1994, pp. 75-76, 80-83; Apps 2000, entire; Aubry *et al.* 2000, pp. 375-390; Mowat *et al.* 2000, pp. 270-294; ILBT 2013, pp. 18, 22-24, 26-34).

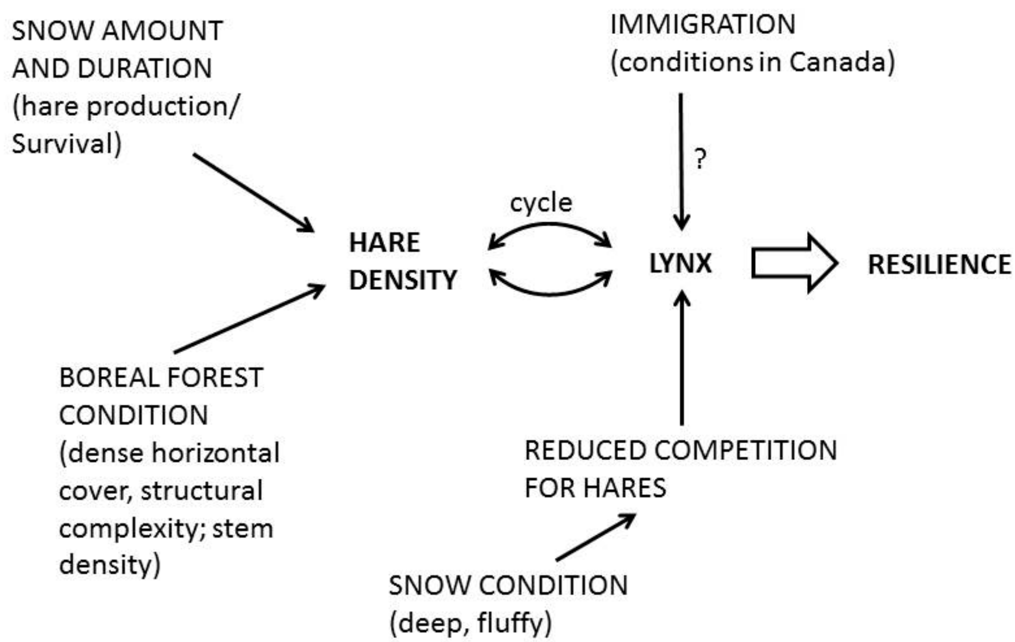


Figure 6. Generalized relationship between habitat conditions and hare and lynx population dynamics and their influence on lynx population resiliency.

Lynx are highly specialized predators of snowshoe hares and are dependent on landscapes with high-density snowshoe hare populations for survival and reproduction (McCord and Cardoza 1982, p. 744; Quinn and Parker 1987, pp. 684-685; Aubry *et al.* 2000, pp. 375-378). Lynx and snowshoe hares are strongly associated with what is broadly described as boreal forest (Bittner and Rongstad 1982, p. 154; McCord and Cardoza 1982, p. 743; Quinn and Parker 1987, p. 684; Agee 2000, p. 39; Aubry *et al.* 2000, pp. 378-382; Hodges 2000a, pp. 183-191 and 2000b, pp. 136-140; McKelvey *et al.* 2000a, pp. 211-232). The predominant vegetation of boreal forest is conifer trees, primarily species of spruce (*Picea* spp.) and fir (*Abies* spp.) (Elliot-Fisk 1988, pp. 34-35, 37-42). Snowshoe hares feed on conifers, deciduous trees, and shrubs (Hodges 2000a, pp. 181-183) and are most abundant in forests with dense understories that provide forage, cover to escape from predators, and protection during extreme weather (Wolfe *et al.* 1982, pp. 665-669; Litvaitis *et al.* 1985, pp. 869-872; Hodges 2000a, pp. 183-195 and 2000b, pp. 136-140). Over much of the lynx's range, hare densities are higher in regenerating, earlier successional forest stages because they often have greater understory structure than mature forests (Buehler and Keith 1982, p. 24; Wolfe *et al.* 1982, pp. 665-669; Koehler 1990, pp. 847-848; Hodges 2000a, pp. 183-195; Homyack 2003, pp. 63, 141; Griffin 2004, pp. 84-88). However, snowshoe hares also can be abundant in mature forests with dense understories, particularly in the Northern Rocky Mountains (Griffin 2004, pp. 53-54; Griffin and Mills 2009, pp. 1492-1496; Hodges *et al.* 2009, p. 876; Squires *et al.* 2010, pp. 1653-1657; Berg *et al.* 2012, pp. 1483-1487). These mature forests may be a source of hares for other adjacent forest types (Griffin and Mills 2009, pp. 1492, 1495-1496), and they may provide especially important winter foraging habitats (Squires *et al.* 2010, pp. 1655-1657), which may be the most limiting habitat for lynx (Squires *et al.* 2010, pp. 1655-1657; ILBT 2013, pp. 17, 27). They also are more temporally-stable (i.e., they provide high-quality hare habitat for a longer period of time) than regenerating stands, which may foster high hare densities for a variable window of time between stand-initiation and stem-exclusion stages of succession, after which they may persist, in the absence of disturbance, for many years as lower-quality hare habitat (ILBT 2013, pp. 62, 71, 127).

Lynx habitat can generally be described as moist boreal forests that have cold, snowy winters and a snowshoe hare prey base (Quinn and Parker 1987, pp. 684-685; Agee 2000, pp. 39-47; Aubry *et al.* 2000, pp. 373-375; Buskirk *et al.* 2000b, pp. 397-405; Ruggiero *et al.* 2000b, pp. 445-447). Because lynx population dynamics, survival, and reproduction are closely tied to snowshoe hare availability, snowshoe hare habitat is the primary component of lynx habitat. However, lynx do not occur everywhere within the range of snowshoe hares in the contiguous U.S. (Bittner and Rongstad 1982, p. 146; McCord and Cardoza 1982, p. 729). This may be due to inadequate abundance, density, or spatial distribution of hares in some places, or the absence of snow conditions that would allow lynx to express a competitive advantage over other hare predators, or a combination of these factors (79 FR 54809).

The boreal forest landscape is naturally dynamic. Forest stands within the landscape change as they undergo succession after natural or human-caused disturbances such as fire, insect epidemics, wind, ice, disease, and forest management (Elliot-Fisk 1988, pp. 47-48; Agee 2000, pp. 47-69). As a result, lynx habitat within the boreal forest landscape is a shifting mosaic of habitat patches of variable and continually changing quality (68 FR 40077). These stands of differing ages and conditions provide lynx foraging or denning habitat (or may provide these in the future depending on patterns of disturbance and forest succession), and some serve as travel routes for lynx moving between foraging and denning habitats (McKelvey *et al.* 2000c, pp. 427-434; Hoving *et al.* 2004, pp. 290-292). Lynx generally concentrate hunting activities in areas where snowshoe hare densities are high (Koehler *et al.* 1979, p. 442; Ward and Krebs 1985, pp. 2821-2823; Murray *et al.* 1994, p. 1450; O'Donoghue *et al.* 1997, pp. 155, 159-160 and 1998, pp. 178-181; Fuller and Harrison 2010, entire; Simons-Legaard *et al.* 2013, pp. 573-575). Because understory density within a forest stand changes over time, hare habitat quality and corresponding hare densities also shift continually across boreal forest landscapes.

Hare populations in the core of the lynx range in Canada and Alaska undergo well-documented dramatic 8 to 11 year cycles during which hare numbers may fluctuate 10 to 25 fold or more, with peak densities as high as 23 hares/hectare (ha; 9.3 hares/acre [ac]) and lows of 0.1/ha (0.04/ac) (Hodges 2000b, pp. 117-121; Vashon 2015, p. 4). Hare densities are generally lower at the southern periphery of lynx distribution, and hare population cycles are generally much less pronounced or absent entirely among some hare populations in southern Canada and in the contiguous U.S. (Hodges 2000a, pp. 163–173; Hodges *et al.* 2009, pp. 870, 875–876; Scott 2009, pp. 1–44; Environment Canada 2014, p. 1; Hodges *in* Lynx SSA Team 2016, pp. 16-17). In the contiguous U.S., average stand-level hare densities may exceed 2 hares/ha (0.8 hares/ac) (Walker 2005, pp. 20, 85; McCann 2006, p. 15; Robinson 2006, pp. 26-36, 62-75; Homyack *et al.* 2007, pp. 10-11; Griffin and Mills 2009, p. 1492; Vashon *et al.* 2012, p. 14), but in many parts of the DPS, landscape-level densities are lower, ranging from just above to well below the 0.5 hares/ha (0.2/ac) density thought necessary to sustain lynx home ranges and populations (Hodges 2000a, pp. 168-169, 185; Ruggiero *et al.* 2000b, pp. 446–447; Squires and Ruggiero 2007, pp. 313-314; Maletzke *et al.* 2008, pp. 1476-1477; Zahratka and Shenk 2008, pp. 910-911; Hodges *et al.* 2009, pp. 873-877; Ivan 2011a, pp. 91-92, 95-102; Berg *et al.* 2012, p. 1483; ILBT 2013, pp. 24, 26, 90).

During lows in snowshoe hare populations, lynx prey opportunistically on other small mammals, especially red squirrels (*Tamiasciurus hudsonicus*), and birds, but alternate prey species do not sufficiently compensate for low availability of snowshoe hares, and lynx populations cannot persist over time in areas with consistently low hare densities (Brand *et al.* 1976, pp. 422–425; Brand and Keith 1979, pp. 833–834; Koehler 1990, pp. 848–849; Mowat *et al.* 2000, pp. 267–268). Nonetheless, even in areas with relatively low or marginal hare densities, hares constitute the majority of the biomass in lynx diets (Koehler and Aubry 1994, p. 85; Apps 2000, pp. 362-363; Aubry *et al.* 2000, pp. 375-378; Roth *et al.* 2007, pp. 2740-2741; Squires and Ruggiero 2007, pp. 310-313; Hanson and Moen 2008, p. 9; Maletzke *et al.* 2008, pp. 1475-1477; Shenk 2009, pp. 13, 16; Ivan *in* Lynx SSA Team 2016, Appendix 3, pp. 13-14).

Lynx typically mate in March and April, and kittens are born from late April to mid-June after a 60- to 70-day gestation period (Koehler and Aubry 1994, p. 81; Mowat *et al.* 2000, p. 285). Female lynx typically reach reproductive maturity in their second year (at 22 months of age); however, when hares are abundant, females may breed at 10 months of age and produce kittens as 1-year-olds (Koehler and Aubry 1994, p. 81; Mowat *et al.* 2000, p. 285). Males do not seem to breed as yearlings, and they do not contribute to rearing of young (ILBT 2013, p. 30). Lynx dens are typically located in areas of dense cover, where coarse woody debris, such as downed logs and windfalls, provides security and thermal cover for lynx kittens (McCord and Cardoza 1982, pp. 743-744; Koehler 1990, pp. 847-849; Slough 1999, p. 607; Squires and Laurion 2000, pp. 346-347; Organ *et al.* 2008, entire; Squires *et al.* 2008, pp. 1497, 1501-1505; Moen and Burdett 2009, entire). Dens have been documented in both mature and younger boreal forest stands (Mowat *et al.* 2000, pp. 274-275; Squires *et al.* 2008, p. 1497; ILBT 2013, pp. 29-30; 78 FR 59441-59442; 79 FR 54809-54810; Organ *et al.* 2008, entire), and the amount of structure (e.g., downed, large, woody debris, tip-up mounds) seems to be more important than the age of the forest stand for lynx denning habitat (Mowat *et al.* 2000, pp. 274-275, Organ *et al.*2008, p. 1516). Denning habitat is not thought to be a limiting factor for lynx in the DPS (Moen *et al.* 2008a, p. 1512; Organ *et al.* 2008, pp. 1514, 1516–1517; Squires *et al.* 2008, p. 1505; ILBT 2013, p. 30; 79 FR 54790). Dens must be near foraging habitat to allow females to adequately provision dependent kittens, and females seem to select den sites near prey sources to minimize time spent away from kittens while foraging (Moen *et al.* 2008a, p. 1507; Vashon *et al.* 2012, p. 16; ILBT 2013, p. 29). Females attend kittens at the natal den site and one or more (up to five) alternate or maternal dens until kittens are about 6-10 weeks old (Squires *et al.* 2008, p. 1502; Olson *et al.* 2011, pp. 458-460; Vashon *et al.* 2012, p. 17; ILBT 2013, p. 29). Thereafter, kittens remain with their mothers through their first winter, apparently learning from her how to hunt and capture prey, initially on a small portion of her home range, but by fall on the larger area the female used before kittens were born (Mowat *et al.* 2000, pp. 269, 278). Juveniles remain closely associated with their mothers until February or March, when family groups begin to break up, with young typically dispersing in April and May (Mowat *et al.* 2000, pp. 278-279) to establish their own home ranges. Female offspring may establish home ranges overlapping or adjacent to their mother's home range and maintain mother-daughter bonds throughout their lives (Mowat *et al.* 2000, pp. 279-280). Male home ranges may slightly overlap adjacent male home ranges. While male home ranges typically overlap one to three female home ranges, and female home ranges are partially or completely encompassed by a male's home range, core areas within home ranges appear to be exclusive except during the breeding season (Koehler and Aubry 1994, pp. 90-91; Mowat *et al.* 2000, pp. 276-280; Vashon *et al.* 2012, pp. 17, 22-23). Fidelity to home ranges over several years has been documented for both sexes, but shifts and abandonment of home ranges have also been documented (Koehler and Aubry 1994, p. 91; Mowat *et al.* 2000, p. 277). Lynx have been documented to live up to 16 years in the wild (Kolbe and Squires 2006, entire).

Lynx populations in Canada fluctuate in response to the cycling of hare populations (Elton and Nicholson 1942, pp. 241–243; Hodges 2000b, pp. 118–123; Mowat *et al.* 2000, pp. 265–272), with synchronous fluctuations in lynx numbers emanating from the core of the Canadian population and spreading over vast areas, generally lagging hare numbers by one year (McKelvey *et al.* 2000a, pp. 232, 239; Mowat *et al.* 2000, pp. 266, 270). When hares are abundant, lynx have higher pregnancy rates and larger litter sizes, higher kitten survival, and lower adult mortality, resulting in rapid population growth during the increase phase of the hare cycle (Slough and Mowat 1996, pp. 955–956; Mowat *et al.* 2000, pp. 266, 270–272, 281–289). When hare populations are low, female lynx produce few or no kittens that survive to independence (Nellis *et al.* 1972, pp. 326–328; Brand *et al.* 1976, pp. 420, 427; Brand and Keith 1979, pp. 837–838, 847; Poole 1994, pp. 612–616; Slough and Mowat 1996, pp. 953–958; O'Donoghue *et al.* 1997, pp. 158–159; Aubry *et al.* 2000, pp. 388–389; Mowat *et al.* 2000, pp. 285–287). When hares decline, lynx mortality rates increase, largely because of starvation, and home range sizes and dispersal/ emigration rates also increase (Ward and Krebs 1985, pp. 2821–2823; O'Donoghue *et al.* 1997, pp. 156, 159; Poole 1997, pp. 499–503; Mowat *et al.* 2000, pp. 265–272, 278, 281–294). Lynx numbers decline dramatically during the ''crash'' phase of the hare cycle (Slough and Mowat 1996, p. 956; Mowat *et al.* 2000, pp. 283-285), when many lynx starve and many others abandon home ranges and disperse in search of food, with many of the latter also dying, often soon after initiating dispersal (Mowat *et al.* 2000, p. 293).

In Canada, lynx abundance may be 3 to 17 times higher at the peak versus the low of the hare cycle, with lynx densities reaching 30-45/100 km^2 (78-117/100 mi^2) in optimal dense regenerating forests 15-40 years post-fire, 8-20/100 km^2 (21-52/100 mi^2) in older forests or further south, and < 3/100 km^2 (< 8/100 mi^2) at the hare cycle low (Slough and Mowat 1996, pp.

952, 955; Mowat *et al.* 2000, p. 283; Hatler and Beal 2003, pp. 2, 5; Environment Canada 2014, p. 1). In southern Canada, where hares are less abundant and hare population cycles are muted or absent, lynx populations may be stable at 2-3/100 km^2 (5-8/100 mi^2) (Environment Canada 2014, p. 1). Lynx densities estimated in the contiguous U.S. have ranged from 9.2-13/100 km^2 (24-34/100 mi^2), including kittens, in Maine's highest-quality habitat when hares were abundant (Vashon *et al.* 2008a, pp. 1483-1484; Vashon *et al.* 2012, pp. 14-15) to 2.3/100 km^2 (6/100 mi^2) in Washington when hare abundance was low (Koehler 1990, pp. 847-850). Correspondingly, hare abundance may also influence lynx home range size. Ward and Krebs (1985, pp. 2819-2820) documented a 3-fold increase in home range size in southwestern Yukon, from 13 km^2 (5 mi^2) on average when hares were abundant and increasing to 39 km^2 (15 mi^2) when hare density was low. Poole (1994, pp. 613-614) documented a similar trend in the Northwest Territories, where lynx home range size increased from 17 km^2 (7 mi^2; males and females combined) when hares were abundant, to 44 km^2 (17 mi^2) and 62 km^2 (24 mi^2) for males and females, respectively, when hare numbers declined. In contrast, Breitenmoser *et al.* (1993, p. 552) reported no change in lynx home range size despite a 10-15 fold increase in lynx density as hare abundance increased in the southern Yukon. Similarly, in Maine, lynx home range size did not increase when hare densities in the best habitats declined from 2/ha (0.8/ac) to 1/ha (0.4/ac) (Mallett 2014, pp. 53-93). In general, hare and lynx densities are lower and lynx home ranges larger at the southern periphery of the lynx's range, including most of the contiguous U.S., and are similar to those of northern populations during the low phase of the hare population cycle (Koehler and Aubry 1994, p. 93; Aubry *et al.* 2000, pp 382-385; Apps 2000, pp. 362-367).

Lynx populations in the contiguous U.S. seem to function as subpopulations or southern extensions of larger populations in northern and eastern Canada (McKelvey *et al.* 2000b, pp. 21, 25, 33; 65 FR 16052–16082; 68 FR 40077–40099; 71 FR 66025–66035; 74 FR 8616–8641; Koen *et al.* 2015, pp. 527-528). Populations in the DPS are relatively isolated from one another, though most are directly connected via dispersal to lynx populations in Canada (McKelvey *et al.* 2000b, pp. 25-34; U.S Fish and Wildlife Service 2005, p. 2). Lynx disperse in both directions across the Canada–U.S. border (Aubry *et al.* 2000, pp. 386-387; Moen *et al.* 2010b, pp. ii, 17, 19; Vashon *et al.* 2012, p. 22), and this connectivity and interchange with lynx populations in Canada is thought to be important to the conservation of lynx populations in the DPS. (McKelvey *et al.* 2000b, p. 33; Schwartz *et al.* 2002, p. 522; U.S Fish and Wildlife Service 2005, p. 2; ILBT 2013, p. 34, 42, 47, 54, 60, 65; Squires *et al.* 2013, p. 187). However, whether and, if so, to what the extent the demographic and genetic health and persistence of populations in the DPS depend on regular or intermittent immigration of lynx from Canada remains uncertain (McKelvey *et al.* 2000a, pp. 241-242; 79 FR 54793).

2.2.1 Ecological Requirements of Individuals

At the most fundamental level, the needs of an individual lynx are met if:

1) it is born to a female that occupies a home range containing
   a) secure denning habitat,

   b) adequate hare abundance to support lactation during the early kitten stage and later provisioning of the kitten with hare meat,
   c) habitat (boreal forest and snow) conditions that reduce the likelihood and effect of competition from other hare predators, and
   d) a low likelihood of encounters with lynx mortality agents (predators, trappers, vehicles, etc.);

2) the mother's home range occurs within a larger landscape that also contains adequate hare abundance and available habitat into which the yearling lynx may disperse and establish its own home range after the period of maternal dependence, with low likelihood of adverse competition and mortality; and

3) the larger landscape also supports other secure lynx home ranges and ensures the opportunity to encounter a lynx of the opposite sex, breed successfully, and contribute to the recruitment of at least one offspring into the breeding population during its lifetime.

In cyclic northern lynx populations, there is a strong element of timing that determines whether these individual needs will be met. During the decline and low phases of the hare population cycle, few kittens are born, very few survive until their first winter, and recruitment may collapse completely or nearly so for several successive years (Slough and Mowat 1996, entire; Mowat *et al.* 2000, pp. 266, 285-287). Therefore, even in the core of the species' range, a kitten born during a period of declining or low hare abundance is very unlikely to survive to independence, breed successfully, and replace itself within the breeding population in its lifetime. Conversely, a kitten born during the increase or high phase of the hare population cycle is much more likely to survive, establish a home range, breed successfully, and replace itself via recruitment of one or more of its offspring into the breeding population.

In southern lynx populations (southern Canada and the contiguous U.S.), hare population cycles are of lower amplitude or absent (Hodges 2000a, pp. 163–173; Hodges *et al.* 2009, pp. 870, 875–876; Scott 2009, pp. 1–44; Environment Canada 2014, p. 1; Hodges *in* Lynx SSA Team 2016, pp. 16-17), and hare and lynx abundances and lynx demographic rates are typically like those of northern populations during hare lows (Koehler and Aubry 1994, p. 93; Aubry *et al.* 2000, pp 382-385; Apps 2000, pp. 362-367). Therefore, the likelihood that an individual lynx will have its ecological requirements met sufficiently so that it may replace itself in the breeding population is probably consistently relatively low, perhaps similar to lynx born during hare declines/lows in the north. Also in the south, there are more diverse assemblages of potential competitors and predators, more natural patchiness and anthropogenic fragmentation of lynx habitat (fewer areas with adequate hare densities and favorable snow conditions distributed broadly across large landscapes), and higher road densities and, thus, greater potential for lynx-vehicle collisions (Wolff 1980, p. 128; Buskirk *et al.* 2000a, entire). These factors probably further reduce the likelihood that an individual lynx in the southern periphery of the range will survive, reproduce successfully, and have one or more offspring recruited into the resident breeding population.

Individual lynx require large areas of boreal forest landscapes to support their home ranges, provide hares in adequate abundance to meet their nutritional needs, provide breeding opportunities, and facilitate dispersal and exploratory travel. Female home ranges must also provide secure denning habitat in close proximity to foraging areas with high hare densities to allow females to adequately provision dependent kittens, and females appear to select den sites near prey sources to minimize time spent away from kittens while foraging (Moen *et al.* 2008a, p. 1507; Vashon *et al.* 2012, p. 16; ILBT 2013, p. 29). The size of lynx home ranges is strongly influenced by the quality of the habitat, particularly the abundance of snowshoe hares, in addition to other factors such as gender, age, season, and density of the lynx population (Aubry *et al.* 2000, pp. 382–385; Mowat *et al.* 2000, pp. 276–280). Generally, females with kittens have the smallest home ranges, likely related to their need to stay close to dens and dependent kittens, and males have the largest home ranges (Moen *et al.* 2005, p. 11; Burdett *et al.* 2007, p. 463; ILBT 2013, p. 24).

The increased natural patchiness and fragmentation of high-quality hare habitat where boreal forest conditions transition to temperate forest types require individual lynx in many parts of the DPS to maintain relatively large home ranges that include patches of higher hare densities within a matrix of lower-quality habitats with lower hare densities (ILBT 2013, p. 126; 78 FR 59434; also see 2.3.3, below). Larger home ranges likely require more energy output associated with greater foraging effort (Apps 2000, p. 364) and possibly increased exposure to predation and other mortality factors than lynx face in the core of their range (78 FR 59438). Annual home range sizes reported for lynx in the contiguous U.S. (Table 3, below) vary greatly across the DPS but are generally larger in the west than the east; however, differences should be interpreted with caution because different methods, sample sizes, and estimators were used to generate them (ILBT 2013, pp. 23-24).

Table 3. Reported annual home range sizes for Canada lynx in the contiguous United States.

Geographic Unit	Mean or Median Annual Lynx Home Range Size km^2 (Range)		References (Page Nos.)
	Female	Male	
N Maine	25-33 (14-70)	39-60 (24-102)	Vashon *et al.* 2008a (1482); Mallett 2014 (169)
NE Minnesota	17-87 (13-122)	160-267 (86-439)	Mech 1980 (263-265); Burdett *et al.* 2007 (460-463); Moen *et al.* 2008a (17)
NW Montana/ NE Idaho	43-90 (11-157)	122-220 (29-552)	Brainerd 1985 (20); Squires and Laurion 2000 (343-344); Squires *et al.* 2004a (13, Table 6)
N-C Washington	37-91 (37-91)	49-69 (29-99)	Brittell *et al.* 1989 *in* Stinson 2001 (5); Koehler 1990 (847); Maletzke *in* Lynx SSA Team 2016 (21)

GYA	50-105 (32-105)	116-824 (98-2,181)	Squires and Laurion 2000 (343-344); Squires *et al.* 2003 (12-13)
W Colorado	75-704 (NA)	103-387 (NA)	Shenk 2008 (10)

Juvenile and adult lynx require about 400 and 600 grams (14 and 21 ounces) of food per day (for adults, 0.4-0.5 hares/day, 170-200 hares/year), respectively, to meet their basic nutritional requirements (Saunders 1963, p. 390; Nellis *et al.* 1972, pp. 324-325). Available research suggests that landscape-level hare densities >= 0.5 hares/ha (0.2/ac) are necessary to support lynx home ranges and resident breeding populations; lynx home range abandonment, dispersal, and mortality increase when hare densities are lower; and lynx may be unable to survive where landscape hare densities are below 0.3/ha (0.12/ac) (Ward and Krebs 1985, pp. 2819-2822; Slough and Mowat 1996, entire; Ruggiero *et al.* 2000b, pp. 446-447; ILBT 2013, pp. 26, 125). Recent research in the contiguous U.S. supports this - in northern Maine, areas with landscape hare densities of 0.74/ha (0.30/ac) supported resident breeding lynx, but areas with hare densities below 0.5/ha (0.2/ac) were not occupied by lynx (Simons-Legaard *et al.* 2013, pp. 567, 574-575). Likewise, in northeastern Minnesota, resident lynx maintained home ranges where landscape hare densities were 0.64/ha (0.26/ac), but nearby Voyageurs National Park, where hare density was estimated at 0.35/ha (0.14/ac), did not support resident breeding lynx (Moen *et al.* 2012, pp. 352–354).

In addition to adequate hare density, individual lynx require landscapes in which they are unlikely to encounter other species that may prey on them (mountain lion [*Puma concolor*], coyote [*Canis latrans*], wolverine [*Gulo gulo*], gray wolf [*Canis lupus*], and fisher [*Pekania pennanti*]) (ILBT 2013, pp. 33, 35). Although lynx have co-evolved with other predators, the influence of predation on lynx populations is unknown (ILBT 2013, pp. 35-36), and mountain lions and coyotes are now more widespread and abundant in the southern periphery of the lynx distribution than they seem to have been historically (Buskirk *et al.* 2000a, p. 83; Gompper 2002, entire). Lynx also need landscapes where they are unlikely to suffer reduced fitness because of competition with other hare predators, or encounter traps or other anthropogenic causes of mortality. Except for fisher and marten (*Martes americana*), lynx predators and potential terrestrial competitors for hares (the species above plus bobcat; maybe red fox [*Vulpes vulpes*] in some situations) all have higher foot-loading (weight per surface area of the foot), making them less efficient at traveling and hunting in the deep powdery snow conditions favorable for lynx (Buskirk *et al.* 2000a, pp 86-95, Krohn *et al.* 2005, entire) and, therefore, likely limiting, at least seasonally, interactions between lynx and these species. Analysis of lynx occurrence data in the contiguous U.S. suggests that lynx require at least four months (December through March) of continuous snow coverage (Gonzalez *et al.* 2007, p. 7). Where snow conditions do not consistently favor lynx, increased potential for predation and competition would be expected (Peers *et al.* 2013, p. 8). Finally, individual lynx are more likely to survive, breed, and replace themselves in the breeding population if they occupy home ranges where trapping is prohibited or trapping pressure is low (Slough and Mowat 1996, entire), high-speed/ high-volume roadways are absent (ILBT 2013, pp. 77-78), and other potential anthropogenic causes of lynx mortality are minimal.

In summary, individual lynx require large landscapes with hare densities that maximize their chances of (1) surviving to independence, (2) establishing and maintaining a home range, (3) breeding successfully, and (4) contributing genes to future generations (Breitenmoser *et al.* 1993, p. 552). These landscapes also must provide conditions that allow lynx to compete sufficiently for hares and minimize the likelihood of predation and other sources of lynx mortality. The available science suggests that landscape-level hare densities consistently >= 0.5 hares/ha (0.2/ac) and favorable snow depth and conditions for about four months are needed to support lynx occupancy, reproduction, and recruitment. At the southern periphery of lynx distribution, some places, including within the range of the DPS, seem to be at minimum thresholds to meet these requirements or do so inconsistently.

2.2.2 Ecological Requirements of Populations and the DPS

Lynx populations require essentially the same things that individual lynx do (see Figure 5 and section 2.2.1, above), but on a larger landscape with hare densities and habitat conditions capable of consistently supporting multiple home ranges, breeding and dispersal opportunities, and reproductive and survival rates such that recruitment and immigration will, on average over the long term, equal or exceed mortality and emigration (Pulliam 1988, pp. 652-654). To support persistent lynx populations, such landscapes must provide for the survival of at least some resident lynx even when hares are least abundant and/or other habitat features (e.g., snow conditions) are least favorable so that the lynx population can recover, perhaps aided by immigration, when hare numbers and/or other habitat conditions improve. As with individual lynx, populations are more likely to persist in landscapes where the effects of competition, predation, and human-caused mortality (e.g., trapping, vehicle collisions) are relatively lower.

In a mainland-island metapopulation structure like that thought to govern lynx population dynamics, the persistence of peripheral island populations is determined by colonization and extinction rates (McKelvey *et al.* 2000b, p. 25). Colonization is driven by the number of islands, the distances between them, and the species' dispersal capabilities and timing. Extinction rates are determined by population size and demographic and environmental stochasticity, with extinction more likely in smaller and more isolated populations (McKelvey *et al.* 2000b, pp. 25-31). Lynx populations in the DPS are at the periphery of the species' range and may behave as islands in a mainland-island metapopulation construct. In such a system, larger islands with higher habitat quality and in closer proximity to the mainland would be more likely to support persistent resident populations and to sometimes act as "sources" that produce surplus animals that may disperse to other islands. Smaller islands with lower habitat quality or at greater distance from the mainland may, in contrast, act as "sinks" that depend on immigration from source populations (McKelvey *et al.* 2000b, p. 30), and which may support resident lynx only occasionally, intermittently, or temporarily.

Formal population viability analyses (PVAs) have not been published for lynx populations in the DPS and may not be possible given limited data and natural temporal variation in demographic rates (McKelvey *et al.* 2000b, pp. 22, 30). Although some demographic data are available for most lynx populations in the DPS, most are limited to relatively few, small study areas or relatively short durations. There remains uncertainty about whether, and if so to what extent, the demographic health of DPS populations relies on immigration from northern (Canadian) populations; and immigration rates are not known for DPS populations (McKelvey *et al.* 2000b, pp. 24-34). These factors likely preclude development of meaningful DPS-wide or unit-specific empirical population viability models (McKelvey *et al.* 2000b, p. 22).

Slough and Mowat (1996, p. 952, Table 4) calculated population growth rate (lambda, λ) = 2.03 (annual doubling) during the 4-year increase-to-peak phase for a lynx population in the core of the species' range in the southern Yukon. This period of rapid growth was followed by a rate of λ = 1.01 (stable) during the first year of a hare decline, and λ = 0.10 and λ = 0.46 (rapid decline) during the first two years of the lynx population decline when hares were scarce. (Note – the value λ = 0.01 presented in Slough and Mowat (1996, p. 952, Table 4) appears to be an error; the correct value for λ in a population in which the estimated number of individuals declined from 135 in 1992 to 13 in 1993 should be 13/135 = 0.10 [as presented above]). However, the natural range in λ that would be expected among peripheral, isolated, or semi-isolated lynx populations where hares are non-cyclic or weakly-cyclic (i.e., in DPS populations), versus those that would signal long-term population decline or instability is unknown. Despite this, and the limitations noted above, Squires (*unpubl. data in* Lynx SSA Team 2016, p. 20) calculated population growth rates in northwestern Montana of λ = 0.92 for lynx in the Seeley Lake area (i.e., declining population trend, 1999-2007) and λ = 1.16 for lynx in the Purcell Mountains (increasing trend, 2003-2007). Likewise, McCollough (2016 *unpubl. data*; USFWS, Vortex10, deterministic population simulation) used demographic data from Vashon *et al.* 2012 (pp. 17-21) to calculate finite growth rates during a period of high hare density (λ = 1.16; increasing trend) and during a period of low hare density (λ = 0.88; decreasing trend) for the lynx population in northern Maine (see also section 4.1.1, below). Neither the Montana nor Maine estimates incorporated rates of immigration/emigration.

Although minimum viable population sizes have not been derived for lynx populations in the DPS, the Service's Recovery Outline (USFWS 2005, p. 5) suggested landscapes of at least 1,250 km^2 (483 mi^2) with sufficient boreal/subalpine habitat, hare densities (at least 0.5 hares/ha [0.2/ac]), and snow conditions favorable for lynx ("fluffy and/or deep...for sufficient periods to favor the competitive advantage of lynx"). These are the minimum landscape size and habitat conditions thought necessary to support a minimum lynx population of at least 25 adults based on a lynx density of one lynx per 50 km^2 (USFWS 2005, p. 5). McKelvey *et al.* (2000b, p. 29) noted that extinction (extirpation) risk should decrease with increasing population size, and that extinction resulting from demographic stochasticity is very unlikely even for a population (generally; not specific to lynx) with as few as 20 reproducing females. Kramer- Schadt *et al.* (2005, entire) developed a spatially explicit population model for Eurasian lynx in Germany which they combined with demographic scenarios to evaluate the likely success of potential reintroduction efforts; they concluded that at least 10 females and 5 males would be required to establish a population with an extinction probability less than 5 percent over 50 years. Rodriguez and Delibes (2003, entire) evaluated extinction among populations of Iberian lynx; they found that extinction occurred only in small populations that occupied habitats of less than

500 km^2 and that extinction within 35 years was unlikely among populations occupying areas of at least 500 km^2 of adequate habitat quality.

In summary, lynx populations need large boreal forest landscapes with snow conditions (consistency, depth, and duration) that allow lynx to outcompete other terrestrial hare predators. These landscapes must have hare densities capable of supporting (1) multiple lynx home ranges, (2) reproduction and recruitment most years, and (3) at least some survival even during years when hare numbers are low. To persist, lynx populations must exhibit recruitment and immigration rates that exceed mortality and emigration rates on average over the long-term. Immigration may be particularly important to the persistence and stability of lynx populations at the southern periphery of the range, including those within the DPS, where hare densities are generally low and hare populations are either non-cyclic or weakly-cyclic compared to northern populations. Low hare densities reduce the likelihood that lynx recruitment will consistently equal or exceed mortality, and non-cyclic or weakly-cyclic hare populations are unlikely to allow the rapid lynx population recovery observed in northern lynx populations when hare numbers increase dramatically after cyclic population crashes. Although immigration rates for DPS populations are unknown, as is the rate and periodicity of immigration needed to provide demographic stability among them, connectivity with and immigration from lynx populations in Canada is believed to be important to the persistence of lynx populations in the DPS (McKelvey *et al.* 2000a, pp. 232-242; 2000b, pp. 32-34; Schwartz *et al.* 2002, entire; USFWS 2005, p. 2; ILBT 2013, pp. 34, 42, 47, 54, 60, 65; Squires *et al.* 2013, p. 187; 79 FR 54789).

2.3 Historical and Current Lynx Distribution

2.3.1 Lynx Distribution and Status in Canada and Alaska

The Canada lynx is broadly distributed across northern North America from eastern Canada to Alaska (McCord and Cardoza 1982, p. 729; Poole 2003, p. 361; Vashon 2015, p. 4; University of Alaska Center for Conservation Science 2016, p. 1). It is strongly associated with the expansive, continuous boreal forests of those areas, and its range largely overlaps that of its primary prey, the snowshoe hare, also a boreal forest specialist (Bittner and Rongstad 1982, p. 146; Mowat *et al.* 2000, pp. 268-269; Aubry *et al.* 2000, p. 375). In Canada, lynx are thought to occupy about 5.5 million km^2 (over 2.1 million mi^2), which represents 95 percent of their historical range in that country (Environment Canada 2014, p. 2), and over 89 percent of the species' entire distribution. Nationally in Canada, lynx are classified as secure, widespread, and abundant; they are managed for long-term population stability, with a conservative estimate of 110,000 individuals during cyclic lows; and no acute, widespread threats to lynx have been identified (Environment Canada 2014, entire; Vashon 2015, pp. 1-6). Provincially, lynx status is considered secure in British Columbia, Manitoba, Ontario, Quebec, Newfoundland and Labrador, Northwest Territories, and the Yukon; sensitive in Alberta and Saskatchewan; at risk/endangered in New Brunswick and Nova Scotia; and undetermined in Nunavut (Environment Canada 2014, pp. 3-4; Vashon 2015, p. 1). Lynx were extirpated from Prince Edward Island (0.1 percent of lynx range in Canada) by the late 1800s, and on the mainland the southern margin of assumed lynx range has contracted northward in Quebec, southeastern Ontario, Manitoba, Saskatchewan, and Alberta (Poole 2003, p. 361; Bayne *et al.* 2008, pp. 1192-1195; Koen *et al.* 2014a, pp. 757-760).

In Alaska, lynx are distributed across roughly 534,454 km^2 (206,354 mi^2) of boreal forest habitats (University of Alaska Center for Conservation Science, 2016, entire; Reimer 2016, *pers. comm.*), which represents about 8.7 percent of the species' distribution. Lynx in Alaska are apparently secure, with low to moderate threats, and populations appear stable statewide, although total abundance is unknown (Alaska Natural Heritage Program 2008, pp. 2-4). In both Alaska and Canada, lynx trapping is managed through regulated seasons and harvest levels, which are adjusted to avoid overexploitation, especially during the low phase of the hare-lynx population cycle (Alaska Natural Heritage Program 2008, pp. 2-6; Vashon 2015, pp. 5-6). Along the Canada-U.S. border in provinces adjacent to DPS lynx populations, lynx trapping is prohibited in New Brunswick (adjacent to northeastern Maine) but regulated trapping is permitted in Quebec (adjacent to northwestern Maine, northern New Hampshire, and northern Vermont), Ontario (adjacent to northeastern Minnesota), Alberta (adjacent to northwestern Montana), and British Columbia (adjacent to northwestern Montana, northern Idaho, and northern Washington).

2.3.2 Lynx Distribution in the Contiguous United States

2.3.2.1 Defining Lynx Distribution at the Periphery of the Range

Several aspects of lynx population dynamics and dispersal patterns have resulted in inconsistent approaches and difficulty in defining the range and/or distribution of the species, especially at the margins (74 FR 66942). These, combined with uncertainty and ambiguity in the historical record of lynx occurrence, with early assessments based largely on trapping harvest records of questionable accuracy, particularly where lynx and bobcats overlap, and a reliance on anecdotal or unverified occurrence information (McKelvey *et al.* 2000a, pp. 208-210; 65 FR 16054), confound efforts to accurately portray the species' historical distribution in the contiguous U.S. and to assess the current distribution relative to historical conditions (79 FR 54814-54815; McKelvey *in* Lynx SSA Team 2016, p.11). They also have resulted in inaccurate portrayals of lynx distribution and misperceptions that the historical range of lynx in the contiguous U.S. was once much more extensive than is ecologically possible (68 FR 40080; 74 FR 66942).

The range of the lynx must be considered differently from those of other species that are less mobile and have more stable population dynamics. Because the lynx is highly mobile and has cyclic population dynamics that are tied to cyclic snowshoe hare populations, numbers of lynx naturally fluctuate and become extremely low at times during a cycle. Additionally, where snowshoe hare populations are not adequate, resident lynx populations cannot be sustained. Resident lynx populations never occurred everywhere boreal forest existed in the contiguous U.S. Where the boreal forest was naturally more patchy and marginal, the habitat was incapable of supporting a snowshoe hare population adequate to support a resident lynx population over time. Only a relatively few areas in the contiguous U.S. historically supported an adequate quantity and quality of habitat to support resident lynx populations continuously over time, and many historical lynx occurrences across a large area of the contiguous U.S. were likely dispersers. The occurrence of dispersing lynx is unpredictable, and dispersing lynx will likely continue to periodically move into areas that are not lynx habitat (68 FR 40077).

The dramatic, cyclic fluctuations in lynx populations across much of the range as they track cyclic hare populations and the mass synchronous dispersals (irruptions) of large numbers of lynx into the contiguous U.S. when northern hare populations crashed are well-documented (Elton and Nicholson 1942, entire; Gunderson 1978, entire; Thiel 1987, entire; McKelvey *et al.* 2000a, pp. 219, 232-242; Mowat *et al.* 2000, pp. 281-294; ILBT 2013, p. 33). These events have resulted in records of lynx occurrence, in some cases very rarely, in others sometimes in large numbers and with intermittent (cyclic) regularity, in places that otherwise lack evidence of persistent lynx presence or the habitats and hare densities necessary to support a resident lynx population (USFWS 2005, pp. 3-4; 79 FR 54787-54789, 54793-54795, 54812-54823). Many records of lynx in the contiguous U.S. appear to be related to such events, including the unprecedented ''explosions'' of lynx observed in the early 1960s and 1970s (Gunderson 1978, entire; McKelvey *et al.* 2000a, pp. 232-242). During these events, many lynx occurred in anomalous habitats, exhibited unusual behavior, suffered high mortality, and numbers declined dramatically within a few years of irruptive peaks (Gunderson 1978, entire; Thiel 1987, entire; McKelvey *et al.* 2000a, p. 242). Because dispersing lynx typically do not persist in these areas of temporary range expansion, disappearing fairly quickly after irruptions, van Zyll de Jong (1971, p. 16) suggested that only areas that support lynx populations throughout both the low and the high phases of the "10-year cycle" (i.e., across the natural range of hare densities) should be considered to constitute the species' range. In its 2003 remanded determination, the Service determined that lynx in the contiguous U.S. exist either as resident populations or as dispersers, that dispersing lynx are often found repeatedly and for variable amounts of time in habitats that cannot sustain breeding populations over time (though some breeding may occur occasionally in some of these areas), and that such areas probably contribute little to the persistence of lynx in the DPS (68 FR 40077, 40079-80). This repeated dispersal into habitats that ultimately cannot support the species (''sink'' habitats) often leads to confusion among scientists and the public about where lynx populations may be viable (74 FR 66938).

In addition to distinguishing between historical occurrence records associated with irruptions/ dispersal and those suggesting resident lynx populations, the "mainland-island" metapopulation structure thought to govern lynx populations in the DPS (McKelvey *et al.* 2000b, pp. 25-31; see Section 2.2, above) and the transitional (and, therefore, increasingly fragmented and isolated) and spatially- and temporally-shifting nature of lynx habitat at the southern periphery of the range (Koehler and Aubry 1994, pp. 78-79; McKelvey *et al.* 2000b, pp. 29-30; 74 FR 66940; 79 FR 54814) also present challenges in defining the distribution of lynx. Both factors suggest that some areas of the contiguous U.S. may naturally support resident lynx only temporarily or occasionally when habitat conditions (both boreal forest vegetation supporting abundant hares and snow conditions favoring lynx) are adequate and/or when immigration is sufficient to offset the lower productivity and recruitment rates expected among lynx populations in marginal or suboptimal habitats. McKelvey *et al.* (2000b, pp. 21, 29-31) described such habitats as "... source-sink mosaics that shift with disturbance and succession," and the contribution, if any, of these places (especially those that act more often as "sinks" than "sources") to the maintenance and persistence of lynx populations in the DPS remains questionable (74 FR 66938).

Finally, the southern periphery of the lynx's range, where lynx are rare in many places, overlaps with the northern distribution of the much more common bobcat; the two species are difficult to distinguish in the field, they often were not reliably differentiated in historical trapping records (McKelvey *et al.* 2000a, pp. 208-209), and errors in early accounts of lynx distribution based on anecdotal information seem likely (Halfpenny and Miller 1980, pp. 1, 3-8; Meaney 2002, pp. 3-5, Hoving *et al.* 2003, pp. 366-367). Because of the large effect that relatively few errors in identification can have on assessments of the distribution of rare animals, especially those that are easily confused with a similar and more common species, McKelvey *et al.* (2000a, p. 209; 2008, pp. 553-554) suggest that anecdotal information should be interpreted with caution, and only verified occurrence data should be used to assess historical and current lynx distributions.

These complexities of lynx population dynamics and our incomplete understanding of the limited lynx occurrence data, combined with a naturally dynamic and transitional habitat, make it difficult, if not impossible, to precisely delineate the historical or current distribution of resident lynx populations in the contiguous U.S. (Koehler and Aubry 1994, p. 79; 68 FR 40084). While recognizing these limitations, we use our best professional judgment of the best scientific and commercial data available to make conclusions about the range of the lynx for the purposes of this SSA. In the following section, we describe the types and distributions of potential lynx habitats in the contiguous U.S., and our current understanding of the historical and current distributions of resident lynx populations in the DPS considering the factors discussed above.

2.3.2.2 Lynx Distribution within the DPS Range

The southern periphery of boreal forest vegetation extends into parts of the northern contiguous U.S., where it transitions to the Acadian forest in the Northeast (Seymour and Hunter 1992, pp. 1, 3), deciduous temperate forest in the Great Lakes regions, and subalpine forest in the Rocky Mountains and Cascade Mountains in the west (Agee 2000, pp. 40-41). In much of the DPS range, these boreal forest landscapes become naturally patchy and transitional because they are at the southern edge of the boreal forest range, and they are limited, particularly in the west, by elevation and/or aspect (Ruediger *et al.* 2000, p. 4-16; 68 FR 40090). There also is increased prevalence of non-forested land uses (e.g., agriculture, development) at the southern periphery of boreal forests. These factors generally limit snowshoe hare populations in the contiguous U.S. from achieving landscape densities similar to those of the expansive northern boreal forest in Alaska and Canada, where hares are generally more abundant and more evenly distributed across the landscape (Wolff 1980, pp. 123-128; Buehler and Keith 1982, pp. 24, 28; Koehler 1990, p. 849; Koehler and Aubry 1994, p. 84; Aubry *et al.* 2000, pp. 373-375, 382, 394). Consequently, important foraging habitat for lynx is often more limited and fragmented in the contiguous U.S. than in boreal forests of northern Canada and Alaska (Berg and Inman 2010, p. 6), and overall habitat quality is typically lower.

The habitats that lynx use in the contiguous U.S. are characterized by patchily-distributed moist forest types with relatively higher hare densities in a matrix of other habitats (e.g., hardwoods, dry forest, non-forest) with lower landscape hare densities (ILBT 2013, p.126; 78 FR 59434). In these areas, lynx incorporate the matrix habitat (non-boreal forest habitat elements) into their home ranges and use it for traveling between patches of boreal forest that support higher hare densities where most lynx foraging occurs. In some areas, patches of habitat containing snowshoe hares become so small and fragmented that the landscape cannot support lynx home ranges (ILBT 2013, p. 77) or populations over time (68 FR 40077). Additionally, the presence of more snowshoe hare predators and competitors at southern latitudes may inhibit the potential for high-density hare populations (Wolff 1980, p. 128). As a result, lynx generally occur at relatively low densities in the contiguous U.S. compared to the high lynx densities that occur in the boreal forest of Canada when hares are abundant (Aubry *et al.* 2000, pp. 375, 393-394) or the densities of species such as the bobcat, which is a habitat and prey generalist.

Snow conditions also determine the distribution of lynx (Ruggiero *et al.* 2000b, pp. 445-449), which are morphologically and physiologically adapted for hunting snowshoe hares and surviving in areas that have cold winters with deep, fluffy snow for extended periods. These adaptations provide lynx a competitive advantage over potential competitors, such as bobcats or coyotes (McCord and Cardoza 1982, p. 748; Buskirk *et al.* 2000a, pp. 86-95; Ruediger *et al.* 2000, pp. 1-11; Ruggiero *et al.* 2000b, pp. 445, 450), which have a higher foot load (more weight per surface area of foot), causing them to sink into the snow more than lynx. Therefore, bobcats and coyotes cannot hunt efficiently in fluffy or deep snow and are at a competitive disadvantage to lynx. Long-term snow conditions presumably limit the winter distribution of potential lynx competitors such as bobcats (McCord and Cardoza 1982, p. 748) or coyotes. These adaptations may also help lynx avoid predators such as mountain lions (Squires and Laurion 2000, p. 346), which also have higher foot-loading (Buskirk *et al.* 2000a, p. 90; Krohn *et al.* 2005, p. 123), making them less efficient in deep and fluffy snow conditions.

Based on verified historical data, lynx occurrence has been documented in 24 states in the contiguous U.S. (McKelvey *et al.* 2000a, 207-232) and, more recently, in a 25th after some of the lynx released into southwestern Colorado dispersed into northern New Mexico (Colorado Division of Wildlife 2000, p. 3; 74 FR 66938), which had previously lacked verified evidence of lynx occurrence (USFS 2009, entire; 74 FR 66940-66943). Of these, and based on our current understanding of lynx and hare habitat requirements, the Service concludes that records in at least 11 states (Connecticut, Illinois, Indiana, Iowa, Massachusetts, Nebraska, Nevada, New Mexico, North Dakota, Pennsylvania, and South Dakota) most likely represent occasional dispersing lynx that arrived in places with no historical or recent evidence of the habitat quality or quantity necessary to support a persistent resident lynx population (68 FR 40099; 74 FR 66940-66942; 79 FR 54807, 54817). These states are not within the distribution of resident lynx in the DPS, and we conclude that they naturally lack the necessary habitat, hare densities, and snow conditions and that they were not capable historically and are not capable now of supporting resident lynx populations.

The Service originally identified the DPS as occurring in forested portions of the remaining 14 states (Colorado, Idaho, Maine, Michigan, Minnesota, Montana, New Hampshire, New York, Oregon, Utah, Vermont, Washington, Wisconsin, and Wyoming; 65 FR 16052, 16085). Some of these states, and parts of others, are thought to have historically supported only dispersing lynx or to have only occasionally supported resident breeding lynx (68 FR 40099; 74 FR 66940). Such areas were included within the range of the DPS because of the possibility that lynx could establish small, local populations in them and perhaps contribute to the persistence of the DPS, though evidence of this was lacking (68 FR 40080; 74 FR 66938). In its 2003 remanded determination for the lynx DPS, the Service concluded that (1) potential lynx and hare habitats in Michigan, Oregon, Utah, Vermont, and Wisconsin were relatively small, isolated, and of marginal quality, and that available information suggested that these states did not historically or recently support resident lynx populations; (2) it was uncertain whether Colorado, New York, and Wyoming historically supported resident populations or only occasional dispersers; (3) New Hampshire probably supported a small resident populations that had been extirpated; and (4) the remaining states (Idaho, Maine, Minnesota, Montana, and Washington) had the best historical and recent evidence of resident breeding populations (68 FR 40082, 40086-40095, 40097-40101). Below we provide our current understanding of these state groupings and the information available since the 2003 remand that informs this understanding.

Michigan, Oregon, Utah, Vermont, and Wisconsin - Additional information and analysis available since 2003 support the determination that Michigan (Linden 2006, pp. 83-90) and Oregon (Aubry 2006, pp. 1-2) did not historically or recently support resident lynx populations, and no evidence has emerged suggesting that resident populations occurred historically or recently in Utah or Wisconsin (ILBT 2013, pp. 45, 58). The best available information continues to suggest that resident lynx did not historically and do not currently occur in Michigan, Oregon, Utah, and Wisconsin; that habitats in these states are naturally incapable of supporting resident breeding populations; and that historical and potential future occurrences of lynx in these states most likely represent occasional dispersing lynx. We conclude, therefore, that these states did not historically, do not currently, and in the future are very unlikely to, contribute to the persistence and conservation of lynx in the contiguous U.S.

In contrast, nine lynx occurrences were confirmed in the 530-km^2 (205-mi^2) Nulhegan Basin of northeastern Vermont from 2003 to 2014, and breeding was confirmed in 2012; intensified surveys since then have resulted in only a single photograph of a lynx in 2014 (Bernier 2015, pp. 1-3; Bernier 2016, *pers. comm.*). This new information indicates that this small area of northernmost Vermont is at least occasionally capable of supporting a small number of resident breeding lynx, but that its ability to support a persistent resident population over time remains doubtful. Based on assessments of the amount and quality of potential lynx and hare habitat, snow conditions, and the presence and distribution of lynx competitors and predators (Hoving *et al.* 2005, pp. 746-749; Bernier 2015, entire), we conclude it is unlikely that northern Vermont can support a persistent resident lynx population (79 FR 54820-54821); that it only occasionally supports lynx reproduction when hare abundance and snow conditions are temporarily adequate; that it most likely represents a “sink” rather than a “source” for the regional lynx population, and that this likely represents its natural historical condition.

Colorado, New York, and Wyoming - When the Service listed the DPS in 2000, it believed that a resident lynx population occurred historically in the Southern Rocky Mountains of western Colorado and southeastern Wyoming, that lynx were also historically resident in northwestern Wyoming (part of the Northern Rocky Mountains), and that the Adirondack Mountains of northern New York may historically have supported a resident population that was by then extirpated (65 FR 16055-16056; 16058-16059). In the 2003 remand, the Service noted inconsistencies and likely errors in historical lynx reports for the Southern Rockies, questioned its original conclusion that Colorado historically supported an isolated resident population, and concluded that it was uncertain whether a resident population occurred historically in Colorado or if historical records were of periodic dispersing lynx during “extremely high populations cycles” and that a resident population never existed in southeastern Wyoming (68 FR 40081, 40091). The Service also noted that in 1999 and 2000 the Colorado Division of Wildlife (now Colorado Parks and Wildlife [CPW]) introduced 96 lynx from Canada and Alaska into southwestern Colorado (with plans to release an additional 186 lynx from 2003-2009) in an effort to reestablish a resident lynx population, that reproduction among some of the released lynx had been documented by 2003, but that it was too early to determine whether the program would be successful (68 FR 40091). In that rule, the Service also concluded that, despite evidence of reproduction in northwestern Wyoming (part of the GYA), potential habitat there is naturally marginal (patchier and composed of drier forest types), may be incapable of supporting a resident lynx population, and that lynx in northern Wyoming are most likely dispersers (68 FR 40090). Also in 2003, the Service concluded that it was possible resident lynx occurred in northern New York prior to 1900 but the potential habitat there is small, marginal, isolated and likely has only supported dispersing lynx since then (68 FR 440086-40087). In 1988-1990, 83 lynx were released into the Adirondacks of northern NY (Brocke et al. 1993, p. 1); however, that effort failed to establish a resident breeding population (65 FR 16055), suggesting that potential habitat there may be inadequate to support lynx persistence (68 FR 44486-44487).

In Colorado, after the initial release of 96 lynx in 1999 and 2000, none were released in 2001 or 2002 while protocols were evaluated and refined based on monitoring of the initially-released lynx (Shenk 2010, pp. 1, 4; Ivan *in* Lynx SSA Team 2016, p. 22). From 2003-2006, another 122 lynx were released, bringing the total to 218 (Devineau *et al.* 2010, p. 526). Reproduction was documented in 2003-2006 and 2009-2010, with 48 dens documented in that time, including a third generation of Colorado-born lynx (Shenk 2010, p. 5; Ivan *in* Lynx SSA Team 2016, p. 22). In 2010, CPW determined that all benchmarks for its lynx program had been met and had resulted in the establishment of a viable, self-sustaining lynx population (Ivan 2011b, pp. 11, 12). Intensive monitoring of the population ceased in 2010 and was replaced by an effort to develop a minimally-invasive long-term monitoring program (Ivan 2011b, entire), which used snow-tracking surveys and camera traps to document continued lynx presence in the core release area of the San Juan Mountains in 2010-11 and again in 2014-15, with evidence of reproduction also documented during that time (Ivan *et al*. 2015, p.1; Ivan *in* Lynx SSA Team 2016, pp. 22-23). In its 2014 revised critical habitat designation for the DPS, the Service concluded that the historical record of verified lynx occurrence in Colorado combined with naturally highly-fragmented and isolated potential habitat and generally low snowshoe hare densities suggest that Colorado and the Southern Rockies were unlikely to have historically supported a persistent resident lynx population and that the long-term persistence of the introduced population is uncertain (79 FR 54787-54789, 54793-54795, 54816-54817). The current size of the resident lynx population in Colorado is unknown but thought to number between 100 and 250 (Ivan *in* Lynx SSA Team 2016, p. 47). We continue to believe that available information suggests Colorado did not historically support a persistent resident lynx population and that the long-term persistence of the introduced population remains uncertain.

Information and analyses since the 2003 remand support the conclusion that New York has inadequate habitat quantity and quality (both vegetation and snow conditions) to support a resident lynx population (Hoving *et al.* 2005, pp. 746, 749). Based on Hoving *et al.* (2005) and our evaluation of the verified records of historical occurrence presented by McKelvey *et al.* (2000a, pp. 215-217), we conclude that the Adirondack Mountains of northern New York have not recently and likely did not historically support a persistent resident lynx population, are likely incapable of doing so, that verified historical records were most likely of dispersing lynx, and dispersing lynx may currently and in the future continue to occur rarely and temporarily in northern New York.

In northwestern Wyoming, additional information available since 2003 documented continued presence of a small number of lynx as recently as 2010, including some evidence of reproduction during that time, and documentation of Colorado-released lynx that dispersed into and through Wyoming (Squires *et al.* 2003, entire; Squires and Oakleaf 2005, entire; Murphy *et al.* 2006, entire; Endeavor Wildlife Research 2008, 2009, entire; Berg 2016, *pers. comm.*; Hanvey 2016, *pers. comm.*; Ivan 2016a, *pers. comm.*; Murphy 2016, *pers. comm.*). However, more recent surveys and research-related trapping efforts have failed to detect lynx in this area or elsewhere in Wyoming since 2010 (79 FR 54791; Squires *in* Lynx SSA Team 2016, pp. 20-21, 45). In the 2014 revised critical habitat designation, the Service noted:

> Although the GYA has a long history of lynx presence and recent evidence of reproduction (Squires and Laurion 2000, entire; Squires *et al.* 2001, entire; Murphy *et al.* 2006, entire), there are relatively few verified records of lynx from Yellowstone National Park and surrounding areas (65 FR 16058, 68 FR 40090). Additionally, lynx habitat in the GYA is naturally marginal (patchier and composed in many places of drier forest types), less capable of supporting snowshoe hares (Hodges *et al.* 2009, entire), and farther from source populations than most other parts of the DPS range (68 FR 40090). Given the naturally marginal habitat in this largely protected area, we believe it is unlikely that the GYA ever supported more than a handful of lynx home ranges in any given year. We find no evidence that the GYA once supported a larger or more robust lynx population than the small one suggested by verified historical and recent records and survey efforts (79 FR 54791).

We concluded that the historical record and recent evidence of lynx occupancy and reproduction suggested the presence of a small but persistent resident lynx population in the GYA of northwestern Wyoming and southwestern Montana (79 FR 54791, 54796-54797, 54825-54826); however, the consistency of occupancy over time remains uncertain (Lynx SSA Team 2016, pp. 11, 45, 57). Uncertainty about whether this area consistently or only intermittently supported resident lynx historically makes it difficult to interpret their recent apparent absence from the area (Lynx SSA Team 2016, p. 57). If residency was intermittent historically, the current apparent absence of resident lynx might be a natural condition related to the area's largely marginal or suboptimal habitat conditions - i.e., it may naturally be capable of supporting resident lynx only intermittently when habitat conditions and hare densities are optimal. In that case, future intermittent residency would be expected, but only if lynx dispersing from a source population immigrate to the GYA when habitat conditions and hare densities return to more favorable levels. Conversely, if the GYA always historically supported a small number of resident lynx but no longer does, it may suggest that some factor or factors have acted to tip the quality of the area's habitat from just barely capable of supporting a small resident population to no longer capable of doing so, resulting in extirpation. We conclude that this uncertainty cannot be resolved based on the available information but, given the protected conservation status of millions of acres in the GYA unit (Yellowstone and Grand Teton National Parks; all or parts of the Absaroka-Beartooth, Bridger, Gros Ventre, Lee Metcalf, Northern Absaroka, Teton, and Washakie Wildernesses), its historical inability to support a robust, persistent resident population and its apparent recent inability to support any resident lynx may be a reflection of naturally marginal and patchy habitats and relatively low hare abundance in much of the unit, resulting in only an intermittent ability of this unit to support resident lynx. We also note that extensive areas of the GYA were burned by the large, intense wildfires of 1988, and that these areas may soon (perhaps in the next 5-15 years) regenerate to a stage containing the dense horizontal conifer structure favorable for hares and, therefore, lynx foraging habitat, perhaps increasing the likelihood that the GYA may support resident lynx again in the near future (Lynx SSA Team 2016, p. 46).

In southern Wyoming, all recent occurrences of lynx appear to be of Colorado-released lynx that moved into or through the area (see Devineau *et al.* 2010, Fig. 1, p. 526), including one female who in 2004 established a den in the Snowy Mountains and produced kittens that did not survive (Bjornlie 2016, pers, comm.; Ivan 2016a, *pers. comm.*). Based on the available information, we conclude that southern Wyoming did not historically or recently support a resident lynx population and is not now capable of doing so.

New Hampshire - There were 18 confirmed lynx records indicating 28 individual lynx in northern New Hampshire from 2006 to 2013, with evidence of reproduction in 2010 and 2011 (79 FR 54820). An additional 8 lynx detections were documented in 2014 (Siren 2014, p. 7), 24 lynx track intercepts were recorded during snow-tracking surveys during the winter of 2014-2015 (Siren 2016, p. 1), and surveys in 2016 also detected lynx (Siren 2016, *pers. comm.*). Most records since 2006 are in the vicinity of Pittsburg in the northernmost reaches of the state, though lynx detections in 2015 and 2016 suggest a southern expansion from the area of 2006-2014 detections (Siren 2016, p. 1; Siren 2016, *pers. comm.*). Despite recent evidence of lynx residency and reproduction, the Service concluded in the 2014 revised critical habitat designation that, based on modeling of the amount of potentially suitable habitat and favorable snow conditions (Hoving *et al.* 2005, pp. 739, 749; Litvaitis and Tash 2005, p. A-298), it is unlikely that northern New Hampshire will support a resident breeding population over the long-term (79 FR 54820-54821). Siren (2014, p. 10) suspected that the relatively few lynx detections documented in 2012-2014 may be related to the presence and abundance of bobcat, coyote, and fisher populations in much of northern New Hampshire. We conclude that northern and central New Hampshire likely supported a small resident lynx population historically that was extirpated during the latter half of the 20th century. We are uncertain whether lynx detections in northernmost New Hampshire over the past decade may represent the natural reestablishment of a small resident breeding population in the state or if it is a temporary phenomenon related to an expanding source population in neighboring northern Maine (79 FR 54821). Although bobcat populations have increased and expanded their range in this region in recent decades (Lavoie *et al.* 2009, pp. 873-874), severe winters and deep snow can substantially limit their populations (Reed 2009, pp. 29-33; McCord, 1974, pp. 433-434). Maine's bobcat harvest declined substantially after two deep snow winters in 2008 and 2009 (Maine Department of Inland Fisheries and Wildlife 2015, p. 37). It is possible that these anomalous deep snow winters provided a temporary competitive advantage to lynx in northern New Hampshire.

Idaho, Maine, Minnesota, Montana, and Washington - These states (along with New Hampshire, above) have the strongest historical evidence of continuous lynx presence and recent evidence of resident lynx populations (McKelvey *et al.* 2000a, pp. 211-228; 68 FR 40086-40095, 40097-40101; McKelvey *in* Lynx SSA Team 2016, p. 11). Historical lynx records exist for much of Idaho, but many, especially in the central and southern part of the state, occurred in anomalous habitats or were associated with large irruptions of lynx from Canada to the northern contiguous U.S. in the early 1960s and early 1970s (McKelvey *et al.* 2000a, pp. 225-227). The historical record and recent surveys (summarized at 79 FR 54818-54820; also see U.S. District Court ID 2016, pp. 18-24) suggest that only dispersing lynx occur throughout most of Idaho, habitats in many parts of the state are drier forest types that support lower densities of hares, and resident lynx seem to be confined to the Purcell, Selkirk, and possibly the Cabinet mountain ranges in the northern panhandle. The number of resident lynx in northern Idaho is unknown but certainly small based on the amount of potential habitat, and resident lynx here are part of a larger population that occurs primarily in northwestern Montana and southeastern British Columbia.

Maine has a long history of continual lynx presence, with evidence of a persistent resident population in much of the northern half of the state (McKelvey *et al.* 2000a, pp. 211-212; Hoving *et al.* 2003, entire;), which currently is believed to support the largest lynx population in the DPS (Vashon *et al.* 2012, pp. 50-60; 79 FR 54784-54785, 54792, 54822-54824; Vashon *in* Lynx SSA Team 2016, p. 18). The current amount and distribution of high-quality lynx and hare habitat and the number of resident lynx in Maine are all much larger than was suspected at the time of listing or the 2003 remand, and all are probably substantially larger now than under likely typical historical conditions. Although the current population size in Maine is uncertain, habitat distribution and lynx home range data suggest this geographic unit could potentially support 750-1,000+ resident lynx (Vashon *in* Lynx SSA Team 2016, p. 18]). The current lynx population in Maine is supported by the broad distribution of high-quality hare habitat that resulted from extensive, large-scale clearcutting in the 1970s and 1980s in response to a massive spruce budworm (*Choristoneura fumiferana*) outbreak (68 FR 40087; 79 FR 54792; also see section 4.1.1, below). As these regenerating clearcuts, which currently provide the dense horizontal structure preferred by hares, mature beyond about 35 years post-harvest, hare densities decline as cover and forage are reduced as a result of forest succession (Simons 2009, p. 217; Simons-Legaard *in* Lynx SSA Team 2016, p. 16). The current lynx population in Maine is probably larger than the likely historical condition, when relatively small amounts of the spruce-fir forests in the state are thought to have been composed of young stands (Lorimer 1977, entire; 68 FR 40094; Vashon *et al.* 2012, pp. 45, 56; 79 FR 54792). With the reduction in clearcutting and the proliferation of partial harvesting following enactment of the Maine Forest Practices Act of 1989, it is projected that lynx densities in Maine will decline by 55 to 65 percent by 2032 (Simons 2009, p. 217; Simons-Legaard *in* Lynx SSA Team 2016, p. 16). Lynx in Maine likely represent the southern periphery of a larger population that occurs in northern New Brunswick and southern Quebec south of the St. Lawrence Seaway/River, which appears to partially isolate lynx in this region, demographically and genetically, from populations in the core of the species' range (Koen *et al.* 2015, entire). The extent to which lynx persistence in Maine relies on immigration from Canada is unknown.

In Minnesota, research conducted since the 2003 remand has demonstrated the continuous presence of a resident lynx population in the northeastern part of the state that seems to be the southern periphery of a larger population in southwestern Ontario (Moen *in* Lynx SSA Team 2016, pp. 19, 39). The number of resident lynx in Minnesota is unknown but believed to be between 50 and 200 (Moen *in* Lynx SSA Team 2016, pp. 19, 39). Lynx are occasionally detected in other parts of the state, but hare densities and snow conditions consistently favorable for lynx appear to be restricted to the northeastern "Arrowhead" region of the state, and areas to the south and west are dominated by bobcats. Although there are currently more lynx in Minnesota than suspected at the time of listing, it is unclear whether current numbers and distribution are similar to the historical condition. The extent to which lynx persistence in Minnesota relies on immigration from Canada is also unknown.

In Montana, research conducted since the DPS was proposed for listing has documented the continued presence and broad distribution of resident lynx in much of the northwestern portion of the state (Squires *in* Lynx SSA Team 2016, p. 20). The number of resident lynx in northwest Montana is unknown but believed to be between 200 and 300 (Squires *in* Lynx SSA Team 2016, p. 41) in three subpopulations - the Purcell Mountains, Seeley Lake/Central, and Garnet Mountains subpopulations (Squires *in* Lynx SSA Team 2016, p. 20). Recent (2014-2015) surveys failed to detect lynx in the Garnet Mountains in the southern part of the area (Squires *in* Lynx SSA Team 2016, p. 20), which had residents as recently as 2010 and is thought to have habitat capable of supporting 7-10 lynx home ranges (Squires 2016, *pers. comm.*). Lynx in northwestern Montana (and northern Idaho) likely represent the southern periphery of a larger population in southwestern Alberta and southeastern British Columbia. The extent to which lynx persistence in this area relies on immigration from Canada is unknown, and there is no indication of substantial immigration from Canada after the 1980s (Squires *in* Lynx SSA Team 2016, p. 20). In southwest Montana, few lynx and no recent evidence of reproduction have been documented in the Montana portion of the GYA where, as with the northwestern Wyoming part of the GYA (discussed above), uncertainty about whether this area consistently or only intermittently supported resident lynx historically makes it difficult to interpret their recent apparent absence from the area (Lynx SSA Team 2016, p. 57). As elsewhere in the West, recent research and habitat assessments suggest that habitats capable of supporting resident lynx in Montana are naturally patchier and less-broadly distributed (Squires *et al.* 2006a, pp. 46-47; Squires *et al.* 2013, p. 191), and lynx therefore naturally rarer, than was thought at the time of listing (ILBT 2013, p. 23; Jackson *in* Lynx SSA Team 2016, p. 12).

In Washington, research and monitoring conducted since the 2003 remand has continued to document a resident lynx population in the Okanogan region of the eastern Cascade Mountains in the north-central part of the state (von Kienast 2003, entire; Maletzke 2004, entire; Koehler *et al.* 2008, entire; Maletzke *et al.* 2008, entire; Maletzke *in* Lynx SSA 2016, pp. 21-22). Since at least 1985, this is the only area of the state with evidence of a resident breeding population (Koehler and Maletzke 2006, p. 4; Koehler *et al.* 2008, p. 1518; ILBT 2013, p. 58; Maletzke *in* Lynx SSA 2016, p. 21), although the Kettle Mountains in the northeastern part of the state are thought to have historically supported a small breeding population, and lynx are detected there occasionally (Stinson 2001, pp. 13–14; Koehler *et al.* 2008, p. 1523; USFWS 2008a, p. 2). Multiple large fires in the Okanogan over the last 24 years have burned about 34 percent of lynx habitat (Lewis 2016, p. 4), resulting in a more than doubling of estimated female lynx home range size and a two-thirds or more reduction in the number of resident females that potentially could be supported in that geographic unit (Maletzke *in* Lynx SSA 2016, p. 21). Although these areas should regenerate into lynx and hare habitat, it may take 35-40 years (Maletzke *in* Lynx SSA 2016, p. 21), during which time additional fire and insect impacts could further diminish habitat availability and the lynx population's probability of persistence (Lynx SSA Team 2016, p. 44; see also sections 3.4, 4.1.4, and 5.1.4, below).

In summary, although uncertainty remains regarding the historical distribution of resident lynx in the DPS and small breeding populations may have been lost from some places, neither broad-scale breeding range contraction nor substantial population declines in the contiguous U.S. from historical conditions until the DPS was listed have been documented based on verified occurrence data (68 FR 40099; 72 FR 1187; 79 FR 54798, 54815; McKelvey *in* Lynx SSA Team 2016, p. 11). New information summarized above indicates that there are many more lynx in Maine and Minnesota than was suspected at the time of listing, and there are naturally fewer lynx and a more limited distribution of suitable habitats in the western U.S. than was previously thought (68 FR 40085, 40091-40092; ILBT 2013, p. 23). Lynx in Maine are at historically high numbers and may currently be facilitating the recolonization of formerly occupied habitat in northern New Hampshire and recent lynx occurrences in northernmost Vermont. However, lynx persistence is uncertain in New Hampshire and unlikely in Vermont, and lynx numbers in Maine are projected to decline over the next several decades. In the West, small breeding populations in the GYA and the Garnet Mountains of Montana may recently have become extirpated (although both also may be only temporarily "winked off" in a metapopulation dynamics sense). In north-central Washington, lynx habitat and numbers have declined because of recent large fires and insect outbreaks, and the persistence of the breeding population there could be threatened if additional such impacts occur with similar magnitude and frequency over the next several decades. As a result of the release of 218 Canadian and Alaskan lynx from 1999-2006, resident lynx currently occur in western Colorado. Although the number of lynx in this population and its future persistence are uncertain, Colorado currently supports more lynx than it likely did, based on the historical record, for much of the previous century. The geographic units evaluated in this SSA include all areas in the contiguous U.S. with strong historical and recent evidence of persistent resident lynx populations. Detailed assessments of the current status and future viability of resident lynx populations and habitats in these areas are presented in chapters 4 and 5 below.

Chapter 3: Factors Influencing Viability of the DPS

In this chapter we discuss factors thought to influence the historical and current distribution and status of lynx populations in the contiguous U.S., their likely influence on the future viability of the DPS, and we describe the cause-and-effects pathways of impacts associated with particular factors. We focus on the factor for which the DPS was listed under the ESA (the inadequacy of regulatory mechanisms in Federal land management plans at the time of listing) and on the anthropogenic influences identified by the ILBT in the revised LCAS as having the potential to exert population-level impacts on lynx and lynx habitats (ILBT 2013, pp. 68-78). Those anthropogenic influences - climate change, vegetation management, wildland fire management, and habitat loss and fragmentation - are considered the most influential factors in the future viability of the lynx DPS.

3.1 Regulatory Mechanisms

A number of activities with the potential to affect lynx habitat suitability, productivity, mortality, and movements via habitat loss or fragmentation, creation of barriers, or that otherwise alter the vegetation mosaics and prey abundances maintained historically by natural disturbance processes may occur in lynx habitats regardless of land ownership and management. The extent to which regulations guide such activities to avoid, minimize, or mitigate impacts to lynx influences the current and future likelihoods that those habitats will provide the physical and biological features needed to support resident lynx populations. As described in more detail below, the lynx DPS was listed as threatened because of the lack of specific conservation direction and associated regulations on Federal lands. At that time, the available information indicated that most lynx habitat in the DPS occurred on Federal lands, predominantly in the western U.S. (65 FR 16061). Since then, research and monitoring have revealed that non-Federal lands contribute more to the conservation of the DPS than was known at the time of listing, particularly in the Northern Maine and Northeastern Minnesota regions. Therefore, in the following sections we describe and compare the Federal regulatory environment for lynx in the DPS at the time of listing and currently, and we describe other regulatory mechanisms as they pertain to lynx on private as well as State and Tribal lands.

Since it was listed in 2000, the DPS has been protected by the ESA's prohibition on take (under section 9), which applies to lynx wherever they occur in the DPS, regardless of land ownership.

The DPS has also been protected since listing by section 7 of the ESA, which requires Federal agencies to use their authorities to conserve listed species and to consult with the Service for any actions they implement, fund, or permit (i.e., for which a "Federal nexus" exists) and which may affect lynx or lynx habitats within the DPS, again regardless of land ownership. Additionally, section 4 of the ESA requires that critical habitat, defined as the specific geographic areas containing the physical and biological features essential for the conservation of a listed species and that may require special management and protection, be designated for listed species, and section 7 prohibits the destruction or adverse modification of such designated habitats. Critical habitat was designated for the lynx DPS in 2007 and was revised in 2009 and 2014. Section 4 also requires recovery planning for listed species; a recovery plan for the lynx DPS has not yet been completed, but part of the purpose of this SSA is to inform near-term recovery planning direction.

3.1.1 Federal Regulatory Mechanisms

Federal lands make up approximately 64 percent of the lands encompassed by the six geographic units evaluated in this SSA. Of those Federal lands, roughly 87 percent is managed by the U.S. Forest Service (USFS), 11 percent by the National Park Service (NPS), and two percent by the Bureau of Land Management (BLM). The amount of Federal land varies by unit, ranging from one percent in the Northern Maine Unit to over 97 percent in the GYA Unit (see Table 2, above, and Chapter 4, below, for ownership in each geographic unit). Federal lands management is guided by a number of statutes and associated regulations, policies, standards, guidelines, and best management practices applied by managing agencies to meet legislative mandates and achieve agency missions (for a summary of relevant Acts and associated regulations and guidance, see USFWS 2014, pp. 24-34). Many of these regulatory mechanisms provide some benefits to lynx and protect lynx habitats (USFWS 2014, pp. 24-34). For example, the conservation priority in the management of NPS lands in accordance with the National Park Service Organic Act (16 USC 1 et seq. as amended), the National Parks and Recreation Act (Public Law 95-625), and the Wilderness Act (16 USC 1131-1136, 78 Stat. 890) likely provides an adequate regulatory framework for the conservation of lynx populations and habitats in the NPS units in which they occur (USFWS 2014, pp. 28-29, 31-33). However, it was the absence of specific management direction and conservation measures for lynx and lynx habitats in USFS and BLM land management plans that led the Service to conclude that the regulatory mechanisms in those plans at the time of listing were inadequate to provide for the conservation of the DPS. Therefore, the evaluation below focuses on the efforts of USFS and BLM, in collaboration with the Service, to address the regulatory inadequacy for which the DPS was listed.

The Service designated lynx in the contiguous U.S. as a DPS and listed it as threatened under the ESA in 2000 because of the inadequacy, at that time, of existing regulatory mechanisms. Specifically, at that time the Service believed that most lynx populations and potential lynx habitats (broad forest vegetation classes defined as "lynx forest types" [65 FR 16071]) in the contiguous U.S. occurred on Federal (USFS, NPS, and BLM) lands in the western states, and that the plans that guided management of those lands (particularly USFS and BLM lands) included "...programs, practices, and activities within the authority and jurisdiction of Federal land management agencies that may threaten lynx or lynx habitat. The lack of protection for lynx in these Plans render them inadequate to protect the species" (65 FR 16052, 16082). At that time, the Service found that USFS and BLM management plans did not adequately address risks to lynx and, as identified in the LCAS (Ruediger *et al.* 2000, pp. 2-1 through 6-3), those plans allowed actions that cumulatively could result in significant detrimental effects to lynx in the contiguous U.S. As a result, the Service concluded in the final rule that the lack of Federal land management plan guidance for the conservation of lynx and the potential for those plans to allow or direct actions that could adversely affect lynx constituted a significant threat to the DPS (68 FR 40096).

In 1998, in anticipation of the DPS's listing under the ESA, regional and state directors of the Service, USFS, BLM, and NPS approved preparation of the interagency LCAS to provide a consistent and effective approach to conserve lynx and to assist with Section 7 consultation on Federal lands. An interagency Steering Committee selected a Science Team to assemble the best available scientific information on lynx and appointed the ILBT to prepare a lynx conservation strategy applicable to Federal land management in the contiguous U.S. (USFWS 2014, p. 15). The first edition of the LCAS was completed in January, 2000 and revised in August, 2000 (Ruediger *et al.* 2000, entire). The Steering Committee subsequently issued several amendments and clarifications, and the most recent revision of the LCAS was completed in August, 2013 (ILBT 2013, entire). The LCAS initially identified and evaluated 17 risk factors (e.g., timber and fire management, recreation, roads, livestock grazing, trapping, etc.) thought to have the potential to affect lynx habitat suitability, productivity, mortality, and movements and that may be addressed under programs, practices, and activities within the authority and jurisdiction of Federal land management agencies. These risk factors included programs or practices with the potential to result in habitat conversion, habitat fragmentation, or obstruction to lynx movement; roads or winter recreation trails that may facilitate access to historical lynx habitat by competitors; and fire suppression, which changes the vegetation mosaic maintained by natural disturbance processes. The risks identified in the 2000 LCAS were based on potential effects to lynx habitats and to individual lynx, lynx populations, or both; therefore, not all of the risks initially identified in the LCAS were thought to threaten lynx populations in the DPS (68 FR 40096). In the 2013 revised LCAS, risk factors were redefined as "Anthropogenic Influences on Lynx and Lynx Habitat," and grouped into two tiers based on the potential magnitude of effects (ILBT 2013, pp. 1, 68). First tier influences (climate change, vegetation management, wildland fire management, and habitat fragmentation - discussed in the remainder of this chapter, below) are those with potential to negatively affect lynx populations and habitats, while second tier influences are those that may affect individual lynx but are not expected to substantially impact populations or habitats (ILBT 2013, pp. 68-85).

In addition to identifying risks, the LCAS also directed Federal agencies to map potential lynx habitat and identify lynx analysis units (LAUs) to evaluate potential impacts of management actions on lynx and snowshoe hare habitats. Finally, the LCAS developed recommended conservation measures, standards, and guidelines to be applied to lynx habitats on Federal lands that were designed to mimic historical conditions and landscape-scale disturbance patterns and to maintain or improve lynx and hare habitats at both local (project-level) and landscape scales (USFWS 2014, p. 16). After its initial completion in 2000, USFS and BLM managers within the range of the DPS agreed to implement the standards and guidelines identified in the LCAS until management plans could be formally amended to specifically address lynx conservation. In 2000, the Service, USFS, and BLM developed and adopted Canada Lynx Conservation Agreements (CAs; BLM and USFWS 2000, entire; USFS and USFWS 2000, entire) in which the BLM and USFS agreed to coordinate assessment and planning efforts with the Service to assure a comprehensive approach to lynx conservation and to use the LCAS, supporting science, and locally specific information as the basis for the approach and to streamline consultation under section 7 of the ESA. The USFS further committed to deferring any actions not involving third parties that would adversely affect lynx until such time as the Forest Plans were amended or revised to adequately conserve lynx (USFS and USFWS 2000, p. 8; 68 FR 40083).

Concurrent with development of the LCAS and interagency CAs, the USFS and BLM in 1999 completed the *Biological Assessment* (BA) *of the Effects of National Forest Land and Resource Management Plans and Bureau of Land Management Land Use Plans on Canada Lynx* (USFS and BLM 1999, entire). The BA identified and evaluated the potential effects to lynx of implementation of 57 USFS Land and Resource Management Plans and 56 BLM Land Use Plans throughout the 14 states in which the lynx DPS was proposed for listing. The BA concluded that the potential for adverse effects to lynx existed on each administrative unit in each geographic area and that, cumulatively, implementation of the existing plans was likely to adversely affect the DPS. It recommended that all of the plans be amended or revised to incorporate conservation measures to reduce or eliminate adverse effects to lynx (USFS and BLM 1999, p. 14). In its 2000 biological opinion on the BA, the Service evaluated the USFS and BLM plans in conjunction with the CAs described above (USFWS 2000, p. 15). The Service concluded that implementation of the existing plans in accordance with the CAs until plans could be formally amended or revised was not likely to jeopardize the DPS, but that amendments or revisions to those plans were needed to further reduce or avoid the potential for adverse effects to lynx (USFWS 2000, pp. 48-50).

In the 2003 remanded rule, the Service similarly determined that adherence to the CAs, the biological opinion, and the LCAS in assessing the impacts of Federal actions on lynx alleviated the potentially-adverse effects of Federal land management activities on lynx, but that amendment of USFS and BLM land management plans to conserve lynx would be the strongest mechanism to ensure long-term conservation of lynx and lynx habitat on Federal lands (68 FR 40096-97). It concluded that although Federal, State, and Tribal regulations and plans had reduced threats to the DPS, the inadequacy of existing regulatory mechanisms still posed a moderate, albeit lower-level threat, and would continue to do so until Federal land management plans were specifically amended to address lynx conservation (68 FR 40097).

Since the 2003 remand, most Forest Service units with lynx forest types have formally amended or revised their land management plans to incorporate the conservation measures, standards, and guidelines identified in the LCAS. From 2004-2006, forest plans for seven national forests with potential lynx habitat in Maine, New Hampshire, Vermont, Michigan, Minnesota, and Wisconsin were revised to include recommendations from the LCAS and the CAs (Jackson 2015, pers. comm.; USFWS 2104, p. 33). In 2007, the USFS completed the Northern Rockies Lynx Management Direction (NRLMD), which formally amended management plans to include lynx conservation measures, standards, and guidelines for 18 national forests covering over 150,000 km^2 (57,915 mi^2) in Idaho, Montana, Wyoming and Utah, including over 72,000 km^2 (27,800 mi^2) of potential lynx habitat (USFS 2007, entire; USFWS 2014, pp. 16-19; 79 FR 54813; Jackson 2015 *in* Lynx SSA Team 2016, Appendix 3, p. 11). In 2008, USFS similarly completed the Southern Rockies Lynx Amendment (SRLA), which formally amended forest plans covering about 59,000 km^2 (22,780 mi^2), including over 30,000 km^2 (11,583 mi^2) of mapped (potential) lynx habitat on 7 national forests or national forest complexes in western Colorado and southern Wyoming (USFS 2008, entire; Jackson 2015 *in* Lynx SSA Team 2016, Appendix 3, p. 11). The management direction adopted in the Northern and Southern Rockies amendments was developed in accordance with the National Forest Management Act of 1976 and the regulations that implement the statute (36 CFR 219.22), which requires public review and comment as part of the decision making process. Among national forests within the geographic units evaluated in this SSA, only those in Washington (the Okanogan-Wenatchee and Colville national forests) have not formally amended or revised their land and resource management plans. However, the plan revision process has been initiated for both forests, and both continue to manage for lynx habitats in accordance with the LCAS and the CA.

BLM lands account for just over 1 percent of the total area within the SSA geographic units, and most occur in Colorado, Montana, and Wyoming (Table 2, above). In the Western Colorado SSA unit, BLM Field Offices that contain potential lynx habitat include the Colorado River Valley, Grand Junction, Gunnison, Kremmling, Little Snake, Royal Gorge, San Luis Valley, Tres Rios, Uncompahgre, and White River Field Offices. These BLM areas were subject to the 2000 interagency CA; however, that CA expired in 2004 (BLM and USFWS 2000, p. 8) and was not renewed. Since then, BLM Resource Management Plans (RMPs) have been revised on the Colorado River Valley, Grand Junction, Kremmling, Little Snake, and Tres Rios Field Offices. RMPs for the Gunnison, Royal Gorge, San Luis Valley, Uncompahgre, and White River Field Offices have not been revised and do not contain specific measures for the conservation of lynx. BLM lands in the Garnet Resource Area in Montana and parts of the Kemmerer and Pinedale districts in Wyoming occur within the Northwestern Montana/Northeastern Idaho and GYA SSA geographic areas, respectively. These areas were also designated as lynx critical habitat. The RMP for the Garnet area was amended in 2004 to formally adopt the conservation measures of the LCAS (BLM 2004a, 2004b, entire), and the RMPs for the Pinedale and Kemmerer districts were revised in 2008 and 2010, respectively, to adopt conservation measures and best management practices for lynx (BLM 2008b, pp. A18-10 - A18-16; BLM 2010b, pp. A-9 - A-12).

The completion and implementation of the LCAS, the interagency CAs, and the subsequent formal management plan revisions and amendments all were undertaken to address the inadequacy of regulatory mechanisms on USFS and BLM lands for which the DPS was listed. Each incorporated the best available scientific information to develop goals, objectives, conservation measures, standards, and best management practices (BMPs) to guide USFS and

BLM management activities at both project- and landscape-level scales to reduce or eliminate the potential for adverse effects to lynx or its habitats and thus promote the conservation of the DPS (Ruediger *et al.* 2000, pp. 7-1 - 7-18; BLM and USFWS 2000, entire; USFS and USFWS 2000, entire; USFS 2007, pp. 8-30, USFS 2008, pp. 6-19, Attachment 1-1 - 1-9). Standards and guidelines developed and implemented in accordance with the NRLMD and the SRLA were designed to promote beneficial effects and limit potentially adverse effects of management activities (vegetation management [e.g., timber harvest, precommercial thinning], wildland fire and fuels management, grazing, recreation, road/access management, energy development, etc.) on important lynx habitats including winter snowshoe hare habitat (high-quality lynx foraging habitat), denning habitat, and linkage/connectivity corridors (USFS 2007, pp. 8-30, USFS 2008, pp. 6-19, Attachment 1-1 - 1-9). The USFS concluded that the vegetation standards adopted in the NRLMD that limit the total amount and the rate at which lynx habitat can be converted to temporarily unsuitable habitat (stand initiation seral stage following timber harvest) ensure that the agency's timber management program is beneficial to lynx and will provide sufficient lynx habitat through time at both LAU and landscape-level scales (USFS 2007, p. 35). In its biological opinion on the NRLMD, the Service concluded that its application "...would substantially reduce or eliminate adverse effects to lynx from Forest Service land management activities on at least 94 percent of this area, and more likely nearer to 98 percent" (USFWS 2000, p. 76). Similarly, in its 2008 biological opinion on the SRLA, the Service concluded that vegetation management standards in the SRLA would prohibit treatments that could adversely affect essential components of lynx habitat on 95.5 percent of the mapped (potential) lynx habitat in the SRLA area (USFWS 2008b, p. 52).

In summary, all USFS and some BLM lands with known or potential lynx habitat within the range of the DPS, including all SSA geographic units, are currently managed in accordance with the specific conservation measures and considerations identified in the LCAS and implemented via the CAs or formally revised and amended management plans described above. These agreements and revised/amended plans constitute the regulatory framework and specific regulatory mechanisms adopted to conserve lynx habitats and populations on USFS and BLM lands that support or are capable of supporting them. They represent the agencies' efforts, in collaboration with the Service, to address and ameliorate the singular threat for which the lynx DPS was listed under the ESA. Although formal effectiveness monitoring has not been completed, it's clear that implementation of the CAs and revised/amended plans, and the associated programmatic and project-specific consultations between BLM/USFS and the Service in accordance with section 7 of the ESA, have resulted in avoidance/minimization of impacts to important lynx and hare habitats on Federal lands and have reduced the likelihood that management activities on these lands may adversely affect lynx in the contiguous U.S.

3.1.2 State Regulations and Tribal Management

Private, State, and Tribal lands make up the remaining 36 percent of the lands encompassed by the six geographic units evaluated in this SSA, accounting for almost 27 percent, almost nine percent, and one percent of the total, respectively (Table 2). The amount of private land varies by unit, ranging from 0.3 percent in the North-central Washington Unit to over 90 percent in the

Northern Maine Unit. Likewise, State ownership varies from less than one percent in the GYA and Western Colorado units to 36 percent in the Northeastern Minnesota Unit. Tribal lands account for about four percent of the Northwestern Montana/Northeastern Idaho Unit and roughly one percent of the Northern Maine and Northeastern Minnesota units; there are no Tribal lands in the North-central Washington, GYA, or Western Colorado units. Private, State, and Tribal lands, combined, constitute 99 percent of the lands in the Northern Maine Geographic Unit and over half of those in the Northeastern Minnesota Unit. Because both of these units support larger resident lynx populations than was suspected when the DPS was listed and, therefore, may contribute more substantially to the conservation of the DPS than was understood at the time of listing, we must evaluate the regulatory mechanisms that pertain to lynx on these lands (Lynx SSA Team 2016, p. 54). Although private, State, and Tribal lands constitute much smaller proportions of the other four (western) geographic units (from about 3 percent to 16 percent, combined), important lynx habitats occur on some of those lands, and regulatory mechanisms may influence their contributions to the conservation and persistence of DPS populations or parts of them. Therefore, in this section, we summarize the relevant regulatory frameworks and mechanisms that may affect lynx on private, State, and Tribal lands within the six geographic units of the DPS, but with a focus on those units with the greatest proportions of these lands and on activities on these lands with the greatest potential to impact lynx.

<u>State Wildlife Management Regulations</u> - The following information is derived from the Service's 2014 Incremental Effects Memorandum prepared in support of the revised designation of critical habitat for the lynx DPS (USFWS 2014, pp. 35-38) and updated as warranted by new information. State furbearer and other wildlife management regulations benefit lynx populations in the states where they occur. In addition to State and private lands, State wildlife regulations govern hunting and trapping activities on many Federal lands where those activities are permitted. Most states within the range of the lynx prohibited trapping and hunting of lynx prior to the 2000 listing of the DPS under the ESA, and those activities were prohibited in all states once the DPS was listed. All states within the lynx DPS range that allow legal bobcat harvest (1) manage in accordance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Export Program for Appendix II Furbearer Species (USFWS 2014, pp. 25-26), (2) have distributed information to bobcat trappers and hunters on how to avoid incidental take of lynx, and (3) report all known incidences of incidental take of lynx to the Service's Division of Management Authority to assure that take does not exceed the amount permitted under the intra-agency section 7 consultation for the CITES Export Program (USFWS 2001, entire). Most states have also adopted special regulations in areas where lynx occur to minimize the potential for incidental take (including injury) of lynx during legal trapping of other furbearers. These efforts benefit lynx and are expected to do so in the future with continued implementation and enforcement.

Unit 1: Northern Maine - In 1967, a bounty on lynx in Maine was repealed, and lynx were given complete protection from trapping and hunting. The Maine Department of Inland Fisheries and Wildlife (MDIFW) has adopted special trapping regulations in Wildlife Management Districts where lynx may occur that address specifics about traps sizes and sets that may be used to

legally harvest other furbearers and that are intended to minimize the likelihood of incidentally trapping lynx (http://www.eregulations.com/maine/hunting/lynx-protection-zone-trap-restrictions/). MDIFW also adopted and made available for download on its web page the interagency brochure *How to Avoid Incidental Take of Lynx while Trapping or Hunting Bobcats and other Furbearers*, and modified it to be more specific to Maine. MDIFW also set-up an incidental lynx capture hotline and requires that all incidentally trapped lynx be reported (http://www.maine.gov/ifw/hunting_trapping/trapping/avoid_lynx.htm, last accessed 8.08.2016), and has staff on stand-by to help immobilize, evaluate, collect tissue and/or hair samples, and release, if appropriate, any lynx reported to the hotline. This program has resulted in the release of 98 lynx from 2000 - 2015 (ten lynx died from traps or illegal shooting in traps) that were reported incidentally trapped in northern Maine (MDIFW 2014, p. 75). After preparing a habitat conservation plan (Incidental Take Plan), the MDIFW in 2014 obtained an incidental take permit from the Service for lynx trapped incidental to predator management and animal damage control activities, and other legal furbearer trapping in Maine. The permit allows incidental trapping of 195 lynx (including 3 mortalities) over a 15-year period. After two lynx were killed in killer-type traps in 2014, MDIFW imposed additional emergency trapping restrictions to further reduce mortality and injury of incidentally-trapped lynx (see Other Factors in section 4.1.1 below). The regulations now require exclusion devices on most killer-type traps, prohibit the use of drag sets on foothold traps, address specific trap types and sets, prohibit visual use of bait and visual attractants, multiple swivels on chains, and require reporting of incidental captures. The trapping incidental take permit is currently being litigated in Federal court. The MDIFW also is responsible for implementing the Maine Endangered Species Act (http://www.mainelegislature.org/legis/statutes/12/title12sec12803.html; MDIFW 2009, p. 9). Although the lynx is not State-listed as threatened or endangered because its population is estimated to exceed the State's listing threshold, it is considered a species of special concern (MDIFW 2011, p 2). The MDIFW works collaboratively with the Service to conduct research and monitor lynx populations and habitats, and it recommends voluntary forest management activities to promote a sustainable supply and large, connected, and widely-distributed blocks of dense, young spruce-fir stands and to conserve large blocks of unfragmented forestland in northern and western Maine (MDIFW 2011, p. 3).

Unit 2: Northeastern Minnesota - Although lynx were unprotected and had a bounty placed on them in Minnesota prior to 1965, lynx trapping and hunting have been prohibited in Minnesota since 1984 (Moen *in* Lynx SSA Team 2016, p. 19). Overlapping the Northeastern Minnesota SSA unit, the State Department of Natural Resources (MNDNR) has identified a specific "Lynx Management Zone" (LMZ) for which it has promulgated and enforces special trapping regulations for other furbearers in lynx habitat. The MNDNR has modified trapping regulations within the LMZ to minimize the incidental take of lynx during the legal trapping of other furbearers. The regulations address specific trap types and sets, prohibit the use of certain baits and visual attractants, and require reporting of any incidentally trapped lynx to DNR conservation officers within 24 hours (pages 53,54 at: http://files.dnr.state.mn.us/rlp/regulations/hunting/2016/full_regs.pdf). In 2015, the MNDNR issued emergency trapping rules in the LMZ mandating additional restrictions on the types of traps that may be used (MNDNR 2015, entire) to further reduce the likelihood of incidentally trapping lynx. Minnesota DNR is under a Federal court order to develop an incidental take plan for lynx and plans to seek an incidental take permit from the Service for lynx trapped incidental to other legal furbearer trapping. Like Maine, Minnesota has a State Endangered Species Statute (84.0895) which requires the Minnesota DNR to adopt rules designating species meeting the statutory definitions of endangered, threatened, or species of special concern (State of Minnesota 2016, entire). The Statute also authorizes the DNR to adopt rules that regulate treatment of species designated as endangered and threatened. Also like Maine, Minnesota has designated the lynx a species of special concern (MNDNR 2013, p. 2), and coordinates with the Service and other agencies to conduct research and monitor lynx populations and habitats.

Unit 3: Northwestern Montana/Northeastern Idaho - Lynx are designated as a species of concern (S3) by the State of Montana and a species of greatest conservation need (S1) by the State of Idaho (ILBT 2013, p. 57). The harvest of lynx was prohibited in Idaho and Montana beginning in 1996 and 1999, respectively. Both States participate in the CITES Export Program for bobcats, and both have promulgated and enforce special regulations for the legal trapping of other furbearers in areas occupied by lynx. In its trapping regulations, Idaho Fish and Game (IDFG) provides information on how to distinguish between bobcats and lynx and provides guidelines to reduce injury and minimize non-target catches, including lynx (IDFG 2016, pp. 36-37). Guidelines recommend (1) a minimum 8-pound pan tension on foothold traps set for wolves, (2) specific trap types and sets for other furbearers, and (3) bait and habitat considerations when making sets. Trappers are also required to contact IDFG or local sheriff's offices to assist with the safe release of incidentally trapped lynx. In response to a lawsuit after several lynx were incidentally trapped recently in northern Idaho, the U.S. District Court for the District of Idaho ordered the State to submit "a plan to protect the lynx from future incidental takes in the Panhandle and Clearwater (northern) Regions of Idaho" (U.S. District Court ID 2016, pp. 25-26). The plan has not yet been completed and negotiations between the State and the court are ongoing (Sallabanks 2016, *pers. comm.*). To minimize and track the incidental capture of lynx, Montana Fish, Wildlife, and Parks (MTFWP) has promulgated an evolving set of trapping regulations and reporting requirements since the DPS was listed (MTFWP 2016, pp. 7-10), including significant changes in 2008 that reduced the reported rate of incidental lynx captures from 1.6 per year in 2000-2007 to 0.4/year in 2008-2015 (MTFWP 2016, p. 5). In 2015, the Federal District Court of Montana approved a settlement agreement reached between the State of Montana and conservation groups aimed at protecting lynx from trapping. The case is now dismissed in accordance with the agreement, which requires Montana to implement a set of reasonable restrictions on trapping in lynx habitat. Currently, these regulations identify designated lynx protection zones (LPZs) and define acceptable trapping methods for public lands within them, which (1) prohibit the use of lethal (non-relaxing) snares for bobcats, (2) specifies the types of sets and baits or attractants that may be used for marten, fisher, and other furbearers where lynx occur, (3) requires a minimum 10-pound pan tension on foothold traps set for wolves, and (4) requires that any incidentally trapped lynx must be released unharmed if possible and reported to MTFWP (MTFWP 2016, pp. 7-10). MTFWP is also responsible for implementing Montana's Nongame and Endangered Species Conservation Act (http://leg.mt.gov/bills/mca/87/5/87-5-103.htm; https://www.animallaw.info/statute/mt-endangered-species-chapter-5-wildlife-protection

Unit 4: North-central Washington - Lynx harvest was prohibited in Washington in 1991, and the lynx was listed as a State threatened species in 1993 and proposed for uplisting to endangered in 2016 (Lewis 2016, pp. *iii*, 1). Under the State's Endangered Species Program, the Washington Department of Fish and Wildlife (DFW) developed a Lynx Recovery Plan (http://wdfw.wa.gov/publications/00394/) and a Status Report (http://wdfw.wa.gov/publications/01521/), and it prepares annual reports to update population and habitat information for the species. The DFW also coordinates with the Service and other agencies to conduct research and monitor lynx populations and habitats. Additionally, the use of body-gripping traps (foothold, conibear, snares, etc.) for trapping other furbearers is prohibited in Washington (except for damage control or nuisance wildlife, which requires special permits). This avoids the potential for lynx to be incidentally captured in traps set legally for other animals.

Unit 5: GYA (Southwestern Montana and Northwestern Wyoming) - See Unit 3, above, for summary of Montana's special trapping regulations to minimize incidental take of lynx. Lynx in Wyoming were offered full protection from trapping and hunting beginning in 1973, and they are designated by the State as a species of greatest conservation need (ILBT 2013, p. 57). The Wyoming Game and Fish Department (WGFD) also participates in the CITES Export Program for bobcats.

Unit 6: Western Colorado - Lynx harvest was prohibited in Colorado in 1970 and the lynx was listed as endangered in the State in 1973. Colorado participates in the CITES Export Program for bobcats, provides information to trappers and hunters on how to distinguish between lynx and bobcats, and requires immediate release of uninjured incidentally trapped lynx as well as reporting of any (uninjured, injured, or killed) incidentally trapped lynx (CPW 2015b, pp. 6-7). Colorado law prohibits the use of foothold or conibear traps and snares for trapping, which avoids the potential for lynx to be incidentally captured in traps set legally for other animals.

<u>State Forest Management Regulations</u> - Timber harvest and other forest management activities on State and private lands are governed by State regulations. Because these activities have the potential for beneficial, benign, or adverse impacts to lynx habitat depending on methods, implementation, and conservation measures, State forestry regulations may influence lynx populations, particularly where substantial amounts of lynx habitat occur on State and private lands. Below, we provide an overview of the forest management regulations in the SSA geographic units and briefly discuss their potential influences on lynx habitat. Additional details on the current and likely future influences of these regulations on lynx populations are provided below in chapters 4 and 5, particularly for the Maine and Minnesota units, where State and private lands constitute the majority of lynx habitats.

Unit 1: Northern Maine - State and private lands constitute seven percent and 90 percent, respectively, of this SSA unit, with the vast majority of private lands managed for commercial timber production. As described above in section 2.3.2.2 and in more detail below in sections

4.2.1 and 5.2.1, the current abundance of lynx in northern Maine is attributable to the landscape-scale clear-cutting that occurred on private timber lands in the 1970s and 1980s in response to an extensive spruce budworm outbreak, which resulted in the recent unnaturally large amount of young (15 to 35 years post-harvest) regenerating forest in prime hare habitat condition. The amount and distribution of this post-clear-cut high-quality hare habitat likely peaked in the late 1990s, when 20-25 percent of the forest in Maine was in an early regeneration stage. The amount of young, regenerating forest at that time was three to eight times higher than natural historical conditions, when only three to seven percent of stands were likely in such condition at any given time (68 FR 40094). Current timber harvest and management on State and private lands in Maine are governed by the Maine Forest Practices Act of 1989 and administered by the Maine Forest Service within the Department of Agriculture, Conservation & Forestry to regulate, among other things, the size, arrangement, regeneration, and management of clearcuts (MEDACF 2014, pp. 42-45). Under the Act, small (up to 250 acre) clear-cuts are still permitted, but require special permits. Because of this regulatory burden and public referendums opposed to clear-cutting, the extensive clear-cutting of the past has largely been replaced by various forms of partial harvest techniques; many of which are unlikely to maintain the current unnaturally high amount and distribution of high-quality hare habitat. The consequences of this large-scale shift in forest management on Maine's current lynx population, which is likely much larger than was possible under the natural historical disturbance regime, are discussed below in sections 4.1.1 and 5.1.1, along with other programs that may influence private lands forest management in this unit.

In Maine, there are no long term management agreements in place on private lands to assure management of lynx. In 2006 and 2007, the Natural Resource Conservation Service (NRCS) provided funds to Maine for a pilot Healthy Forest Reserve Program (HFRP) specifically to manage for Canada lynx and American marten. Five landowners enrolled in the program, but one withdrew. The remaining four landowners were provided funding to develop lynx plans on a total of about 630,000 acres (about 10 percent of the critical habitat area). These landowners selected one or two township-sized (23,000 acre) areas within their ownerships to develop and implement a lynx management plan. Thus, about 161,000 acres within the larger area was targeted for managing lynx. All four landowners completed lynx plans using guidelines in the Service's *Canada lynx management guidelines for Maine* (McCollough 2007). NRCS contracts with the landowners last 10 years and will expire in 2016 and 2017. The HFRP described an opportunity for enrollees to apply for Safe Harbor Agreements when their contracts expired, although none have indicated an interest yet in doing so. Management plans were written for a 70-year period so some landowners may continue voluntary lynx management activities. Many private landowners in Maine are enrolled in forest certification programs; the Sustainable Forestry Initiative (SFI) and Forest Stewardship Council (FSC). Both programs require landowners to protect endangered species and their habitats, but there are not specific recommendations pertaining to lynx. About 2.5 million acres in northern Maine is under conservation easement (http://web.colby.edu/stateofmaine2012/state-of-large-landscape-conservation-in-maine/ last accessed 8.18.2016), but easements do not require management prescriptions or commitments for lynx. To our knowledge, there are no private landowners in

Maine who have committed to long-term or permanent protection and creation of lynx habitat according to the Service's lynx management guidelines or LCAS.

State lands include Baxter State Park (~200,000 acres) and the various lots owned and managed by the Maine Bureau of Parks and Lands (MBPL). Most of Baxter State Park is managed as wilderness area, and lynx sightings in the Park are rare because most of the park is mature forest. MBPL integrated resource policy requires that they promote the conservation of Federally listed species, but so far no lynx management plans have been developed. Mitigation for Maine Department of Inland Fisheries and Wildlife's incidental take permit for trapping requires management of 6,200 acres of lynx habitat within a 22,046-acre habitat management area on the MBPL's Seboomook Unit for a 15-year period.

Unit 2: Northeastern Minnesota - State and private lands constitute about 36 percent and 16 percent, respectively, of this SSA unit. The Minnesota Department of Natural Resources (MN DNR) Division of Forestry regulates timber harvest and management on State and private lands. Under the Sustainable Forest Resources Act of 1995 (revised most recently in 2014 [MFRC 2014a, p. 1]), the Minnesota Forest Resources Council (MFRC) has developed voluntary guidelines for site-level timber harvesting and forest management (MFRC 2012, p. 1) that are intended for private and State landowners and include some general recommendations for wildlife including lynx. However, because they are voluntary, the extent to which these guidelines benefit lynx is uncertain (see sections 4.1.2 and 5.1.2 below).

Unit 3: Northwestern Montana/Northeastern Idaho - State and private lands constitute about four percent and eight percent, respectively, of this SSA unit and almost all are in the Montana portion of the unit. The Montana Department of Natural Resources and Conservation (MTDNRC) administers several laws pertaining to forest practices on State and private lands. These laws are intended to protect streamside management zones, reduce fire hazards, and provide BMPs to minimize non-point source water pollution (http://dnrc.mt.gov/divisions/forestry/forestry-assistance/forest-practices, accessed July 18, 2016). Although these laws may provide indirect benefits to lynx and other wildlife, they do not include specific measures to conserve or avoid impacts to lynx habitats. However, the MTDNRC and the Service collaborated on a multi-species habitat conservation plan (HCP) for forested State Trust lands that includes a Lynx Conservation Strategy to minimize impacts of forest management activities on lynx and describes conservation commitments that are based on recent information from lynx research in Montana (USFWS 2104, pp. 22-23; 79 FR 54835-54837). This HCP covers about 64 percent of the State lands in this SSA unit, regulates activities primarily associated with commercial forest management to conserve lynx foraging, denning, and connectivity habitats, and includes a 50-year commitment (79 FR 54835-54836). Additional details on this HCP and other programs for conserving lynx habitats on State and private lands in this unit are provided in section 4.1.3 below.

Unit 4: North-central Washington - State and private lands constitute about eight percent and 0.3 percent, respectively, of this SSA unit and most are State Trust lands in the Loomis State Forest, which accounts for all 426 km^2 (164 mi^2) of State lands in this unit. The Washington

Department of Natural Resources (WADNR) administers rules guiding forest practices, such as timber harvests and road building, on State, private, and tribal forests in Washington. The Forest Practices Board, an independent State agency, adopts forest practices rules to protect water quality, fish habitat, other public resources and guide DNR’s permitting process for timber harvests and other forest practices statewide. The WADNR developed a Lynx Habitat Management Plan (LHMP) for WDNR-managed lands distributed throughout north-central and northeastern Washington in areas delineated as Lynx Management Zones in the Washington State Lynx Recovery Plan (Stinson 2001, entire; Washington DNR 2006, entire). The WADNR LHMP guides timber harvest and other vegetation management on these lands, including the part of the Loomis State Forest that occurs in this unit, with the goal of creating and preserving quality lynx habitat through its forest management activities. Additional information on the LHMP is provided in sections 4.1.4 and 5.1.4 below.

Unit 5: GYA - State and private lands constitute about 0.3 percent and just over two percent, respectively, of this SSA unit and, combined, likely have little influence on lynx population persistence. Forestry regulations for the Montana portion of this unit (26 percent) are described above. In the Wyoming portion (74 percent of the unit), the Wyoming State Forestry Division is responsible for the management of forested trust land across the state, including timber management and harvest, for long term forest health and productivity. Although the Division’s programs may provide some indirect benefits to lynx, they do not include species- or habitat-specific regulations or conservations measures.

Unit 6: Western Colorado - State and private lands constitute about 0.6 percent and over 9nine percent, respectively, of this SSA unit. The Colorado Department of Natural Resources and the State Division of Forestry oversee forest management activities on State and private lands in Colorado.

<u>Tribal Management</u>: Tribal lands encompassed by SSA geographic units include those of the Passamaquoddy Tribe and the Penobscot Indian Nation in Maine (248 km^2 [96 mi^2] in Unit 1), Grand Portage Band of Lake Superior Chippewa in Minnesota (202 km^2 [78 mi^2] in Unit 2), and the Confederated Salish and Kootenai Tribes of the Flathead Nation - Flathead Reservation in Montana (958 km^2 [370 mi^2] in Unit 3). Tribal management of these lands is expected to benefit lynx and lynx habitats. No tribal lands occur within SSA units 4, 5, or 6.

Unit 1: Northern Maine - Tribal lands represent less than one percent of this unit. The Passamaquoddy Tribe has lands enrolled in the Healthy Forest Reserve Program, described above. The Passamaquoddy Tribe’s stated environmental mission is “...to protect the environment and conserve natural resources within all Passamaquoddy lands, waters, and the air we share” (Passamaquoddy Tribe 2014, entire). That of the Penobscot Indian Nation Department of Natural Resources is “...to manage, develop and protect the Penobscot Nation’s natural resources in a sustainable manner that protects and enhances the cultural integrity of the Tribe” (Penobscot Indian Nation 2014, entire). Hunting, trapping or possessing lynx are prohibited in accordance with the Penobscot Indian Nation Chapter VII Inland Fish and Game Regulations – Section 204 (Penobscot Indian Nation 2012, p. 15).

Unit 2: Northeastern Minnesota - Tribal lands of the Grand Portage Indian Reservation and the Bois Forte Indian Reservation—Vermillion Lake District represent one percent of this SSA unit. The Grand Portage Band of Chippewa has been actively working on lynx conservation since 2004. In October 2007, the Band hosted an international conference on lynx research and conservation where more than 50 researchers from the United States and Canada presented results of research on lynx diet, habitat, and management. Additionally, on-reservation timber sales and harvest practices follow an integrated management plan for priority wildlife management, sustainable economic development, and recreational uses. The Band's timber management practices benefit populations of snowshoe hares, the lynx's primary prey (Deschampe 2008, entire).

Unit 3: Northwestern Montana/Northeastern Idaho - Tribal lands of the Confederated Salish and Kootenai Tribes of the Flathead Nation, Flathead Reservation represent nearly four percent of this SSA unit. The mission statement of the Tribes' Fish, Wildlife, Recreation and Conservation Division is "...to protect and enhance the fish, wildlife, and wildland resources of the Tribes for continued use by the generations of today and tomorrow" (Confederated Salish and Kootenai Tribes 2014a, entire). An objective of the Tribes' Tribal Wildlife Management Program Plan is to ''. . . develop and implement habitat management guidelines for Canadian lynx in coordination with the Forestry Department as specified in the Forest Management Plan'' (Confederated Salish and Kootenai Tribes. 2014b, p. 5). The Forest Management Plan states that ''Standards for lynx management and habitat protection are set forth in the Canada Lynx Conservation Assessment and Strategy. This strategy guides land management activity in lynx foraging and denning habitat. Lynx occurrence and populations will continue to be monitored on the Reservation'' (Confederated Salish and Kootenai Tribes 2000, p. 285).

In summary, a variety of State wildlife and forestry regulations and conservation efforts, along with Tribal resource management objectives, influence activities in lynx habitats across the range of the DPS. While many of these clearly benefit lynx habitats and likely contribute to the persistence of resident populations, uncertainty remains regarding the effectiveness of some regulations and voluntary programs or measures in maintaining or restoring lynx habitats. This may be especially important with regard to timber management regulations and programs on private lands, which constitute the majority of lands in the Northern Maine geographic unit and a substantial amount of the Northeastern Minnesota unit.

3.2 Climate Change

In 2014, the International Panel on Climate Change (IPCC) released its Fifth Assessment Report, which represents the current scientific consensus on global and regional climate change and the best scientific data available in this rapidly changing field. The Fifth Assessment Report largely reaffirms the conclusions of previous reports that the global climate is warming at an accelerating rate and that this warming is largely the result of human activities and the associated release of carbon dioxide and other greenhouse gases into the atmosphere (IPCC 2014a, entire).

‘‘Climate’’ refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007a, p. 78). The term ‘‘climate change’’ thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is a result of natural variability, human activity, or both (IPCC 2007a, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007a, pp. 8–14, 18–19). In our analyses, we weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

The IPCC’s Fifth Assessment Report concludes that the strongest and most comprehensive evidence of the impacts of climate change is in natural systems, where many species have responded by shifting their geographic ranges, seasonal activities, migration patterns, abundances, and species interactions (IPCC 2014a, p. 4). The report also concludes that projected climate change during and beyond the 21st Century will increase extinction risk for many terrestrial and freshwater species (IPCC 2014a, pp. 14–15). In North America, observed impacts attributable to climate change that may affect lynx habitats and distribution include upslope and northward shifts in species distributions across multiple taxa, and increased wildfire activity, fire frequency and duration in boreal and subarctic conifer forests of Canada and the western U.S. (IPCC 2014a, p. 31).

At the time of listing, the Service determined there was no evidence to support global warming as a threat to lynx (65 FR 16068-16069). In the 2003 remanded determination, we concluded that the best information available at that time regarding the potential impact of climate change on lynx (warming leading to long-term reductions in snow depths needed to support lynx in the eastern U.S. and eastern Canada south of the St. Lawrence Seaway; Hoving 2001, pp. 72-75) was speculative and did not demonstrate a threat to lynx (68 FR 40083, 40098). In the 2005 recovery outline for the DPS, the Service acknowledged that continued climate warming was likely to negatively affect the boreal forest ecosystem for which lynx are highly adapted, eventually causing it to recede north and/or to higher, colder elevations, potentially resulting in a substantial reduction or even elimination of lynx habitats from the contiguous U.S. (USFWS 2005, pp. 11, 14). In the 2009 critical habitat rule, the Service acknowledged that new science concerning climate change was available, and that climate change may pose a risk to the future conservation of lynx (74 FR 8617, 8621). In the 2014 revised critical habitat rule, we concluded that recent information on regional climate changes and potential effects to lynx habitat (e.g., Knowles *et al.* 2006, pp. 4545–4559; Carroll 2007, pp. 1098–1102; Danby and Hik 2007, pp. 358–359; Gonzalez *et al.* 2007, entire; Iverson *et al.* 2008, pp. 390–400; Beckage *et al.* 2008, entire; Burns *et al.* 2009, p. 31; Johnston *et al.* 2012, pp. 6–13) suggested that climate change is likely to be a significant issue of concern for the future conservation of the lynx DPS (79 FR 54811). Specifically, climate models project reductions in the extent of boreal forest habitats and snow conditions needed to support lynx throughout the DPS, with both features modeled to migrate to higher elevations (in locations where this is possible) and northward in latitude. This would result in fewer, smaller, and more fragmented and isolated areas capable of supporting resident lynx and, therefore, smaller and more isolated lynx populations that would likely be more vulnerable to stochastic environmental and demographic events (79 FR 54811). Climate change also may have synergistic effects with other stressors (e.g., forest insect outbreaks and wildfire frequency, size, and intensity) that could further reduce and isolate lynx populations within the DPS and reduce connectivity to lynx in Canada. Climate change may also affect human interactions in the DPS that could benefit or stress lynx (e.g., growing older forests to increase carbon sequestration, developing biomass and wind energy in lynx areas).

Lynx biologists identify climate change as the most important and overarching factor influencing resiliency of the DPS (Lynx SSA Team 2016, pp. 14, 17, 19, 21-22, 35-47, 50, 53-57; ILBT 2013, pp. 43, 48, 53, 55, 63, 66, 69-71, 98). Climate change is likely to be exacerbated at the southern edge of the range where habitat and snow conditions are patchy and becoming increasingly marginal for the continued existence of lynx (Gonzalez *et al.* 2007, p. 8). Across North America, a significant increase in proportion of winter precipitation falling as rain rather than snow has resulted in reduced persistence of the winter snowpack (Dyer and Mote 2006, entire), increased snow density (Hodgkins and Dudley 2006, entire), and decrease in the extent of deeper snowpacks (Dyer and Mote 2006 p. 1; Brown 2000, pp. 2347-2354). Climate change models suggest that future snow cover in the contiguous U.S. will be further reduced in extent and distribution (McKelvey *et al.* 2011, pp. 2892-2896).

Warming and more frequent winter thaws are contributing to changes in snowpack structure, namely replacing deep, fluffy snow with harder, crustier snow. These suboptimal snow conditions are expected to occurr at higher latitudes (Callaghan *et al.* 2011, entire) and higher elevations in the Rockies (Abatzoglou 2011, pp. 1138-1141). The frequency of winter warm spells is correlated to the hardness of the snow surface, sinking depth, and, in turn, influence the hunting efficiency of lynx (Stenseth *et al.* 2004, p. 10633). As the climate warms, winter temperatures are rising above freezing more often. This results in more rain on snow events and winter thaws that change the structure of the snowpack; larger grain size, basal ice layers, depth hoar (weak layers in the snowpack), and slip planes (crusts and ice layers within the snowpack;Callaghan *et al.* 2011, p. 23). Hard snow surfaces (crust) and other structure in the snowpack are believed to reduce the competitive advantage of lynx over bobcats and other mesocarnivore competitors and predators.

Although it is believed that high elevation areas in the West may provide snow refugia for lynx (Lynx SSA Team 2016, p. 45), these areas will also be affected. Mountainous regions in the western U.S. have historically been snow-covered from November through March. By 2050, the length of snowfall-conducive temperatures over many western mountain ranges will be reduced from approximately five months (November–March) to approximately three months (December-February) of the year (Klos *et al.* 2014, p. 4566). Many relatively large areas that contain lower relief, mid-elevation mountain ranges will likely shift relatively quickly into new precipitation phase regimes (e.g., the Northern Rockies, North Cascades; Klos *et al.* 2014, p. 4566). The interior northwestern U.S. shows a greater sensitivity of its strongly snow-dominated areas to warming because much of the region is characterized by relatively warm winter temperatures and by mainly mid-elevation mountain ranges. The climatic rain-snow transition zone will move up in altitude and north in latitude.

It is possible that in high elevation areas of the DPS range in the West, snow conditions suitable for lynx may move up slope at a faster rate than boreal forest habitat will migrate, providing a mismatch of these important habitat elements for lynx. During prehistorical periods of warmer climate, the alpine treeline ecotone (upper elevation of lynx boreal habitat) and deciduous-boreal forest ecotone (lower elevation of lynx boreal habitat) have readily moved upslope in both the northern (Kearney and Luckman 1983) and Southern Rockies (Legg and Baker 1980). Boreal treelines in Scandinavia moved upslope an average of 40 m (but in some locations up to 100 m) during a recent 50-year period of warming (Kullman 1990). However, despite recent warming, the alpine treeline in North America has thus far remained relatively static (Butler *et al.* 1994). Upslope migration of the treeline of boreal forest may be limited by high winds, desiccation, and soil depth not conducive to colonization by conifers. Upslope migration of boreal forest will occur either gradually or as a series of scattered, rapid advances as climate thresholds are crossed (Kupfer and Cairns 1996, p. 259-261). At lower elevations, the upslope movement of the deciduous-boreal ecotone is limited by an isocline of excessively cold winter temperatures (generally -40C), moisture (cloud, fog line), and acidic soils (Kupfer and Cairns 1996, p. 263-264). The rate that boreal forest will retreat upslope is highly speculative depending on how climate change will affect complex moisture and temperature regimes, and there could be a lag time before these community types move up slope (Kupfer and Cairns 1996, p. 268). In the Yukon, upslope migration of spruce-fir seemed to be triggered by climate thresholds and was characterized by slow, gradual change followed by rapid advances (Danby and Hik 2007, p. 361). However, in Vermont, the northern hardwood-boreal ecotone moved upslope 91 to 119 m between 1962 and 2005 consistent with rapidly increasing cloud ceilings in the Northeast, which is believed to be closely associated with this ecotone transition (Beckage *et al.* 2008, pp. 4200-4201).

In contrast, there have been no lag time or thresholds slowing changes in the precipitation and snow regime. Much of the Rockies have already experienced declines in spring snowpack in response to climate change, especially since midcentury, despite increases in winter precipitation in many places (Mote *et al.* 2005, entire; Scalzitti *et al.* 2016, pp. 5367-5368). Some mountainous regions are warming at a faster rate than global land averages (Rangwalla and Miller 2012, entire). It is likely that the losses in snowpack observed to date will continue and even accelerate (Hamlet and Lettenmaier 1999; Payne *et al.* 2004), with faster losses in milder climates like the Cascades and the slowest losses in the high peaks of the northern Rockies and southern Sierras. For every 1 °C increase in temperature, snowline increases about 150 m in elevation (Beniston 2016, p. 106). If greenhouse gas emissions continue at the current rate, by 2100, the altitude above which it snows and below which it rains will climb as much as 800 feet in the Colorado Rockies, by 1,400 feet in the Rockies of Idaho and Wyoming, and the snow line will rise by an average of 950 feet across six Western mountain regions (Scalzitti *et al.* 2016, p. 1564). Thus, it is possible that boreal forest will persist for a while, but deep, fluffy snow conditions will retreat upslope and preclude the use of boreal habitat by lynx and instead favor competitors such as bobcats.

The effects of climate warming are already occurring and have accelerated over the past three to four decades (Hansen *et al.* 2006, entire). Globally, greenhouse gas emissions are increasing and tracking levels predicted by models for high emissions scenarios (e.g., RCP8.5) (Peters *et al.* 2013; Friedlingstein *et al.* 2014, p. 709, 712; Fuss *et al.* 2014, p. 851; IPCC 2013, p. 180, 187-189). Analysis of paleoclimate indicates 20th century warming is likely to have been the largest of any century within the last 1000 years (Folland *et al.* 2001, pp. 99-101). These changes are predicted to continue and accelerate under future climate scenarios (Hall and Fagre 2003, Fig. 7). The range of warming projected over this century runs from 3.6 °F (2 °C) to 10.8 °F (6 °C) for North America, with warming higher than this average in areas that are inland, northerly, or mountainous.

Climate change is manifested in different ways throughout the northern contiguous United States and the lynx DPS. To date, the observed and predicted increases in surface temperatures have been greatest in the northern Rockies and Northeast (much of the lynx DPS) than elsewhere in the contiguous United States (IPCC 2014, pp. 12, 61, Lynx SSA Team 2016, pp. 14-15). Climate history and projections from regional climate models for regions associated with the lynx DPS units corroborate global models, and indicate that both eastern and western North America, including all portions of the lynx DPS, have warmed in the last century and are likely to warm 1.8 °F (1 °C) to 5.4 °F (3 °C) by the year 2050 (IPCC 2007b, p. 889). For example, in the Northern Rocky Mountains at Glacier National Park, mean summer temperatures have increased 3.0 °F (1.66 °C) between 1910 and 1980 (Hall and Fagre 2003, pp. 134–137) resulting in lower snowpack, earlier spring melt, and distributional shifts in vegetation (Hall and Fagre 2003, pp. 138–139; Fagre 2005, pp. 4–9).

Climate change is diminishing snow conditions (reduced depth, quality, persistence) considerably throughout the DPS. The strong warming in recent decades corresponded to a large decline in snow cover in North America, particularly in the mountains of the western U.S. (Mote *et al.* 2005, p. 47-48). In most mountain ranges, relative declines vary from minimal at ridgetop to substantial at snow line. Temperature has increased more in the winter than summer (Knowles *et al.* 2006), which has increased the amount of winter precipitation falling as rain instead of snow throughout the DPS (Huntington *et al.* 2004, entire; Knowles *et al.* 2006, entire; Feng and Hu 2007, entire). The rate of decline in the snowpack of the northern Rockies is unprecedented in the last 1000 years (Pederson *et al.* 2011, entire). An analysis of potential snow cover under a range of IPCC future climate scenarios and modeling of vegetation using a dynamic vegetation model indicates that potential lynx habitat could decrease by as much as two-thirds in the contiguous U.S. by the end of this century (Gonzalez *et al.* 2007, pp. 4, 7–8, 10, 13–14). Climate modeling suggests that lynx habitat and populations are anticipated to decline accordingly (Carroll 2007, pp. 1098–1102) and may disappear completely from parts of the range of the DPS by the end of this century (Johnston *et al.* 2012, pp. 6–13).

Climate change is expected to substantially reduce the amount and quality of lynx habitat in the contiguous U.S., with patches of high-quality boreal and subalpine forest habitat becoming smaller, more fragmented, and more isolated (Carroll 2007, pp. 1099–1100; Johnston *et al.* 2012, p. 11). Various forms of snow compaction and structure within the snowpack (see above) give a competitive advantage to bobcats and other predators/competitors with higher foot loading that would normally have difficulty traveling and hunting efficiently in deep, fluffy snow conditions (Murray and Boutin 1991; Murray *et al.* 1994; Kolbe *et al.* 2010). Remaining lynx populations would likely be smaller than at present and, because of small population size and increased isolation, populations would likely be more vulnerable to stochastic environmental and demographic events (Carroll 2007, pp. 1100–1103). These trends indicate the range of the lynx in the DPS is likely to contract as a direct result of climate change. Because of climate change and other stressors, lynx biologists believed that only one to three of the six units may persist to the end of the century (Lynx SSA Team 2016, p. 48).

Near-term effects of climate warming on lynx are more certain than long-term effects. Lynx experts anticipate a downward trend for the probability of persistence of lynx in all six geographic units primarily because of the effects of climate warming (Lynx SSA Team 2016, pp. 35-47). The rates of change and magnitude of effects of climate warming is difficult to predict. Climate change is anticipated to affect each unit differently as summarized below.

Climate change is affecting many of the requirements necessary for the continued existence of lynx in the DPS. Climate warming will continue to stress populations into the foreseeable future. Direct effects to lynx, hares, and their habitat that are occurring or can be reasonably anticipated include 1) range contraction, 2) reduction in the periodicity and amplitude of the hare cycle, 3) reduction in snow conditions necessary to give lynx a competitive advantage, 4) reduction in hare habitat quality and populations, 5) reduction in the amount of lynx and hare habitat in the U.S., 6) changes in the frequency and pattern of disturbance events, 7) introduction of disease and parasites, and 8) reduced gene flow. Synergistic effects between these factors and other stressors (e.g., forest management, trapping, development) may intensify their effects (Carroll 2007). Diminished snow, increasing drought and fire, and increased forest pests and disease are believed to currently be the most important stressors for lynx in the DPS, but it is possible that other pathways are, or may become, equally important. Over the next decades, southern lynx populations will continue to be affected by climate change and associated shifts in habitat, prey base, and competition. The extent of such changes and whether lynx are able to adapt to them will determine not how, but if, this species can persist in the contiguous U.S. (Murray *et al.* 2008).

<u>Range Contraction in the DPS</u> - In response to climate change, lynx range in the DPS is expected to contract as a result of boreal habitat shifting to higher elevation (Danby and Hik 2007, pp. 360-362) and northward shifts in latitudinal distribution of boreal habitat and snow conditions (Sturm *et al.* 2001, pp. 342-342; Gonzalez *et al.* 2010, pp. 761-766; Koen *et al.* 2015. p. 528; ILBT 2013, p. 69). For example, lynx distribution in southeastern Ontario has shifted northward >175 km over the past 40 years (Koen *et al.* 2014a, pp. 757-758). Habitat patches will become smaller, more fragmented and isolated (Carroll 2007, pp. 1099-1100; Johnston *et*

al. 2012, p. 11), bobcat distribution will expand northward (see below), and lynx will become more vulnerable to stochastic and environmental and demographic effects because of smaller population sizes and increased isolation.

Reduction in Periodicity and Amplitude of the Hare Cycle - Climate change is altering large-scale climate systems such as the North Atlantic Oscillation, Southern Oscillation, Pacific North American Index, and North Pacific Index which, in turn, affect patterns of temperature and snow in North America (Stenseth *et al.* 2003, entire). Climate change-induced disruptions are believed to have caused the collapse of cycles in voles, lemmings, and snowshoe hare populations (Ims *et al.* 2008, p. 81; Krebs *et al.* 2010, pp. 484-488; Cornulier *et al.* 2013, entire). The geographical borders between cyclic and noncyclic populations are shifting, and the spatial extents of regions that have cycles are shrinking. The collapse of cycles in herbivores with high-amplitude population cycles also would imply collapses of important ecosystem functions such as pulsed flows of resources and disturbances throughout the ecosystem, including declines in predator communities (Schmitz *et al.* 2003, p. 1202; Ims *et al.* 2008, p. 85). A common denominator of cycles that exhibit spatial gradients, such as the more pronounced snowshoe hare cycles in the northern part of its North American range, is that the cycles seem to fade as winters become shorter (Ims *et al.* 2008, p. 81).

Changes in large-scale climate systems have already influenced the climate and snow conditions throughout the geographic range of the lynx in North America (Stenseth *et al.* 1999, entire; Brown 2000, pp. 2347-2354; Krebs *et al.* 2001a, p. 34). Yan *et al.* 2013 (p. 3269) provide the first evidence of the negative effects of climate warming on hare-lynx cycles in Canada. The authors concluded that climate forcing is not only essential in producing sustained cycles, but also in modifying the cycle intervals (Yan *et al.* 2013, p. 3269). Greatly reduced lynx fur harvests in Canada beginning in the mid-1980s may be linked to climate warming (Yan *et al.* 2013, p. 3269). With more pronounced troughs in hare abundance cycles, lynx populations will decline (Hone *et al.* 2011, p. 424). Diminished lynx populations in the core of the range in Canada is a concern because most of the populations of lynx in the DPS are believed to be dependent on periodic immigration from Canada for demographic persistence and genetic stability (McKelvey *et al.* 2000a, pp. 232-242; 2000b, pp. 32-34; Schwartz *et al.* 2002, entire; USFWS 2005, p. 2; ILBT 2013, pp. 34, 42, 47, 54, 60, 65; Squires *et al.* 2013, p. 187; 79 FR 54789, 68 FR 40091, 40097-40100). If diminished amplitude of the hare cycle in Canada persists, it will likely translate into a reduced potential for lynx to expand into new or unoccupied habitat in Canada or the adjoining U.S. (ILBT 2013, p. 69).

Reduction in Snow Conditions that are Necessary to Provide Lynx a Competitive Advantage - Climate-induced changes in snow depth and quality are critical because they reduce the extent of deep, fluffy snow habitat available to lynx (Knowles *et al.* 2006, p. 4557; Carroll 2007, p. 1103; Gonzalez *et al.* 2007, pp. 7-8; McKelvey *et al.* 2011, pp. 2893-2895; ILBT 2013 p. 69). Across their worldwide distribution, lynx rely on deep, powdery and persistent snow because they restrict potential lynx competitors such as bobcat or coyote and predators such as fishers and cougars from effectively encroaching on or hunting hares in winter lynx habitat (Peers *et al.* 2016, entire; 79 FR 54809).

Warmer winter temperatures are reducing snowpack in all portions of the lynx DPS through a combination of a higher proportion of precipitation falling as rain and higher rates of snowmelt during winter (Hamlet and Lettenmaier 1999, p. 1609; Brown 2000, p. 2347; Hoving 2001, pp. 73–75; Mote 2003a, p. 3–1; Christensen *et al.* 2004, p.347; Knowles *et al.* 2006, pp. 4548–4549). These trends are expected to continue with future climate warming (Hamlet and Lettenmaier 1999, p. 1611; Christensen *et al.* 2004, p. 347; Mote *et al.* 2005, p. 48; IPCC 2007b, p. 850). The IPCC (2007b, p. 850) concludes that ''snow season length and snow depth are very likely to decrease in most of North America except in the northernmost part of Canada where maximum snow depth is likely to increase.'' Shifts in the timing of the initiation of spring runoff toward earlier dates in western North America are also well documented (Hamlet and Lettenmaier 1999, p. 1609; Brown 2000, p. 2347; Cayan *et al.* 2001, pp. 409–410; Christensen *et al.* 2004, p. 347; Mote *et al.* 2005, p. 41; Knowles *et al.* 2006, p. 4554). In addition, a feedback (albedo) effect is likely to accelerate the rate of loss of snow cover because of the reflective nature of snow and the relative heat-absorbing properties of non-snow-covered ground. This feedback effect causes the greatest warming to occur at the interface of snow-covered and exposed areas, increasing the rate at which melting occurs in spring (Groisman *et al.* 1994a, pp. 1637–1648; Groisman *et al.* 1994b, pp. 198–200). This effect has led to the average date of peak snowmelt to shift 3 weeks earlier in spring in the Intermountain West (Fagre 2005, p. 4). This albedo effect is further exacerbated by atmospheric soot and desert dust on the snow surface (Painter *et al.* 2007, entire; Qian *et al.* 2009, entire) and fire-darkened landscapes (Amiro *et al.* 2006, pp. 47-49). Snow accumulation and duration are expected to decline generally in the geographic areas that contain the central and eastern portion of the lynx DPS (IPCC 2007c, p. 891; Burns *et al.* 2009, p. 31). Because lynx require prolonged periods of deep fluffy snow, current habitats that lose this feature would decline in value for lynx (Hoving 2001, p. 73; Carroll 2007, p. 1092; Gonzalez *et al.* 2007, entire).

Reduced snow depth and duration may reduce lynx's competitive advantage over bobcats, which have similar ecology to lynx but are not as well-adapted to hunting hares in deep fluffy snow (Hoving 2001, pp. 23–24; Carroll 2007, p. 1102; ILBT 2013, pp. 69, 71). The bobcat is the closest related species to lynx in North America, and it outcompetes or displaces lynx wherever the two species overlap, at both broad (Peers *et al.* 2016, entire) and local (Parker *et al.* 1983; Robinson 2006, pp. 120-129) geographic scales. In areas where they do overlap, lynx are subjected to niche displacement to habitats of inferior quality, which probably limits lynx survival and productivity at the southern edge of their range (Peers *et al.* 2016, entire; Robinson 2006, pp. 120). Snow depth likely acts as a mediator of competition between the two species. Bobcats have a higher foot loading than lynx, are unable to hunt hares successfully in areas with deep, soft snow (Krohn *et al.* 2005, pp. 122-129, Hoving *et al.* 2005, entire), and experience high mortality in deep snow winters (Litvaitis *et al.* 1986, p. 116). Lynx have a low foot loading and long legs (Buskirk *et al.* 2000a, p. 90; Krohn *et al.* 2005, pp. 122-129) that gives them a competitive advantage over bobcats in deep, fluffy snow conditions. This has important implications for lynx persistence and range distribution at the southern edge of their range considering the current and projected changes in snow cover, stable or increasing bobcat populations in the DPS (Roberts and Crimmins 2010, p. 170), and the predicted northward expansion of bobcats into areas currently occupied by lynx (Anderson and Lovallo 2003, p. 758; Lavoie *et al.* 2009, pp. 873-874; Roberts and Crimmins 2010, p. 172).

Buskirk *et al.* (2000a, entire) described exploitation (competition for food) and interference (avoidance) competition from bobcats and other species that may compete with lynx. Exploitation competition could contribute to lynx starvation and reduced recruitment. Of several predators examined (raptors, coyote, gray wolf, cougar, bobcat, and wolverine), coyotes were deemed the most likely to pose local or regionally important exploitation impacts to lynx. Coyotes, bobcats, and cougars are possibly capable of imparting interference competition effects on lynx. Interference would be most probable during summer and during winter in areas lacking deep, unconsolidated snow (ILBT 2013, p. 36). Cougars are also predators of lynx in the West (ILBT 2013, p. 35), but, like bobcats, cougars also have high foot loading, which limits their efficiency in deep, fluffy snow (Buskirk *et al.* 2000a, p. 90). Fishers are predators of lynx in Maine (Vashon *et al.* 2012), but their distribution and movements in winter are also limited by deep, unconsolidated snow (Krohn *et al.* 2005, entire).

The effects of lynx-bobcat hybridization on lynx populations in the DPS are uncertain. Bobcats have hybridized with lynx in Minnesota, Maine, and New Brunswick (Schwartz *et al.* 2004, entire; Homyack *et al.* 2008, entire), where low topographic relief and variability in winter severity may allow more interaction between the two species during the breeding season (ILBT 2013, p. 34). Hybrids were capable of reproducing successfully (Homyack *et al.* 2008, p. 507). The hybridization rate is currently low between the species (0.24 percent) but could increase as bobcat populations move north with climate change (Murray *et al.* 2007, p. 1465; Koen *et al.* 2015, p. 528).

<u>Reductions in Hare Populations</u> - In addition to affecting the synchronicity and amplitude of hare cycles, climate change will likely affect hare populations in other ways, especially at the southern extent of the range. Changing snow conditions may influence lynx hunting behavior and effectiveness. For example, hard-packed snow is reported to be associated with a higher kill rate of hares by lynx and coyotes than soft snow (Buskirk *et al.* 2000, p. 94; Stenseth *et al.* 2004, p. 10633). The higher kill rate could generate a numeric response by lynx and other hare predators (Hone *et al.* 2011, p. 420) that could drive hare populations to lower levels (Stenseth *et al.* 2004, p. 10633). Predator communities are more diverse at the southern part of the lynx range than in central Canada (Murray *et al.* 2008, pp. 1464-1465). The diverse predator community could explain why hare populations have declined and seem to remain low in Maine (Scott 2009, p. 43). Climate change will cause increased annual precipitation, periods of drought and extreme precipitation, and hotter summers across the northern tier of U. S. (i.e., throughout the DPS) in eastern North America (Jacobson *et al.* 2009, pp. 14-15, Romero-Lankao 2014, pp. 1452-1456). Increased precipitation may reduce hare numbers because the second litters of snowshoe hares have lower survival in wet summers (Meslow and Keith 1971, entire). However, because hares have two to four litters per summer, there is opportunity for compensatory survival of later litters if one is affected by weather (Krebs *et al.* 2014, p. 1043). Decreased hare survival may also be expected during prolonged hot, dry summer conditions. For example, hare densities in the GYA are believed to be low, in part, because of the dry conditions there

(Hodges *et al.* 2009). In dry western forests like those in the GYA, increased precipitation may result in more herbaceous forage and cover, which may promote hare survival and reproduction (Ivan *et al.* 2014, p. 590). Thus, climate change may have both positive and negative effects on hares.

Finally, the shorter duration and diminished snow cover in the DPS is causing an increasingly pronounced mismatch in the phenology of hare pelage change that may reduce hare survival (Mills *et al.* 2013, entire; Zimova *et al.* 2013, entire). Diminished snow duration by as much as 8 weeks by the end of the century could have population-level effects on hares at the southern edge of their range. Hares exhibit plasticity in the rate at which they can molt from white to brown in the spring, but not in the initiation date of color change or the fall transition from brown to white (Mills *et al.* 2013, pp. 7362-7363). Hares do not seem to compensate for mismatched pelage by changing their behavior related to concealment, thus predisposing them to predation (Mills *et al.* 2014, entire). There is wide variability in the timing of pelage change by individual hares within populations, and "mismatched" hares experience increased mortality rates (Zimova *et al.* 2016, p. 302). Under high emission scenarios, this could lead to an 11 percent decline in hare survival by mid-century and a 23 percent decline by late century. Diminished survival would lead to steep (high emissions) to moderate (medium-low emissions) declines in hare populations (Zimova *et al.* 2016, p. 304). It is also possible that this phenological mismatch may dampen hare cycles (Zimova *et al.* 2016, p. 305). Snow patterns have been proposed to potentially play a role in dampening cycles (Cornulier *et al.* 2013, pp. 64-65, Sultaire *et al.* 2016a, entire).

The range of the snowshoe hare is contracting northward in the southern part of its range in the contiguous U. S. because of changing snow conditions and reduced survival because of delayed pelage changes (Diefenbach *et al.* 2016, p. 245; Sultaire *et al.* 2016a, entire). In Wisconsin, snowshoe hare range has been contracting northward an average of 8.7 km per decade and will continue to recede northward with climate change (Sultaire *et al.* 2016a, entire). Loss of snow now contributes more than loss of habitat in determining the range of snowshoe hares in the Great Lakes region (Sultaire *et al.* 2016a, entire).

<u>Reduction in Lynx and Hare Habitats</u> - Climate change will diminish the amount of lynx habitat throughout the DPS by a) reducing the areas where snow conditions give lynx a competitive advantage over bobcats and other species, and b) reducing the amount of spruce-fir habitat required by snowshoe hares. An analysis of potential snow cover under a range of IPCC future climate scenarios and modeling of vegetation using a dynamic vegetation model indicates that potential lynx habitat could decrease by as much as two-thirds in the contiguous U.S. by the end of this century (Gonzalez *et al.* 2007, pp. 4, 7–8, 10, 13–14). Areas of contiguous spring snow cover will become smaller and more isolated throughout the Columbia, Upper Missouri, and Upper Colorado Basins, with greatest losses at the southern periphery, which likely is an indicator of the trajectory of lynx habitat (McKelvey *et al.* 2011). Deteriorating snow conditions caused by climate change is causing range contraction of snowshoe hares and the southern edge of their range (Sultaire *et al.* 2016b, pp. 900-904). Similarly, because of diminishing snow

resources, potential lynx habitat is diminishing in the northern Appalachians and small areas in the Canadian Maritime Provinces (Carroll 2007, p. 1093).

Changes in temperature and rainfall patterns are expected to shift the distribution of ecosystems northward and up mountain slopes (McDonald and Brown 1992, pp. 411–412; Danby and Hik 2007, pp. 358–359; IPCC 2007c, pp. 230, 232). As climate changes over a landscape, the ecosystems that support lynx are likely to shift, tracking the change of temperature, but with a time lag depending on the ability of individual plant and animal species to migrate (McDonald and Brown 1992, pp. 413–414; Hall and Fagre 2003, p. 138; Peterson 2003, p. 652). On the basis of the best existing data for 130 tree species in North America and associated climate information, and assuming no limitations to individual tree growth, McKenney *et al.* (2007) predicted that the average range for a given tree species will decrease in size by 12 percent and will shift northward by 700 km during this century. In the contiguous U.S., researchers expect that lynx in mountainous habitat will, to some extent, track climate changes by using higher elevations on mountain slopes, assuming that vegetation communities supportive of lynx and hare habitats also move upslope (Gonzalez *et al.* 2007, p. 7). Some areas of the DPS (e.g., Maine, Minnesota) lack potential elevational refugia and, therefore, lynx populations are anticipated to decline accordingly (Carroll 2007, pp. 1098–1102).

Lynx and hare habitats—boreal spruce-fir and subalpine forests—and, therefore, lynx distribution, are likely to shift upward in elevation within its currently occupied range and recede northward as temperatures increase (Gonzalez *et al.* 2007, pp. 7, 13–14, 19; Beckage *et al.* 2008, entire; Jacobson *et al.* 2009, pp. 26–27, 30–31; Vashon *et al.* 2012, pp. 60, 64; ILBT 2013, p. 69). Lienard *et al.* (2016, p. 7) conclude that spruce-fir forest types in New England, the Northern Great Plains, and higher elevations in the Rockies are vulnerable to drought-related stress from climate change during the next century. The boreal spruce-fir forests that provide habitat for lynx and snowshoe hares are thought to be limited by higher summer temperatures and drought (Iverson and Prasad 2001, pp.192–196) and, under a suite of emissions and climate change scenarios, are projected to diminish dramatically or disappear from much of the eastern U.S. (Iverson and Prasad 2001, p. 196; Iverson *et al.* 2008, pp. 390–400). Within the last 20 to 25 years, widespread mortality and reduced growth in red spruce in the Northeast are believed to be linked to climate stress (McLaughlin *et al.* 1987, p. 501, Johnson *et al.* 1988, p. 5373.). Climate modeling suggests that lynx habitat and populations are anticipated to decline accordingly (Carroll 2007, pp. 1098–1102) and may disappear completely from parts of the range of the DPS by the end of this century (Johnston *et al.* 2012, pp. 6–13). Remaining lynx populations would likely be smaller than at present and, because of small population size and increased isolation, populations would likely be more vulnerable to stochastic environmental and demographic events (Carroll 2007, pp. 1100–1103).

Climate change is disproportionately affecting the boreal forest in Canada, the source of lynx dispersing into the DPS. Arctic and alpine ecosystems are among the most sensitive to climate warming (Diaz and Eischeid 2007, entire). Boreal forests have been identified as a critical "tipping element" of the Earth's climate system and are believed to be more sensitive to drought than other forests (Lenton *et al.* 2008, pp. 1788, 1791). Studies suggest a threshold for boreal forest dieback of ~ 3 °C global warming (Lucht *et al.* 2006, entire, Joos *et al.* 2001, entire). Global temperatures are increasing and snowfall is declining at the fastest rate in higher latitudes within the boreal forest region of Canada and Eurasia (IPCC 2007). Predicted changes to the boreal forest are already occurring, and much of the climate-induced change is occurring faster than originally predicted, suggesting rapid change as opposed to slow linear change (Soja *et al.* 2007, pp. 5-6). General circulation models are in agreement that winter warming across the circumboreal region will be in excess of 40 percent above the global mean (Soja *et al.* 2007, p. 4). Increases in precipitation are expected in the boreal region of Canada, particularly during the winter, but may be offset with increases in summer drought, heat stress and evapotranspiration (Stocks *et al.* 1998, entire). Thus, boreal forests are experiencing increases in tree mortality (Peng *et al.* 2011, entire). Several authors have suggested that grasslands, aspen parklands, and temperate forest will expand northward resulting in decreases in boreal forest (Rizzo and Wiken 1992, p. 50; Starfield and Chapin 1996, entire; Rupp *et al.* 2000, entire), which could further fragment spruce-fir habitat (Iverson *et al.* 2008, p. 404; Tang and Beckage 2010, pp. 152-156; Simons-Legaard *et al.* 2016, p. 5; Rustad *et al.* 2012, p. 15). Climate change is expected to further fragment boreal forest in southern Canada (Hogg 1994, entire) and would reduce habitat connectivity between lynx populations in the contiguous U. S. and southern Canada.

<u>Changes in the Frequency and Pattern of Disturbance Events</u> – The distribution, amount, and composition of lynx habitat could be rapidly and dramatically altered by an increasing occurrence and persistence of drought, along with associated outbreaks of insects and pathogens, wind and ice storms, and wildfires (ILBT 2013, p. 70). All of these factors are potentially interrelated with multiple feedback mechanisms, and some have a cascading effect (Dale *et al.* 2001, p. 729). For example, drought can weaken trees, increasing their vulnerability to insects and pathogens. Insects and pathogens can create dead trees or increase fuel loads, potentially increasing the risk and intensity of fire. The boreal forest is a complex and variable system, and these effects are expected to vary in time and space. Climate change may compound these complex interactions into new domains that may be unprecedented and unpredicted (Dale *et al.* 2001, p. 729). These interactions may appear slowly and be difficult to detect because trees live for so long or they be manifested quickly after a catastrophic perturbation to the forest.

Climate change-induced drought and heat stress have already affected temperate and boreal forest (Allen *et al.* 2010, entire), particularly in the West, where tree mortality rates have increased rapidly in recent decades (van Mantgem *et al.* 2009, entire). Droughts occur irregularly in forests in eastern North America and the Pacific Northwest, annually at the end of the growing season in forests at the midcontinental prairie–forest border, and annually in summer in western interior dry forests that depend on winter precipitation (Dale *et al.* 2001, p. 727). Increase in growing-season temperature could increase evaporative demand, triggering moisture stress. Under several climate scenarios, future increases in drought stress are expected in the Southern Rockies and parts of the Northwest (Dale *et al.* 2001, p. 727). The Great Lakes region and parts of the Northwest could experience drought stress within two decades, even though these regions may become wetter in later decades (Dale *et al.* 2001, p. 727).

The frequency of wildfire is increasing in boreal forests of North America. Extended fire seasons and increases in the total area burned are anticipated in the western U.S. with continued climate warming (McKenzie *et al.* 2004). Evaluating wildfire patterns in the western U.S. from 1970-2004, Westerling *et al.* (2006, entire) found rapid and dramatic increases in the frequency of large fires, wildfire durations, and the length of the wildfire season beginning in the mid-1980s. Mesic, middle- and high-elevation forest types (such as lodgepole pine and spruce-fir) in the northern Rocky Mountains experienced the greatest increases. Increased spring and summer temperatures and an earlier spring snowmelt strongly influenced large wildfires, suggesting that climate is the primary driver of these changes rather than fire exclusion (suppression), which appears to have had little impact on natural fire regimes of these higher-elevation forest types in this area (ILBT 2013, p. 70). In contrast, climate change is increasing precipitation in boreal forest regions of eastern North America, which has reduced wildfire frequency (Bergeron *et al.* 2001, p. 388). Under multiple climate scenarios, large increases in fire frequency are expected for boreal forest in central and western Canada, and reduced frequency in eastern Canada - a situation that reflects past Paleoclimates that were warmer than the present (Flannigan *et al.* 2001, pp. 860-862). Increased fire frequency at the grassland – aspen parkland – boreal forest transition in western Canada may hasten the conversion of boreal forest to aspen parkland and aspen parkland to grassland (Flannigan *et al.* 2001, p. 860-861), which could affect connectivity and gene flow in lynx populations.

Warmer springs could increase the frequency and duration of wildfires, which in turn could increase vulnerability of surviving trees to bark beetle attack (Westerling *et al.* 2006; ILBT 2013, p. 70). Increasing temperatures and forest homogeneity could create conditions favorable for bark beetle outbreaks that exceed natural disturbance thresholds, perhaps increasing the likelihood of additional outbreaks in the resulting large areas of even-aged forests (Raffa *et al.* 2008; ILBT 2013, p. 70).

Climate change is dramatically affecting the frequency and intensity of some eruptive boreal forest insect pests and pathogens that affect disturbance patterns in spruce-fir forests. Changes in temperature and precipitation affect herbivore and pathogen survival, reproduction, dispersal, and distribution. For example, native bark beetles, such as the spruce beetle (*Dendroctonus rufipennis*) and mountain pine beetle (*Dendroctonus ponderosae*), are key agents of change in coniferous forest ecosystems in western North America and have recently defoliated millions of hectares – among the largest and most severe in recorded history (Bentz *et al.* 2009). Drought-stressed conifers have increased vulnerability to insect attack. By the end of the century, changes in temperatures across the boreal forests of western North America may cause markedly high probability of outbreak of these species (Bentz *et al.* 2010. pp. 607, 609). In contrast, the range of the spruce budworm, a major pest of spruce-fir ecosystems in eastern North America, is expected to shift northward reducing vulnerability of spruce-fir forests in Maine and Minnesota (Regniere *et al.* 2010, entire). Widespread clearcutting following the most recent spruce budworm outbreak in Maine was the primary driver creating the current broad distribution of high-quality lynx habitat (Hoving *et al.* 2005; Vashon *et al.* 2012).

Introduced species can affect forests through herbivory, predation, habitat change, competition, alteration of gene pools via hybridization with natives, and disease (as either pathogens or vectors) and can alter the diversity, nutrient cycles, forest succession, and fire frequency and intensity of some ecosystems (Dale *et al.* 2001, p. 727). Climate change will modify the distributions of many introduced species. Currently, there are few exotic species in North American boreal forests. This is likely because remote areas with little human intervention receive fewer exotic species. However, exotic species could be introduced in the future as boreal systems are increasingly exploited for forest products, mining, energy production, and other natural resources (Schinder and Lee 2010, entire).

Ice storms occur throughout the northern U.S.but are most frequent in the Northeast (Dale *et al.* 2001, p. 728). For example, in January, 1998 a severe ice storm extensively damaged the canopy of many northeastern U.S. and eastern Canadian forests, causing moderate to severe forest damage to over 10 million acres in the Northeast U.S. and southern Quebec (Jones and Mulhern 1998, p. 19; Irland 2000, entire; Millward and Kraft 2004, entire). Ice storm damage to stands can range from light and patchy to total breakage of all mature stems over extensive areas (Irland 2000, entire). It is uncertain how climate change will affect the frequency, intensity, location, and extent of ice storms; however, atmospheric warming will most likely shift the locations of prevailing ice storms northward.

<u>Introduction of Lynx or Hare Disease and Parasites</u> - Climate change can increase pathogen development and survival rates, disease transmission, and host susceptibility, and some species are predicted to experience more frequent or severe disease impacts with warming while others may be relieved of pathogens (Harvell *et al.* 2002, entire, Harvell *et al.* 2009, entire). Climate change is likely to cause major changes to the geographic range and incidence of insect and tick-borne diseases (Daszak *et al.* 2000).

No apparent climate-influenced parasites or diseases have been identified that would affect Canada lynx or snowshoe hares, but lynx experts believed this is difficult to predict and remains a possibility (Lynx SSA Team 2016, pp. 27, 37-39). A few pathogens have been documented in lynx in the DPS. For example, plague, a flea-borne disease caused by the bacterium *Yersinia pestis*, which is not native to North America, was reported for the first time in lynx in Colorado (Wild *et al.* 2006). Pneumonic plague appeared to be the direct or indirect cause of death of 6 lynx released in Colorado between 2000 and 2003. When translocated from Canada and Alaska, none of the lynx had antibody titers to *Y. pestis*; it appears likely that lynx were exposed to plague by infected prey after their release in Colorado. Exposure of some lynx to feline parvovirus was detected in six areas in western North America (Montana-Alaska; Biek *et al.* 2002). *Troglostongylus wilsoni* is a nematode that infects the lungs of lynx and bobcats (Sarmiento 1956; Van Zyll de Jong 1966; Kumar 1974; and Reichard 2004) and was detected in Maine lynx (Vashon *et al.* 2012, p. 24). Lynx with heavy infestations have difficulty breathing and succumb to starvation, as occurred with several Maine lynx (Vashon *et al.* 2012, p. 24).

Reduction in Gene Flow - Koen *et al.* (2014a, entire) hypothesized that climate change would create increasingly unsuitable environmental conditions for lynx (e.g., milder winters with reduced snow quality, declining and fragmented boreal forest), which was associated with low genetic diversity and high genetic differentiation at the trailing (southern) edge of the range. Furthermore, high winter temperature, low snow depth, and low proportion of suitable habitat were strongly correlated with neutral genetic diversity, low allelic richness, and high genetic differentiation (Koen *et al.* 2014a, p. 757). The authors surmised that genetic structuring in southern lynx populations could be caused by a northward shift in optimal conditions, resulting in isolation and extirpation of lynx populations at the trailing edge of their range or climate-induced changes in the distributions of snowshoe hare or bobcats causing lynx to shift northward. Lynx with the greatest allelic richness were found in areas with the deepest snow in the core of their range in northern Ontario (Koen *et al.* 2014a, p. 758). The authors concluded that climate warming has reduced gene flow at the receding (southern) edge of the lynx's range, and that southward gene flow from Canada into threatened U.S. populations is unlikely (Koen *et al.* 2014a, p. 760). Stenseth *et al.* (2004, entire) documented population and genetic structuring in the lynx populations east and west of Hudson Bay based on differences in snow conditions on either side of this divide. This may be explained by the reluctance of lynx to disperse between areas having different snow regimes and snow quality. Snow conditions may be the key factor in the spatial, ecological, and genetic structuring of Canada lynx (Stenseth *et al.* 2014, pp. 10633-10644).

Climate warming may further isolate lynx populations, thus reducing gene flow, by reducing connectivity between populations. For example, gene flow between eastern Canada and Maine lynx populations depends on an ice bridge for dispersal across the St. Lawrence River. Although some lynx currently cross the river, Koen *et al.* (2014a, entire) found genetic structuring on either side of the river. Thus, the river already restricts gene flow. Climate-induced deteriorating ice conditions on the St. Lawrence River could further restrict gene flow between lynx populations north and south of the river (Koen *et al.* 2015, p. 528). Between 1969 and 2002 there was a 20 to 40 percent reduction in sea-ice cover during the spring thaw in the Gulf of the St. Lawrence (Johnston *et al.* 2005). Conversely, reduced ice on the St. Lawrence may prevent bobcats from dispersing northward into lynx areas in central Quebec (Koen *et al.* 2015, p. 528).

3.3 Vegetation Management

Forest management occurs across the range of the lynx and can directly affect important habitats and prey. At the time of listing, management activities uninformed by consideration of negative impacts to the species were identified as being of greatest potential concern to lynx conservation (68 FR 40076-40101). Forest management is the most prevalent land use throughout the lynx DPS and can have beneficial, neutral, or adverse effects on lynx and snowshoe hare habitat and populations (65 FR 16071; 68 FR 40083; ILBT 2013, p. 71). Forest management affects stand structure, composition, and arrangement on the landscape, which are important elements of habitat for snowshoe hares and lynx. At the home range scale, lynx throughout the DPS select landscapes having the greatest snowshoe hare densities. In Maine and Minnesota these are young, regenerating spruce-fir forests (Hoving *et al.* 2004; McCann and Moen 2011) and in the West regenerating lodgepole pine (Koehler, Maletzke, Berg *et al.* 2012) and dense mature conifer forest, as well as young stands with dense spruce-fir saplings (Griffin 2004, Squires *et al.* 2010, pp. 1648, 1653–1656; Berg *et al.* 2012). Silvicultural prescriptions and cutting practices in boreal forest types vary widely throughout the lynx DPS depending on the landowner, forest ecology and ecoregion, tree species, site conditions (e.g. moisture, slope, aspect), disturbance regimes (e.g., fire, insect outbreaks), forest policy and regulations, logging equipment, and markets for forest products. Forest management that creates habitat for hares and lynx in one geographic area may not be beneficial to hares and lynx in another.

Nevertheless, snowshoe hares throughout the DPS range respond to one common denominator. Dense understory (horizontal cover) is the most important forest structural characteristics for hares throughout their range (Ferron and Ouellet 1992; Wolfe *et al.* 1982; Litvaitis *et al.* 1985). Dense, horizontal cover provides hares with a source of browse and cover from predation. Softwood (e.g., spruce-fir) has about three times more cover value than hardwoods (Litvaitis *et al.* 1985). Thus, stem density (or stem cover units) and snowshoe hare density are directly and positively correlated (Conroy *et al.* 1979; Sullivan and Sullivan 1988; Koehler 1990b; Koehler and Brittell 1990; Thomas *et al.* 1997; Hodges 2000a; Mowat *et al.* 2000; Homyack *et al.* 2006; Robinson 2006; Scott 2009; Fuller and Harrison 2013). Forest practices that promote high stem density and dense horizontal cover can increase snowshoe hare densities (Keith and Surrendi 1971; Fox 1978; Conroy *et al.* 1979; Wolff 1980; Parker *et al.* 1983; Livaitis *et al.* 1985; Bailey *et al.* 1986; Monthey 1986; Koehler 1990a, b; Robinson 2006; Fuller *et al.* 2007; Homyack *et al.* 2007; Scott 2009; McCann and Moen 2011). Forest practices that reduce dense understory generally reduce habitat quality for hares and lynx.

Effects of forest practices on snowshoe hare habitats have been studied across the range of the species (Conroy *et al.* 1979; Sullivan and Sullivan 1988; Koehler 1990b; Thomas *et al.* 1997; Homyack *et al.* 2005; Robinson 2006; Griffin and Mills 2007; Scott 2009; Berg 2010; Ivan 2011a; Lewis *et al.* 2011; McCann and Moen 2011). Similarly, the effects of forest management on lynx habitat use, movements, and home range have been investigated by Koehler (1990a), Koehler and Brittell (1990), Fuller *et al.* (2007), Homyack *et al.* (2007), Moen *et al.* (2008), Vashon *et al.* (2008b), Simons (2009), Squires *et al.* (2010), Simons-Legaard *et al.* (2013), Simons-Legaard *et al.* (2016).

Historically, the dominant natural disturbance processes that created young, regenerating conifer forest conducive to hares and lynx were wind events, fire, and insect and disease outbreaks (Kilgore and Heinselman 1990; Heinselman 1996; Veblen *et al.* 1998; Agee 2000; Seymour *et al.* 2002; Lorimer and White 2003). In forests of northern Maine, wind, fire, insects, and diseases were predominant natural disturbance agents, while fire, insects, and diseases were predominant in the Great Lakes Geographic Unit and across the western U.S. After disturbances, forests generally develop through several stages described by Oliver (1980) as “stand initiation,” “stem exclusion,” “understory reinitiation,” and “old growth.” Stand dynamics, particularly within-stand competition for light, nutrients, and space, determine how forests grow and respond to intentional manipulations and natural disturbances (Oliver and Larson 1996). The frequency and severity of disturbances have a large role in determining which species will dominate in a stand after the disturbance event. Snowshoe hare and lynx habitat are created during the stand initiation stage, after the young trees have established and grown tall enough (1-3 meters [m]) to protrude above the snow and provide adequate horizontal cover. During the stem exclusion stage (~10 m depending on tree species) the tree crowns lift and lower branches self-prune, thus reducing the live horizontal branches providing food and cover for snowshoe hares. In the old growth stage, understory may re-develop (e.g., in forest gaps where mature trees die or fall down) and food and cover may again become available to support snowshoe hares.

Commercial timber management of conifer forests traditionally has been designed to: in very young, regenerating forest to select for desired species (e.g., herbiciding, plantations) and reduce tree density to promote tree growth (e.g., precommercial thinning); in young middle-aged forest to improve growth and vigor of mature trees (e.g., commercial thinning, pruning, thinning from below); and in mature forest to reduce the vulnerability of commercially valuable trees to insects, disease, and fire (e.g., commercial thinning, group selection, fuels reduction). The culmination of the process (or a forest rotation) is harvesting of forest products. Just as the timing and intensity of a natural disturbance affects the composition of the succeeding forest, the season, climate, machinery, and type of final harvest (e.g., clearcut v. partial harvest) have a large role in determining the species composition and health of the next crop of trees. Timber management practices may mimic natural disturbance processes but often are not an exact ecological substitute. Some practices, such as use of herbicides to suppress hardwood regeneration or plantations do not have an historical analogue. Timber harvest may differ from natural disturbances by:

- Removing most standing biomass from the site, especially larger size classes of trees, and down logs, which alters microsite conditions and nutrient cycling;
- Creating smaller, more dispersed patches and concentrating harvest at lower elevations in mountainous regions and on more nutrient rich soils, resulting in habitat fragmentation;
- Causing soil disturbance and compaction by heavy equipment, which may result in increased water runoff and slower tree growth at the site; or
- Giving a competitive advantage to commercially-valuable tree species and reducing the structural complexity of the forest through the application of harvest, planting, thinning, and herbicide treatments.
- Forest practices often have a smaller footprint on the landscape than widespread fire, insect, or wind damage.

Forest management may (or may not) be compatible with creating or maintaining habitats capable of supporting hares and lynx. Where the objective is to provide snowshoe hare habitat by creating additional early-successional forest conditions, management considerations include selecting areas that are capable of, but not currently providing, dense horizontal cover, designing the appropriate size and shape of treatment units, retaining coarse woody debris, and maintaining high stem densities in regenerated forests (Koehler and Brittell 1990; Homyack *et al.* 2004; Bull *et al.* 2005; Fuller and Harrison 2005; Ivan 2011a).

North America is the world's leading producer and consumer of wood products. Therefore, worldwide trends in forest products markets greatly affect forest management outcomes and thus, the amount and quality of lynx habitat in the DPS. Forest management decisions (e.g., to focus on hardwood or softwood production) can change dramatically in response to unpredictable and changing forest products markets. Globalization of manufacturing and expanded use of electronic media have reduced demand in pulp and paper since the late 1990s, and the collapse of housing construction since 2006 have contributed to declines in U. S. wood product output. Within the northern region of the U. S. (Maine to North Dakota) there has been a considerable decline in terms of employment, mill numbers, wood consumption and forest harvests since 2000 (Woodall *et al.* 2011). As a large amount of this region's forest industry is print paper manufacturing and composite panel production, the rise of electronic media and decline of home construction has precipitated a decade of decline, which only deepened since the recession of 2007-2009. The West, prior to the recession, was a major softwood lumber producing region, and was particularly hard hit by the recession and housing collapse. Employment dropped by 30 percent or nearly 80,000 workers and annual value of output fell by more than 25 percent (Keegan *et al.* 2011). Under depressed markets, landowners may reduce harvests, which may be to the detriment of lynx in some parts of the DPS (e.g., Maine and Minnesota), and to the benefit of lynx in others (the West).

Markets for softwood products are particularly volatile and depend on demand for paper and housing. Thus, softwood management is affected by economic factors that are difficult to predict. In recent years, the forest products industry throughout the U. S. experienced a downturn in output levels not seen in decades, and employment losses in the hundreds of thousands (Woodall *et al.* 2011, p. 595). Despite depressed markets, one area of increasing interest is bioenergy production. Rising energy costs and growing concerns over global climate change have increased interest in bioenergy production, and the U. S. Energy Independence and Security Act (2007) mandates a five-fold increase in biofuel production (Benjamin *et al.* 2009, p. 125). The wood pellet sector is expected to grow, although woody biomass is typically the lowest value wood commodity sold from the forest. Thus, it is questionable whether wood energy revenues would be enough to sustain forest investments and forest management into the future (Woodall *et al.* 2011, p. 601).

Whereas management of State and Federal forest lands have been relatively stable in recent decades, management and ownership of private forest land ownership has been extremely unstable. This has resulted in major shifts in forest management strategies, outcomes, and products. For example, in the last two decades in Maine, where nearly all the lynx critical habitat is on private land, about 23.8 million acres (80 percent) of industrial land ownerships in the "northern forest" (Adirondacks to northern Maine) were sold to many different kinds of financial groups (Hagan *et al.* 2005). These groups have short-term investment goals and different management objectives and have dramatically changed harvest practices. Whereas the previous large industrial landowners focused on the forest land base as a supply for their manufacturing facilities, the new Timber Investment Management Organizations (TIMOs) and Real Estate Investment Trusts (REITs) focus on maximizing return on their investment (Jin and Sader 2006, p. 178). Initially, the effects of ownership changes were uncertain (McWilliams *et al.* 2005), but an evaluation of harvesting in the last decade indicates these landowners increased harvest rates, shortened rotation rates, and shifted to managing and harvesting hardwood tree species (Jin and Sader 2006, p. 183-185). On one hand, these trends in Maine private lands management make lynx management commitments more difficult because short-term landowners are not interested in long-term commitments. On the other hand, some easement owners may have an incentive to manage for lynx to meet forest certification requirements.

The extensive sale of private forestlands initiated the growth of conservation easements in this region (deGooyer and Capen 2004; Lilieholm *et al.* 2010). Conservation land as a percentage of Maine's State area increased from less than 5 percent in 1987 to approximately 19 percent by 2012 (Beck *et al.* 2012, p. 15). Conservation easements restrict development but usually do not affect forest management; neither do they typically require management for lynx and other rare species. Some private forestlands were sold to State and Federal agencies and conservation interests. For example, in recent years The Nature Conservancy purchased 310,000 acres of private forestland in Montana and 185,000 acres of private forestland in northern Maine. Lands in conservation ownership have a high probability of being managed to benefit hares and lynx.

Finally, future trends in forest management will be affected by climate change (Irland *et al.* 2003, entire). Many models have been developed to project how U.S. timber production and markets may adapt to climate change (e.g. Burton *et al.* 1998, Joyce *et al.* 1995, Perez-Garcia *et al.* 1997, Sohngen and Mendelsohn 1998). Economic models predict that under climate change, total U.S. timber inventories will increase, timber harvest will increase, and product prices will decrease relative to an assumed stable climate. Some models predict that consumers will gain from climate change while landowners in some regions will lose. The forest industry will adapt to climate change in many ways including using alternate tree species in manufacturing, shifts to geographic regions of the country with economic advantages in timber growth, and increasing forest plantations with new species that are favorably adapted to the new climate and markets. Many strategies have been evaluated to increase the quantity of carbon stored in North American forests (Irland *et al.* 2003) including discontinuing or greatly reducing harvest in some forests to build carbon reserves, increased recycling to reduce use of forest products, converting agricultural lands to forests, and substituting wood products for more energy-intensive products. Increased atmospheric carbon will increase forest growth slightly, except for softwood (Irland *et al.* 2001, p. 757-758). Sawtimber production, which sequesters more carbon, is expected to increase (Irland *et al.* 2001, p. 758). Expanding landscapes with older growth conifer forest to sequester carbon could benefit lynx in the West and be to the detriment of lynx in the East.

Climate change will affect forest-related recreation. Warmer lowland temperatures will attract more people to relatively cooler mountainous and northern forests (Irland *et al.* 2001, p. 759). The ski industry is currently in decline, and climate-induced changes in snowfall will further stress this industry, except for higher elevation western resorts where snowfall is more dependable and where artificial snow is less expensive to make (Irland *et al.* 2001). These climate-induced trends in recreation are anticipated to bring more people into the lynx DPS, which could bring additional social pressures concerning decisions related to forest management (e.g. clearcutting; Swanson and Loomis 1996). At this time, there are many uncertainties concerning the socioeconomic implications of climate change and adaptation in the northern forests supporting the lynx DPS.

Past and future forest management affects many of the requirements necessary for the continued existence of lynx in the DPS. Forest management is expected to be the predominant land use throughout the DPS into the foreseeable future, and major climate-induced changes in forest industry are anticipated (Irland *et al.* 2001, entire). Beneficial effects of forest management include 1) creating lynx habitat, 2) maintaining an undeveloped landscape conducive to lynx, and 3) long term management planning for lynx (especially on Federal lands). Adverse effects to lynx, hares, and their habitat that are occurring or can be reasonably be anticipated include 1) reduced quality of hare habitat in some parts of the DPS, 2) loss and fragmentation of lynx and hare habitat in the U. S., and 3) changes in the frequency and pattern of disturbance events. Synergetic effects between forest management and other stressors (e.g., climate change, trapping, development) may intensify their effects (Carroll 2007). Habitat loss and fragmentation are believed to currently be important stressors for lynx in the DPS, but it is possible that other pathways for forest management are, or may become, equally important. Hares and lynx will continue to be affected (both positively and negatively) by forest management into the foreseeable future. Forest management stressors primarily affect lynx by lowering landscape hare densities, which in turn reduces lynx reproduction and survival.

<u>Reduced Quality of Hare Habitat</u> - Throughout the lynx DPS, some vegetation management practices, especially thinning in young, dense regeneration, reducing overstory canopy in mature multi-story spruce-fir forests (in the West), and partial harvesting (in northern Maine) reduce the quality of boreal forest habitats for snowshoe hares and lynx. This could cause lynx to increase their home ranges, reduce productivity, or in extreme cases to abandon their home range or cause mortality.

Thinning of young, dense sapling stage conifers (precommercial thinning) is a forest management practice used widely throughout the DPS to increase the growth and value of selected trees and to reduce the time to maturity of a stand of trees. Precommercial thinning removes competing trees of the same species or shrubs and trees of other species (Daniel *et al.* 1979; Homyack *et al.* 2005, 2007). Reducing the density of sapling-sized conifers in young regenerating forests to increase the growth of certain selected trees promotes more homogeneous patches and reduces the amount and density of horizontal cover, which is needed to sustain snowshoe hares (Sullivan and Sullivan 1988, Hodges 2000b, Griffin and Mills 2004, Ausband and Baty 2005, Griffin and Mills 2007, Homyack *et al.* 2007, Ellsworth 2009). Hares reach highest densities in stands with stem densities ranging from 4,600–33,210 stems/ha (1,862–13,445 stems/ac)(Wolff 1980, Parker 1984, Litvaitis *et al.* 1985, Monthey 1986, Parker 1986, Koehler 1990a, Griffin 2004, Fuller and Harrison 2005, Robinson 2006, Scott

2009), whereas thinned stands have densities of 2990 (6-foot spacing) to 1,682 (8-foot spacing) stems/ha (Pitt and Lanteigne 2008, p. 593). Precommercial thinning has been shown to reduce hare numbers by as much as 2- and 3-fold (Griffin and Mills 2004, 2007; Homyack *et al.* 2007) because of reduced cover and decreased availability of browse. Griffin and Mills (2007) reported that, if their results were representative, the practice of precommercial thinning could significantly reduce snowshoe hares across the range of lynx.

There are anecdotal examples of precommercially thinned stands that subsequently "filled in" with understory trees. Some have suggested this could be a technique to extend the time that understory trees and low limbs provide the dense horizontal cover that constitutes snowshoe hare habitat. The duration between time of thinning and regrowth to a height providing winter snowshoe hare habitat would likely vary by tree species, each having different regenerative capacities that could be influenced by a variety of local factors (e.g., topographic relief, moisture, and mineral and organic content of the soil; Baumgartner *et al.* 1984, Koch 1996). Bull *et al.* (2005) reported that the slash and coarse woody debris remaining after precommercial thinning provided both forage and cover for snowshoe hares up to a year following treatment. However, Homyack *et al.* (2007) found that snowshoe hare densities were reduced following precommercial thinning for 1–11 years post-thinning. They further suggested that after precommercial thinning, the stands did not regain the structural complexity in the understory that would be needed to support pre-treatment snowshoe hare densities. At this time, no other data are available to quantify the re-establishment of snowshoe hare habitat and over what time period, or the response by snowshoe hares, as compared with sites that were not precommercially thinned, so this remains an unproven management technique. As an alternative to standard precommercial thinning (i.e., complete thinning resulting in a homogeneous patch), Griffin and Mills (2007) suggested retaining at least 20 percent of the patch in untreated clumps of about ¼ ha (½ ac), which would maintain hare habitat in the short term. However, Lewis *et al.* (2011) found that landscapes with patches of high-quality habitat surrounded by similar vegetation supported more hares than did more fragmented landscapes composed of high-quality patches in a matrix of poorer-quality habitat. Further long-term studies of modified thinning methods are needed.

Because of documented adverse effects of precommercial thinning to snowshoe hares and lynx, in 2007 and 2008 the USFS amended Forest Plans to incorporate management that would conserve lynx, including direction that prohibited precommercial thinning in most lynx foraging habitat (USFS 2007, pp. 8, 11-14, 36; USFS 2008, pp. 6-9, 23-26). However, precommercial thinning is not regulated on private forest lands throughout the remainder of the DPS.

Uneven-aged management (single tree, partial harvest, and small group selection) practices can be employed in stands where there is a poorly developed understory, but have the potential to produce dense horizontal cover for snowshoe hares. Removal of select large trees can create openings in the canopy that mimic gap dynamics and help to maintain and encourage multistory attributes within the stand. However, if removal of large trees opens the canopy to the extent that the patch functions as an opening, this may discourage use by lynx (Koehler 1990a, von Kienast 2003, Maletzke 2004, Squires *et al.* 2010). Removal of larger trees from mature multi-story forest stands to reduce competition and increase tree growth or resistance to forest insects may reduce the horizontal cover (e.g., boughs on snow), thus degrading the quality of winter habitat for lynx (Robinson 2006, Koehler *et al.* 2008, Squires *et al.* 2010). Similarly, removing understory trees from mature multi-story forest stands reduces the dense horizontal cover selected by snowshoe hares, and thus reduces winter habitat.

Partial harvesting broadly describes many methods of removing a portion of the overstory trees from a forest stand. Partial harvesting includes selective cuts, shelterwood cuts, and uneven-aged management. Partial harvest may be "light" (e.g., <10 percent of trees removed) to "heavy" (e.g., 90 percent of trees removed). Since passage of the Maine Forest Practices Act in 1989, various forms of partial harvesting have replaced clearcutting as the predominant form of forest management in northern Maine (Sader *et al.* 2003, entire). In recent years, about 425,000 acres of Maine forest are harvested annually and 96 percent of this land is partially harvested (Maine Forest Service 2016). After 17 years of extensive partial harvests, much of the northern Maine landscape has been influenced by this form of forestry, and will continue to be into the future. The popularity of this form of harvesting extends beyond Maine. From the mid-1980s to mid-1990s, partial harvesting comprised 62 percent of the harvest in the U. S., and clearcuts comprised the other 38 percent. Partially harvested stands result in a wide range of residual stand conditions, but many have lower conifer stem densities and higher hardwood density than regenerating clearcuts (Robinson 2006). On average, partially harvested stands supported about 50 percent of the hare densities observed in regenerating clearcuts (Robinson 2006). Shelterwood cuts, a form of even-aged management, are the exception and have maintained densities similar to regenerating clearcut stands (D. Harrison, U. Maine, unpubl. data). Current hare densities in partially harvested stands in Maine average about 0.4 hares/ha (Simons 2009), which is below the landscape hare densities (0.5 hares/ha (Ruggiero *et al.* 2000b, Simons-Legaard *et al.* 2013) needed to support lynx.

In the Great Lakes Geographic Unit, prescribed burning is used in lynx habitat primarily as a tool to reduce fuels (including from blow-down) and mimic a more natural fire regime in pine forest types. In these instances there is a short-term (10–30 years) impact on snowshoe hare habitat. In the western U.S., prescribed fire for ecosystem restoration is most applicable to the dry ponderosa pine and Douglas-fir forests that are not lynx habitat. Because spruce-fir forests are generally composed of thinner-barked trees that are easily killed even with light fire, this technique is not used frequently in most lynx habitat.

Biomass removal for energy production targets the removal of dead trees, logging slash, and small-diameter trees and shrubs. Biomass removal is similar to fuels treatments in reducing cover and habitat for snowshoe hares.

Fuels treatments commonly are designed to remove understory biomass and reduce stem density in forests that are outside their historical range of variability, and to clear fuels adjacent to human developments for safety or to protect investments. These types of projects are becoming more common. In the western U.S., projects designed to restore forests to a condition more representative of the historical range of variability are generally targeted to drier, lower-elevation forests affected by fire suppression (Hessburg *et al.* 2005), which are not lynx habitat. Lynx habitats in higher-elevation spruce-fir forests have been less affected by past fire suppression and are mostly within the historical range of variability (Agee 2000). Fuels treatments may be needed to protect human communities and capital improvements by reducing the intensity and rate of spread of a fire, affording control actions with a higher probability of success and providing safer conditions for firefighters. By removing or reducing the understory and ladder fuels to meet those objectives, dense horizontal cover important to snowshoe hares is reduced and habitat value is diminished for hares and lynx.

<u>Loss, Degradation and Fragmentation of Boreal Forest Habitat</u> - Forest management rarely results in conversion of lands to non-forest. In fact, forested landscapes have increased in some parts of the DPS (especially in the Northeast) because of farm abandonment and recolonization by second-growth forest. However, some forms of forest management such as selective harvesting and fire suppression can intentionally (or not) alter tree species composition away from boreal forest types that support snowshoe hare and lynx. Similarly, lack of forest management can alter tree species composition (Trani *et al.* 2001, pp. 415-417). Other stressors, such as insects and climate change, can work in synergy with forest management to reduce boreal forest. For example, in northern New England clearcutting sometimes leads to drying of the forest floor and consequent heavy mortality in spruce and fir regeneration and increased light levels that increase hardwood competition (White and Cogbill *in* Eagar and Adams 2012, p. 32).

Plantations can convert native forest communities into monocultures of a native or exotic tree species that may lack hardwood browse for snowshoe hare. Cutting rotation can be reduced by half through mechanical site preparation, planting, and suppression of hardwood competition. Conifer stem densities in plantations range from 800-5,000 stems/ha and may support relatively low populations of snowshoe hares because of the initial wide spacing of trees (Bellefeuille *et al.* 2001, p. 44). Hare densities may increase after trees in a plantation reach the sapling stage and branches intermingle at the ground level creating horizontal cover if the lateral branches are not pruned (Parker 1984, p. 163; Parker 1986 p. 160; Roy *et al.* 2010, p. 285). However, the period of time that spruce plantations may support high hare densities in Maine and eastern Canada may be relatively short (10 to 17 years post-harvest) compared to regenerating softwood clearcuts (15-35 years post-harvest; Simons-Legaard *et al.* 2013, p. 569).

Under certain forest stand conditions, herbicide treatment may have long-term effects on stand composition and structure (MacLean and Morgan 1983, Daggett 2003), thus potentially reducing food, cover, and habitat for hares (Borrecco 1976, Bellefeuille *et al.* 2001, p. 43, Thompson *et al.* 2003 p. 462). Understory deciduous stems were lacking in stands treated with herbicide (Homyack *et al.* 2004). Although herbicide treatments reportedly do not directly affect survival, fecundity, or other demographic parameters of snowshoe hares (Sullivan 1996), treatments have indirect effects on hares via changes in vegetative cover and browse (Homyack *et al.* 2005, p. 10). In Norway, hares use of plantations was reduced up to 10 years after herbicide application (Hjeljord *et al.* 1988).

Fragmentation - Lynx achieve highest densities in >100 km^2 landscapes having a high percentage of large, contiguous patches of high quality hare habitat (Simons 2009, Simons-Legaard *et al.* 2013). In Maine and northern Washington, landscapes where boreal forest habitat was more contiguous supported more snowshoe hares than landscapes that were more fragmented (Simons 2009, Lewis *et al.* 2011). Within their home ranges, lynx strongly select for habitat patches that enhance their foraging opportunities (Moen *et al.* 2008, Vashon *et al.* 2008a, Fuller and Harrison 2010, Squires *et al.* 2010). Analysis of winter movements of lynx in Maine indicated that lynx responded to habitat heterogeneity at a coarse scale within their home ranges, by maximizing their access to snowshoe hare prey (Fuller and Harrison 2010). In Montana, lynx selected homogeneous spruce-fir patches that supported snowshoe hares and avoided recent clearcuts or other open patches (Squires *et al.* 2010). Similarly, in Washington, Lewis *et al.* (2011) reported that landscapes in which hare habitat was more contiguous, or surrounded by a mosaic of similar habitat quality, supported more hares than did more fragmented landscapes.

Forest management can fragment and isolate patches of high quality hare habitat (Simons-Legaard *et al.* 2016). In an intensively managed landscape, lynx habitat is described as a shifting mosaic of patches of habitat suitable to support the needs of resident lynx. Fragmentation of the naturally patchy pattern of lynx habitat in the contiguous U.S. can affect lynx by reducing their prey base and increasing the energetic costs of using habitat within their home ranges. Buskirk *et al.* (2000a) identified direct effects of fragmentation on lynx to include creation of openings that potentially increase access by competing carnivores, increasing the edge between early-successional habitat and other habitats, and changes in the structural complexities and amounts of seral forests within the landscape. At some point, landscape-scale fragmentation from forest management can make patches of foraging habitat too small and too distant from each other to be effectively accessed by lynx as part of their home range. For example, in Maine the proliferation of partial harvesting will actually increase the patches of high quality hare habitat by 57 percent, but the average size of patches will be diminished by 87 percent, and patches will become more isolated (Simons-Legaard *et al.* 2016, pp. 5-6).

Changes in Frequency and Pattern of Disturbance Events - Prior to European settlement, the dominant natural disturbance processes that created early-successional stages within the range of the lynx were wind events, fire, and insect and disease outbreaks (Kilgore and Heinselman 1990, Heinselman 1996, Veblen *et al.* 1998, Agee 2000, Seymour *et al.* 2002, Lorimer and White 2003). In forests of the Northern Maine Unit, wind, fire, insects, and diseases were predominant natural disturbance agents, while fire, insects, and diseases were predominant in the Great Lakes Geographic Unit and across the western U.S.

Today, forest management is the predominant form of disturbance in boreal forest types throughout the DPS, but in the West insect outbreak or wildfire are also critical agents of disturbance that influence and interact with forest management. Throughout the DPS, the frequency of harvesting accelerates in response to salvaging insect damaged stands. In some instances, forest management has greatly altered the disturbance regime. For example, prior to logging, the Acadian forest in Maine and eastern Canada likely exhibited forest gap dynamics similar to some parts of the West today, and true stand-replacing disturbances were quite uncommon with recurrence intervals of thousands of years. After several centuries of forest management, stand age structures in the Acadian forest have become simplified, and commercial timber rotations are a fraction (15 to 40 percent) of the lifespan of boreal tree species (Seymour 2002). Although the prevalence of these younger even-aged forest stands on the landscape may benefit hares and lynx in Maine, forestry has shifted the species composition of Maine's forest to tree species favored by frequent harvest disturbance, such as red-maple, paper birch, aspen, and balsam fir.

3.4 Wildland Fire Management

Wildfire is a natural and essential component of boreal and montane forests that plays an important role, along with forest insects and other disturbance factors, in creating and maintaining the shifting mosaic of stand ages and forest structure across large boreal landscapes that provide snowshoe hare and lynx habitats (Agee 2000, p. 47; Ruediger *et al.* 2000, pp. 1-3, 2-5, 7-6; ILBT 2013, p. 75). Wildfire creates and maintains lynx habitats by providing periodic vegetation disturbances that result in the spatial and temporal distribution of early-successional forest stands or patches within older stands featuring dense horizontal cover at ground and snow level. These stands/patches provide high-quality hare foraging habitat and typically support high hare densities, which in turn provide high-quality lynx foraging habitat. They are generated by (1) high-intensity, stand-replacing fires that result initially in removal of all or most vegetation, followed by regeneration of dense horizontal cover, or (2) low- or moderate-intensity fires that stimulate understory development in older stands without killing all the overstory, resulting in patches of dense horizontal cover within multi-storied stands (Agee 2000, p. 53; Ruediger *et al.* 2000, p. 7-6). These habitats become most favorable for hares and lynx when regenerating conifers grow tall enough to protrude above the snow, providing cover and food for hares throughout the winter (ILBT 2013, pp. 10-12). They remain important as winter foraging habitat, which may be the most limiting habitat for lynx (Squires *et al.* 2010, p. 1656; ILBT 2013, pp. 17, 27), until they reach the stem-exclusion structural stage and self-pruning results in the loss of dense horizontal cover above the snow, or until another disturbance resets them to the stand-initiation structural stage (Agee 2000, pp. 62-71; Ruediger *et al.* 2000, p. 1-3; ILBT 2013, p. 27). The length of time to achieve favorable hare and lynx habitat after fire (or other vegetation disturbance) and the duration for which those conditions persist vary across the lynx range depending on soil and vegetation potential, temperature and precipitation patterns, topography, fire intensity, and perhaps other local conditions (Agee 2000, pp. 62-71; Ruediger *et al.* 2000, p. 2-5; ILBT 2013, pp. 27-29, 75). Generally, regenerating forests in the DPS range may begin providing winter hare habitat within 10-20 years after fire or other disturbance, with favorable conditions persisting for 20-30 years after that (Koehler and Aubry 1994, pp. 86-87; Agee 2000, pp. 67-71; Fuller *et al.* 2007, p. 1985; McCann and Moen 2011, p. 515; Vashon *et al.* 2012, p. 15; ILBT 2013, pp. 28-29), although it may take longer, perhaps 35-40 years, for lynx habitat to recover in some parts of the range (e.g., Maletzke *in* Lynx SSA 2016, p. 21).

Fire frequency, size, intensity, and return intervals also vary across the range of the lynx and depend on localized vegetation communities, climatic conditions, and topography (Agee 2000, pp. 47-56; Ruediger *et al.* 2000, p. 4-8; ILBT 2013, pp. 75-76). In lynx habitats, fire intensity is typically high and fire return intervals long but variable, with large areas affected by infrequent stand-replacing fires and, in mixed fire regimes, moderate- or low-intensity fires in the intervals between stand-replacing events (Agee 2000, pp. 49-54; Ruediger *et al.* 2000, pp. 4-8, 7-6). Within the DPS range, fire return intervals in the Great Lakes Region appear similar to those in the core of the lynx's range in the Canadian and Alaskan taiga (roughly 50-150 years), with longer return intervals in Western (150-300 years) and Northeastern (up to 500 years) U.S. forests (Agee 2000, pp. 52-53; ILBT 2013, pp. 75-76). Despite these long intervals, fire is the dominant natural disturbance mechanism in lynx habitats in the DPS range except in the Northeast, where insects and wind are more important (Agee 2000, p. 53).

Current Federal wildland fire management policy recognizes fire as a natural ecological process essential to the health and resilience of some forest systems, and it attempts to balance the ecological, social, and legal aspects of wildfire (USDA and USDI 2009, p. 6). However, the prior history of fire response was largely one of active suppression for most of the last century (Zimmerman and Bunnell 2000, p. 288; USDI *et al.* 2001, p. 1-1; USDA and USDI 2003, p. 3; 68 FR 40092; Calkin *et al.* 2015, pp. 1-3) which, combined with other land-use practices, dramatically altered fire regimes in some places and created conditions prone to larger and more severe fires (USDI *et al.* 2001, p. 1-2). Because of (1) fire's important role in creating and maintaining high-quality early-successional hare habitat in most lynx habitats in the contiguous U.S., (2) the potential for fire suppression to alter this dynamic to the detriment of hares and lynx, and (3) the limited ability of land managers (at that time) to use fire to benefit hares and lynx, wildland fire management was identified as a "Lynx Risk Factor Affecting Lynx Productivity" (Ruediger *et al.* 2000, pp. 2-5, 5-2). To address these concerns, the authors developed objectives, standards, and guidelines for Federal land managers to restore fire's role in maintaining lynx habitats, attempt to mimic historical natural fire regimes, and integrate lynx habitat objectives into fire management plans (Ruediger *et al.* 2000, pp. 7-6 - 7-8). They also directed Federal land managers to evaluate whether fire suppression or other management practices had altered fire regimes and ecosystem function in potential lynx habitats and, where so, to use fire (naturally ignited fires or prescribed burns) as a tool to restore and maintain lynx habitat by creating or regenerating snowshoe hare habitat (Ruediger *et al.* 2000, p. 7-7).

In its 2000 listing rule and 2003 remanded determination, the Service recognized the potential for fire suppression to adversely affect lynx and hare habitats at local and regional scales, particularly in the Great Lakes Region, where fire suppression policies across land ownerships likely prevented fire from assuming its natural role in creating a landscape mosaic of vegetation communities and age classes (65 FR 16076; 68 FR 40095). In the Northeast, the Service concluded that the very long fire return intervals and maritime influence in lynx forest types indicated that fire did not historically play a significant role in creating or maintaining lynx and hare habitats and, thus, fire suppression was unlikely to have affected lynx habitat (68 FR 40094). In the West, the Service concluded that the effects of fire suppression were likely lower in lynx forest types because of their typically long fire return intervals compared to lower and drier forest types (65 FR 16074; 68 FR 40093-94). Overall, the Service concluded that fire suppression did not represent a threat to lynx in the Northeast and was a low-magnitude threat in Great Lakes, S. Rockies, and N. Rockies/Cascades (65 FR 16075-16076; 68 FR 40093-40098).

In response to the guidance provided in the LCAS, the USFS, when developing the NRLMD and the SRLA to amend forest plans to address lynx conservation (see 3.1.1, above), evaluated whether fire suppression had adversely affected potential lynx habitats on national forests in the Northern and Southern Rockies. The USFS concluded that many forests in potential lynx habitat are in Condition Class 1, which means they have not missed a fire cycle because large, stand-replacing fire only occurs every 100 to 200 years; the long fire return interval has not been affected to any large degree by more recent fire suppression as is the case in drier forests with short fire return intervals; and they are close to historical conditions (USFS 2007, pp. 18, 20; USFS 2008, p. 11). In addition to the national forests covered by the NRLMD and SRLA (all national forests in the Northwestern Montana/Northeastern Idaho, GYA, and Western Colorado SSA units), the Superior National Forest, which accounts for 45 percent of the Northeastern Minnesota unit, revised its forest plan to adopt lynx conservation measures consistent with the LCAS (USFS 2004a, Appendix E). The Okanogan-Wenatchee National Forest in the North-central Washington unit is currently revising its management plan and continues to manage for lynx conservation in accordance with the LCAS, including direction to restore fire to its natural ecological role and to use it as a tool to restore and maintain hare and lynx habitats.

As described above in section 3.1.1, current Federal management on most USFS and BLM lands, in accordance with formally revised or amended management plans, includes limits on the proportion of lynx habitat within LAUs that can be in an unsuitable condition at any given time, including such conditions, usually temporary, created by wildfire. Although some exemptions and exceptions to these limits are permitted for activities to reduce fire risks to communities and infrastructure in the wildland-urban interface (WUI) or to achieve other resource benefits, even these potential impacts are limited on the larger landscape scale (USFWS 2007, p. 7). These conservation measures and the direction to use fire management as a tool to restore hare and lynx habitats and return to natural temporal and spatial patterns of fire disturbance, which were not in place when the DPS was listed, likely further reduce what was even then considered the low potential threat to lynx of past fire suppression activities. Based on the information above, we conclude that fire suppression and other fire management activities have not substantially impacted lynx and hare habitats in the DPS range and are unlikely to do so in the future.

However, warming temperatures attributed to climate change are reducing snowpack, causing earlier snowmelt and longer and more extensive droughts, resulting in longer wildfire seasons and increased fire frequency, size, and intensity in boreal forests of the north and in boreal and montane forests in some parts of the DPS range (Weber and Flannigan 1997, entire; Stocks *et al.* 1998, entire; Gillett *et al.* 2004, entire; Kasischke and Turetsky 2006, entire; Soja *et al.* 2007, entire; Pierce *et al.* 2008, entire; Flannigan *et al.* 2009, entire; Krawchuk *et al.* 2009, entire; Le Goff *et al.* 2009, entire; Bergeron *et al.* 2010, entire; Salathe *et al.* 2010, entire; Abatzoglou 2011, entire; McKelvey *et al.* 2011, entire; Abatzoglou and Kolden 2013, entire; Pederson *et al.* 2013, p. 1815; Price *et al.* 2013, pp. 342-343, 352-354; Barbero *et al.* 2014, entire; Trenberth *et* *al.* 2014, entire; Barbero *et al.* 2015, entire; Jolly *et al.* 2015, entire; Lute *et al.* 2015, entire; USEPA 2015, entire; Lienard *et al.* 2016, entire; Littell *et al.* 2016, entire; Westerling 2016, entire; see also section 3.2 above). Increases in fire frequency and size have the potential to adversely affect lynx and hare habitats in the DPS range by rapidly converting large areas to the temporarily unsuitable stand-initiation successional stage, thus reducing the amount and altering the distribution of higher-quality habitats (ILBT 2013, p. 70). Although this would likely be a temporary impact, with burned areas subsequently regenerating into higher-quality habitat, it would likely reduce landscape-level hare densities and, therefore, lynx numbers, potentially compromising an area's ability to support a resident lynx population until burned habitats recover.

Because lynx habitats are naturally patchily-distributed and landscape-level hare densities already naturally marginal in many parts of the DPS range, it is possible that very large wildfires or many over a short time period could, perhaps in concert with other influencing factors, tip an area from just barely capable of supporting a resident lynx population to no longer capable of doing so, resulting in extirpation. For example, multiple large fires in north-central Washington over the last 24 years have burned about 34 percent of lynx habitat (Lewis 2016, p. 4), resulting in a more than doubling of estimated female lynx home range size and a two-thirds or more reduction in the number of resident females that potentially could be supported in that geographic unit (Maletzke *in* Lynx SSA 2016, p. 21). It may take 35-40 years for these areas to recover as lynx and hare habitat (Maletzke *in* Lynx SSA 2016, p. 21), during which time additional fire and other habitat impacts could further diminish habitat availability and the lynx population's probability of persistence (Lewis 2016, pp. 5-6; Lynx SSA Team 2016, p. 44; also see section 2.3.2.2, above, and sections 4.1.4 and 5.1.4, below). The loss of habitat resulting from these fires and its potential demographic impacts on the State's only resident lynx population contributed substantially to the Washington Department of Fish and Wildlife's recent recommendation to uplist lynx from threatened to endangered under its State Endangered Species Program (Lewis 2016, entire).

Wildfire frequency, size, and intensity have also increased in the Northwestern Montana/ Northeastern Idaho geographic unit, where about 4,172 km^2 (1,611 mi^2; over 15 percent of the unit) have burned in western Montana from 2000-2013 (Squires *in* Lynx SSA Team 2016, p. 20). Large fires have also impacted lynx habitat in the Western Colorado geographic unit, where fire size, frequency, and intensity are expected to increase with climate change (Ivan *in* Lynx SSA Team 2016, p. 23). As mentioned in section 2.3.2.2, large areas of the GYA unit were burned by the extensive wildfires of 1988. The extent to which those fires may have diminished lynx and hare habitats and contributed to the recent absence of resident lynx is uncertain, as is the potential for those burned areas to support high hare densities and resident lynx in the future. However, some burned areas may soon develop the dense horizontal conifer structure favorable for hares and, therefore, for lynx foraging habitat, perhaps increasing the likelihood that they may support resident lynx in the near future.

Fire suppression was in the past thought to be a potential risk factor for lynx in the DPS range. However, given the trends discussed above and the likely continued increase in future fire activity related to continued climate warming, it may be necessary to reconsider whether fire suppression in some lynx habitats could benefit lynx by reducing the potential for extirpation of lynx populations, especially in places already affected by increased fire activity and those that are naturally only marginally capable of supporting resident lynx.

3.5 Habitat Loss and Fragmentation

Boreal forest habitats in the DPS are patchy and marginal for both snowshoe hares and Canada lynx. In this region, boreal forest transitions to various types of northern hardwood forest. The transitional nature of the boreal forest at its southern extent is believed (along with competition from other hare predators) to limit the numbers of both hares and lynx, preventing either from regularly achieving densities comparable to those regularly achieved in the classic boreal forests at the centers of their ranges in north-central Canada and Alaska (79 FR 54790). Lynx must contend with aspects of their habitat at the southern extent of the boreal forest for which they are not as well-adapted.

Fragmentation has been variously defined to describe a reduction of total area, increased isolation of patches, and reduced connectedness among patches of natural vegetation (Rolstad 1991). “Patchiness” is sometimes used to refer to natural processes (Buskirk *et al.* 2000a, p. 85), whereas “fragmentation” refers to anthropogenic disruption of natural patterns. Habitat loss is conversion of forest to another land use or vegetative cover.

Forest loss and fragmentation are relatively low in the DPS compared to other forested regions in the United States (Heilman *et al.* 2002, p. 416). Since 2000 in the western United States, land uses associated with residential development, roads, and highway traffic have resulted in a 4.5% loss in area (20,000 km^2) of forest, and continued expansion of residential development will likely reduce forested patches by another 1.2% by 2030 (Theobold *et al.* 2011, entire). Human-caused fragmentation in the forested western landscape resulted in a decline of weighted mean patch size from roughly 35,000 to 3,200 km^2 from natural to current conditions, but models predict relatively small declines in the size of forested patches over the next 30 years (Theobold *et al.* 2011, p. 2451). In the eastern United States, nearly half or more of the natural forest was cleared in the past three centuries, but as agriculture and settlement relocated westward and some eastern farmlands were abandoned, eastern forest cover rebounded (Williams 1989, Smith *et al.* 2005). Maine’s forest area has increased 0.79 percent since 1982 (Maine Forest Service, Department of Conservation 2010, p. 25). Similarly, a large portion of Minnesota forests were cleared in the last century, but forest cover has rebounded. The forest area in northern Minnesota has decreased 4 percent since 1977 (Miles *et al.* 2007, p. 22). Preliminary findings from the 2002 U.S. timber assessment (Haynes 2003) indicate that approximately 15 to 20 million acres of U.S. forest land could be converted to urban and developed uses over the next 50 years. Such land use conversions could result from residential development in forested landscapes, as the U.S. population is estimated to grow by another 126 million people.

Habitat patchiness and fragmentation directly affect snowshoe hares and lynx by various mechanisms; reducing hare survival and landscape hare densities, increasing lynx home ranges, reducing lynx reproduction and survival, and affecting lynx movements throughout the landscape. They also increase the diversity of mesocarnivore communities that coexist with lynx and the level of competition for space and food resources. Fragmentation from anthropomorphic sources results in habitat alteration, direct habitat loss, vehicle collisions and behavioral disturbance from roads and changes in landscape features such as edges.

Landscapes in which hare habitat is more contiguous or more broadly-distributed support more hares than landscapes that are more fragmented or include matrix habitats that are of poorer quality (Lewis *et al.* 2011, p. 565). Thus, southern transitional boreal forests generally have lower landscape snowshoe hare densities than boreal forests further north (Wolff 1980, pp. 123–128; Buehler and Keith 1982, pp. 24, 28; Koehler 1990, p. 849; Koehler and Aubry 1994, p. 84). This may have as much to do with the lower quality of the matrix habitat between high-quality patches as the hare densities that occur in the high quality patches themselves (Lewis *et al.* 2011). Low-quality matrix habitat, typical throughout much of the DPS, could decrease survival for hares, because predators might have higher hunting success or be more numerous and diverse in the matrix habitats (Griffin and Mills 2009). In contrast, a high-quality matrix, typical of Canadian boreal forest, can provide alternative or supplemental resources (Dunning *et al.* 1992; Norton *et al.* 2000), thus supporting higher densities of hares in the prime habitats.

The patchy distribution of hares and differences between landscape hare densities in the contiguous United States require lynx in most areas to incorporate more land area into their home ranges than lynx do in the north to acquire adequate food (Mowat *et al.* 2000, pp. 265, 277–278). At some point, landscape hare densities become too low, making some areas incapable of supporting lynx. Larger home ranges likely require more energy output associated with greater foraging effort (Apps 2000, p. 364) and possibly increased exposure to predation, roads, trapping, and other mortality factors than lynx face in the core of their range.

Throughout the northern part of their range, snowshoe hares are found in continuous areas of boreal forest; conversely, southern populations occur primarily in insular patches of suitable habitat set amidst less-preferred areas (Wolff 1980; Keith *et al.* 1993). This disparity has led a number of biologists to speculate that habitat fragmentation may be ultimately responsible for the non-cycling nature of snowshoe hare populations in the northern U. S. and southern Canada (Dolbeer and Clark 1975; Buehler and Keith 1982; Keith *et al.* 1993, Strohm and Tyson 2009). Wolff (1980, 1981) described the mechanism by which a fragmented habitat might dampen or eliminate cyclic population fluctuations.

Naturally patchy forests and those fragmented by humans may exacerbate competition between lynx and other predators (Buskirk *et al.* 2000a, entire). Forest patchiness, fragmentation, and competition are strongly linked because vegetation mosaics in landscapes provide high quality environments for generalist species such as the bobcat, red fox, and coyote (Goodrich and Buskirk 1995; Buskirk *et al.* 2000a, p. 84). Under such conditions, generalist predators tend to dominate the predator guild in patchy or fragmented landscapes (Oehler and Litvaitis 1996).

Hares fluctuate less dramatically in the southern part of the range of lynx, thus there is more competition for a limited resource and exploitation competition inflicted by generalists (e.g., coyotes) and other predators (Buskirk *et al.* 2000a, p. 95).

Snowshoe hares in the south are concentrated in isolated patches of suitable habitat and subject to predation by a suite of generalist predators (e.g., Litvaitis *et al.* 1985; Sievert and Keith 1985; Keith *et al.* 1993; Cox *et al.* 1997). Keith *et al.* (1993) found that extremely high predation rate on hare living in high quality hare habitats, rather than predation on naturally dispersing individuals, seemed to be driving the changes in distribution and abundance in a snowshoe hare population in Wisconsin. In this study, predation pressure on populations occupying small (<7 ha) patches of preferred habitat was so severe that 3 of the 5 populations under investigation went extinct in the course of the 3-year study. Fragmentation of landscapes exacerbate the effect of predation by allowing carnivores to concentrate their hunting efforts on small patches of habitat used by their preferred prey instead of preying disproportionately on dispersing individuals (Wirsing *et al.* 2003, p. 170). In predator-rich landscapes characteristic of the DPS, this can result in intense predation and competition for a limited prey resource.

Canada lynx seem to be flexible in their response to habitat fragmentation, whereas closely related species, such as bobcats and Iberian lynx, are sensitive to habitat fragmentation (Ferreras 2001, Crooks 2002). In a southern Ontario landscape Hornseth *et al.* 2014 (pp. 8-9) demonstrated that lynx exhibited a wide range of responses to habitat alteration. In general, lynx responded most positively to areas having greater than 50 percent suitable habitat and generally avoided areas having less than 30 percent suitable habitat. However, lynx showed no sensitivity to the degree of forest fragmentation in areas of high or low suitable habitat.

All of these factors likely lead to lower reproductive output and more tenuous conservation status for lynx in many parts of the DPS relative to those in Canada and Alaska (Buskirk *et al.* 2000a, p. 95). Thus, human activities that further fragment boreal forests in the DPS (e.g., climate change, forest management, roads, and development) further reduce the probability of lynx persistence.

The snow environment in the DPS is also patchy and marginal in both space and time for snowshoe hares and Canada lynx. Snow depth (Hoving *et al.* 2005, Peers *et al.* 2013, entire) and duration (Gonzalez *et al.* 2007) give lynx a competitive advantage over generalist predators in the conterminous United States. Too little snow or crusting conditions favor competitors and predators like bobcat, fisher, and coyotes. High elevations may provide snow conditions that favor lynx, whereas low elevations favor conditions for competitors. Lynx may have competitive advantage at higher elevations in the DPS in the winter, but not in summer months when competitors may have free access to all habitats. In contrast, extensive deep, fluffy snow conditions favor lynx in broad areas of north-central Canada and Alaska.

Landscape features further fragment hare and lynx habitat. In lynx units in the western contiguous U.S., potentially suitable boreal forests and appropriate snow conditions occur in relatively narrow elevational bands in the Cascade and Northern and Southern Rocky mountains. Thus, appropriate habitats for lynx are naturally fragmented by topography and vegetation gradients. These “islands” of habitat can be extensive (e.g., the Okanagan in Washington or most of northwestern Montana) or smaller and relatively isolated (e.g., the Garnet Range in western Montana) depending on topography and precipitation patterns. Some of these areas of boreal forest are separated by unsuitable habitats in the low valleys (e.g., sage flats, urban corridors, agricultural lands) or by snow regimes (e.g. snow shadows) that may restrict lynx dispersal between habitat patches. In some western parts of the DPS range, lynx habitat is also fragmented by rugged, high elevation terrain (Carroll *et al.* 2001, p. 976). In other areas of the DPS where there is little topography, including Minnesota and Maine, matrix forest facilitates lynx movements between suitable habitats. Large rivers are unlikely to fragment habitat as lynx readily swim across large bodies of water (Feierabend and Kielland 2014, entire) or cross them on ice in the winter (Koen *et al.* 2015).

Snow is an important component of lynx habitat (79 FR 54809). Snowfall can be patchily-distributed, variable and unpredictable from year to year, and affected by local topography, water bodies, and climate gradients. Snow conditions that provide lynx a competitive advantage over other terrestrial hare predators are most consistent in the high-elevation regions of the western U.S., although snow alone does not constitute lynx habitat (i.e., many places receive sufficient snow but lack other features lynx need, typically adequate hare densities). Snow conditions are less consistent in the East. For example, lake-effect snow from Lake Superior can increase snow depth and duration in the Arrowhead region of Minnesota in some years, but not others. The Gulf of Maine has the reverse effect, and its warming influence reduces snow depth and duration inland. Distribution models by Hoving (2001, p. 74) indicate that eastern Maine has extensive areas of boreal forest but does not achieve snowfall thresholds that gave lynx an advantage over bobcats and other competitors.

Lynx populations are clearly most viable in areas having extensive, unfragmented boreal forest habitats with large patches of high-quality foraging habitat and persistent deep, fluffy snow. Both lynx and hares are influenced by the spatial arrangement of preferred habitat. In Ontario, lynx preferred habitats with a high degree of connectivity (Walpole *et al.* 2012, p. 769). In Maine and northern Washington, landscapes where habitat was more contiguous supported more snowshoe hares than landscapes that were more fragmented (Simons 2009, Lewis *et al.* 2011). Several studies (Koehler 1990a, Mowat *et al.* 2000, von Kienast 2003, Maletzke 2004, Squires and Ruggiero 2007, Squires *et al.* 2010) have reported that lynx avoid large openings, especially during winter. Mowat *et al.* (2000) suggested that relatively few snowshoe hares use large openings, and consequently lynx spend little time hunting in these areas. Koehler (1990a) speculated that vegetation management prescriptions that result in distance to cover >100 m (328 ft) may change lynx movement and use patterns until such time as sufficient reestablishment of forest vegetation occurs. Opening size can also influence seedling regeneration and stocking densities (Kreyling *et al.* 2008).

Similarly, individual lynx have the smallest home ranges and greatest survival and productivity in landscapes that have extensive, large patches of habitat in combination with deep, fluffy snow. Within their home ranges, lynx strongly select for habitat patches that enhance their foraging opportunities (Moen *et al.* 2008, Vashon *et al.* 2008a, Fuller and Harrison 2010, Squires *et al.* 2010). Analysis of winter movements of lynx in Maine indicated that lynx responded to habitat heterogeneity at a coarse scale within their home ranges by maximizing their access to snowshoe hare prey (Fuller and Harrison 2010). In Montana, lynx selected homogeneous spruce-fir patches that supported snowshoe hares and avoided recent clearcuts or other open patches (Squires *et al.* 2010). Similarly, in Washington, Lewis *et al.* (2011) reported that landscapes in which hare habitat was more contiguous, or surrounded by a mosaic of similar habitat quality, supported more hares than did more fragmented landscapes.

<u>Anthropogenic Sources of Fragmentation</u> - Human activities can exacerbate the naturally-patchy habitat that is typical throughout much of the DPS range. Anthropogenic activities such as forest management, development, and highways alter natural landscape patterns. They cumulatively can reduce the total area of habitat, diminish the quality of habitat, increase the isolation of habitat patches, and impair the ability of lynx and other wildlife to effectively move between patches of habitat. Anthropogenic fragmentation may be permanent, for example by converting forest habitat to residential, industrial, or agricultural purposes, or temporary, for example by conducting forest management but allowing trees and shrubs to regrow. Habitat fragmentation (both natural and anthropogenic) increases the risk of extirpation of small lynx populations.

Human-caused fragmentation of the already naturally patchy pattern of lynx habitat in the contiguous U.S. can affect lynx by reducing their prey base and increasing the energetic costs of using habitat within their home ranges. Buskirk *et al.* (2000a) identified direct effects of fragmentation on lynx to include creation of openings that potentially increase access by competing carnivores, increasing the edge between early-successional habitat and other habitats, and changes in the structural complexities and amounts of seral forests within the landscape. At some point, landscape-scale fragmentation can make patches of foraging habitat too small and too distant from each other to be effectively accessed by lynx as part of their home range. Maintaining a mosaic of large (>100 acres) patches of young to old stands in patterns that are representative of natural ecological processes and disturbance regimes would be conducive to long-term conservation of lynx (ILBT 2013, p. 77).

Roads, development, climate change, and forest management fragment snowshoe hare and lynx habitat in the DPS. We know little about how hare and lynx respond to these anthropomorphic changes to their habitat, which requires additional research (Murray *et al.* 2008, p. 1464; Squires *et al.* 2013, p. 194). In the next decades, southern lynx populations will incur further habitat loss and fragmentation and the effects of climate change. Changes in habitat, prey base, and competitor guild will further stress southern lynx populations and possibly populations in southern Canada. Ultimately, the extent of such changes and whether lynx are able to adapt to them will determine not how, but if, this species can persist in its current southern range (Murray *et al.* 2008, p. 1469).

<u>Roads</u> - Paved highways fragment lynx habitat. In the West, they typically follow natural features such as rivers, valleys, and mountain passes that may have high value for lynx in

providing habitat or connectivity. They surround large blocks of lynx habitat in Minnesota and northern Maine. Various studies have documented lynx crossings of highways. A male lynx in western Wyoming was documented to have successfully crossed several 2-lane highways during exploratory movements (Squires and Oakleaf 2005). However, in Alberta, Canada, high road densities, human activity, and associated developments appeared to reduce the habitat quality based on decreased occupancy by lynx (Bayne *et al.* 2008). Apps *et al.* (2007) found lynx were 13 times less likely to cross the Trans-Canada Highway relative to random expectation, but only 2.2 and 3.1 times less likely to cross smaller highways (93 and 1A, respectively). In southeastern British Columbia, lynx avoided crossing highways within their home ranges (Apps, 2000). Squires *et al.* 2013 (p. 194) documented 44 radio-collared lynx with home ranges within an 8 km buffer of 2-lane highways, however, only 12 of these individuals crossed the highway.

Paved highways also pose a risk of direct mortality to lynx and may inhibit lynx movement between previously connected habitats. If lynx avoid crossing highways, this could lead to a loss of effective habitat within a home range and reduced interaction within a local population (Apps *et al.* 2007). Lynx and other carnivores may avoid using habitat adjacent to highways, or become intimidated by highway traffic when attempting to cross (Gibeau and Heuer 1996, Forman and Alexander 1998).

Carnivores are especially vulnerable to highway-caused mortality in areas with dense and high traffic volume roadways (Clevenger *et al.* 2001). As the standard of roads increases from gravel to 2-lane or 4-lane highways, traffic volumes and the degree of impact are expected to increase. Walpole *et al.* (2012, p. 770) found that small logging roads with low traffic volume had no effect on lynx distribution. Four-lane highways, such as the interstate highway system, commonly have fences on both sides, service roads, parallel railroads or power lines, and impediments like "Jersey barriers" that make successful crossing more difficult, or impossible, for wildlife (ILBT 2013, p. 78). Alexander *et al.* (2005) suggested traffic volumes between 3,000 and 5,000 vehicles per day may be the threshold above which successful crossings by carnivores are impeded. In Colorado, lynx successfully and repeatedly crossed major highways, including I-70 (Ivan 2011c, d, 2012; J.Squires, personal communication 2012). Colorado lynx crossed two-lane highways an average of 0.6 times per day and more frequently during dusk and night when traffic volume was lower (Baigas *et al.* 2017, p. 204). They also crossed 4-lane highways (I-70), especially forested areas under large, elevated bridges that spanned streams (Baigas *et al.* 2017, p. 204).

Between 2000 and 2015, 54 lynx were reported to have been killed on roads (both paved and unpaved) in Maine (J. Vashon, Maine Department of Inland Fisheries and Wildlife, unpub. data), 11 in Minnesota (T. Smith, U. S. Fish and Wildlife Service, unpub. data), 1 in Idaho and 5 in Montana (compiled by K. Broderdorp, USFWS, unpub. data 2016). Between 1995 and 2011, 15 lynx were reported killed on British Columbia highways (British Columbia Wildlife Accident Reporting System 2012). Most of these mortalities are on higher-speed paved highways. However, in Maine, about 41 percent (22 of 54) were killed on dirt logging roads with low traffic volume and lower speed limits.

Translocated animals may be more vulnerable to highway mortality than resident lynx (Brocke *et al.* 1990), because they often move extensively after their release and are unfamiliar with their surroundings. In the Adirondack Mountains of New York, an attempt to reintroduce lynx failed and 18 of 37 documented mortalities of translocated animals were attributed to road kills (Brocke *et al.* 1990). Over a 7-year period in Colorado, 13 of 102 documented mortalities of translocated lynx were killed on highways (Devineau *et al.* 2010). Traffic volumes on Colorado highways where the 13 lynx mortalities occurred were estimated to range from about 2,300 to >25,000 vehicles per day (K. Broderdorp 2012 , *pers. comm*.).

Roads of all sizes have many indirect effects to lynx including increased human access (e.g. trapping and illegal shooting), and creating edge habitats that promote co-occurrence with competitors like coyotes and bobcats (Bayne *et al.* 2008, p. 1195).

<u>Vegetation Management</u> - As described in section 3.3, above, forest management can further fragment boreal forest in the northern contiguous United States affecting habitat suitability for both snowshoe hares and lynx. Large-scale forest fragmentation or maturation can be deleterious to snowshoe hares because they become increasingly restricted to small patches with adequate cover, and higher predation rates from a variety of carnivores tend to increase local extinction risk (Wolff 1981, Keith *et al.* 1993, Wirsing *et al.* 2002; see also Barbour and Litvaitis 1993).

Although some forest management can benefit lynx by creating or maintaining a shifting mosaic of lynx habitat, it can also be detrimental by fragmenting habitat into small, widely-spaced parcels. Changes to vegetation structure can increase landscape resistance to lynx movements (Squires *et al.* 2013). In Montana, fragmentation from forest thinning decreased the probability of lynx movements across the forested landscape (Squires *et al.* 2013, p. 192). Lynx in the Northern Rockies are sensitive to changes in forest structure and tend to avoid large forest openings (Koehler, 1990; Squires *et al.* 2010) like recent clearcuts and thinned areas. In Maine, the shift to partial harvesting forms of forest management will continue to increase the number of patches of high quality hare habitat, but it will greatly reduce the size of patches and increase their isolation (Simons-Legaard *et al.* 2016, pp. 5-6). This is diminishing landscape conditions conducive to supporting lynx.

<u>Residential and Commercial Development</u> - Residential and commercial development is increasing on private forest lands. Increased traffic and urbanization are projected for the Northern Rockies (Hansen *et al.* 2002) and Maine (also see section 5.2.1, below). It is uncertain to what degree lynx can tolerate habitat fragmentation from roads and clearing forest for development, and how human and pet activity associated with development may affect lynx use of habitats. Some anecdotal information suggests that lynx are quite tolerant of humans, although given differences in individuals and contexts, a variety of behavioral responses to human presence may be expected (Staples 1995, Mowat *et al.* 2000). The degree to which residential development and associated roads reduce connectivity of mesocarnivore populations (including lynx) likely depends on the physical design of highway improvements, the

surrounding environmental features, the density of increased urbanization, and the increased traffic volume (Clevenger and Waltho, 2005; Grilo *et al.* 2009).

<u>Ski Resorts</u> - Ski area development also results in permanent habitat loss and fragmentation. One ski run is often separated from the next only by small inter-trail forest islands. Ski runs often are intermixed with other open areas such as open or gladed bowls, rock outcrops, or barren tundra ridges. Ski resorts that are built or expanded in lynx habitat may impact lynx by removing forest cover, reducing the snowshoe hare prey base, and creating or increasing human disturbance in or near linkage areas. There is limited information on lynx behavior and habitat use in and around ski areas. Lynx have been known to incorporate smaller ski resorts within their home ranges, but may not utilize the large resorts. Preliminary information from an ongoing study in Colorado suggests that some recreational use may be compatible, but lynx may avoid some areas with concentrated recreation use. In some areas, lynx habitat may be limited and concentrated in the ski area development footprint (Squires 2012, *pers. comm.*).

More than 50 ski areas exist throughout the range of the lynx in the contiguous U.S. (ILBT 2013, pp. 82-83). Most ski areas are located on north-facing slopes, where ample snow conditions provide for extended ski/snowboard recreational seasons. In the western states, many of these landscapes feature spruce-fir forests. While ski resorts occupy a small proportion of the landscape, spruce-fir forests provide important habitat for snowshoe hares and lynx at the southern extent of their range. In winter, alpine and Nordic skiing and snowboarding are the primary uses. Most of these resorts offer year-round recreation, with summer activities typically including hiking and mountain biking.

<u>Mining Leasable Minerals</u> - Activities associated with exploration and development of leasable minerals occur primarily in western units of the DPS. Very little mining development occurs in Minnesota and northern Maine. Mining affects lynx habitat by changing or eliminating the native vegetation, human disturbance, and contributes to habitat fragmentation. Development of a high density of wells, as is typical of coal-bed methane development (e.g., 1 well per 2–4 ha [5–10 ac]), could affect lynx by directly removing habitat or causing sufficient human presence to displace lynx. The development of associated roads, powerlines, and pipelines to facilitate exploration and development also result in a loss of lynx habitat and contribute to fragmentation of habitat. In some areas, for example in the Wyoming Range, extensive oil and gas development is occurring within lynx habitat.

<u>Locatable Minerals</u> - Only a fraction of the historical number of mines is operating today. Those that continue to operate do so with more stringent environmental protection measures. However, in some parts of the United States, minerals exploration and new development seem to be increasing. Activities associated with exploration and development of locatable minerals could affect lynx habitat by changing or eliminating the native vegetation, and by contributing to habitat fragmentation. The effects can be variable depending on the size of the associated mining operation or development. Locatable minerals are extracted through both open pit and sub-surface mines with potential habitat alteration ranging from tens to thousands of hectares. In some instances, such as larger mining operations, land exchanges are conducted to

consolidate private ownership of the surface above a deposit prior to mine development. Depending on lands exchanged this could retain lynx habitat in public ownership, but could still result in a net loss of habitat. Development of road and railroad access to facilitate exploration and development also directly impact lynx habitat, contribute to fragmentation, facilitate increased competition as a result of snow-compacted routes, and result in direct mortality. Despite these potential effects, mining exploration and development is generally anticipated to affect only a small portion of lynx habitat in the contiguous United States.

Salable Minerals - In general, salable minerals are found close to the surface. During exploration activities, equipment is moved to the site and a number of test pits are dug or holes drilled to determine the quality of material. If desired minerals are found in suitable quantity, then vegetation is removed and materials are excavated. For example, gravel pits are needed for logging road development and maintenance and are common occurrences throughout areas of the DPS that are in active forest management. Areas developed for salable minerals can vary in size from a single truck load to tens of acres. Impacts to lynx include the potential alteration or removal of lynx habitat, increased fragmentation, and the potential for human-caused mortality from road development.

Wind Energy - Wind energy development and associated transmission lines in lynx habitat is increasing across the nation. Facilities are located on ridge tops or other areas exposed to consistent wind. The construction of wind facilities including access roads may result in loss of lynx habitat and increased fragmentation from permanent forest clearings. Noise and human activity associated with the construction and operation of wind facilities could disturb or displace lynx from important habitats. Effects would likely continue through the life of the project, which may exceed 20 years.

Utility Corridors - Utility corridors contain developments such as overhead or buried powerlines and gas pipelines, and often are located within or adjacent to existing road rights-of-way. Utility corridors potentially could have short- or long-term impacts to lynx habitats, depending on location, type, vegetation clearing standards, and frequency of maintenance. Those that are extensively cleared of vegetation and maintained in grass or herbaceous vegetation likely equate to a permanent habitat loss. When associated with highways and railroads, utility corridors may further widen the right-of-way. Utility corridors may facilitate human access into previously remote areas thus exposing lynx to increased trapping and possible illegal shooting.

Agriculture - Agricultural activity is not expanding currently in lynx habitat areas in the DPS range. In fact, in the late 1800s, over 3 million acres of northern Maine was in farming, compared to about 700,000 acres today (Ahn *et al.* 2002, p. 8). Most of the current farming is in northeastern Maine, where it fragments the forested landscape corridor between core habitats in northern Maine and western New Brunswick, Canada. Forest clearing for agriculture may have contributed (along with increasing road densities and an expansion in coyote distribution) to the recent contraction in the southern part of lynx range in eastern Alberta (Bayne *et al.* 2008, p. 1195).

Habitat Loss and Fragmentation in Corridor Areas Connecting Lynx Populations in the DPS with Adjacent Populations in Canada - Lynx conservation in the contiguous U.S. is thought to depend in part on maintaining connectivity with habitat areas and lynx populations in Canada. Maintaining connectivity for lynx may become increasingly difficult because of climate change and other anthropogenic influences, as evidenced by reduced connectivity for other boreal species (van Oort *et al.* 2011). Potential corridors have been identified in the northern Rockies (Squires *et al.* 2013, entire). There are likely broad, forested corridors with suitable dispersal habitat connecting core habitats in Maine to southern Quebec and northern Minnesota to southern Ontario. Given the perceived importance of lynx immigration from Canada to the persistence of the DPS (FR 68 40076– 40101; Squires *et al.* 2013, p. 187), roads and other forms of habitat loss and fragmentation that may impede lynx movements in the border regions of Canada and the U.S. are of concern.

Chapter 4: Current Conditions

In this chapter, we present our understanding, based on the best available scientific information, including the professional judgment and opinions of lynx experts, of the current status of the lynx DPS in terms of redundancy, representation, and resiliency. We then provide brief summaries of the current conditions in each geographic unit, followed by a more detailed evaluation of the status of lynx populations and habitats and the factors currently believed to influence them in each unit. Where appropriate, we compare our current understanding to what was known or believed when the DPS was listed under the ESA in 2000 and to our understanding of historical conditions.

4.1 Summary of Current Conditions DPS-wide

Because of the limitations and uncertainty in the historical records of lynx occurrence in the contiguous U.S. (described above in section 2.3.2.1), it is difficult to compare the current distribution and status of resident lynx populations in the DPS with what may have been the historical condition (but see evaluation in section 2.3.2.2, above). However, research and surveys over the last two decades have significantly improved our understanding of the current distribution, habitats, and the status of resident populations compared to what was known when the DPS was listed in 2000. For example, although we knew there were some resident lynx in Maine (Unit 1), we lacked information on the quality and distribution of lynx and hare habitats and the potential number of lynx. We now know this unit currently has large areas of high-quality habitat created by the regeneration of extensive clear-cutting in the 1970s and 1980s in response to a large spruce budworm outbreak, that there are probably more lynx in Maine now than was likely under historical natural disturbance regimes and habitat distributions, and that this unit currently supports the largest resident lynx population in the DPS. Similarly, when the DPS was listed, we were uncertain whether Minnesota (Unit 2) supported a resident population. We now know that a persistent population of perhaps several hundred lynx occupies the northeastern corner of the state. Research also suggests that lynx and habitats in the western U.S. (Units 3, 4, 5, and 6) are naturally less abundant and more patchily-distributed than was thought at the time of listing, and several areas thought to have historically supported small resident populations currently do not (the GYA [Unit 5], the Garnet Mountains in western Montana [Unit 3], and the Kettle Mountains of northeastern Washington). We also know that recent extensive wildfires in north-central Washington (Unit 4) have substantially reduced (probably temporarily) the amount of high-quality lynx habitat and likely caused a decline in lynx numbers there. Finally, as a result of the release of 218 Canadian and Alaskan lynx from 1999-2006, and their subsequent survival and reproduction, resident lynx currently occupy parts of western Colorado (Unit 6), although the current number and distribution of lynx there are uncertain.

With regard to redundancy, defined as the ability of the DPS to withstand catastrophic events, we find that the current broad distribution of resident lynx populations in large, geographically discrete areas makes the DPS invulnerable to extirpation caused by a single catastrophic event. The DPS range currently spans the northern contiguous states from Maine to Washington and south along the Rocky Mountains to southern Colorado. Resident breeding lynx populations currently occupy five of the six geographic units (all but the GYA; Figure 1). Of the five occupied units, four are larger than 20,000 km^2 (7,722 mi^2), and the other (North-central Washington) is over 5,000 km^2 (1,931 mi^2) (see tables 2, above, and 4, below). Our analyses and lynx expert imput indicate no single catastrophic event that could result in the functional extirpation (loss of the ability to support resident lynx populations) of the entire DPS and, further, no or a very low likelihood of functional extirpation of any of the individual geographic units caused by a single catastrophic event (Lynx SSA Team 2016, p. 56).

Because we lack evidence that persistent lynx populations have been lost from any other large geographic areas in the contiguous U.S., it also seems that redundancy in the DPS has not been meaningfully diminished from historical levels. That is, the loss of resident lynx populations in the DPS, to the extent suggested by verified historical records, was likely in areas (e.g., northern New Hampshire, the Kettle/Wedge area of northeastern Washington, perhaps Isle Royale in Lake Superior) peripheral to the geographic units that currently support resident lynx. Any small populations that were lost were not in large, discrete geographic units that would have represented substantially greater redundancy in the contiguous U.S. However, the implications of the potential recent loss of resident lynx in the GYA for the redundancy of the DPS are unclear. The historical record and recent research show that the GYA has supported resident lynx. However, it is unclear whether the area consistently supported a resident breeding population over time or whether it naturally supported resident lynx only some of the time ("winked on" in a metapopulation sense) when habitat conditions and hare densities were favorable, and at other times, when habitats and hare densities were less favorable, it did not support resident lynx ("winked off" in a metapopulation sense). Given the protected conservation status of millions of acres in the GYA unit (Yellowstone and Grand Teton National Parks; all or parts of the Absaroka-Beartooth, Bridger, Gros Ventre, Lee Metcalf, Northern Absaroka, Teton, and Washakie Wildernesses), its apparent recent inability to support resident lynx may be a reflection of naturally marginal and patchy habitats and relatively low hare abundance in much of the unit, resulting in only an intermittent ability of this unit to support resident lynx. If so, the contribution of the GYA to redundancy within the DPS is questionable.

Representation, defined as the ability of the DPS to adapt to changing environmental conditions, is characterized by the breadth of genetic and ecological diversity within and among populations (Lynx SSA Team 2016, p. 25). Lynx experts and geneticists indicated high rates of dispersal and gene flow and, therefore, generally low levels of genetic differentiation across most of the species' range, including the DPS (Lynx SSA Team 2016, pp. 12-14, 55-56). Although hybridization with bobcats has been documented in the DPS (in Maine and Minnesota), it is not considered a substantial current threat to the DPS (Lynx SSA Team 2016, p. 13). Further, despite differences in forest community types and other habitat parameters (e.g., topographic/ elevation settings) lynx across the range of the DPS occupy a similarly narrow and specialized ecological niche defined by specific vegetation structure, snow conditions, and the abundance of a single prey species. Therefore, lynx naturally have little ability to adapt to changing environmental conditions (i.e., shift to other forest habitats, snow conditions, or prey species). However, although some small populations may have become extirpated recently, resident lynx in the DPS remain broadly distributed across the range of ecological settings that seems to have supported them historically in the contiguous U.S. Because there are no indications of current threats to the genetic health or adaptive capacity of lynx populations in the DPS, and the current level of representation does not appear to represent a decrease from historical conditions, we find that the DPS currently displays an adequate level of representation.

Resiliency, the ability to withstand stochastic disturbance events, is currently exhibited in the lynx DPS by the persistence of individual lynx populations and their broad distribution across the geographic scope of the DPS. However, because we lack reliable estimates of the sizes and trends of most lynx populations in the DPS, we are unable to use these parameters to evaluate the current resiliency of individual populations or geographic units. Although some demographic data (survival, reproductive rates) are available for each geographic unit (see Table 4, below), they were collected using different methods, at different times and for different intervals, and possibly at different points in hare population cycles or fluctuations and, therefore, do not provide a consistent measure of resiliency. Efforts to understand resiliency within the DPS are also confounded by the metapopulation structure thought to govern lynx populations at the southern margin of their continental range, which suggests that some populations may be naturally ephemeral (i.e., "winked on" when conditions are favorable; "winked off" when conditions are not favorable). The related uncertainty about the extent to which DPS populations may rely on cyclic immigration of lynx from Canada during population irruptions and the ambiguity in the historical record that limits our understanding of the relative persistence of lynx in various geographical areas also limit our ability to characterize, rank, or model the relative contribution of each geographic areas to the resiliency of the DPS.

Despite uncertainties and data deficiencies, qualitative factors provide some hints about current relative resiliency among some geographic areas or parts of them. For example, in Maine, lynx appear to have demonstrated resiliency by responding positively to substantial anthropogenic increases in the amount and distribution of high-quality foraging habitat. Conversely, the current absence of resident lynx in the GYA (Unit 5) and in the Garnet Mountains of Unit 3 may indicate the lower level of resiliency expected among small and relatively more isolated populations. The persistence of lynx in north-central Washington (Unit 4) despite the substantial recent wildfire-mediated loss of habitat suggests resiliency in that population; however, the post-fires increase in home range size and likely decrease in lynx numbers may indicate the population is currently less resilient (less able to persist if additional or similar habitat losses occur) than it was previously. Overall, the apparent long-term (historical and current) persistence of resident lynx populations in at least four of the six geographic units (Units 1-4) and the absence of reliable information indicating that the current distribution and relative abundance of resident lynx are substantially reduced from historical conditions suggest adequate historical and recent levels of resiliency of lynx populations in the DPS.

In summary, the lynx DPS currently exhibits adequate redundancy to preclude extirpation as a result of catastrophic events. The genetic health and ecological diversity expressed across the DPS range likewise suggest a currently adequate level of representation. The long-term persistence and apparent broad geographical distribution of lynx populations in four of the six geographic units also suggests the historical and recent adequacy of resiliency in the DPS, although the potential recent extirpation of several small populations may be an indication of inadequate or declining resiliency in those places.

4.1.1 Summaries of Current Conditions in Each Geographic Unit

Unit 1 - Northern Maine: This geographic unit encompasses northern hardwood and spruce-fir forest (the Acadian forest) in northern Maine, but small areas of similar habitat also occur in northern New Hampshire and northern Vermont. Resident lynx in this unit are part of a larger population that also occupies southern Quebec (where trapping is legal) and northern New Brunswick (where lynx are a provincially-endangered species and harvest is prohibited), Canada. There are no reliable estimates of current or historical resident lynx numbers in this unit. At the time of listing, the Northern Maine Unit was not believed to contribute significantly to the DPS. However, we now know that there currently is sufficient habitat in this unit to possibly support the largest reproducing resident population of lynx in the DPS (numbers and trends unknown, but enough habitat currently exists to support possibly 500 to 1000 lynx). Small numbers of reproducing lynx have also been documented recently in northern New Hampshire and northern Vermont. Historically, when Maine had a greater proportion of mature forest, lynx distribution in this unit was likely patchier, and lynx populations were likely low and dependent on immigration from Canada. Forest management is now the primary driver of hare and lynx habitat in this DPS unit. Current lynx and hare habitat is historically high because of young, regenerating softwood forests created by extensive clearcutting and herbiciding to salvage spruce-fir following a severe spruce budworm outbreak in the 1970s and 1980s (Hoving *et al.* 2004, Vashon *et al.* 2008b). Lynx responded to these conditions with high survival and reproduction, small home ranges, and moderate population densities. State forestry regulations passed in 1989 caused landowners to shift to various forms of partial harvesting that have resulted in lower landscape hare densities across much of the unit. Hares do not seem to cycle in this region, but underwent a 50 percent decline starting in 2006 and have remained at lower levels. Reproduction and survival rates in the low-hare environment after 2006 suggest a slightly declining population. Unlike other units of the DPS, lynx habitat in northern Maine occurs nearly entirely on private, industrial forest lands, and landowners do not have long-term commitments to lynx management. The majority of lands in Maine are owned now by investment companies who wish to diversify income from their investments, which could result in forest practices inconsistent with hare and lynx habitat maintenance and conservation. Other potential stressors on private lands include incidental trapping, road mortality, large-scale wind energy development, residential and resort development, and parcelization of forestlands from rapid turnover in investment company landowners. The next spruce budworm outbreak is imminent, but forestry response by investment landowners is uncertain. Climate change is a concern as snow depth and duration are currently at the minimum thresholds believed necessary to give lynx a competitive advantage over bobcats and other mesocarnivores. There is currently no clear evidence of climate change effects on lynx distribution.

<u>Unit 2 - Northeastern Minnesota</u>: This geographic unit contains a mix of upland conifer and hardwood interspersed with lowland conifer, alder or willow shrub swamps, and black spruce or tamarack bogs. Despite uncertainty when the DPS was listed, it has become apparent that a reproducing resident population of roughly 50 to 200 lynx exists in northeastern Minnesota. This unit is directly connected to lynx habitats and populations in Canada, and lynx in this unit likely represent the southern extent of a larger cross-border population, most of which occurs in Ontario, where trapping of lynx is legal. Lynx in Minnesota select regenerating forest, dominated by conifer with extensive forest edge; lynx beds (resting and hunting) and kill sites are associated with regenerating and mixed forest (Burdett 2008, p. 57). Hare densities in parts of northeastern Minnesota appear to be sufficient to support a viable lynx population; and densities are highest in regenerating forests (McCann and Moen 2011, p. 513). The Superior National Forest continues to manage lynx habitats in accordance with its 2004 Forest Plan, which includes measures to minimize several risk factors and promote lynx conservation on the forest. Management of lynx habitat on State and private lands is voluntary and lacks long-term commitments to lynx management. Factors affecting current conditions in this unit primarily include forestry management, roads, incidental trapping, mining development, snow compaction, competition with bobcats, and lynx-bobcat hybridization. Since 2000, 45 lynx mortalities have been documented in Minnesota from unknown causes (16), incidental trapping (11), vehicle collisions (9 on roads and 2 on railroads), and illegal shooting (7). Six lynx radio-collared in Minnesota died after traveling north into Ontario, four from legal trapping/hunting, and two of unknown causes.

<u>Unit 3 - Northwestern Montana/Northeastern Idaho</u>: There are no reliable estimates of current or historical resident lynx numbers in this geographic unit, but it is thought to be capable of supporting 200-300 lynx home ranges. Habitats capable of supporting resident lynx in this unit are naturally patchier and less-broadly distributed (Squires *et al.* 2006a, pp. 46-47; Squires *et al.* 2013, p. 191), and lynx therefore naturally rarer, than was thought at the time of listing (ILBT 2013, p. 23; Jackson *in* Lynx SSA Team 2016, p. 12). Minor genetic differences suggest three subpopulations in the northwest (Purcell Mountains), central (Seeley Lake), and southern (Garnet Mountains) parts of the unit. No lynx have been detected in the Garnets after 2010, but whether this indicates the extirpation of a small (7-10 individuals) previously persistent resident population or the temporary loss of an historically ephemeral population is uncertain. Most

(about 90 percent) of this unit, including Federal, State, Tribal, and some private lands, is managed to conserve and restore lynx and hare habitats. Past timber harvest and associated management (thinning, road construction, fire suppression) appear to have had localized impacts but not to have diminished the unit's ability to support resident lynx, with the Garnets being a possible exception. The size and intensity of wildfires have increased over the past several decades, likely in response to climate warming, but impacts to lynx are uncertain. Whether and if so to what extent other climate-mediated factors have influenced the current condition of lynx populations or habitats in this unit is also unknown. Regulations prohibit lynx trapping and require measures to reduce the likelihood of trapping lynx incidentally when legally trapping other species. Hare densities have not been estimated broadly throughout the unit but appear to be low or marginal even in what is considered the highest-quality habitat, suggesting that even small decreases in habitat quality/hare densities could influence its continued ability to support resident lynx. The role of past and recent immigration in maintaining the demographic and genetic health of current lynx populations in this unit is unknown, but peaks in cyclic lynx numbers in Canada have declined, especially when compared to the unprecedented irruptions of the early 1960s and 1970s, and there is no evidence of significant immigration into this unit since then.

<u>Unit 4 - North-central Washington</u>: This geographic unit encompasses approximately 5,176 km^2 (1,988 mi^2), 91.5 percent Federally owned. It contains extensive boreal forest vegetation types and the components essential to the conservation of the lynx. Additionally, lynx populations exist in British Columbia, directly north of this unit, and maintaining connectivity with Canada is considered important to maintaining lynx populations in this unit. There are no reliable estimates of current or historical resident lynx numbers in this unit, but recent habitat and home range analyses (summarized in Lewis 2016) suggest that it may have been capable of supporting 65-90 lynx prior to recent large wildfires. Those fires affected about 50 percent of the potential lynx habitat, led to increased home range size, and may have reduced the current carrying capacity of this unit to 40-55 lynx. Recent wildfire severity, extent, and intensity in lynx habitat within this geographic unit may have been influenced by climate change (Westerling *et al.* 2006, pp. 942-943). There is significant risk for potential future wildfires to further affect the viability of lynx in this geographic unit. Burned habitats are expected to regenerate back into suitable lynx habitat, but this may take 35-40 years. The Kettle Range to the east of this unit was suspected to have supported a small (likely fewer than 20 individuals) resident population until about 30 years ago when over-trapping may have resulted in its extirpation (Koehler *et al.* 2008, p.1523). Potential impediments to lynx movement between the Kettle Range and the Cascades and British Columbia may make natural recolonization of the Kettle Range unlikely. Results of snowshoe hare research suggest that the hare population density in Washington exists at the low end of the range thought necessary to support lynx reproduction (>= 0.5 hares/ha). The OWNF and CNF, which administer more than 90 percent of lynx habitat in Washington, continue to manage lynx habitat on their forests in accordance with the LCAS. Additionally, the WADNR, which manages approximately 4 percent of lynx habitat in Washington, has developed and is implementing its 2006 Lynx Plan, which is also largely based on the LCAS.

Unit 5 - Greater Yellowstone Area (GYA): There are no reliable estimates of current or historical lynx numbers in this unit but, given its naturally-fragmented potential habitat, generally low hare densities, and the paucity of verified records, it appears unlikely this unit ever supported a large resident population. No lynx have been verified in this unit since 2010, but whether this indicates the extirpation of a small but previously persistent resident population or the temporary loss of an historically ephemeral population is uncertain. Over 97 percent of this unit consists of Federal lands that are currently managed to conserve and restore lynx and hare habitats. Past timber harvest and associated management (thinning, road construction, fire suppression) appear to have had localized impacts but not to have diminished the unit's ability to support resident lynx. The size and intensity of wildfires have increased over the past several decades, predominantly in the northern half of the unit (including the large fires of 1988 in Yellowstone National Park) and likely in response to climate warming, but impacts to lynx are uncertain. Whether and, if so, to what extent other climate-mediated factors have influenced the current condition of lynx populations or habitats in this unit are also unknown. Snow conditions currently appear to be adequate, with most of this geographic unit modeled to have a 95 percent probability of providing snow cover conditions supportive of lynx presence (Gonzalez *et al.* 2007, p. 12). Hare densities were very low in most of Yellowstone National Park but high in parts of the Bridger-Teton National Forest in the southern half of the unit. The role of past and recent immigration in maintaining the demographic and genetic health of lynx populations in this unit is unknown. This unit lacks direct connectivity to other lynx populations, and there is only anecdotal evidence that irruptions of lynx from Canada resulted historically in immigration into this unit. Some lynx released in Colorado dispersed northward into this unit and temporarily occupied home ranges in areas used previously by native resident lynx, but there is no evidence of reproduction among these lynx.

Unit 6 - Western Colorado: There are no reliable estimates of current or historical resident lynx numbers in this unit. Lynx habitat in Colorado is distributed west of US Interstate-25. This unit is not directly connected to lynx populations in Canada. Compared to the time of listing and completion of the Southern Rockies Lynx Amendment, two bark beetle epidemics have altered large areas of lynx habitat in Colorado. Similarly, large wildfires have reset successional conditions in many areas. Areas affected by beetles that contained multistoried stand conditions likely continue to provide habitat to support snowshoe hares and lynx. Areas affected by beetles and fire require 20 plus years to recover to a point where the stands will again support snowshoe hares. The CPW completed their lynx reintroduction, and based on information generated during on-going studies, and reports received by CPW and the USFS, lynx continue to persist, at least in the San Juan Mountains. However, we believe it is reasonable that lynx continue to occupy all National Forests within the State of Colorado (Odell undocumented pers comm. April 4, 2016), and Rocky Mountain National Park (Shenk 2008, page 3). Habitat that supports snowshoe hares is patchily distributed in this geographic unit, which limits their abundance. Because the majority (90 percent) of lynx habitat in Colorado is under Federal land management, actions occurring on other ownerships are unlikely to result in significant losses of lynx habitat within this unit. The USFS manages over 85 percent of the lynx habitat in this unit, providing conservation through the Southern Rockies Lynx Amendment. However, regulatory mechanisms for the conservation of lynx are lacking on approximately 3,159 km^2 (1,220 mi^2; over 12 percent) of this unit, including lynx habitats on some BLM and some non-Federal lands.

Table 4. Summary of current conditions in six geographic units within the DPS range.

	Unit 1 - Northern ME	Unit 2 - Northeastern MN	Unit 3 - Northwestern MT, Northeastern ID	Unit 4 - North-central WA	Unit 5 - Greater Yellowstone Area	Unit 6 - Western CO
Unit Size (km^2)	28,909	21,101	26,997	5,176	23,687	25,294
Percent of Unit in Conservation Ownership (i.e., Federal, State, Tribal, Conservation Org.)	10	75 - 90	> 95	> 90	> 95	> 90
Connectivity to Lynx Populations/ Habitats in Canada	Directly connected to lynx habitats/ populations in s. Quebec and n. New Brunswick; evidence of natural movement, but rates of immigration/ emigration unknown	Directly connected to lynx habitats/ populations in s. Ontario; evidence of natural movement, but rates of immigration/ emigration unknown	Directly connected to lynx habitats/ populations in s. Alberta and s. British Columbia; evidence of natural movement, but rates of immigration/ emigration unknown	Directly connected to lynx habitats/ populations in s. British Columbia; evidence of natural movement, but rates of immigration/ emigration unknown	No direct connection; rates of immigration/ emigration unknown	No direct connection; rates of immigration/ emigration unknown
Home Range Size (Adult Female, km^2)	25 - 33	17 - 21	43 - 115	37 - 91	50 (1 female, 3 yrs)	75 - 704
Productivity – Percent Females with Kittens	89% (high hares); 30% (low hares);	100%	83% (Purcells); 61% (Seeley Lake)	100% (2 females)	Few data	24%
Productivity - Litter Size	2.74 (high hares); 2.25 (low hares)	3.3	2.95 (Purcells); 2.24 (Seeley Lake)	2.25 (2 females)	3.0 (1 female, 2 yrs)	2.75
Average Annual Adult Survival Rate	0.80 (high hares); 0.71 (low hares)	0.75 - 1.00	0.85 (Purcells); 0.75 (Seeley Lake)	0.86	Few data	0.93 (in Core Release Area [CRA]); 0.82 (out of CRA)
Lambda (Annual Rate of Population Change)	1.16 (high hares, 6 yrs); 0.88 (low hares, 4 yrs)	No estimate	1.16 (Purcells, 4 yrs); 0.92 (Seeley Lake, 8 yrs)	No estimate	No estimate	No estimate

4.2 Current Conditions - Detailed Descriptions by Geographic Unit

4.2.1 Unit 1 - Northern Maine

The “Northern Maine unit” includes the core, occupied habitat in northern Maine, which is designated critical habitat. It also includes areas where lynx have recently occurred in western and eastern Maine and northern New Hampshire and Vermont. To be consistent with the Workshop Report, we refer to this collective region as the Northern Maine unit.

Unit Description: This unit encompasses northern hardwood and spruce-fir forest (the Acadian forest) primarily in northern Maine, but also small areas of northern New Hampshire and Vermont. Climate in this region is characterized by warm summers and some of the coldest temperatures and highest snowfalls in the eastern U. S.; a function of latitude, elevation, and distance from the ocean. The average terrain rises in northern Maine to 1,000-1,500 feet with mountain peaks, particularly in western Maine, northern New Hampshire and Vermont from 3,000 to 5,000 feet. This region is far enough inland to be unaffected by marine influences. Average annual precipitation is currently 104 cm (41 in), with greatest precipitation in winter in the form of snow (average total snowfall is 228-280 cm (90 -110 in), with higher amounts at the highest elevations. Snow duration is about four months (mid-November through mid-April).

Maine - Much of the lynx habitat in northern Maine occurs within the designated critical habitat boundary, which is approximately 28,909 km^2 (11,162 mi^2) all in northern Maine (79 FR pp. 54823-54828). Land ownership in the critical habitat unit boundary is about 90 percent private, seven percent State (primarily Baxter State Park), one percent Federal (the newly-designated Katahdin Woods and Waters National Monument and Appalachian Trail Corridor), and one percent Tribal (Passamaquoddy Tribe, Penobscot Indian Nation). Private lands are almost entirely commercial forest lands. Lynx regularly occur outside of the designated critical habitat boundary in parts of northeastern, eastern, and western Maine and, recently, in northernmost New Hampshire and Vermont (see below).

New Hampshire - Habitat in northern New Hampshire is not within the designated critical habitat. Potential habitat is limited (Hoving 2001, p. 59), and the few habitat patches that support lynx in New Hampshire are much smaller than those in northern Maine (Litvaitis and Tash 2005, Fig. 2 and p. A–298; Robinson 2006, Fig. 3.3, p. 99). Hoving estimated approximately 1,000 km^2 (386 mi^2) of potential habitat having a greater than 50 percent probability of being occupied by lynx (68 FR 40086). Litvaitis and Tash (2005, p. A–298) estimated that New Hampshire contains about 888 km^2 (343 mi^2) of potential Canada lynx habitat. Historical distribution in New Hampshire included Coos and northern Carroll and Grafton counties (i.e., White Mountain National Forest; Siegler 1971, Silver 1974, Hoving *et al.* 2003). Habitats with the highest probability of occurrence are in Pittsburg in northern New Hampshire and the White Mountain National Forest in the central area of the State (Siren 2014, p. 34). The majority of the habitat in northern New Hampshire is located on the 101-km^2 (39-mi^2) Connecticut Lakes Natural Area (CLNA), which is owned and managed by New Hampshire Fish and Game. Surrounding habitat is owned and managed by the Connecticut Lakes Timber Company under a conservation easement held by the State. Occurrence records from the past 10 years have been centered on these two ownerships (Kilborn 2015, App. A, pp. 42-43). The CLNA includes 61 km^2 (23 mi^2) considered core lynx habitat with a conservation easement under which it will be allowed to mature to a climax forest type potentially providing good denning habitat but restricting the amount of snowshoe hare habitat in the foreseeable future. Current conditions are in a transition state, and portions of the core area currently support higher densities of snowshoe hare because of past forest management (Kilborn 2015, App. A pp. 42-43). Regional-scale modeling suggests that a high component of deciduous forest and insufficient snow conditions in New Hampshire are unlikely to support viable lynx populations over time (Hoving *et al.* 2005, pp. 739, 749).

Vermont – Potential lynx habitat in northern Vermont is not within the designated critical habitat. Recent modeling to determine lynx habitat connectivity in the Northeast suggests that the Nulhegan River Basin contains Vermont's best lynx habitat (Farrell 2012). The 530-km^2 (205-mi^2) area is approximately 20 percent Federal (Nulhegan National Wildlife Refuge), 17 percent State (Vermont Department of Natural Resources), and 63 percent private commercial timber lands (with conservation easement). The future persistence of lynx in Vermont is unlikely because of the patchy and limited amount of potential habitat, climate change (decreasing snow), trends toward hardwood management, and increasing human disturbance (Vermont Fish and Wildlife 2015, Appendix A5 p. 127).

The Northern Maine geographic unit is directly connected to lynx habitats and populations in southern Quebec and northern New Brunswick, Canada. Lynx in this unit represent the southern extent of a larger cross-border population, most of which occurs in the Gaspe region of southern Quebec and northern New Brunswick (Ray *et al.* 2002, pp. 17-20). Lynx in the northern Maine unit are geographically isolated by the St. Lawrence River from lynx populations in central Quebec (120 km [75 mi] north of Maine). Lynx populations in Maine and eastern Canada are geographically isolated from other lynx populations on the island of Newfoundland (900 km [559 mi] east of Maine), and on Cape Breton Island, Nova Scotia (650 km [404 mi] southeast of Maine) (Koen *et al.* 2015, entire). The closest lynx population in the DPS is located in northeastern Minnesota, about 1,700 km (1,056 mi) west of Maine.

<u>Habitat Description</u>: In the Northern Maine Unit, most lynx occurrence records are found within the broadly described ''Mixed Forest-Coniferous Forest-Tundra'' cover type (68 FR 40086). This habitat type occurs along the northern Appalachian Mountain range from southeastern Quebec, northern New Brunswick, and northern and western Maine, south through northern New Hampshire. This habitat type becomes naturally fragmented and begins to diminish to the south and west, with a disjunct segment running north-south through Vermont, and a patch of habitat in the Adirondacks of northern New York (McKelvey *et al.* 2000a, pp. 248-250). This area is part of the Acadian Forest Region (Rowe 1972, p. 112-129) representing a transition between northern boreal spruce and balsam fir and southern temperate deciduous forests (Seymour and Hunter 1992, pp. 3-4). Northern Maine is characterized by low-relief, hilly terrain, but with some higher elevations up to 1,600 m (5,250 ft; e.g., Katahdin Highlands, western Maine, White Mountains in central New Hampshire). Higher elevations support a predominantly coniferous forest (white, red, and black spruce; balsam fir; eastern white pine) intermixed with northern hardwoods (red maple, aspen, white birch, sugar maple, beech, and yellow birch). Lowland areas include spruce-fir flats interspersed with peatlands (black spruce, tamarack).

Current lynx and hare habitats are associated with spruce-fir stands repeatedly harvested for forest products. Hares and lynx are associated with stands of regenerating sapling (15–35 years old) spruce-fir forest that provide dense horizontal cover (Robinson 2006, pp. 26–36; Vashon *et al.* 2012, p. 15). Lynx are more likely to occur in large (100 km^2 [40 mi^2]) landscapes having a high percentage (>27 percent) of regenerating forest, and less likely to occur in landscapes with very recent clearcut or extensive partial harvest (Hoving *et al.* 2004, pp. 291–292; Simons-Legaard *et al.* 2013, entire). Regenerating stands used by lynx generally develop after forest disturbance (almost exclusively logging) and are characterized by dense horizontal structure and high stem density within one m of the ground. These habitats support the highest snowshoe hare densities (Homyack 2003, p. 63; Fuller and Harrison 2005, pp. 716, 719; Vashon *et al.* 2005a, pp. 10–11). At the stand scale, lynx in northwestern Maine selected older (11- to 26-year-old), tall (4.6 to 7.3 m [15 to 24 ft]) regenerating clearcut stands and older (11- to 21-year-old) partially harvested stands (Fuller *et al.* 2007, pp. 1980, 1983–1985). At the home range scale, lynx select landscapes having extensive regenerating conifer forest, but also with some mature conifer forest (Simons-Legaard *et al.* 2013, pp. 572–573). Lynx may select partial harvested and mature conifer stands because of increased ease of travel and prey access along the extensive edges with high-quality (regenerating clear-cut) habitats (Simons-Legaard *et al.* 2013, p. 574).

Most of the high-quality hare and lynx habitat in northern Maine is the result of extensive landscape-scale clearcut timber harvesting in response to a spruce budworm outbreak in the 1970s–1980s (Simons 2009, pp. 64, 218). Many of these clearcuts were also treated with herbicides to promote conifer regeneration by suppressing deciduous tree species. Both the current amount of high-quality habitat and the lynx population in Maine are likely larger than occurred prior to European settlement, when a relatively smaller proportion of the forest was in an early successional stage (Lorimer 1977, entire; Vashon *et al.* 2012, pp. 45, 56). Historically, the natural disturbance regime (fires, windthrow, insect outbreaks) resulted in smaller, more frequent disturbances and long intervals between larger disturbances.

Snowshoe hare populations in Maine do not seem to cycle at 10-year intervals, but they have experienced a period of high (1995-2005) and low (2006 to present) populations (Scott 2009, pp. 1-44; D. Harrison, Univ. Maine, unpub. Data; Vashon *et al.* 2012, p. 14). Prior to 2006, several estimates of hare densities in the highest quality, regenerating conifer or mixed forest averaged 1.9 (Homyack *et al.* 2007, p. 8) to 2.1 hares/ha (Robinson 2006, p. 26,). After 2006, hare densities declined by about half in all stand types and have remained at these lower levels (Scott 2009, p. 109; D. Harrison, Univ. Maine, unpub. data). Similar trends were observed in the Gaspe Region of Quebec (Assells *et al.* 2007, entire). In 1990, hare densities in dense, regenerating spruce-fir stands in New Hampshire were 0.5 hares/ha at low and high elevation (Brocke *et al.* 1990, p. 61). More recently, Siren *et al.* (2015) reported lower densities in New Hampshire (0.25 to 0.36 hares/ha) in both montane and lowland spruce-fir. Densities in high elevation (krumholtz, stunted spruce-fir) were only 0.19 to 0.28 hares/ha. Comparable hare density data are not available for Vermont or New York. The average landscape hare density in home range-sized areas occupied by lynx in Maine was 0.74 hares/ha (Simons-Legaard *et al.* 2013, p. 567). Based on these observations, Simons-Legaard *et al.* (2013, p. 576) recommended maintaining landscape hare densities of at least 0.74 hares/ha (or 27 percent of 100-km^2 areas in high-quality hare habitat) to conserve lynx.

<u>Habitat Status</u>: As elsewhere in the DPS, boreal spruce-fir forest habitats in the Northern Maine Unit are patchily distributed and intermixed with northern hardwoods, riparian areas, and peatlands. USFS forest inventory data indicate that over 16,000 km^2 of forestland are classified as spruce-fir in Aroostook, Penobscot, Piscataquis, and Somerset Counties in northern Maine (McWilliams *et al.* 2005, p. 122), although not all of this forest type is in areas occupied by lynx. In a roughly 14,500-km^2 area in northern Maine (approximately 50 percent of the designated critical habitat), Simons-Legaard (2016, p. 9-10) estimated that approximately 3,845 km^2 of the forested landscape was comprised of spruce-fir in a young, regenerating stand condition that provide high quality hare habitat. This habitat is similar to, and contiguous with, forested areas in Quebec and New Brunswick, Canada that support lynx (Hoving *et al.* 2005, pp. 740-741). The current range of lynx in the Northern Maine Unit is associated with areas of deep snowfall,

extensive (100-km^2 [40-mi^2]) forested landscapes, and areas having a high proportion of regenerating conifer-dominated forest that had previously been clearcut and treated with herbicides to suppress hardwoods (Homyack 2003, p. 2; Hoving *et al.* 2004, p. 287).

Lynx habitat in the northern Maine unit is associated with large-scale, intensive forest management (Harper *et al.* 1990, entire; Hoving *et al.* 2004, pp. 291-292; Simons 2009, p. 8; FR 74 8616–8701). Patches of boreal forest in New Hampshire, Vermont, and New York are more highly fragmented and smaller than in northern Maine. These more southerly forests also contain a higher proportion of northern hardwood and are believed to lack an adequate conifer component needed to produce sufficient snowshoe hare densities to consistently support resident lynx populations (Hoving *et al.* 2005, p. 749; Carroll 2007, p. 1100).

In general, landscape scale and home range scale habitat selection by lynx on industrial forest lands reinforce the importance of dense regenerating conifer forest along with a component of mature conifers (Hoving *et al.* 2004, p. 286; Vashon *et al.* 2008b, pp. 1494-1495, Simons 2009, pp.64-110; Simons-Legaard *et al.* 2013, p. 568). Simons-Legaard *et al.* (2013, p. 573) found the probability of lynx occurrence was >50 percent when snowshoe hare landscape densities were >0.74 hares/ha (0.39/ac) and there was >10 percent mature conifer forest. In Maine, lynx selected softwood-dominated (spruce and fir) regenerating stands (Fuller *et al.* 2007, pp. 1983-1985; Vashon *et al.* 2008b, pp. 1492-1495) and adjacent older (11–21 years post-harvest) partially-harvested stands (Fuller *et al.* 2007, pp. 1983-1985). Lynx were more likely to occur in landscapes with abundant regenerating forest, and less likely to occur in landscapes dominated by recent clearcut or partially harvested stands (Hoving *et al.* 2004, pp.289-292). Regenerating stands used by lynx typically developed 15–30 years after harvest (Hoving *et al.* 2004, p. 291), and were characterized by high stem density and dense horizontal cover within 1 m (3 ft) of the ground (Robinson 2006 pp. 33-35, Scott 2009, pp. 81-93; Fuller and Harrison 2010, p. 1276-1278). These habitats supported high snowshoe hare densities (Homyack 2003, p. 53; Fuller and Harrison 2005, p. 716, Vashon *et al.* 2008b, p. 1492; Scott 2009, pp. 24, 32, 36-44). At a landscape scale, lynx habitat selection did not differ between sexes; however, at a home range scale, males tended to use more mature forest dominated by conifers than females, and both male and female lynx tended to avoid mature forests that had a high deciduous component (Vashon *et al.* 2008b, pp. 1492-1493).

During winter, lynx primarily selected tall (4.4–7.3 m [14.5–24 ft]) regenerating clearcuts and established partially harvested stands that were 11–21 years post-harvest (Fuller *et al.* 2007, pp. 1984-1985). Lynx selected against mature second-growth stands (>40 years old), short (3.4–4.3 m [11–14 ft]) regenerating clear-cut or partially harvested stands <10 years post-harvest, and roads and road edges (Fuller *et al.* 2007, pp. 1980, 1983-1985). Research of year-round habitat use yielded similar results, with lynx preferentially using conifer-dominated sapling stands that were 3.4–7.3 m (11–24 ft) in height and supported high densities of snowshoe hares (Vashon *et al.* 2008b, pp. 1492-1495). Lynx tended to forage in areas with intermediate to high snowshoe hare densities (tall regenerating or older partial harvest stands), which afforded lynx with greater mobility and where snowshoe hares were more vulnerable to predation, rather than in the densest stands (short regenerating stands; Fuller and Harrison 2010, pp. 1276-1278).

Denning habitat included various types of coarse woody debris; blowdown, deadfalls, and root wads. In northern Maine, the majority of natal dens (12 of 26) occurred in conifer-dominated sapling stands, and 6 dens were found in mature or mixed multi-story forest stands dominated by conifers (Organ *et al.* 2008, pp. 1515-1517).

Historically lynx habitat in the northern Maine unit was likely uncommon. Both the current amount of high-quality habitat and the lynx population in Maine are likely larger than occurred prior to European settlement, when a relatively smaller proportion of the forest was in an early successional stage (Lorimer 1977, entire; Vashon *et al.* 2012, pp. 45, 56). In the Northeast prior to European settlement, lynx habitat was created and maintained by frequent, small-scale forest gap dynamic events and infrequent, large-scale stand-replacing forest disturbances (Seymour *et al.* 2002, pp. 359-365; Lorimer and White 2003, pp. 54-58). Higher elevation boreal forests often exhibit an even-aged wind-throw phenomenon known as fir-waves (Sprugel 1976, entire). Large, stand-replacing events (fire, wind and ice storms, insect outbreaks) are rare (interval of several hundred to several thousand years) and highly variable in size (Seymour *et al.* 2002, entire; Lorimer and White 2003, pp. 50, 54, 59). Spruce budworm, spruce beetle, beech bark disease, and sugar maple defoliators have been important influences affecting forest landscape patterns (McNab and Avers 1994, Chapter 14). The frequency and intensity of spruce budworm outbreaks, the most likely insect to affect lynx habitat, have been highly variable in Maine and eastern Canada in recent centuries (Blais 1983, entire). In this geographic area, wildfire is less significant as a natural agent of disturbance. The typical fire regime is infrequent surface fires in the dormant season in the hardwood forests, and slightly more frequent but long-interval fires in conifer forests (Kilgore and Heinselman 1990, entire; Seymour *et al.* 2002, pp. 359-365, Lorimer and White 2003, p. 59). For the past several decades, early successional forests and lynx habitat in northern Maine, New Brunswick, and southern Quebec have been created almost exclusively by forest management (Lorimer and White 2003, pp. 42-43).

Favorable habitat conditions for snowshoe hare and lynx in Maine resulted from large-scale salvage cutting (clearcutting) following a spruce budworm outbreak in the 1970s and 1980s (Hoving *et al.* 2004, p. 291). After salvage harvest of the affected trees, a portion of the area was sprayed with herbicide to reduce deciduous competition (Scott 2009, pp. 7, 14). The resulting vegetation was dominated by balsam fir and red or black spruce (Scott 2009, p. 60). This created favorable habitat conditions for snowshoe hares and lynx. Habitat conditions for hares and lynx in the unit improved from the late-1980s to present, benefitting from stand-replacing salvage harvests during the last budworm outbreak (Simons 2009, pp. 122-229; Simons-Legaard *et al.* 2016, entire). During this time period, the percentage of forestland with an average landscape hare density greater than 0.5 hares/ha increased 400 percent (Simons-Legaard *et al.* 2016, p. 7).

Current habitat is likely at historically high levels, but this habitat has peaked and lynx habitat will decline in the near future. In response to the widespread clearcutting in the 1980s, in 1989 Maine passed the Forest Practices Act. This Act regulated clearcutting. Various forms of partial harvesting replaced clearcutting as the predominant form of forest management in northern

Maine. Partially harvested stands (e.g., selection harvest, shelterwood harvest, overstory removal) have a wide range of residual stand conditions, but many have lower conifer stem densities and higher hardwood density than regenerating clearcuts (Robinson 2006, p. 29). On average, partially harvested stands support about 50 percent of the hare densities observed in regenerating clearcuts (Robinson 2006, p. 26-27).

Maine's forest practices shifted dramatically after the Maine Forest Practices Act. Over 95 percent of cutting that occurs now in northern Maine is partial harvesting compared to 59 percent in 1988 (Scott 2009, p. 8; Simons 2009, pp.45-47, 69-71; Simons-Legaard *et al.* 2013). This new cutting regime results in lower landscape densities of snowshoe hares (Fuller 1999, Homyack 2003, Robinson 2006, Scott 2009). Another consequence of partial harvesting is that a much greater acreage needs to be cut annually to attain similar harvest volume (as compared to clearcutting). Annual harvest rates have increased from about 100,000 acres per year (before the Forest Practices Act) to about 500,000 acres per year (after the Act). Thus, 17 years after the Maine Forest Practices Act, much of the forested landscape in northern Maine has been partially harvested.

Long-term, binding land management commitments are lacking in the northern Maine unit. Unlike Federal lands, there is no requirement that private landowners comply with lynx management guidelines, and a Federal nexus for review of forestry projects is almost nonexistent. Furthermore, there continues to be high turnover in forest land ownership (Hagan *et al.* 2005; Nadeau-Drillen and Ippoliti 2006) and little funding to provide incentives or to work with private landowners. As of 2005, there were 23 landowners in northern Maine with land holdings in excess of 100,000 acres including the State, Federal government (White Mountain National Forest south of lynx range), a conservation group (The Nature Conservancy), two tribes (Penobscot Indian Nation and Passamaquoddy Tribe with much land south of lynx range) and 18 private forest landowners (Nadeau-Drillen and Ippoliti 2006, p. 13).

There are short-term commitments to manage lynx habitat in the northern Maine unit. In 2003, Congress passed the Healthy Forest Restoration Act. Title V of this Act designates a Healthy Forest Reserve Program (HFRP) with objectives to: (1) promote the recovery of threatened and endangered species, (2) improve biodiversity, and (3) enhance carbon sequestration. In 2006, Congress provided the first funding for the HFRP, and Maine, Arkansas, and Mississippi were chosen as pilot States to receive funding through their respective Natural Resources Conservation Service (NRCS) State offices. Based on a successful pilot program, in 2008, the HFRP was reauthorized as part of the Farm Bill, and in 2010, NRCS published a final rule in theFederal Register (75 FR 6539) amending regulations for the HFRP based on provisions amended by the bill.

In 2006 and 2007, the NRCS offered the HFRP to landowners in the proposed Canada lynx critical habitat unit in Maine to promote development of Canada lynx forest management plans. Since that time four private landowners, The Nature Conservancy, the Passamaquoddy Tribe, Merriweather LLC, and Katahdin Forestlands successfully enrolled in the program. Collectively, these land ownerships comprised 2,443 km^2 (943 mi^2), or 9.3 percent of the total designated critical habitat in northern Maine in 2014 (79 FR 54828).

The NRCS required that lynx forest management plans must be based on the Service's ''Canada Lynx Habitat Management Guidelines for Maine'' (McCollough 2007, entire). These guidelines were developed from the best available science on lynx management for Maine. The guidelines required maintenance of landscapes having hare densities that support reproducing lynx populations. Notably, HFRP forest management plans provided a net conservation benefit for lynx, which was achieved by employing the lynx guidelines, identifying baseline habitat conditions, and meeting NRCS standards for forest plans. Plans met NRCS HFRP criteria and guidelines and complied with numerous environmental standards. Plans were reviewed and approved by the NRCS with assistance from the Service. The details of the plans are proprietary and will not be made public per NRCS policy.

Short-term commitments to lynx management will expire in 2016 and 2017. Unlike lynx forest plans on Federal lands, HFRP plans lack long term commitments beyond an initial 10-year contract period. Plans were prepared for a forest rotation (70 years) and include a decade-by-decade assessment of the location and anticipated condition of lynx habitat on the ownership. However, landowners are only committed to a 10-year contract, and long-term commitments to lynx management are voluntary. Some landowners developed plans exclusively for lynx, and others combined lynx management (umbrella species for young forest) with American marten (umbrella species for mature forest) and other biodiversity objectives. All four plans have been completed and contracts with NRCS will expire in 2016 and 2017. Landowners have the option to convert HFRP contracts into Safe Harbor Agreements or other agreements to provide regulatory assurances, however, at this time this option has not been explored with landowners.

Many large private forest landowners in the northern Maine unit could potentially include lynx management as part of endangered species management required by forest certification programs. For example, The Nature Conservancy land enrolled in the HFRP is also enrolled in the Forest Stewardship Council (FSC) forest certification program, which requires safeguards for threatened and endangered species. Other landowners are certified under the Sustainable Forestry Initiative (SFI). Both certification programs require planning for threatened and endangered species. However, certification programs are also voluntary and may not include long-term commitments. Few certified landowners have consulted with the Service on forest management for lynx. Given the frequent turnover in Maine forest lands, new landowners do not always renew certification or resume the certification programs initiated by the previous landowner.

<u>Lynx Status</u>: Historically, Maine seems to have consistently had a breeding population of lynx. Early written accounts did not consistently distinguish bobcats from lynx (Hoving 2001). Prior to 1939, lynx observations were based largely on written accounts of lynx from museum records, journals, and periodicals (Vashon *et al*. 2012, p. 56). Hoving *et al*. (2003, pp. 368-369) compiled 118 lynx occurrence records (509 individual lynx) from 1833-1999, which suggest that lynx were widespread throughout the state except for coastal areas. These records included 39 kittens

representing at least 21 litters, primarily in northern and western Maine, from 1864-1999 (Hoving *et al*. 2003, p. 371). Populations apparently fluctuated, and in some years 200-300 lynx were harvested in Maine (Hoving *et al*. 2003, pp. 373-374). Lynx were later documented in winter snow track surveys conducted by MDIFW during 1994-1998 (Vashon *et al*. 2012, p. 56).

At the time of listing, lynx were known to be present in northern Maine but little was known about their distribution, population size, and trend, snowshoe hare populations, and relationships to forest management. Since then, research from the Maine Department of Inland Fisheries and Wildlife (Vashon *et al.* 2008a, entire; 2008b, entire; and 2012 entire) and the University of Maine (Hoving *et al.* 2003, entire; Hoving *et al.* 2004, entire; Hoving *et al.* 2005, entire; Homyack *et al.* 2005, entire; Homyack *et al.* 2007, entire; Homyack *et al.* 2006, entire; Fuller *et al.* 2007, entire; Fuller *et al.* 2004, entire; Fuller and Harrison 2005, entire; Simons-Legaard *et al.* 2013, entire; Simons-Legaard *et al.* 2016, entire) have greatly increased our knowledge. Snow track surveys and confirmed occurrence records (Vashon *et al.* 2012, entire; Siren 2015, entire) document that lynx occur throughout northern Maine and in small, isolated pockets in western and eastern Maine, northern New Hampshire, and Vermont (Siren 2015, entire). Population size and trends are still uncertain.

The Northern Maine Unit currently supports a breeding population of lynx that encompasses most of northern Maine, with recent lynx occurrence and reproduction also documented in northernmost New Hampshire and Vermont. This geographic unit is part of a larger, contiguous lynx population that extends into northern New Brunswick and the Gaspe region of southern Quebec. Extensive areas of contiguous forestland in this region provide high connectivity between populations in Maine and Canada. Lynx populations in adjacent southern Quebec may exhibit cyclic populations (Ray *et al*. 2002, entire), but obvious immigration of large numbers of lynx into Maine associated with hare cycles (if they occur) has not been documented (Hoving *et al*. 2003, pp. 373-374). Although potential lynx habitat in New Hampshire and Vermont is fragmented, there is near contiguous forest and connectivity for lynx movement between these areas and habitats in northern Maine (Farrell 2013, *pers*. *comm*.; 79 FR 54821). Breeding lynx in New Hampshire and Vermont are not directly connected to Canadian populations, but they are connected to the larger population in northern Maine via habitat corridors in western Maine.

Lynx in the Northern Maine Unit and adjacent populations in southern Quebec and northern New Brunswick are separated from lynx populations in the interior of Canada. The St. Lawrence River restricts lynx dispersal and demographically isolates this population from those in northern Quebec, Labrador, and Ontario. However, sufficient numbers of individuals cross the river on the ice each generation to prevent genetic drift of this population (Koen *et al.* 2015).

At the time of listing, the Northern Maine Unit was not believed to contribute significantly to the DPS. However, we now believe that the extensive young, regenerating spruce-fir habitat created by large-scale clearcutting in the 1970s and 1980s may currently support the largest lynx population in the DPS, numbering at least several hundred and perhaps more than 1,000 resident lynx (Vashon *et al.* 2012, pp. 58-59, Appendix IV; Vashon *in* Lynx SSA Team 2016, p. 18) . Habitat in northern Maine can support lynx densities in localized areas of high-quality habitat that are substantially greater than densities elsewhere in the DPS (LCAS 2013, p. 23). In 2003 when hare populations were high, lynx density (juveniles and adults) in one of Maine's highest-quality habitats was estimated to be 9.2-13.0 lynx/100 km^2 (Vashon *et al.* 2008a, Vashon *et al.* 2012, p. 15). At about the same time, the density of lynx in nearby Gaspe Peninsula, Quebec was estimated to be 10 lynx/100 km^2 (Ray *et al.* 2002). These densities are intermediate to those in Canada during the high (17.0-44.9/100 km^2) and low periods (2.3-3.0/100 km^2) of the lynx-hare cycle (Poole 1994, Slough and Mowat 1996, O'Donaghue *et al.* 1997). Simons (2009, p. 102) estimated that habitat on a 14,407-km^2 (5,563-mi^2) study area (about half of the critical habitat area designated in 2014) in northern Maine could potentially support a population of 236 to 355 adult lynx, and Vashon *et al.* (2012, pp. 58-59 and Appendix IV) estimated the potential for a population of 750 to 1,000 adult lynx in all of northern Maine in 2006. The actual number of lynx is unknown because there are no methods available to measure and produce true population estimates over such a large geographic area.

Lynx seem to have maintained a similar distribution throughout northern Maine since the 1970s, and are found primarily north of Moosehead Lake and west of Interstate 95, with scattered pockets in western and eastern Maine (Hoving *et al*. 2003, p. 369; Vashon *et al*. 2012, pp. 10-12.) Resident lynx in small pockets of habitat outside of the core range in Maine may occur only ephemerally, winking on an off over time as would be expected at the periphery of the range of a mainland-island metapopulation structure, and as suspected for other lynx populations at the periphery of the range (McKelvey *et al.* 2000b, pp. 25-31; Apps 2007, pp. 81, 95-104). From 1995-1998 and 2003-2008, the Maine Department of Inland Fisheries and Wildlife conducted snow track surveys in 66 townships to document the distribution of lynx and to inform habitat modeling at the University of Maine (Vashon *et al*. 2012, p. 91). Modeled areas of potential lynx habitat were well-distributed throughout northern Maine in the early 2000s (Simons-Legaard *et al*. 2016, entire; Simons 2016, entire).

Lynx populations in New Hampshire and Vermont may consist of only a few animals and they may be ephemeral, although breeding has been documented in both locations in recent years. Most historical lynx records from New Hampshire are from trapping records from the 1930s to the 1960s (Brocke *et al.* 1993, McKelvey *et al.* 2000a, pp. 212-214). There were only two records in the 1990s. In 2003, the Service determined that, despite a lack of breeding records, a small resident population likely occurred historically in New Hampshire but no longer exists (68 FR 40087). Lynx were detected in northern New Hampshire in 2006 and have occurred there annually since (Siren 2014, pp. 53, 55). In 2011, 4 lynx kittens were observed in Pittsburg and were considered evidence of breeding in New Hampshire (Kilborn 2015, Appendix A, p.44). There were only four historical records of lynx in Vermont prior to 2003. Since then, nine lynx sightings have been confirmed, and reproduction was first confirmed in 2012 in the Nulhegan Basin when the tracks of three lynx, a presumed family group, were observed travelling together in late February (Vermont Fish and Wildlife 2015, Appendix A5, p. 126). Since 2012, more intensive surveys in Vermont have resulted in only a single photograph of a lynx in 2014 (Bernier 2015, pp. 1-3; Bernier 2016, *pers. comm.*).

Resident lynx do not presently occur in New York. A resident population reportedly occurred historically in the Adirondack Region of northern New York, but it was considered extirpated by 1900 (Brocke 1982, McKelvey *et al.* 2000a, pp. 215-217). However, there are 23 verified lynx occurrences since 1900, primarily from the Adirondack Mountains, including the most recent verified record from 1973 (McKelvey *et al.* 2000a, p. 216. Habitat and prey conditions were deemed suitable for a lynx reintroduction in 1989–1991, when 83 lynx were released into the Adirondacks over three winters (Brocke 1982). The reintroduction was unsuccessful in establishing a resident population, and in 2003 the Service concluded that a resident population may have existed in New York prior to 1900, however, records of lynx since 1900 likely represent dispersers (68 FR 40087).

Maine lynx had spatial and demographic parameters similar to some northern populations during the cyclic high in the snowshoe hare cycle (Brand *et al.* 1976, Parker *et al.* 1983, O'Donaghue *et al.* 1997). From 1999 to 2011, biologists with the Maine Department of Inland Fisheries and Wildlife trapped and radio-marked 85 lynx in northern Maine and documented lynx movements and home range (Vashon *et al*. 2008a, entire), resource use (Vashon *et al*. 2008b, entire), survival (Vashon *et al*. 2012, pp. 18-21), productivity (Vashon *et al*. 2012, pp. 17-19), and other aspects of their life history (Vashon *et al*. 2012, entire).. During the period when snowshoe hare populations were highest (2000-2006), Maine lynx had among the highest reproductive rates (average litter size 2.74, 89 percent of adult females producing litters) in the DPS (Vashon *et al.* 2012, pp. 18-19). During the current (2006-present) period of low hare density, litter size was smaller, only 30 percent of females had litters, and mortality was greater. Maine lynx have among the smallest home ranges documented in the DPS (Vashon *et al*. 2008a, p. XX; LCAS 2013, p. 24; also see Table 3, above). Home range sizes were similar during periods of high and low hare density (Mallett 2014). Lynx populations likely increased during the period of high hare density (lambda [λ] = 1.16) and declined during periods of low hare density (λ = 0.88) (USFWS, Vortex10, deterministic population simulation 2016; demographic data from Vashon *et al.* 2012).

In summary, Maine lynx and hare habitats are believed currently to be at historical highs. In the Northeast prior to European settlement, lynx habitat was created and maintained by small-scale, frequent forest gap dynamic events and large-scale, infrequent (stand-replacing) forest disturbances (Seymour *et al.* 2002, Lorimer and White 2003). Historically, lynx distribution was patchy, and lynx populations likely fluctuated and were dependent on immigration from Canada. Current habitat is the result of widespread clearcutting to salvage spruce and fir damaged by a spruce budworm outbreak in the 1970s and 1980s and subsequent use of herbicides to suppress hardwoods (Hoving *et al.* 2004, Vashon *et al.* 2008b). Maine lynx at multiple scales select extensive areas of regenerating, dense (7,000 – 14,000 stems/ha) spruce-fir stands 15 to 35 years after clearcut or other even-aged harvest (Hoving *et al.* 2005, Fuller *et al.* 2007, Vashon *et al.* 2008b, Simons-Legaard *et al.* 2013). Lynx habitat is expected to remain stable for the next few years then decline because of changing forest practices (Simons-Legaard *et al.* 2016).

<u>Factors Affecting Current Conditions</u>

Climate Change - Climate change is affecting temperature, snow, and precipitation patterns in the Northeast at rates faster than expected (Rustad *et al.* 2014). Rapid winter warming in recent decades is believed to be caused by reduced albedo effect caused by the diminished persistence of snow in winter (Hayhoe *et al.* 2006). Average winter temperatures are increasing 0.42-0.46^{o} C/decade with the greatest warming occurring in the winter months (especially January and February; Burakowski *et al.* 2008). Under mid- to high-emissions scenarios, average mean temperatures in northern Maine are projected to increase by 12 to 14 degrees F by 2080-2099 relative to 1971-2000 (Galbraith *et al*. 2013, p. 43). Under a higher emissions scenario, snow covered days in northern Maine (December to February) could decrease from 30 days per month (100% of the time) observed from 1961-1990 to about 18-20 days per month in 2070-2099 (Galbraith *et al*. 2013, p. 49). Climate change has, and will continue to affect lynx by reducing snow and boreal forest (see section 5.2.1).

Snow Duration, Depth, and Quality - As noted in chapter 2, lynx occur where there is regularly at least four months (120 days) of continuous snow coverage (Gonzalez *et al.* 2007). Snow cover days in northern New England (1965-2005) ranged from 60-121 days and declined an average of 3.6 days/decade from 1965-2005 (Burakowski *et al.* 2008). Snow duration declined by 16 days in the Northeast from 1970 to 2001 (Wake 2005) and is expected to diminish another two weeks in Maine by mid-century (Fernandez *et al.* 2015). Thus, average conditions in Maine are currently at or below the snow persistence thresholds believed to be needed to support lynx (Gonzalez *et al.* 2007). Similarly, the largest decreases in snow depth observed in Canada in the last six decades have occurred in the lower St. Lawrence Valley, immediately north of Maine (Brown and Braaten 1998, pp. 48-52).

Lynx in the Northeast U.S. and eastern Canada occur where there is regularly total snowfall of at least 270 cm/yr (106 in/yr; Hoving *et al.* 2005), which defines the distribution of lynx (to the north) and bobcat (to the south) in this region (Hoving *et al.* 2005, Carroll 2007, Peers *et al.* 2013). Average annual snow depth at all five NOAA weather stations within the range of the lynx in northern Maine (1981-2010) was below this threshold and ranged from 228-263 cm (90-104 in; NOAA 2011, http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html, https://www.currentresults.com/Weather/Maine/annual-snowfall.php, last accessed 31 March, 2016). In the last 50 years, 18 of 23 snow sampling sites in and near Maine experienced reduced depth of snowpack (Hodgkins and Dudley 2006). Snow depth in New England (1965-2005) declined an average of 4.6 cm/decade (1.8 in/decade; Burakowski *et al.* 2008). Thus, average snow conditions in Maine are currently at or below snow depth thresholds for lynx, and further declines in annual snow depth would be expected to reduce the probability of lynx persistence in the region (Hoving *et al.* 2005).

As noted in chapter 2, deep, fluffy snow provides lynx with a competitive advantage over bobcats and gives snowshoe hares the ability to reach winter browse. Snow quality (“fluffiness”) has deteriorated in the Northeast. Unlike other units, annual precipitation in Maine is increasing because of climate change, but primarily as rain (A. Siren *in* Lynx SSA Team 2016, p. 15; Fernandez *et al.* 2016), and especially rain on snow events in winter in northern Maine

(Huntington and Hodgkins 2004, Deser *et al.* 2013, Fernandez *et al.* 2015). Snow density and compaction and crust conditions (caused by wet, heavy snow or rain on snow events in winter) have increased in northern New England (Dudley and Hodgkins 2002, Huntington *et al.* 2004, Huntington 2005, Hodgkins and Dudley 2006) and southern Canada (Karl *et al.* 1993).

Vegetation Management - The effects of forest management on foraging and denning habitat for lynx in northern Maine are discussed in the Habitat Description and Habitat Status sections above.

Wildland Fire Management - Although fire is frequent in many boreal forest regions, it is not a stressor for lynx in northern Maine. Annual precipitation is comparatively greater in this unit than others, and conditions for fire are infrequent. The fire regime in this unit is infrequent (50- to 200-year interval) and generally small (several acres) surface fires in the dormant season. Large (up to 80,000 acres) stand-replacing fires are rare and occur at a less frequent interval (800- to 9000-years) (Seymour *et al.* 2002, p. 360). In contrast, spruce budworm outbreaks cause stand-replacement over large areas every 100–250 years (Cogbill, 1985).

Habitat Fragmentation - Habitat fragmentation (smaller and more isolated patches of high quality hare habitat) caused by current forest practices in northern Maine is discussed in the Habitat Description and Habitat Status sections above.

Other Factors: *Trapping* - This unit is directly connected to lynx habitats and populations in southern Quebec, where trapping of lynx is legal. Several lynx that were captured and radio-tagged in northern Maine were subsequently trapped in southern Quebec (Vashon *et al.* 2012).The lynx trapping and hunting seasons were closed in the Northern Maine Unit (including New Hampshire and Vermont) for decades prior to lynx being listed as a threatened species. Hunting and trapping were discontinued in Maine in 1967 (Vashon *et al*. 2012, p. 28). Carroll (2007) modeled lynx populations in this unit and demonstrated that increased trapping pressure in Quebec could have a negative effect on protected lynx populations in Maine and New Brunswick. About 400 lynx are trapped and killed annually in Quebec south of the St. Lawrence River (http://mffp.gouv.qc.ca/english/wildlife/statistics/index.jsp last accessed May 19, 2016).

In 2014, the Maine Department of Inland Fisheries and Wildlife (MDIFW) worked with the Service to develop an *Incidental Take Plan for Maine's Trapping Program* (MDIFW 2014a, 2015b as amended, entire) and obtained a permit from the Service for lynx trapped incidental to other furbearer trapping in Maine. From 2000 to 2016, 114 lynx have been reported captured in traps set for other species and 8 of those were killed (Vashon *et al.* 2012, MDIFW 2014, p. 75). In Maine, after two lynx were killed in killer-type traps in 2014, the MDIFW imposed additional trapping restrictions to further reduce mortality and injury of incidentally-trapped lynx, (e.g., requiring killer-type traps be placed in exclusion boxes, eliminating the use of drag sets for foothold traps, and requiring multiple swivels on trap chains. No lynx have been reported incidentally trapped in New Hampshire or Vermont since 2000.

In areas where lynx are trapped for furs (Canada and Alaska), trapping can be additive to other sources of mortality and have population-level effects (Brand and Keith 1979, Koehler and Aubrey 1994). Thus, harvest regulations for lynx are modified (e.g., lynx quotas per trapper are reduced) when hare and lynx populations are low (Bailey *et al.* 1986). Trapping injury and mortality are not believed to have a population-level effect on lynx in northern Maine and adjacent Canada when lynx may be at historically high numbers, but trapping could have a synergistic and negative effect if hare and lynx populations decline, habitat declines, or climate change further stresses lynx (Slough and Mowatt 1996, Carroll 2007).

Wind Power Development - In response to climate change, interest in wind energy development has increased in northern and western Maine, posing a potential threat to high- and low-elevation spruce-fir habitats (Whitman *et al.* 2013). Maine has experienced a rapid increase in wind energy development (http://www.eia.gov/electricity/data/browser, last accessed August 2, 2016), and there is increased interest in placing developments on private lands in unpopulated areas in northern Maine, New Hampshire, and Vermont. Wind energy is an increasingly appealing source of income for investment companies and other landowners who own forestland in the northern Maine unit. As of 2016, at least 11 wind projects have been proposed in northern Maine and five projects are in operation; two have been proposed in northern New Hampshire and two are in operation; and three have been proposed for northeast Vermont and two are in operation or under construction. Maine's two largest wind projects (combined over 300 turbines covering 932 km^2 [360 mi^2]) are proposed entirely within Maine's designated lynx critical habitat. The effects of wind energy projects on lynx, hares, and their habitats are unknown. Potential direct effects include disturbance or displacement of resident lynx from large landscapes and loss and fragmentation of habitat from turbines, roads, and transmission lines. Increasing power infrastructure associated with these projects could greatly change development potential and patterns in northern Maine by bringing electricity into the interior of Maine's vast undeveloped forest region. Extensive road construction would further fragment habitat and increase access for recreation, including trapping.

Changing Land Ownership and Development - Until recently, the northern Maine unit was largely undeveloped and owned by about a dozen large, industrial forestland owners, but land ownership patterns have changed dramatically in the last 15 years (Nadeau-Drillen and Ippoliti 2006). Large tracts of land have been sold, lumber and pulp mills shut down, and much of the area has been sold to investment-oriented owners. Some investment-oriented landowners are seeking diversified financial returns on their investment, including developing residential housing, second homes, and resorts. Two large residential and resort areas have been proposed on forestlands within the Maine critical habitat area. Both development projects would result in the development of several thousand acres of potential lynx habitat, but would be mitigated by substantial (100,000s of acres) conservation easements on surrounding forestland. A private landowner recently donated 354 km^2 (137 mi^2) within designated lynx critical habitat that was subsequently designated as the Katahdin Woods and Waters National Monument. This area currently has a legacy of young-regenerating spruce-fir habitat from previous industrial forest landowners, but its new monument designation may limit future forest management activities (timber harvest or other vegetation management) that could benefit lynx. Another conservation landowner, The Nature Conservancy, continues forest management on about half of its 750-km^2 (290-mi^2) ownership, including managing part of the area for lynx.

Construction or expansion of developed areas such as residential areas and resorts and smaller recreational sites like Nordic ski huts or campgrounds may directly remove forest cover. Such habitat alteration and associated human recreation in lynx habitat could decrease prey availability, affect lynx movement within home ranges, result in a more fragmented landscape, affect lynx movement, or displace them from high quality habitats. Development further fragments habitat from road and highway construction (along with associated increases in traffic volumes and/or speeds) and increases the probability of road mortality.

In summary, lynx were historically and are currently widespread throughout northern Maine, and they currently occur (and probably occurred historically) as small resident or ephemeral populations in small patches of habitat in eastern and western Maine, northern New Hampshire, and northern Vermont. Habitat in northern Maine may currently support a potential population of 500 to 1000 lynx, although the actual population size is unknown. Habitat created by extensive clearcutting 30 to 40 years ago is peaking and will decline by 50 percent in the next 15 to 20 years (Simons-Legaard 2016, pp. 10-18; also see section 5.2.1, below). Furthermore, hare populations declined by 50 percent starting in about 2006 and have remained at lower levels. Future hare fluctuations or cycles are uncertain. Recent history demonstrates that some forms of forest management have the potential to create lynx habitat, but forest practices have shifted to partial harvesting, which is less likely to maintain or create high-quality lynx habitats, and private landowners do not have long-term commitments to manage for lynx conservation. Land ownership has dramatically changed in northern Maine, and the majority of lands are owned now by investment companies who wish to diversify income from their investments, which could result in forest practices inconsistent with lynx habitat conservation. The greatest stressors to resident lynx in this unit are habitat loss (shifts in forest management from clearcutting to partial harvesting resulting in lower landscape hare densities), lack of forest planning for lynx, and projected continued climate warming (diminishing snow depth, quality and duration; competition from bobcats and fishers; loss of spruce-fir to northern hardwoods; and future isolation of the metapopulation because of diminishing ice conditions on the St. Lawrence River).

4.2.2 Unit 2 - Northeastern Minnesota

<u>Unit Description</u>: This unit encompasses approximately 21,100 km^2 (8,147 mi^2) in northeastern Minnesota. It includes the area designated as critical habitat in 2014 (79 FR 54782) and an additional relatively small area of tribal land in northern Minnesota that was excluded from critical habitat. Land ownership in this unit is about 47 percent Federal (primarily USFS, with some NPS and BLM land); 36 percent State; 16 percent private; and 1 percent Tribal (Grand Portage Reservation) (see Table 2). This unit includes most of Superior National Forest (SNF; including the Boundary Waters Canoe Area Wilderness [BWCAW]) and Voyageurs National Park. This unit is directly connected to lynx habitats and populations in Canada, and lynx in this unit likely represent the southern extent of a larger cross-border population, most of which occurs in Ontario (ON). Relative to other DPS lynx populations, this unit is about 1,480 km (920

mi) east of the Northwest Montana/Northeast Idaho Unit and about 1,610 km (1,000 mi) west of the Northern Maine geographic unit.

Habitat Description: In Minnesota, most lynx occurrences are associated with the Mixed Deciduous/Conifer Forest (McKelvey *et al.* 2000a, pp. 246, 248) within the Laurentian Mixed Forest Province (McNab *et al.* 2007, p. 5). Most of this province is characterized by low-relief hilly landscapes with glacial features and an elevation from sea level to 730 m (2,400 ft), including many lakes and rivers. This unit contains a mix of upland conifer and hardwood interspersed with lowland conifer, alder or willow shrub swamps and black spruce or tamarack bogs. Coniferous and mixed-coniferous/deciduous vegetation types are dominated by balsam fir; black and white spruce; northern white cedar; Jack, white and red pine; hemlock; and tamarack; mixed with aspen and paper birch (Burdett 2008, p.5; Moen *et al.* 2009, pp.1-2; McCann and Moen 2011, p. 510). Burdett (2008, p. 57) reported that lynx in Minnesota selected regenerating forest, dominated by conifer with extensive forest edge; lynx beds (resting and hunting) and kill sites were associated with regenerating and mixed forest. McCann and Moen (2011, p. 513) found snowshoe hare densities were highest in regenerating forests. Females selected large woody debris and dense horizontal cover in lowland conifer cover for denning in northern Minnesota (Moen *et al.* 2008, p. 1510), but other cover types were used if recent blowdowns were present (Moen and Burdett 2009, p. 5).

Hare density in parts of northeastern Minnesota appears to be sufficient to support a viable lynx population (Moen *et al.* 2008, p. 1512), with stand-level densities ranging from 0.3–2.0 hares/ha (0.12–0.8 hares/ac; McCann 2006, p. 17). Hare populations in northeastern Minnesota appear to be patchily distributed, but are most consistently abundant in 10-30 year old regenerating forests (McCann 2006, p.45). Pellet count data prior to the 1990s show evidence of density fluctuations of snowshoe hare populations occupying Minnesota (Fuller and Heisey 1986, pp. 262-263), but these fluctuations were not observed during the 1990s (Hodges 2000a, p. 172). Snowshoe hare habitat in Minnesota primarily consists of conifer forests with dense low-growing understories, lowland shrub and conifer bogs. Conifer bogs or lowland conifer forests may be especially important during low points in hare cycles by acting as refugia for hares. Early regenerating or pole-sized stands are not used as much as in other portions of their range, although older regeneration stands were used frequently in Minnesota (McCann 2006, p. 45). Sapling-sized aspen adjacent to conifer cover may also provide functional snowshoe hare habitat. McCann and Moen (2011, pp. 512-513) mapped the distribution of predicted snowshoe hare habitat across northeastern Minnesota. In northeastern Minnesota, edge habitats and regenerating conifer stands appeared to be important for snowshoe hare populations (Burdett 2008, p. 58; McCann 2006, p. 45), as were dense habitats containing balsam fir, white spruce, and cedar (Fuller and Heisey 1986, p. 263). Recent research indicates that the red squirrel is not an important prey species for lynx in northeastern Minnesota (Burdett 2008, p. 62; Hanson & Moen 2008, p. 9).

Average annual snowfall in this unit ranges from about 180 cm (71 in) in the northwestern part of the unit near International Falls, Minnesota to 219 cm (86 in) in Duluth, Minnesota, on the southern end of the unit, to 228 cm (90 in) in Tofte, Minnesota, near the lake shore on the far eastern-central part of the unit, to 228 cm (90 in) in Isabella, Minnesota, near the center of the unit, to the 107 cm (42 in) in Grand Portage, Minnesota, at the northeastern tip of the unit. More snow is produced along Lake Superior, because of the lake effect (https://snowfall.weatherdb.com/d/a/Minnesota; accessed 4/25/2016).

Habitat Status: Friedman and Reich (2005, p. 732) conducted a spatially explicit forest composition change analysis on a 3.2 million hectare study area in northeastern Minnesota, which was based on General Land Office Survey records from the late 1800s and the 1990 USFS Inventory and Analysis Survey. The study documents altered forest tree species abundance, proportional basal area, and spatial distribution patterns. The proportionally most abundant species in northeastern Minnesota shifted from the presettlement period (spruce, 21 percent; larch, 15 percent; and paper birch, 15 percent) to aspen (30 percent), spruce (16 percent), and balsam fir (16 percent) in 1990. White pine declined from 20 percent to 5 percent basal area dominance, birch from 16 percent to 13 percent, spruce from 14 percent to 9 percent, and larch from 12 percent to 2 percent, while aspen increased from 8 percent to 35 percent basal area dominance.

In 2015, the SNF estimated that there were approximately 759,700 acres (60 percent of lynx habitat on the SNF) of suitable snowshoe hare habitat on the SNF and that only 23,800 acres of habitat on the SNF was in a condition unsuitable to lynx (USFS 2016, unpublished data).

The SNF continues to manage in accordance with its 2004 Forest Land and Resource Management Plan (USFS 2004a, entire). The Forest Plan emphasizes providing sustainable amounts of timber, maintaining or enhancing biodiversity, contributing to economic and social needs of the community, and managing in an environmentally sound manner to produce goods and services that provide for long-term public benefits. The Forest Plan includes many objectives, standards, and guidelines for the protection of lynx and enhancement of lynx habitat (USFS 2004a, Appendix E, pp. E-1 – E-12) that are based on recommendations in the 2000 LCAS (Ruediger *et al*. 2000, entire). LAUs were delineated on the SNF in 2000 as the smallest landscape scale on which to analyze effects to lynx. The boundaries have remained in place since that time to allow for long term analysis of project effects. However, the SNF Plan proposed several changes of current LAU boundaries, such as adding LAUs to the Virginia Management Unit of the Laurentian Ranger District, and designating the BWCAW a lynx refugium.

This unit is directly connected to lynx habitats and populations in southern Ontario, where trapping of lynx is legal. Habitat connectivity within and between portions of northeastern Minnesota and Canada appears functional based on radio-telemetry data that have documented lynx movements between Minnesota and Ontario (Burdett *et al.* 2007, p. 458; Moen 2009, pp. 4-6; Moen *et al.* 2010b, p. 5).

Lynx Status: At the time of listing, the Minnesota population was not believed to contribute significantly to the DPS. However, we now know that a reproducing resident population exists in northeastern Minnesota. Moen (*in* Lynx SSA Team 2016) recently estimated the potential for a population of about 50 to 200 lynx to occur in northeastern Minnesota. In 2008, Moen *et al.* (2008b, p. 30), estimated the number of lynx that might be resident in northeastern Minnesota at a given time as between 190 and 250 individuals, assuming that about 25 percent of northeast Minnesota is suitable lynx habitat, coupled with assumptions about residence time and detectability. The actual number of lynx is unknown because methods have not been implemented to measure and produce precise population estimates over such a large geographic area. We have no estimates of lynx densities in Minnesota.

Average home range sizes in Minnesota were reported as 194 km^2 (75 mi^2) for males and 87 km^2 (34 mi^2) for females (Mech 1980, p.263). Later radio-telemetry data showed that males had much larger average home range sizes (267 km^2 [103 mi^2]) than females (21 km^2 [8 mi^2]), and that females with kittens had the smallest home ranges (Burdett *et al.* 2007, pp. 460-461). A study of radio-collared lynx in Minnesota documented approximately 40 percent of male and female lynx making long distance movements outside of their home ranges and into southern Ontario, Canada (Moen *et al.* 2010b, p. 17). Among lynx that made long-distance movements, females tended to move 100-200 km (62-124 mi) and did not return to their original home ranges in Minnesota, while males moved 50-80 km (31-49 mi) back and forth between Ontario and Minnesota (Moen *et al.* 2010b, p. 17). While topographic features may influence lynx movements in mountainous western states, lynx in Minnesota tended to move along nearly straight paths (Moen *et al.* 2010b, p. 13).

The SNF and others have identified 268 unique individual lynx (48 percent Female, 51 percent Male) from DNA samples taken since 2000 (Catton *et al.* 2015, p. 1). Of the 1,306 DNA samples, 1,039 were identified as lynx; however, 42 samples were identified as F1 lynx-bobcat hybrids (Catton *et al.* 2015, p. 1). Of those 42 hybrids, 13 unique individual lynx-bobcat genotypes (5 Female, 8 Male) were also identified (Catton *et al.* 2015, p. 1). The DNA analyses also showed persistence of individual lynx in Minnesota of 2 years (N = 27 lynx), 3 years (N = 11), 4 years (N = 5), 5 years (N = 6), and 1 female lynx tracked for over 5 years, who produced 7 kittens in Minnesota (Catton *et al.* 2015, pp. 3-5).

Since 2000, the Service has documented 45 lynx mortalities in Minnesota including 16 that died of unknown causes, 11 that died after being incidentally captured in traps set for other species, nine that were hit by vehicles on roads, seven that were illegally shot, and two that were hit by trains (USFWS 2016, *unpublished data*). In addition to the 11 trapping mortalities, another 15 lynx were documented to have been incidentally trapped but released alive. The documented incidents largely occurred during legal trapping that targeted bobcat, coyote, fox, and marten, and involved a variety of traps including foot-holds, body gripping traps, and snares. It is probable that other lynx were incidentally trapped but not reported each year (Moen 2009, p. X). Additionally, lynx emigrating from Minnesota to Ontario are exposed to legal trapping and shooting in accordance with regulated harvest in Canada. At least a third of lynx radio-collared in Minnesota spent time in Ontario; 4 radio-collared lynx were legally harvested (trapped) in Canada between 2003 and 2010, and two died in Ontario of unknown causes (USFWS 2016, *unpublished data*). Minnesota has relatively high forest road and highway densities that intersect lynx habitat and several radio-collared lynx in Minnesota inhabited home ranges that were bisected by highways.

Factors Affecting Current Conditions

Identified factors affecting to the current conditions of lynx in Minnesota include reduction in habitat quality or quantity, habitat fragmentation, climate change, increased access for competing carnivores, and human-caused mortality. The SNF is currently implementing the 2004 SNF Plan (USFS 2004a, entire), which has direction based on the LCAS (Ruediger et al. 2000, entire) and the Canada Lynx Conservation Agreement (CA) between the Forest Service and the Service (USFS and USFWS 2000, entire), for all forest activities that occur within LAUs. Active management of forest lands can produce lynx habitat, and the SNF has a long-term commitment for doing so; however, private landowners do not. Under the Sustainable Forest Resource Act of 1995, the Minnesota Forest Resources Council (MFRC) has developed guidelines for site-level timber harvesting and forest management (MFRC 2012, p. 1) - these voluntary guidelines are intended for private and State landowners and include some general recommendations for wildlife including lynx. The implementation of the MFRC guidelines is monitored annually (e.g., MDNR 2015, entire). Thus, the several risk factors are being minimized and managed to promote the conservation of lynx within the SNF, however implementation of the guidelines on privately owned lands is voluntary.

Activities that change forest structure can affect habitat quantity and quality for lynx and snowshoe hares, their primary prey source. Thinning and other timber management practices that reduce stem density and downed material and promote more open, mature stands can reduce habitat quality and quantity. Throughout the SNF and northern Minnesota, human activities have reduced connectivity between patches of suitable lynx habitat. Development for residential and commercial uses, as well as roads, railroads, and utility corridors have all interrupted linkage corridors. Mineral exploration and development is increasing in portions of Minnesota, particularly for hard rock (non-ferrous) minerals. Some of the area of interest for minerals overlaps with lynx habitat in northeastern Minnesota. Mineral exploration may result in short-term displacement of lynx. Mining activities and associated development may result in an irreversible loss of habitat or increased mortality risk. The specific effects to lynx and their habitat will depend on the scale and type of each project.

Roads are a factor in human-caused lynx mortality where they provide access to areas where lynx occur, increasing the risk of negative interactions between people and lynx. Throughout the SNF outside the BWCAW, high and low standard roads bisect many areas that provide potential or suitable lynx habitat. Additionally, bobcat harvest in northeastern Minnesota has been increasing over the last decade (Erb 2012, unpaginated). Where lynx and bobcat overlap, there is potential for accidental shooting of lynx, or for bobcat hunting with dogs to harass or harm lynx.

Snow compacts under natural conditions; however, snow compacted by human activity may increase access by coyotes and bobcats to prey in deep snow conditions where historically they were excluded or rare. Winter road use, snowmobiling, cross country skiing, and dog sledding all may increase the amount and distribution of compacted snow conditions. Outside the BWCAW, snowmobile activity is extensive and increasing significantly. The SNF has 705 miles of snowmobile trails and 1,562 miles on all ownerships within the proclamation boundary (USFS 2011, p. 38). Advances in snowmobile capabilities have raised concerns about intrusion and new snow compaction in areas previously not vulnerable to high levels of snowmobile use. In addition, new road construction in lynx habitat has made more areas accessible during winter. These routes could be used by snowmobiles even if new roads are designated as closed to motorized public travel during other seasons. The SNF has 1,927 miles of low standard roads (OML 1 and 2) and 158 miles of temporary roads (USFS 2011, p. 38). All of these factors have potential to reduce the deep and fluffy winter snow conditions and to reduce the competitive advantage of lynx in areas that typically receive deep snows.

As described in Chapter 2, above, lynx are adapted for surviving in areas that have cold winters with deep, fluffy snow, where they outcompete potential competitors such as bobcats, coyotes, and wolves (Buskirk *et al.* 2000a, pp. 90-91; McCord & Cardoza. 1982, pp. 748-749; Ruediger *et al.* 2000, pp. 445-449). The geographical distribution of bobcat harvest in Minnesota has remained relatively static with a lack of harvest in the Arrowhead Region of Minnesota (the region encompassed by Cook, Lake, and St. Louis counties in northeastern Minnesota; Erb 2009 cited in Kapfer 2012, p. 16; Erb 2012, unpaginated) and annual snow track and scent stations surveys support the conclusion that bobcats are as rare in the Arrowhead Region as harvest indicates (MN DNR unpublished data cited in Kapfer 2012, p. 23). However, this may change with decreased snow conditions predicted to result from continued climate warming (Kapfer 2012, p. 25). Bobcat and coyote populations already appear to be increasing in Minnesota (Erb 2014, p. 40). If snow depth and duration decrease in the Arrowhead Region, deer mortality may be reduced; this may potentially increase bobcat densities and facilitate bobcat expansion into northeastern Minnesota (Kapfer 2012, p. 25). According to annual track surveys, wolf populations in Minnesota are currently stable (Erb 2014, p. 40); however, similar to bobcat, wolf populations may increase with changing snow conditions and prey availability as influenced by climate change.

Furthermore, in Northeastern Minnesota, several lynx-bobcat hybrids have been documented (Catton *et al.* 2015, p. 1), however, most bobcat records occur south and west of the core part of the lynx range in Minnesota (see figure 1.1 *in* Kapfer 2012, p. 51). Bobcat populations are increasing in Minnesota (Erb 2014, p. 40) and more bobcat-lynx hybridization may occur as a result of climate change (Koen *et al.* 2014b, p. 113).

4.2.3 Unit 3 - Northwestern Montana/Northeastern Idaho

<u>Unit Description</u>: This geographic unit includes the parts of northwestern Montana and northeastern Idaho the Service designated as critical habitat (Unit 3) for lynx in 2014 and some Tribal and State lands that were excluded from that designation (79 FR 54825). It encompasses approximately 27,000 km^2 (10,424 mi^2) in portions of Boundary County in Idaho and Flathead, Glacier, Granite, Lake, Lewis and Clark, Lincoln, Missoula, Pondera, Powell and Teton Counties

in Montana, with ownership that is 84 percent Federal (USFS,NPS, and BLM); 8 percent private; 4 percent State; and 4 percent Tribal. Most Federal lands in this unit (82 percent) are on national forests managed by the USFS; with NPS (16 percent) and BLM (almost 2 percent) contributing most of the remainder. This unit includes most of Glacier National Park and parts of the Flathead, Helena, Idaho Panhandle, Kootenai, Lewis and Clark, and Lolo national forests, the BLM's Garnet Resource Area, and the Confederated Salish and Kootenai Tribes Flathead Reservation. It also includes (from northwest to southeast) all or parts of the Purcell, Cabinet, Salish, Whitefish, Lewis, Flathead, Swan, and Garnet mountain ranges. Several areas adjacent to this unit are known or thought to support a small number of resident lynx, at least intermittently, including the southern Selkirk Mountains of northern Idaho and northeastern Washington and the western Cabinet Mountains of northern Idaho (B. Holt 2016, *pers. comm.*; USFS 2015, pp. 9-10), and a small area of the Helena National Forest just south of MacDonald Pass, between Helena and Missoula (Gehman *et al.* 2011, p. 21). This unit is directly connected to lynx habitats and populations in Canada, and lynx in this unit may represent the southern extent of a larger cross-border population that also occurs in southwestern Alberta and southeastern British Columbia (B.C.). Relative to other DPS lynx populations, this unit is about 200 km (125 mi) east of the north-central Washington unit, about 145 km (90 mi) northwest of the GYA, and about 1,480 km (920 mi) west of the Northeastern Minnesota geographic unit.

<u>Habitat Description</u>: In the Northern Rocky Mountains, most lynx occurrences are associated with the Rocky Mountain Conifer Forest or Western Spruce-Fir Forest vegetative classes (Kuchler 1964, p. 4; McKelvey *et al.* 2000a, p. 246) at elevations ranging from 1,250 m (4,100 ft) to 2,500 m (8,200 ft) (Aubry *et al.* 2000, pp. 378–380; McKelvey *et al.* 2000a, pp. 243–245). The dominant vegetation that constitutes lynx habitat in these areas is subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmanii*) and lodgepole pine (*Pinus contorta*) (Aubry *et al.* 2000, p. 379; Ruediger *et al.* 2000, pp. 4-8 - 4-10). Within these vegetation types, lynx appear to prefer areas of moderate to gentle topographic relief (Koehler and Aubry 1994, p. 86; Apps 2000, p. 352; Squires *et al.* 2013, pp. 187, 191). Lynx use large landscapes that include a temporally- and spatially-shifting mosaic of forest age classes, where natural or anthropogenic disturbances may reset forest succession (ILBT 2013, p. 28). Early successional stages that often provide dense horizontal cover at ground/snow level and support high hare densities (Griffin 2004, pp. 53-54, 70; Squires *et al.* 2010, pp. 1654-1656) may be created and maintained by natural disturbance processes including wildfire, insect infestations, tree diseases, and wind events (ILBT 2013, p. 28). Timber harvest, other silvicultural treatments, wildfire management, or other vegetation management, which may be beneficial, benign, or adverse to lynx and hare habitats depending on prescription, extent, and implementation, can also influence the amount and distribution of early successional stands (Agee 2000, p. 39; ILBT 2013, pp. 28, 71-76). Likewise, natural disturbance regimes and forest management can also influence the amount and distribution of mature multistoried spruce-fir stands, which can include dense horizontal structure, support high hare densities (Griffin 2004, pp. 53-54, 70; Squires and Ruggiero 2007, pp. 313-314; Berg *et al.* 2012, pp. 1483-1485), and provide preferred winter foraging habitat for lynx (Squires *et al.* 2010, pp. 1653-1657).

In northwestern Montana, lynx generally occur in mid-elevation (1,260 – 2,355 m [4,130 – 7,730 ft]) moist subalpine mixed-conifer forests dominated by Englemann spruce and subalpine fir and including Douglas fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), and lodgepole pine (Squires *et al.* 2010, pp. 1653-1654). Lynx home ranges occur in areas with low surface roughness (i.e., low topographic relief; gently-sloping to moderately-steep terrain), high canopy cover indices, and little open grassland (Squires *et al.* 2013, p. 191). These lynx habitats occur below the alpine zone and above drier, more open forest types (e.g., ponderosa pine [*Pinus ponderosa*] and dry Douglas-fir/western larch/lodgepole pine) that do not provide lynx habitat (Agee 2000, p. 42; Berg 2009, p. 20; Squires *et al.* 2010, p. 1655). As elsewhere in the western portion of the DPS, this elevational pattern contributes, along with the transition from boreal to more temperate forests, to a naturally patchier, more fragmented distribution of lynx habitat than in the continuous boreal forest landscape in the core of the lynx's North American range in northern Canada and interior Alaska (65 FR 16052-53; 68 FR 40089; Squires *et al.* 2006[a], pp. 46-47; ILBT 2013, pp. 76-77; Squires *et al.* 2013, p. 191; 78 FR 59438). Squires *et al.* (2013, pp. 187-189) used telemetry data to model the distribution of probable lynx habitat in a 36,096-km^2 (13,937-mi^2) study area that completely overlaps this geographic unit. Their results indicate that much of the area has a low to moderate probability of selection by lynx, and that the areas with higher selection probabilities are relatively small and patchily- but widely- distributed throughout the unit and are separated by intervening areas of low probability of lynx use (Squires *et al.* 2013; see Figure 1(a), p. 189). This patchy distribution of high-quality habitats interspersed with areas of low-quality or non-habitat results in naturally lower densities of both snowshoe hares and lynx than those in the continuous boreal forests of northern Canada and Alaska (Wolff 1980, pp. 123–128; Buehler and Keith 1982, pp. 24, 28; Koehler 1990, p. 849; Koehler and Aubry 1994, p. 84; Aubry *et al.* 2000, pp. 373–375, 382, 394).

In winter in this unit, lynx preferentially use mature multistoried forest stands, predominantly spruce-fir, with dense horizontal cover, and they avoid clearcuts and large forest openings (Squires *et al.* 2010, pp. 1648, 1653–1656). In summer, lynx also select young stands with dense spruce-fir saplings, do not appear to avoid openings as in winter, and use slightly higher elevations (Ibid.). Both mature multistoried and young regenerating stands provide dense horizontal structure at ground/snow level, which supports higher snowshoe hare densities than more open young or mature forests. In the central (Seeley Lake study area) part of this unit, during an apparent regional hare decline in 1999-2001, summer hare densities were highest (up to 1.4 hares/ha in one study area) in dense young stands, and winter densities were highest (up to 1.8 hares/ha in one study area) in dense mature stands (Griffin and Mills 2009, pp. 1492-1496). Over a longer interval (1999-2003) when hare populations in this area were thought to be stable (Squires and Ruggiero 2007, p. 314), mean summer and winter hare densities, respectively, were 0.34 hares/hectare (ha) and 0.53/ha in dense mature stands and 0.64/ha and 0.47/ha in dense young stands – habitats selected by lynx, compared to 0.18/ha and 0.20/ha in open mature stands and 0.18/ha and 0.12/ha in open young stands that lynx did not select (Squires and Ruggiero 2007, pp. 313-314). Even the relatively higher hare densities in the dense mature and dense young stands only marginally achieve the threshold density of 0.5/ha thought necessary to support lynx within home ranges (Ruggiero *et al.* 2000b, pp. 446–447; ILBT 2013, pp. 24, 26, 90). Nonetheless, hares accounted for 96 percent of the biomass in lynx diets in this unit based on evidence at kill sites (Squires and Ruggiero 2007, pp. 310-313), suggesting that even small declines in landscape-level hare densities could reduce the ability of habitats in this unit to support resident lynx (Squires *et al.* 2010, p. 1656).

Lynx in this unit generally den in mature spruce-fir forests among downed logs or root wads of wind-thrown trees in areas with abundant coarse woody debris and dense understories with high horizontal cover in the immediate areas around dens (Squires *et al.* 2004a, Table 3; Squires *et al.* 2008, pp. 1497, 1501–1505). Few dens are located in young regenerating or thinned stands with discontinuous canopies (Squires *et al.* 2008, p. 1497). Many dens have northeasterly aspects and are farther from forest edges than random expectation (Squires *et al.* 2008, p. 1497).

Average annual snowfall in this unit ranges from about 142 cm (56 in) in the Kalispell/ Whitefish/ West Glacier area of northwestern Montana to 183 cm (72 in) in Nordman in northern Idaho, to 216 cm (85 in) in Lincoln, Montana, near the southern end of the unit, to 259 cm (102 in) in Rexford, Montana near the Canada - U.S. border, to 345 cm (136 in) in Seeley Lake, Montana, in the central part of the unit, with most snow falling from November to March in each place (https://snowfall.weatherdb.com/d/a/Montana; accessed 4/2/2016).

Habitat Status: Lynx habitats in this unit are currently designated as critical habitat in accordance with the ESA. Over 84 percent (22,761 km^2 [8,788 mi^2]) of this unit is in Federal ownership, including 18,695 km^2 (7,218 mi^2) in national forests under USFS management, 3,658 km^2 (1,412 mi^2) in Glacier National Park managed by NPS, and 397 km^2 (153 mi^2) managed by BLM in its Garnet Resource Area. As described above, potential lynx habitat in this unit is patchily- distributed and interspersed with areas of non-habitat (matrix). Among the six national forests that contribute lands to this geographic unit, potential lynx habitat was mapped on about 54 percent of the total national forest area (both inside and outside this SSA unit; USFWS 2007, pp. 32, 95, 122-123). In Glacier National Park, 2,976 km^2 (1,149 mi^2; about 73 percent of the park) is considered “lynx forest types” (65 FR 16073), but only 1,103 km^2 (426 mi^2; 27 percent of the park, 37 percent of lynx forest types) is estimated to be lynx habitat (68 FR 40086, 40089). In the Garnet Resource Area, the BLM designated five LAUs (which approximate a lynx home range) covering 947 km^2 (366 mi^2), of which, 574 km^2 (222 mi^2; about 61 percent) was mapped as lynx habitat (Sparks 2016a, *pers. comm.*).

Federal lands are managed as either ‘‘developmental’’ or ‘‘nondevelopmental’’ land use allocations (68 FR 40093). Lands in developmental allocations are managed for multiple uses, such as recreation and timber harvest, some of which may conflict with lynx conservation. Management within non-developmental allocations focuses on the maintenance of natural ecological processes, or conservation of rare ecological settings or components, and these areas include wilderness, roadless, and semi-primitive non-motorized areas (USFWS 2007, pp. 33, 77). Timber harvest, road construction, and fire suppression typically do not occur or are very limited in lands managed in non-developmental allocations.

In this SSA unit, almost 46 percent of the Federal land and 40 percent of the entire unit is in designated wilderness or national park land, including (in addition to Glacier National Park) the 6,297-km^2 (2,431-mi^2) Bob Marshall Wilderness Complex (Bob Marshall, Great Bear, and Scapegoat wilderness areas) on the Flathead, Lewis and Clark, Helena and Lolo national forests, the 302-km^2 (117-mi^2) Mission Mountain Wilderness on the Flathead National Forest, the 139-km^2 (54-mi^2) Rattlesnake Wilderness Area on the Lolo National Forest, and the 371-km^2 (143-mi^2) Mission Mountain Tribal Wilderness on the Flathead Reservation. Management of NPS lands and both national forest and Tribal wilderness areas provides restrictions on land use beneficial to lynx (65 FR 16073; USFWS 2014, pp. 28-29; 79 FR 54831), and adverse effects of management activities on lynx habitats in these areas are unlikely. Among the six national forests that contribute to this unit, 56 percent of potential lynx habitat is in designated wilderness or roadless areas (USFWS 2007, p. 34).

Much of the remaining USFS lands and the BLM lands have developmental land-use allocations where some management activities have the potential to impact lynx or its habitat. However, as described above in section 3.1.1, USFS lands in this unit are managed in accordance with the NRLMD, which formally amended all forest plans to adopt and implement lynx conservation measures (USFS 2007, pp. 8-30 and Attachment 1, pp. 1-9) that were developed based on the scientific findings and recommendations of the LCAS (Ruediger *et al.* 2000, pp. pp. 7-1 - 7-18). Similarly, the BLM in 2004 amended the Resource Management Plan (RMP) for the Garnet Resource Area to incorporate the conservation measures identified in the LCAS (BLM 2004a, 2004b, entire; Sparks 2016b, *pers. comm.*). Both documents provide guidance on the kinds of activities that can and cannot be implemented in important lynx habitats and thresholds for the proportions of lynx habitat in LAUs that can be in an unsuitable state at any given time and how much can be converted from suitable to (temporarily) unsuitable over particular time frames. Implementation of these plans has likely benefitted lynx by providing a consistently- applied framework for conserving and restoring important hare and lynx habitats.

Habitat status on private lands, which account for about 8 percent of lands in this unit (2,172 km^2 [839 mi^2]), is governed by some Federal and State regulations and by a number of private-public conservations partnerships and State agency efforts. As described in section 3.1., above, some Federal and State regulations guide some activities on private lands, including the ESA's prohibition on take of listed species, and State regulations governing trapping and timber management. In addition to these protections, there have been several other notable lynx conservation achievements on private lands in this unit since the DPS was listed. Two of these, the Clearwater-Blackfoot Project and the Montana Legacy Project, are multi-partner and community efforts led by The Nature Conservancy in Montana to purchase large tracts of private commercial timberlands, conveying some to the State of Montana and the USFS for conservation management, and acquiring conservation easements on others (TNC 2016a, 2016b, 2016c, entire). These land acquisitions have resulted in protection of roughly 673 km^2 (260 mi^2) of important lynx habitat within this SSA unit and another 583 km^2 (225 mi^2) just to the south and west that may occasionally or temporarily support lynx or provide dispersal habitat. Additionally, the MTFWP has acquired fee title or conservation agreements on 3,096 km^2 (1,195 mi^2) of private lands in western Montana, including 162 km^2 (63 mi^2) in designated lynx critical habitat in this SSA unit, with ongoing efforts on another 106 km^2 (41 mi^2) in the northwest part of the unit (MTFWP 2016, pp. 1, 3).

In addition to the MTFWP's efforts to acquire private lands and protect them through fee title or conservation agreement, the State of Montana has also worked to protect lynx habitat on State-owned lands, which account for about 4 percent of the lands in this unit (1,106 km^2 [427 mi^2]). As described above in section 3.1.2, the MTDNRC worked closely with the Service to develop the *State of Montana Department of Natural Resources and Conservation Forested State Trust Lands Habitat Conservation Plan* (MTDNRC HCP; MTDNRC and USFWS 2010a, 2010b, 2010c, entire); a multi-species HCP that focuses primarily on commercial forest management. The HCP includes a Lynx Conservation Strategy that minimizes impacts of forest management activities on lynx, describes conservation commitments that are based on recent information from lynx research in Montana, and commits to active lynx monitoring and adaptive management programs. The HCP covers about 2,220 km^2 (857 mi^2) of forested State trust lands in western Montana, including 703 km^2 (271 mi^2) within this SSA geographic unit (about 64 percent of State lands in this unit). The goal of the HCP's Lynx Conservation Strategy is to support Federal lynx conservation efforts by managing for habitat elements important to lynx and their prey that contribute to the landscape-scale occurrence of lynx. Specific objectives to achieve this goal include protecting den sites and potential denning habitat, mapping and maintaining lynx foraging habitats and limiting the spatial and temporal scope of their conversion to unsuitable conditions from forest management activities, and providing for habitat connectivity (MTDNRC and USFWS 2010b, pp. 2-45 - 2-61). The HCP was finalized and permitted by the Service in 2011, and includes a 50-year commitment by the State to manage for lynx conservation on these lands (79 FR 54835-37).

Tribal lands of the Flathead Reservation account for almost 4 percent of this unit. In addition to the Tribe's approach to lynx management described in section 3.2.1, above, most lynx and lynx habitat on the reservation occur in areas with formal protective status, including: (1) The long-designated Mission Mountains and Rattlesnake Tribal Wilderness Areas, which are largely roadless and managed for wilderness qualities; (2) the South Fork/Jocko Primitive Area, which is open to use only by Tribe members and in which commercial timber harvest is prohibited; and (3) the Nine-mile Divide country, which is marginal in terms of lynx habitat, but which is also partly roadless (Courville 2014, *pers. comm.*; 79 FR 54831).

As elsewhere in the DPS, winter foraging habitat is thought to be the most limiting habitat for lynx in this unit (Squires *et al.* 2010, p. 1656; ILBT 2013, pp. 20, 27). As described above, lynx selected mature multistoried stands with dense horizontal structure and relatively higher winter hare densities (Squires *et al.* 2010, pp. 1648, 1653–1656). Because of this preference, the Forest Service in the NRLMD adopted a vegetation management standard (VEG S6) that precludes all vegetation management activities that could reduce winter snowshoe hare habitat in multistoried forests, not just precommercial thinning as recommended in the LCAS (USFS 2007, pp. 13-14). Also as elsewhere (Moen *et al.* 2008a, p. 1512; Organ *et al.* 2008, pp. 1514, 1516–1517, ILBT 2013, p. 30; 79 FR 54790), denning habitat is not thought to be a limiting factor for lynx in this unit (Squires *et al.* 2008, p. 1505). Nonetheless, the NRLMD includes guidance to ensure adequate denning habitat remains well distributed in LAUs and, therefore, across the larger landscape and to design projects to create or retain coarse woody debris in areas where denning habitat may be lacking (USFS 2007, p. 17). Snow conditions in this unit also appear to remain suitable to allow lynx to outcompete other terrestrial hare predators. Gonzalez *et al.* (2007, pp. 4-7) compared the highest-precision lynx occurrence data in the contiguous U.S. from 1966-1998 with snow-cover data available for those locations and concluded that lynx require nearly continuous snow cover from December through March. The authors modeled the probability of suitable snow across North America, showing that this geographic unit currently has a 90-95 percent probability of providing snow cover conditions supportive of lynx presence (Gonzalez *et al.* 2007, p. 12).

Overall, although naturally fragmented and patchily-distributed, lynx habitat in this geographic unit appears to be largely intact relative to historical conditions and disturbance regimes, with only a small proportion apparently impacted by past management (timber harvest and precommercial thinning) activities (65 FR 16072). Despite some likely localized impacts of past timber management and infrastructure (e.g., highway) development and evidence of minor genetic differentiation among lynx subpopulations (see *Lynx Status*, below), past management activities do not appear to have diminished this unit's ability to support resident lynx or to have created barriers to lynx movement, or to have had other landscape- or population-level effects.

A possible exception may be in the Garnet Mountains, which are known to have supported a small number of resident lynx in the 1980s and recently from 2002-2010, but where more recent surveys and research trapping efforts have failed to detect lynx (Squires *in* Lynx SSA Team 2016, p. 20; also see Lynx Status, below). This small and relatively isolated island of lynx habitat (Squires 2014, p. 4) at the southern end of this unit is thought to be capable of supporting 7-10 lynx home ranges (Squires 2016, *pers. comm.*). The BLM (2004, pp. 4-5) contrasted current and historical distributions of lynx habitats in the Garnets and found that early- successional stands (future hare and lynx foraging habitats) were at 25-50 percent of the historical condition in lower- elevation (1,370-1,830 m [4,500-6,000 ft]) lynx habitats, and 10-30 percent in higher- elevation (1,675-2,130 m [5,500-7,000 ft]) habitats. Late- successional (mature multistoried) stands (25-75 percent of historical condition) and large (> 100 ha [250 ac]) patches (25-50 percent of historical condition) were also underrepresented at lower elevations, but at higher elevations, late- successional stands and large patches exceeded 200 percent and 100 percent of historical conditions, respectively. Lower elevation habitats were fragmented by roads and past management practices (i.e., timber harvest), while higher-elevation habitat patterns were attributed to the absence of disturbance, including fire (BLM 2004, p. 5), though fire absence was not attributed to suppression.

As discussed for the GYA in section 2.3.2.2, above, whether the recent absence of lynx in the Garnets represents the extirpation of a previously- persistent small resident population (and, therefore, a contraction in the range of resident lynx in this unit) or a temporary “winking off” of a small peripheral population that would be expected in a mainland-island metapopulation structure is uncertain and perhaps irresolvable. If residency was intermittent or ephemeral historically, the current absence of lynx might be a natural condition related to the area’s naturally fragmented habitats and generally low hare densities - i.e., it may naturally be capable of supporting resident lynx only intermittently when habitat conditions and hare densities are optimal. If so, future intermittent lynx occupancy would be expected, but only if lynx dispersing from a source population immigrate to the Garnets when habitat conditions and hare densities return to more favorable levels. Conversely, if the Garnets historically supported a small but persistent population that was recently extirpated, it may suggest that the alteration of the historical distribution of some habitats in some parts of the range, described above, was enough to tip the quality of the area's habitat from capable of supporting a small resident population to no longer capable of doing so.

In summary, almost all lands in this unit are managed to conserve lynx and hare habitats in accordance with Federal, State, and Tribal regulations and management direction, conservation easements, and an approved HCP. Much of the area consists of designated Federal and Tribal wilderness areas and other nondevelopmental land use allocations, where management activities with the potential to adversely affect lynx generally do not occur. On lands with development allocations, USFS, BLM, and State management are based on plans that incorporate the conservation guidance identified in the LCAS as informed by more recently-available scientific information. The State and TNC, working with other conservation partners, have bought or acquired conservation easements on large tracts of high-quality private lands in the unit that are known or suspected to be occupied by resident lynx. These efforts and management across multiple ownerships likely preclude landscape-level management-related adverse impacts to the vast majority of existing lynx and hare habitats in this unit. Nonetheless, past management activities that occurred prior to implementation of current regulations and other conservation efforts may exert continuing influence on current habitat quality in some places, as described above for the Garnet Mountains. Because lynx habitats in this unit, like most other areas of the DPS range, are naturally highly-fragmented, and most have hare densities that barely meet the 0.5 hares/ha threshold thought necessary to support resident lynx, relatively minor impacts, especially to hare and lynx foraging habitats, may strongly influence lynx persistence in some parts of this unit.

<u>Lynx Status</u>: There are no reliable estimates of the historical or current number of resident lynx in this unit although, as described in section 2.3.2.2 above, it is thought to be capable of supporting perhaps 200-300 lynx (Squires *in* Lynx SSA Team 2016, p. 41). This is substantially fewer than previous estimates of more than 1,000 lynx, which were based on a habitat area/ density index and broad assumptions regarding habitat suitability and lynx distribution (65 FR 16058) that are not supported by current understanding of lynx habitat requirements. As described above, habitats capable of supporting resident lynx in this unit are naturally patchier and less-broadly distributed (Squires *et al.* 2006a, pp. 46-47; Squires *et al.* 2013, p. 191), and lynx therefore naturally rarer, than was thought at the time of listing (ILBT 2013, p. 23; Jackson *in* Lynx SSA Team 2016, p. 12). Although the exact distribution of resident lynx remains uncertain, this unit has a long and continuous history of lynx occurrence and evidence of reproduction (McKelvey *et al.* 2000a, pp. 224-225; Squires and Laurion 2000, pp. 346-348; Squires *et al.* 2008, entire; Squires *et al.* 2013, entire; ILBT 2013, p. 57; 65 FR 16058; 68 FR 40090; 74 FR 8643; 79 FR 54825). Genetic analyses revealed minor fine-scale genetic sub-

structuring among lynx subpopulations in the southern (Garnets), central (Seeley Lake), and northern (Purcells) parts of this unit, suggesting limited interaction among lynx in those areas (Schwartz *in* Lynx SSA Team 2016, p. 12 and Appendix 5; Squires *in* Lynx SSA Team 2016, p. 20). Lynx in this unit likely represent the southern periphery of a larger population in southwestern Alberta and southeastern British Columbia, but the extent to which lynx persistence in this area may rely on immigration from Canada is unknown, and there is no indication of substantial immigration (irruptions) of lynx from Canada into this unit after the 1980s (Squires *in* Lynx SSA Team 2016, p. 20).

From 1998 to 2007, researchers with the Forest Service's Rocky Mountain Research Station in Missoula trapped and radio-marked 175 lynx in northwestern Montana and collected nearly 170,000 GPS and over 3,000 VHS telemetry locations documenting lynx movements, resource use, survival, and productivity (Squires *in* Lynx SSA Team 2016, p. 20). From 1999-2007, litter sizes averaged 2.24 kittens/litter (N = 33) in the Seeley Lake area and from 2003-2007, 2.95 kittens/litter (N = 22) in the Purcell Mountains. In Seeley Lake, 61 percent of breeding-age females (N = 52) produced kittens; in the Purcells, 83 percent of females (N = 28) produced kittens. Recent research (Kosterman 2014, entire) suggests that the probability that a female produces a litter and initial litter size are correlated positively with mature forest connectivity and negatively with fragmentation in female home ranges (Squires *in* Lynx SSA Team 2016, p. 20 and Appendix A). Annual survival rates for subadult and adult female lynx were 0.52 and 0.75, respectively, in Seeley Lake, and 0.68 and 0.85, respectively, in the Purcells. There was no evidence of cyclicity in these vital rates, and no indication of substantial immigration of lynx into these study areas from Canada. Starvation, predation by mountain lions, and human-caused deaths each accounted for roughly one-third of documented sources of lynx mortality. Population viability analyses yielded population growth rates (λ) of 0.92 for the Seeley Lake area (i.e., declining population trend, 1999-2007) and 1.16 for the Purcells (increasing trend, 2003-2007). However, as described in section 2.2.2, above, estimates of λ in a cyclic Canadian population of lynx ranged from 2.03 (annual doubling) when hares were abundant to 0.10 (order of magnitude decline) after hare populations crashed (Slough and Mowat 1996, p. 952, Table 4), and the natural range in λ that would be expected among peripheral, isolated, or semi-isolated and non-cyclic or weakly-cyclic lynx populations in the DPS versus those that would signal long-term population decline or instability is unknown.

As described above, lynx distribution in this unit may have contracted with the recent apparent disappearance of resident lynx from the Garnet Mountains in the southern part of the unit. Lynx were documented in the Garnets in the 1980s and from 2002-2010, but no lynx were detected during snow-track and camera-trap surveys in winter 2014-2015 (Squires *in* Lynx SSA Team 2016, p. 20 and Appendix 5). This area is thought to have habitat capable of supporting 7-10 lynx home ranges (Squires 2016, *pers. comm.*); 5 lynx were monitored via telemetry in 2002, 3 in 2003-2004, 2 in 2005, and single lynx each year in 2006, 2007, and 2010 (Squires *in* Lynx SSA 2016, Appendix 5 [2015 10 14 - 8, p. 26]). As described in section 2.3.2.2 and above, whether the recent absence of lynx from this part of the unit represents the extirpation of a small but previously persistent population (and, therefore, a permanent contraction of lynx distribution in this unit) or the temporary “winking off” of a peripheral subpopulation that may become “winked on” again in the future is unknown and perhaps irresolvable.

Snow-tracking, hair-snare, and camera-trap surveys in other parts of this unit since the DPS was listed continued to detect lynx on the Flathead, Helena, Idaho Panhandle, Kootenai, Lewis and Clark, and Lolo national forests (USFS 2015, pp. 9-27). On the Flathead, the USFS Rocky Mountain Research Station(RMRS) trapped and radio-marked 7 lynx (3 females, 4 males) in the Flathead River watershed from 2010-2015, and surveys detected lynx in several other areas including the Salish Mountains, the area just south of Glacier National Park, and in the vicinity of Hungry Horse Reservoir (USFS 2015, pp. 10-11). The Swan Lake District in the southern part of the Flathead, along with the Seeley Lake District of the Lolo National Forest and the Lincoln District of the Helena National Forest, is part of the 6,070-km^2 (2,344-mi^2) Southwestern Crown of the Continent, which was intensively surveyed from 2012-2014 by the Southwestern Crown Carnivore Monitoring Team (SCCMT 2014, entire). The SCCMT conducted snow track surveys and used hair snares, bait stations, and camera traps to detect lynx in 36 of the 82, 8 x 8 km (5 x 5 mi) grid cells they surveyed (SCCMT 2014, pp. 3, 17-20). The surveys resulted in collection of DNA that allowed identification of 18 individual lynx (5 females, 13 males), 13 of which were new to regional lynx databases (SCCMT 2014, pp. 3, 17-20).

On the Helena National Forest, few lynx have been detected outside the Lincoln District/ Southwest Crown described above. In the south MacDonald Pass area, just south of this SSA unit and south of designated critical habitat, an individual male lynx was verified by DNA evidence over four winters (2007-2011), and an individual female was verified in the same area in the winter of 2008-2009 (Gehman *et al.* 2011, p. 21; USFS 2015, p. 27). Other surveys on the Helena failed to detect lynx in the disjunct Big Belt and Elkhorn Mountains, although telemetry data indicated that three lynx released in Colorado passed through the Big Belts in 2004-2006 (USFS 2015, pp. 26-27). Likewise, during snow tracking surveys on the Lolo in 2010-2011 (prior to the Southwestern Crown monitoring described above), lynx were also confirmed on the Seeley Lake District in the eastern part of the forest, but no lynx were documented on the Missoula or Ninemile districts, nor on the Superior and Plains/Thompson Falls districts in the western part of the forest (USFS 2015, pp. 12-14). The USFS concluded that lynx presence in districts other than Seeley Lake is extremely rare and likely represents occasional dispersing lynx (USFS 2015, p. 21).

On the Kootenai National Forest, RMRS research efforts continued to document the long-term presence of lynx, where trapping and radio-marking efforts yielded 50,000-60,000 lynx telemetry locations from 2003-2012 (USFS 2015, p. 10). On the Lewis and Clark National Forest, lynx are considered “still present” in the Rocky Mountain Front portion of the forest, which is within this geographic unit and designated critical habitat, and snow track surveys from 2010-2013 in the disjunct Little Belt and Crazy Mountains documented the continued absence of resident lynx in those ranges (USFS 2015, pp. 25, 27-34). On the Idaho Panhandle National Forest, surveys detected individual lynx in the Selkirk Mountains in 2010 and 2011 and in the Purcell Mountains in 2012. All detections were within 15 miles of the Canada-U.S. border (USFS 2015, p. 10). No lynx were detected during surveys in 2007 or 2013-2014, and snow surveys were not done in

2015 because of poor snow conditions (USFS 2015, p. 9). However, in 2012-2014 three lynx were incidentally trapped on the Idaho Panhandle (one in 2012 in the Purcells, and two in 2014 in the Cabinet Mountains), and another was documented by a Service grizzly bear trapping crew in the Purcells in 2014 (USFS 2015, pp. 9-10; U.S. District Court ID 2016, pp. 6-7).

In summary, although the number of lynx in this geographic unit is uncertain, resident lynx appear to remain broadly distributed throughout most of the unit. The recent apparent absence of lynx in Garnet Mountains may indicate extirpation of a small resident population and a contraction in lynx distribution in the southern part of the unit, or it may reflect natural source-sink dynamics of a naturally ephemeral peripheral population in a mainland-island metapopulation structure. Lynx are rarely detected on surveys on other national forests (or parts of those above) that are outside but adjacent to this geographic unit (Patton 2006, entire; USFS 2105, pp. 1-9, 25-34), suggesting that these areas lack the habitat features and/or landscape-level hare densities necessary to support resident lynx populations (79 FR 54818-54820).

Factors Affecting Current Conditions

Regulatory Mechanisms - Federal management activities (especially timber harvest and precommercial thinning, perhaps fire suppression) that occurred prior to listing and before implementation of current Federal regulatory mechanisms likely impacted some lynx and habitats by altering the distribution and quality of hare and lynx habitats. However, because these activities occurred in low proportions of lynx habitat on Federal lands and impacts appear to have been localized, they were deemed a low-level threat to lynx at the time of listing (65 FR 16072-16076; 68 FR 40091-40095). Nonetheless, past Federal management activities may continue to influence the current quality and distribution of lynx habitats in some parts of this unit. For example, as described above in *Habitat Status* and *Lynx Status*, past timber harvest/management and associated road construction may have fragmented, reduced the amount, and altered the distribution of lynx habitats in the Garnet Mountains, perhaps contributing to the apparent recent loss of that area's ability to support resident lynx.

Currently, as described above and in section 3.1, all Federal and Tribal lands, most State lands, and large blocks of private or formerly-private land in this unit are managed for the conservation of lynx habitats, and much of the unit is in designated wilderness or other nondevelopmental land-use allocations. Regulatory mechanisms and conservation measures associated with these management strategies are intended to conserve and restore lynx and hare habitats across large landscapes and multiple ownerships. Although their effectiveness has not be quantitatively evaluated, and despite the potential extirpation of a small population in the Garnets, lynx habitats and resident lynx appear to remain well distributed throughout most of this unit.

Other regulations prohibit lynx trapping and require measures to reduce the likelihood of trapping lynx incidentally when legally trapping other species. Since the DPS was listed in 2000, 16 lynx are documented to have been incidentally trapped in Montana, with 13 of those occurring before 2008, when more protective regulations (e.g., lethal snares prohibited for bobcat sets, leaning pole sets limited to <4" pole and must be 48" above ground for marten, fisher, and wolverine) were put in place (MTFWP 2016, pp. 5-10). Of the 16, eight were released uninjured, one was released with an injury, and seven were killed; all incidences of mortality occurred prior to 2008 and the implementation of the more protective regulations (MTFWP 2016, p. 5). In Idaho, in addition to the three lynx incidentally trapped on the Idaho Panhandle National Forest from 2012-2014 (described above under *Lynx Status*), one other lynx was incidentally trapped in 2012 on the Salmon-Challis National Forest further south (U.S. District Court ID 2016, p. 6).

Although lynx are legally trapped in Canada adjacent to this unit in southern Alberta and southern British Columbia, trapping there is managed through regulated seasons and harvest levels, which are adjusted to avoid overexploitation, especially during the low phase of the hare-lynx population cycle (Environment Canada 2014, entire; Vashon 2015, pp. 5-6). Lynx harvest in Alberta varied from about 4,000 to 14,000 annually in the late 1970s and early 1980s, but declined to fewer than 2,000 for most years from 1984-2000, and restrictive quotas and season closures were implemented beginning in the late 1980s (Poole and Mowat 2001, pp. 16, 28). Similarly, harvests in British Columbia peaked at over 12,000 in the early 1960s and over 8,000 in the early 1970s, then declined to fewer than 2,000 for most years from the mid-1980s until the year 2000 (Hatler and Beal 2003, p. 2). Whether, and if so to what extent, trapping in Canada may influence lynx dispersal across the border and into this geographic unit is unknown; however, such dispersal was documented historically when harvest levels in Canada were much higher than under current management.

Climate Change - As elsewhere, increased temperatures, reduced snowpack, earlier snowmelt, and increased drought leading to increased fire all have been documented in this geographic unit (e.g., Hall and Fagre 2003, entire; Mote 2003b, entire; Fagre 2005, entire; Knowles *et al.* 2006, entire; Harvey *et al.* 2016, entire; Siren *in* Lynx SSA Team 2016, pp. 14-15; Squires *in* Lynx SSA 2016, p. 20; Westerling 2016, entire). A number of potential impacts to lynx have been described, and climate projections suggest these impacts are likely to result in future loss and increased fragmentation and isolation of lynx and hare habitats and declining lynx populations in the DPS (Carroll 2007, entire; Gonzalez *et al.* 2007, entire; ILBT 2013, pp. 69-71; 79 FR 54810-54811; Lawler and Wilsey *in* Lynx SSA Team 2016, pp. 15-16; Siren *in* Lynx SSA Team 2016, p. 15; see also section 3.2, above, and 5.2.3, below). Although climate change has probably already had some impact on lynx habitats in this geographic unit, and such impacts are likely to continue to occur, there currently is no evidence that climate change has had population-level effects or has reduced the ability of this unit to support persistent resident lynx populations. However, such impacts would be difficult to document and, as described under *Habitat Status*, above, because lynx habitats in this unit are naturally highly-fragmented and hare densities, even in areas considered high-quality habitat for this DSP unit, often appear to barely meet the 0.5 hares/ha threshold thought necessary to support resident lynx, relatively minor impacts, especially to hare and lynx foraging habitats, may strongly influence lynx persistence in some parts of this unit. Modeling vegetation and snow suitability for lynx across North America, Gonzalez *et al.* (2007, pp. 12, 15) indicated that boreal and temperate conifer forest biomes were broadly distributed across this geographic unit and that snow conditions suitable for lynx occurred with 90-95 percent probability from 1961-1990. (Future conditions based on this modeling are described in section 5.2.3, below). As described in section 3.2, above, climate change has also been implicated in recent increases in the frequency and intensity of outbreaks of boreal forest insect pests, with warmer winters resulting in increased insect survival and drought increasing conifer vulnerability to insects. This trend is expected to continue through the end of the century with continued climate warming (Bentz *et al.* 2010. pp. 607, 609). Although insect outbreaks have affected some parts of the DPS, no major outbreaks have been documented in lynx habitats in this unit (Lynx SSA Team 2016, p. 41).

Vegetation Management - As elsewhere in the DPS range, timber harvest and related vegetation management (precommercial thinning and other silvicultural techniques designed to optimize forest products outputs; ILBT 2013, pp. 71-72) are the dominant land uses potentially affecting lynx habitats in this unit (68 FR 40075, 40092; 79 FR 54825). As described in section 3.3, above, these activities can reduce hare and lynx habitats by reducing horizontal cover and altering natural disturbance regimes and forest successional patterns. In this unit, precommercial thinning was shown to reduce short-term hare abundance (Griffin and Mills 2007, entire) and appeared to influence lynx movements (Squires *et al.* 2013, p. 192-194), and lynx rarely traveled across recent clearcuts or other large openings, especially in winter (Squires *et al.* 2010, p. 1654; ILBT 2013, p. 77). However, as described under *Habitat Status*, above, these activities on Federal lands, which account for most of the lands in this unit, occur only on lands with developmental allocations and historically appear to have impacted only a small proportion of potential lynx habitats in this unit (65 FR 16072; 68 FR 40093). Additionally, timber harvest levels on Federal lands in the West, including the Northern Rockies, and specifically with regard to “lynx forest types,” had declined consistently and dramatically for a decade or longer prior to the DPS being listed (68 FR 40093), and have remained at levels much lower than those from most of the previous century. Despite some likely localized impacts, past vegetation management does not appear to have broadly diminished this unit's ability to support resident lynx, although, as described above, it may have contributed to the current absence of a small number of resident lynx from the Garnet Mountains. Also as described above, current vegetation management in this unit on all Federal, most State and Tribal, and some private lands, is conducted in accordance with formally amended USFS and BLM management plans, an approved State HCP, Tribal regulations, and conservation easements designed to avoid or minimize impacts to lynx habitats, especially important hare and lynx winter foraging habitats.

Wildland Fire Management - As described above in section 3.4, wildfire suppression in this unit, as elsewhere in the West, has likely had little impact on lynx habitats (65 FR 16074; 68 FR 40093-94; USFS 2007, pp. 18, 20; USFS 2008, p. 11; ILBT 2013, p. 76). Also as described in that section, wildfire frequency, size, and intensity have increased in this geographic unit, where about 15 percent (4,172 km^2 [1,611 mi^2]) of the unit has burned from 2000-2013 (Squires *in* Lynx SSA Team 2016, p. 20), likely in response to climate warming and related increases in drought conditions (e.g., Harvey *et al.* 2016, entire; Westerling 2016, entire). Despite this increase, we are aware of no evidence that increased fire activity in the unit has thus far impacted resident lynx populations or reduced this unit’s ability to support resident lynx.

Habitat Loss and Fragmentation - As described above, the dominant land use in this unit, and that most likely to result in habitat loss and fragmentation, is timber harvest and associated vegetation management (e.g., precommercial thinning) and road construction. In the Northern Rocky Mountains, the forests upon which lynx depend have had less timber harvest, road construction, and have been modified much less than other drier forests (65 FR 16073), and these activities appear not to have had population-level impacts on lynx or to have measurably reduced the ability of this geographic unit to support resident lynx (with the possible exception of the Garnet Mountains). Few highways intersect lynx habitats in the Northern Rockies (ILBT 2013, p. 63) and there are few records of lynx killed by vehicle collisions in Montana (5) and Idaho (1) (Broderdorp, unpubl. data; MTFWP unpubl. data). Other potential sources of habitat loss and fragmentation include recreation, minerals/energy development, and forest/ backcountry roads and trails; these are all considered second tier anthropogenic influences (ILBT 2013, pp. 78-85) that are unlikely to exert population-level influences, despite potential impacts to individual lynx.

Other Factors - Connectivity/Immigration - As elsewhere in the range of the DPS, resident lynx populations in this geographic unit are thought to be influenced by connectivity with, and immigration of lynx from, populations in Canada (see section 2.2, above). However, whether and, if so, to what the extent the persistence of populations in this geographic unit may depend on regular or intermittent immigration of lynx from Canada remains uncertain, and historic, recent, and current immigration rates are unknown. This unit is directly connected to lynx habitats and populations in southwestern Alberta and southeastern British Columbia, where lynx habitats are also (like Montana and Idaho) patchily-distributed and generally support low hare densities, and where some lynx populations may be ephemeral and the persistence of others reliant on periodic influx of immigrants (Apps 2007, pp. 81, 95-104). Additionally, connectivity between this geographic unit and lynx habitats and populations in southern Alberta and southern British Columbia may be facilitated by only a few predicted corridors that extend south from the international border (Squires *et al.* 2013, pp. 187, 191-193).

Although lynx occurrence and harvest records in this geographic unit reflect the unprecedented irruptions of lynx from Canada into the northern contiguous U.S. in the early 1960s and early 1970s (McKelvey *et al.* 2000a, pp. 224-226, 232-242), there is no evidence of irruptions of lynx into this unit after the 1980s (Squires *in* Lynx SSA Team 2016, p. 20). This is supported by lynx trapping records from Canada, which suggest that the magnitude of lynx populations cycles in Alberta and British Columbia dampened dramatically after the early 1980s (McKelvey *et al.* 2000a, p. 226; Poole and Mowat 2001, p. 28; Hatler and Beal 2003, p. 2; Bowman *in* Lynx SSA Team 2016, p. 13; also see Appendix 5, 2015 10 13 - 5, pp. 4-5 [https://www.fws.gov/mountain-prairie/es/species/mammals/lynx/SSA2016/Appendices/Appendix%205%20Presentation%20PDFs/2015%2010%2013%20-%205%20-%20Bowman%20Lynx%20Southern%20Canada.pdf]).

A number of climate-mediated factors have been suggested as contributing to changes in the periodicity and amplitude of northern lynx and hare population cycles (see section 3.2, above), which would be expected to alter the timing and magnitude of irruptions of lynx from Canada into the contiguous U.S. If lynx populations in this unit are reliant on immigration from Canada which is no longer occurring or has been substantially reduced relative to historical conditions, population declines and a reduced probability of persistence among resident populations would be expected. Although the extent to which this factor has influenced the current condition of lynx populations in this unit is unknown, the population growth rate estimated for the Seeley Lake area (λ = 0.92, declining trend 1999-2007; Squires *in* Lynx SSA Team 2016, p. 20) may reflect a gradual decline of a resident lynx population that needs but is not receiving adequate immigration. In contrast, the growth rate estimated for the lynx population in the Purcell Mountains in the northwestern part of this unit (λ = 1.16, increasing trend 2003-2007; Squires *in* Lynx SSA Team 2016, p. 20) suggests that the level of immigration, if necessary for demographic stability, has been adequate or that productivity and recruitment have been high enough to offset potentially diminished immigration. It is also possible that, despite the documented historical intermittent (cyclic) influxes of lynx from Canada into lynx populations in this geographic unit, immigration does not contribute meaningfully to the demographic stability of these populations. If that is the case, the estimated growth rates suggest that recruitment has failed to offset mortality in the Seeley Lake population but that it has more than done so in the Purcell Mountains population.

4.2.4 Unit 4 - North-central Washington

Unit Description: This geographic unit is located in the northern Cascade Mountain Range of north-central Washington in portions of Chelan and Okanogan Counties and includes mostly Okanogan-Wenatchee National Forest lands as well as BLM lands in the Spokane District that were designated as critical habitat (Unit 4) for lynx in 2014 (79 FR 54825). The unit also includes State Forest lands (portion of the Loomis State Forest) that were excluded from designation as critical habitat (79 FR 54825). It encompasses approximately 5,176 km^2 (1,988 mi^2), with ownership that is 91.5 percent Federal (USFS, BLM), 8.2 percent State, and 0.3 percent private lands; there are no Tribal lands. This area was occupied at the time lynx was listed and is currently occupied by the species. Evidence from recent research and DNA analysis shows lynx distributed within this unit, with breeding being documented. Although researchers have fewer records in the portion of the unit south of Highway 20, this area contains boreal forest habitat and the components essential to the conservation of the lynx. Further, it is contiguous with lynx habitat north of Highway 20, particularly in winter when deep snows close Highway 20. The northern portion of the unit adjacent to the Canada border also appears to support few recent lynx records; however, it is designated wilderness, so access to survey this area is difficult. This northern portion contains extensive boreal forest vegetation types and the components essential to the conservation of the lynx. Additionally, lynx populations exist in British Columbia directly north of this unit.

As it is throughout the range of lynx in the contiguous U.S., maintaining connectivity with Canada is important to lynx populations in northern Washington and the Cascade Mountains. Singleton *et al.* (2002, entire) evaluated landscape permeability for large carnivores in Washington. They reported broad landscape permeability for lynx between the Thompson River watershed in British Columbia and the U.S. portion of the northern Cascades (Singleton *et al.* 2002, p. 46). According to the LCAS, connectivity currently appears functional, as lynx dispersal from Washington into Canada was recently documented. A male lynx radio-collared in 2008 in the Loomis State Forest remained there until late winter in 2009, when it dispersed north into Canada toward Hope, British Columbia, and then headed north-east toward Kamloops where it appeared to establish a home range just southeast of Kamloops. This individual was later trapped and killed in British Columbia, highlighting the need for cooperation and shared management goals across political boundaries (LCAS 2013, p. 65).

Several areas adjacent to this geographic unit (e.g., Kettle Range, the Wedge, Little Pend Oreille, Selkirk Mountains of northeast Washington) are known or thought to support a small number of lynx, at least intermittently. One of these areas in particular (Kettle Range) contains the second largest block of potential lynx habitat in Washington comprising approximately 987 km^2 (381 mi^2), which is significantly smaller than the North Cascades that supports approximately 8,923 km^2 (3,445 mi^2) of lynx habitat (Stinson 2001, p. 18). Historically, although the Kettle Range supports a fairly small block of lynx habitat (relative to other geographic areas supporting persistent lynx populations), it was considered to be a stronghold for lynx in Washington (Stinson 2001, p. 14). The Kettle Range was suspected to have supported a resident population until about 30 years ago when over-trapping may have resulted in their extirpation from the mountain range (Koehler *et al.* 2008, p.1523). For example, lynx were consistently trapped in the Kettle Range in the 1960s, 1970s, and 1980s. In the Kettle Range, a total of 81 lynx were trapped from 1961 through 1986. One lynx was harvested in 1963, 3 in 1966, 7 in 1967, 2 in 1969, 26 in 1970, 14 in 1976, and 17 in 1977. A single lynx was taken each year in 1980, 1983, 1985, and 1986 (Stinson 2001, p. 63). Prior to 1961, lynx trapping records were not maintained in Washington. Beginning in 1978, trapping seasons in Washington for lynx were reduced to one month. In 1987 a restricted permit system was implemented, and in 1990 a statewide closure on lynx trapping was implemented (USFWS 2008a, p. 2).

Lynx habitat in the Kettle Range is limited in size and potentially capable of supporting only a few lynx. According to Koehler *et al.* (2008, p. 1523), the Kettle Range could support between 10 to 23 lynx based upon a lynx density of 2.3 lynx/100km^2 and 400 km^2 (154 mi^2) to 987 km^2 (381 mi^2) of lynx habitat. It should be noted that the lynx density estimate was derived from research conducted in the Cascade Range within a large area of contiguous, high quality habitat (Koehler 1990, pp. 845, 847). Lynx habitat in the Kettle Range is much smaller and likely more fragmented, and thus may not be capable of supporting a density of 2.3 lynx/100 km^2. The Kettle Range is also somewhat isolated from other lynx habitats in Washington (e.g., the Cascades) and British Columbia. The Kettle Range is separated from the Cascades in Washington by low elevation valleys dominated by shrub-steppe and Douglas-fir and ponderosa pine forests (Koehler *et al.* 2008, p. 1523), and from British Columbia by the Kettle River Valley (Stinson 2001, p. 20) and a major highway corridor with associated fence in British Columbia (Koehler *et al.* 2008, p. 1523). These natural topographic and anthropogenic features may present impediments to lynx movement between the Kettle Range and the Cascades and British Columbia, making natural recolonization of the Kettle Range by lynx difficult. Thus, it may be difficult for lynx to reestablish a persistent and viable resident breeding population in the Kettle Range.

Habitat Description: In the northern Cascades most lynx occurrences are associated with the Rocky Mountain Conifer Forest (Aubry *et al.* 2000, p. 379; McKelvey *et al.* 2000a, p. 246) at elevations between 1,400 m (4,593 ft) and 2,150 m (7,053 ft) (McKelvey *et al.* 2000d, p. 322; Stinson 2001, p. 9). Within this area lynx primarily use forests dominated by Engelmann spruce, subalpine fir, or lodgepole pine on mild to moderate slopes (less than 30 degrees), and avoid Douglas-fir and ponderosa pine forests, forest openings, recently burned areas with sparse canopy and understory cover (less than 10 percent), low elevations [less than 915 m (3,000 ft)], and steep slopes (greater than 30 degrees) (Koehler *et al.* 2008, pp. 1518, 1521; Maletzke 2004, pp. 16-17). Similar to the northern Rocky Mountains, lynx habitat in the Cascades is naturally fragmented (Koehler *et al.* 2008, p. 1523). Disturbance is common in boreal forests, and fires and insect epidemics are major drivers of this disturbance, but other factors including wind and disease also contribute to the process of disturbance (Agee 2000, p. 47). Fire return intervals in the north Cascades ranges between approximately 100 to 250 years (Agee 2000, p. 50).

Snowshoe hares are the primary prey of lynx throughout their range in North America (Mowat *et al.* 2000, p. 267) comprising 35-97 percent of their winter diet (Koehler and Aubry 1994, p. 75). Lynx also consume other prey species, including red squirrels, mice, voles, grouse, ptarmigan, and other species of mammals and birds, especially during summer or when snowshoe hare population densities decline (Mowat *et al.* 2000, pp. 267-268). Koehler (1990, p. 848) found snowshoe hares were the primary prey of lynx in the north Cascades of Washington occurring in 23 of 29 (79 percent) lynx scats examined, but the remains of red squirrels were identified in 7 of the 29 (24 percent) lynx scats, as were the remains of other species including deer and mice. Von Kienast (2003, p. 39), who also conducted a lynx study in the north Cascades of Washington, found snowshoe hares in 87% (40 of 46) of lynx scats, while red squirrels were identified in 28% (13 of 46) of lynx scats.

Results of lynx research in the northern portion of its range suggest that a minimum density of 0.5-1.0 hares/ha (0.2-0.4 hares/ac) is needed to support lynx reproduction, but it is unknown if a similar snowshoe hare density is required to support lynx reproduction in the southern portion of its range (Ruggiero *et al.* 2000b, p. 446). In the northern portion of lynx range (i.e., the taiga) peak snowshoe hare densities regularly exceed 4-6 hares/ha (1.6-2.4 hares/ac), and cycle as low as 0.1-1 hares/ha (0.04-0.4 hares/ac) (Hodges 2000b, pp. 119-120). In the southern portion of lynx range (e.g., the U.S.) snowshoe hare densities are low compared to those in northern regions (Aubry *et al.* 2000, p. 375). Walker (2005, p. 20) estimated an average snowshoe hare density of 0.89 hares/ha (0.36 hares/ac) with a range of 0.03 to 4.85 hares/ha (0.01 to 1.94 hares/ac) in north central Washington (i.e., the Cascades). The Washington Department of Natural Resources (WADNR) found snowshoe hare densities between 0.3 and 0.7 hares/ha (0.1 and 0.3 hares/ac) on the Loomis State Forest (WADNR 2006, p. 87).

Lynx distribution is nearly coincident with the distribution of snowshoe hares (McCord and Cardoza 1982, entire; Bittner and Rongstad 1982, entire), and lynx occupy habitats where snowshoe hares are abundant (Koehler and Aubry 1994, p. 84). Snowshoe hares are limited to environments with snowy climates (Ruggiero *et al.* 2000b, p. 448). Average annual snowfall is consistent throughout this unit and is approximately 291 cm (114.5 in) (https://snowfall.weatherdb.com/d/a/Washington; accessed 4/27/2016).

Habitat Status: The range of lynx in the contiguous U.S. is broadly delineated by the distribution of the southern extensions of boreal forest. However, the complexities of lynx population dynamics and our incomplete understanding of the limited lynx occurrence data, combined with naturally dynamic habitat, make it difficult to precisely delineate the historical range of lynx in the U.S. (68 FR 40084). McKelvey *et al.* (2000a, pp. 245-246) described the historical range of lynx in the western U.S., encompassing at least 75 percent of lynx occurrences, as associated with the Rocky Mountain Conifer Forest containing the primary vegetation types of Douglas-fir and western spruce/fir forests. These western spruce fir forests represent the southern extension of boreal forests into the U.S. (Agee 2000, pp. 40-42, 46). The amount of boreal forest habitat in the contiguous U.S. has not changed substantially in the past 100 years (68 FR 40085).

However, while the boreal forest may not have changed substantially within the past 100 years (i.e., permanent or long-term reductions in the quantity or size), it is naturally dynamic with fire and insects representing major disturbance processes (Agee 2000, p. 47) that can create areas temporarily unsuitable for lynx through regeneration of forested stands to early successional conditions (Agee 2000, pp. 62-63). In 2001, the Washington Department of Fish and Wildlife (WDFW) estimated there was approximately 8,923 km^2 (3,445 mi^2) of potential lynx habitat within this geographic unit. Several wildfires affected lynx habitat in the north Cascades during the middle 1990s and early 2000s: 1994 Whiteface Burn (1,554 ha (3,840 ac)); 1994 Thunder Mountain Fire (3,686 ha (9,108 ac)); 2001 Thirty-Mile Fire (2,565 ha (6,338 ha)); and 2001 Farewell Fire (32,278 ha (79760 ac)) (Vanbianchi 2015, p. 23). Subsequent to these fires and incorporating new science on lynx habitat use, Koehler *et al.* (2008, pp. 1521-1522) estimated this geographic unit contained approximately 2,411 km^2 (930 mi^2) of suitable lynx habitat based on studies conducted from 2002 through 2004. More recent wildfires, including the 2006 Tripod Fire (70,644 ha (175,656 ac)) (Vanbianchi 2015, p.23), have affected approximately 1,000 km^2 (386 mi^2) of lynx habitat within this geographic unit (Lynx SSA Team 2016, p. 21). Cumulatively, over the past 2 decades these wildfires have burned greater than 50 percent of the suitable lynx habitat within this geographic unit (Koehler *et al.* 2008, p. 1523). These acres are expected to regenerate back into suitable lynx habitat, but it may take several decades for this to occur.

Lynx Status: In Washington, there is little information on the status of the lynx population prior to the early 1960s (Stinson 2001, p. 13). From 1960-61 to 1990-91 a total of 234 lynx were harvested in Washington, with the most lynx trapped in Ferry County (35 percent of the 234), followed by Okanogan (23 percent) and Stevens (10 percent) counties (Stinson 2001, p. 13). The WDFW identified six lynx management zones (LMZs) in Washington: Okanogan, Vulcan-Tunk, Kettle Range, The Wedge, Little Pend Oreille, and Salmo-Priest (i.e., essentially the Selkirk Mountain Range in northeast Washington (Stinson 2001, p 14). In 2001, the WDFW considered lynx to be present in the Okanogan, Kettle Range, Little Pend Oreille, and Salmon-Priest LMZs; at that time lynx had not been detected in the Wedge LMZ since 1987 nor the Vulcan-Tunk LMZ since 1990 (Stinson 2001, p.15).

In 2001, based on data collected from lynx telemetry studies conducted in the Cascade Range during the 1980's, the WDFW estimated that Washington contained approximately 12,579 km^2 (4,857 mi^2) of lynx habitat which could theoretically support up to 238 lynx (based on a lynx density of 2.5 lynx/100 km^2) (Koehler 2008, p. 1518; Stinson 2001, p. 16). However, based on professional opinions of individuals knowledgeable about lynx and lynx habitat, the WDFW adjusted this number down suggesting that Washington likely supported fewer than 100 individual lynx (Stinson 2001, p. 16). More recently, Koehler *et al.* (2008, p. 1523), estimated there was approximately 3,800 km^2 (1,467 mi^2) of lynx habitat in Washington potentially supporting up to 87 lynx. This more recent population estimate was based on a study investigating lynx habitat use in the Okanogan from 2002 to 2004, and used a lynx density estimate of 2.3 lynx/100 km^2 derived from a radio-telemetry study conducted on lynx in the Cascades from 1985-1987 (Koehler 1990, pp. 845-847). However, the study area in which the 2.3 lynx/100 km^2 density estimate reported by Koehler (1990, p.847) was derived is located in an area of the northern Cascades known as the "Meadows". During the time of Koehler's (1990, entire) study the Meadows provided some of the best lynx habitat in Washington, whereas most other lynx habitat in Washington is lower in elevation and more highly fragmented (Walker 2005, pp. 3, 6). Thus, the lynx densities Koehler observed in his study area in the Meadows may not translate to lynx densities throughout the rest of lynx habitat in Washington, because as habitat becomes more fragmented and isolated (i.e., marginal), the carrying capacity for a particular species declines. Thus, applying Koehler's estimated lynx density uniformly throughout Washington, may overestimate the overall lynx population capable of being supported in Washington.

Relative to the Okanogan LMZ (i.e., the north Cascades), which supports the only known persistent breeding population of lynx in Washington State, in 2001, the WDFW estimated the LMZ could support a maximum of 149 lynx (Stinson 2001, p. 16). This number was derived by estimating that the LMZ contains approximately 8,923 km^2 (3,445 mi^2) of lynx habitat (which was decreased by 33 percent to account for unsuitable areas) combined with an average lynx population density estimate of 2.5 lynx/100km^2 derived from two studies conducted in the 1980s (Stinson 2001, p. 16). The estimated quantity of lynx habitat was based on mapping areas supporting the forest-type and physiographic characteristics identified as being used by lynx during telemetry studies conducted in the 1980s (Koehler *et al.* 2008, p. 1518), irrespective of the current condition (successional stage, or stand type, structure, or age, etc.) of the habitat. The estimation of lynx habitat was based purely on forested areas potentially supporting a forest-type potential of subalpine fir/Engelmann spruce, and the physiographic characteristics of elevations greater than 1,400 m (4593 ft) on mild to moderate slopes (Koehler *et al.* 2008, p. 1518), and did not consider whether the area was recently burned, harvested, etc. Recognizing that new information on lynx and snowshoe hare habitat use patterns had been learned since the 1980's, and that several large, stand-replacing fires had burned in lynx habitat, Koehler *et al.* (2008, entire) conducted a lynx telemetry study in the Okanogan from 2002 to 2004 to reassess the suitability of lynx habitat. They estimated that the Cascades contained approximately 2,411 km^2 (930 mi^2) of suitable lynx habitat based on mapping areas supporting Engelmann spruce/subalpine fir forests with moderate canopy cover on flat to moderate slopes at elevations from 1,525 m (5003 ft) to 1,829 m (6000 ft) (Koehler *et al.* 2008, pp. 1521-1522). Therefore, at that time and using Koehler's (1990, p. 847) lynx density estimate of 2.3 lynx/100 km^2, the Cascades could theoretically support approximately 55 individual lynx.

From 1985 to 1987, the movements of five adult male and two adult female radio-collared lynx were monitored by Koehler (1990, entire) in the Cascades of north-central Washington. During the study two kittens were also captured and ear-tagged (Koehler 1990, p. 847). Results of the study indicated female average home range size was 39 km^2 (15 mi^2) and average male home range size was 69 km^2 (27 mi^2). Based on occupancy of the 640 km^2 study area by 15 adult lynx, adult lynx density was estimated to be 2.3 adults/100 km^2. Annual adult survival rates of the radio-collared lynx were 0.73 in 1986 and 1.00 in 1987, and kitten mortality was high at 88 percent with only 1 of 8 known kittens surviving its first year (Koehler 1990, p. 847).

As stated previously, fire is a common disturbance factor in boreal forests (Agee 2000, p. 47). Fire return intervals within western subalpine fir forests in the Cascades range from 109 to 250 years (Agee, 2000, p. 50) with typically high fire intensities in lynx habitat resulting in extensive areas of regenerating forest (Agee, 2000, p. 53). Maletzke assessed the effects of recent fires in the Cascades and their potential impacts to the lynx population there as follows:

> "From 1990-2002, there were about 2,600 km^2 of lynx habitat in the Okanogan (Eastern Cascades) area, and female home ranges were estimated at 39 – 41 km^2, suggesting the potential to support roughly 90-115 resident females (home ranges include "matrix" or non-habitat). By 2014, habitat had been reduced by fire to about 1,600 km^2, and habitat loss and fragmentation resulted in female home ranges increasing to an estimated 91 km^2, with a potential to support roughly 27 resident females" (Lynx SSA Team 2016, p. 21).

Therefore, using Maletzke's method and assuming a 2:1 sex ratio of females to males, the total theoretical lynx population that may have been supported in the Cascades prior to 2002 may have ranged between 135 and 172 individual lynx. Subsequent to the fires the total theoretical lynx population potentially supported in the Cascades has been reduced to approximately 40 individual lynx, which potentially represents a 70 percent to 77 percent decline in the lynx population. Note: while the area (lynx habitat in the Cascade range) used to generate the population estimate of 55 lynx in the Cascades prior to the fires based on Koehler's (1990, p. 847) lynx density estimate is the same as the area used by Maletzke to generate his population estimate of 90 – 115 resident females based on simulated female home ranges with an empirically derived size and arbitrary minimum threshold of habitat, the two dissimilar population estimates used differing methodologies, and thus the population estimates themselves are not comparable. However, using Koehler's lynx density estimate of 2.3 lynx/100 km^2 and applying it to the 1,600 km^2 of lynx habitat remaining after the fires results in an estimated lynx population of approximately 37 individual lynx, which represents an approximate 33 percent reduction in the lynx population. Further informing the effects of these recent fires in the Cascades on lynx habitat is illustrated by evaluating the average size of a female lynx home range prior to and after the fires. Prior to the fires, Koehler (1990, p. 847) estimated an average female lynx home range size of 39 km^2 (15 mi^2), whereas after the fires Maletzke estimated the average female home range size had increased to 91 km^2 (35 mi^2) (Lynx Workshop Report 2016, p. 21). The important point is the recent large, stand replacing fires in the Cascades has resulted in significant temporary losses of lynx habitat, and thus the ability of the Cascades to support a persistent and viable reproducing lynx population may have been significantly impacted. The areas impacted by these recent fires are expected to regenerate into suitable lynx habitat, but it may take 35-40 years to do so (Lynx Workshop Report 2016, p. 21).

Factors Affecting Current Condition

In 1993, lynx were classified by the Washington Fish and Wildlife Commission as a State threatened species (Stinson 2001, p. 22). On July 12, 2016, the WDFW recommended that the Washington Fish and Wildlife Commission uplist the lynx from a State threatened to a State endangered species (WDFW 2016, p.1). According to the Draft Washington State Periodic Status Review for the Lynx, the WDFW recommended listing the lynx as endangered because of: 1) observed range contraction in Washington following protection efforts; 2) the substantial loss of habitat in the last 20 years; and 3) the ongoing and anticipated threats to lynx population persistence.

Within Washington, the vast majority of lynx habitat is administered by the Okanogan/ Wenatchee (OWNF) and Colville (CNF) National Forests. The North Cascades (aka the Okanogan LMZ in north-central Washington), which supports the only known, long-term persistent lynx breeding population in Washington, and within which critical habitat was designated for lynx in 2014 (79 FR 54782), is administered by the OWNF. Subsequent to listing lynx under the ESA, the Forest Service entered into a Conservation Agreement (CA) with the Service in 2000 (USFS and USFWS 2000, entire), which was revised and extended in 2006 (USFS and USFWS 2006, entire). The CA committed the ONWF and CNF to use the Lynx Conservation Assessment and Strategy (LCAS) for management of lynx and its habitat on their ownerships, and will remain in place until the forests amend or revise their individual LRMPs.

The LCAS, which was also developed pursuant to the listing by an interagency team comprised of USFS, BLM, Service, and NPS personnel, identified four primary risk factors potentially exerting population level effects upon the status of lynx: climate change, vegetation management, wildland fire management, and habitat fragmentation. To promote conservation of lynx and its habitat, the LCAS contains conservation measures addressing the identification and maintenance of lynx habitat (foraging, denning, and connectivity habitats) on Federal lands. Toward this end, the LCAS recommends that Federal land managers identify and map lynx habitat on their ownerships, and delineate LAUs containing the mapped lynx habitat, within which the effects of management actions on lynx habitat will be monitored and analyzed. The LCAS also recommends that the size of LAUs should be based on the average size of a female lynx home range and contain year-round habitat components (i.e., foraging and denning habitat). Thus, in Washington, and the north Cascades specifically, it appears that the single threat for which lynx were listed under the ESA (i.e., inadequacy of regulatory mechanisms) has largely been addressed through the development of the LCAS, and CA between the Forest Service and Service which commits the Forest Service, specifically for Washington the OWNF and CNF, to use the LCAS in the management of lynx habitat on their ownerships and when designing and implementing projects within LAUs.

The WADNR manages approximately 4 percent of the lynx habitat within portions of each of the delineated LMZs (WADNR 2006, p.9) in Washington State, including the Loomis State Forest that is located in the north Cascades of north-central Washington within the Okanogan LMZ. In 1996, the WADNR developed and implemented a Lynx Habitat Management Plan (1996 Lynx Plan) in response to listing of the lynx as a State threatened species by Washington State (WADNR 1996, entire). After the DPS was Federally listed as threatened, the WADNR in 2006 modified its Lynx Habitat Management Plan to incorporate new science and management standards and guidelines to avoid the incidental take of lynx in accordance with the ESA (WADNR 2006, entire). These standards and guidelines address maintenance of lynx denning and foraging habitat, as well as habitat connectivity within and between LAUs and lynx populations within Washington (i.e., LMZs) and Canada.

For example, the WADNR 2006 Lynx Plan includes, among other things: (1) Encouraging genetic integrity at the species level by preventing bottlenecks between British Columbia and Washington by limiting size and shape of temporary non-habitat along the border and maintaining major routes of dispersal between British Columbia and Washington; (2) Maintaining connectivity between subpopulations by maintaining dispersal routes between and within zones and arranging timber harvest activities that result in temporary non-habitat patches among watersheds so that connectivity is maintained within each zone; (3) Maintaining the integrity of requisite habitat types within individual home ranges by maintaining connectivity between and integrity within home ranges used by individuals and/or family groups; and (4) Providing a diversity of successional stages within each LAU and connecting denning sites and foraging sites with forested cover without isolating them with open areas by prolonging the persistence of snowshoe hare habitat and retaining coarse woody debris for denning sites. The 2006 Lynx Plan also describes how WADNR will monitor and evaluate the implementation and effectiveness of the plan. The WADNR has been managing for lynx for almost two decades, and the Service has concluded that the management strategies implemented are effective. In the final revised critical habitat designation, published in the Federal Register on February 25, 2009 (74 FR 8657–8658), we determined that the benefits of excluding lands managed in accordance with the WADNR 2006 Lynx Plan outweighed the benefits of including them in the designation, and that doing so would not result in extinction of the species. We, therefore, again are considering excluding 164.2 mi^2 of lands managed in accordance with the WADNR 2006 Lynx Plan from the revised lynx critical habitat designation.

Recent wildfires have temporarily eliminated or reduced the quality of greater than 50 percent of lynx habitat within the north Cascades (Koehler *et al.* 2008, p. 1523), which has significantly affected the status of and current viability of the lynx population within this geographic unit. As discussed below under *Potential Threats/Stressors/Factors Influencing Viability*, there is significant risk of potential future wildfires to further affect the viability of lynx in this geographic unit. Recent wildfire severity, extent, and intensity in lynx habitat within this geographic unit may have been influenced by climate change (Westerling *et al.* 2006, pp. 942-943), and as discussed below, climate change may similarly affect the future viability of lynx within this geographic unit.

4.2.5 Unit 5 - Greater Yellowstone Area

Unit Description: This geographic unit includes the parts of southwestern Montana and northwestern Wyoming the Service designated as critical habitat (Unit 5) for lynx in 2014 (79 FR 54825-54826). It encompasses approximately 23,691 km^2 (9,147 mi^2) in portions of Carbon, Gallatin, Park, Stillwater, and Sweetgrass Counties in Montana; and Fremont, Lincoln, Park, Sublette, and Teton Counties in Wyoming, with ownership that is 97.5 percent Federal (USFS, NPS, and BLM); 2.2 percent private; and 0.3 percent State. This unit includes parts of Grand Teton and Yellowstone national parks and the Bridger-Teton, Custer-Gallatin, and Shoshone national forests, and lands managed by the BLM's Kemmerer and Pinedale Districts. It includes parts of the Absaroka, Beartooth, Gallatin, Gros Ventre, Salt River, Teton, Wind River, and Wyoming mountain ranges. This unit is not directly connected to lynx habitats and populations in Canada or to other DPS populations, although lynx dispersing from the north likely arrived intermittently into the area historically and, more recently, some lynx released into Colorado traveled into and through this unit (see Devineau *et al.* 2010, p. 526). Relative to other DPS lynx populations, this unit is about 145 km (90 mi) southeast of the Northwestern Montana/Northeastern Idaho unit, and roughly 400 km (250 mi) northwest of the Western Colorado geographic unit.

Habitat Description: In northwestern Wyoming and the GYA, lynx are generally associated with Englemann spruce-subalpine fir and lodgepole pine of the Rocky Mountain Conifer Forest vegetation class, as described above (Section 4.1.3) for the northwestern Montana, although this habitat and, thus, lynx typically occur at higher elevations (2,000-3,000 m [6,550-9,850 ft]) in the GYA (McKelvey *et al.* 2000a, p. 245; ILBT 2013, p. 60). Potential lynx habitat in much of the GYA is naturally marginal (patchier and composed in many places of drier forest types), with fewer shrubs and a more open understory, and generally low to marginal hare densities, resulting in a spatially-limited distribution of lynx with large home ranges (Squires *et al.* 2003, pp. 5, 12-13; 68 FR 40090; 71 FR 66010, 66029; 74 FR 8624, 8643–8644; Hodges *et al.* 2009, entire; Berg and Gese 2010, p. 1750; 79 FR 54796; Lynx SSA Team 2016, p. 45). Among the three national forests that contribute lands to this geographic unit, potential lynx habitat was mapped on about 42 percent of the total national forest area (both inside and outside this SSA unit; USFWS 2007, pp. 32, 95, 122-123).

In Yellowstone National Park, 7,732 km^2 (2,985 mi^2; about 86 percent of the park) is considered "lynx forest types" (65 FR 16073), but only 2,784 km^2 (1,075 mi^2; 31 percent of the park, 36 percent of lynx forest types) is estimated to be potential lynx habitat (68 FR 40086). However, hares were completely absent from more than 36 percent of surveyed stands in Yellowstone National Park, and 96 percent had estimated hare densities below the 0.5 hare/ha threshold thought necessary to support resident lynx (Hodges *et al.* 2009, 870, 873-877). In contrast, estimated hare densities were >= 0.48 hares/ha in all surveyed stands on the Bridger-Teton National Forest in the southern portion of the GYA, with highest densities (1.7 hares/ha) in 30-70-year-old regenerating lodgepole pine stands with dense horizontal cover, and densities of

1.2 - 1.6 hares/ha in mature multi-storied spruce-fir and mixed spruce-fir (containing aspen or lodgepole pine) stands (Berg *et al.* 2012, p. 1483). In the central Wyoming Range in the southern part of this unit, hare tracks were more abundant in seral aspen stands with a significant spruce-subalpine fir component than in aspen stands with little or no spruce-fir, and hares appeared to be absent from pure aspen stands except where they bordered spruce/fir areas (Endeavor Wildlife Research 2009, p. 4). The only lynx den sites described for this unit (the natal den and a subsequent maternal den of one female in 1998) occurred in a mature subalpine fir-lodgepole pine forest in the Wyoming Range, where coarse woody debris and high sapling density provided dense horizontal cover (Squires and Laurion 2000, pp. 346-347).

Average annual snowfall in this unit ranges from about 127 cm (50 in) in Bozeman and 556 cm (219 in) in West Yellowstone, Montana, on the northern and northwestern peripheries of the unit, respectively, to 280-310 cm (110-122 in) in Alpine, Dubois, and Jackson, WY near the central and southern peripheries, with most snow falling from November to March in each place (https://snowfall.weatherdb.com/d/a/Montana; accessed 8/17/2016). In potential lynx habitats on the Bridger-Teton National Forest in the southern half of this unit, deep snow persisted from late October through May (Berg *et al.* 2012, p. 1481).

Habitat Status: Potential lynx habitats in this unit are currently designated as critical habitat in accordance with the ESA. Over 97 percent (23,109 km^2 [8,922 mi^2]) of this unit is in Federal ownership, including 18,877 km^2 (7,292 mi^2) in national forests under USFS management, 3,944 km^2 (1,523 mi^2) in national parks managed by NPS, and 271 km^2 (105 mi^2) managed by BLM. As described above in section 3.1.1, USFS lands in this unit are managed in accordance with the NRLMD, which formally amended all forest plans to adopt and implement lynx conservation measures (USFS 2007, pp. 8-30 and Attachment 1, pp. 1-9) that were developed based on the scientific findings and recommendations of the LCAS (Ruediger *et al.* 2000, pp. pp. 7-1 - 7-18). Similarly, the BLM in 2008 and 2010 revised its RMPs for the Pinedale and Kemmerer districts, respectively, to include conservation measures and BMPs for lynx based on the LCAS (BLM 2008, pp. A18-10 - A18-15; BLM 2010, pp. A-9 - A-12). On lands with developmental land-use allocations, these amended forest plans and the revised BLM RMPs provide guidance on the kinds of activities that can and cannot be implemented in important lynx habitats and thresholds for the proportions of lynx habitat in LAUs that can be in an unsuitable state at any given time and how much can be converted from suitable to (temporarily) unsuitable over particular time frames. Implementation of these plans has likely benefitted lynx by providing a consistently-applied framework for conserving and restoring important hare and lynx habitats.

As elsewhere in the DPS (Squires *et al.* 2010, p. 1656; ILBT 2013, pp. 20, 27), winter foraging habitat is likely the most limiting habitat for lynx in this unit, and denning habitat is not thought to be limiting. Standards, guidelines and BMPs in the NRLMD and in revised BLM plans restrict vegetation management activities that could reduce winter snowshoe hare habitat and direct the creation or retention of coarse woody debris in areas where denning habitat may be lacking (USFS 2007, Attachment 1, pp. 2-5; BLM 2008, pp. A18-10 - A18-15; BLM 2010, pp. A-9 - A-12). Snow conditions in this unit also appear to remain suitable to allow lynx to outcompete other terrestrial hare predators. Gonzalez *et al.* (2007, pp. 4-7) compared the highest-precision lynx occurrence data in the contiguous U.S. from 1966-1998 with snow-cover data available for those locations and concluded that lynx require nearly continuous snow cover from December through March. The authors modeled the probability of suitable snow across North America, showing that most of this geographic unit has a 95 percent probability of providing snow cover conditions supportive of lynx presence (Gonzalez *et al.* 2007, p. 12).

This unit includes substantial areas in nondevelopmental land-use allocations, including (in addition to Yellowstone and Grand Teton national parks) the Absaroka-Beartooth, Bridger, Gros Ventre, Lee Metcalf, Northern Absaroka, Teton, and Washakie designated wilderness areas. Among the three national forests that contribute to this unit, 75 percent of potential lynx habitat is in designated wilderness or roadless areas (USFWS 2007, p. 34). Management activities in these areas are unlikely to adversely impact lynx and hare habitats.

Large parts of Yellowstone National Park burned in the extensive wildfires of 1988. Although the extent to which those fires may have impacted potential lynx habitats is uncertain, some of the burned areas may soon reach a stage of regeneration capable of supporting increased densities of hares, perhaps increasing the likelihood that lynx could reestablish and maintain home ranges in some parts of the park (Lynx SSA Team 2016, p. 45).

Because non-Federal lands make up less than 3 percent of lynx habitats in this unit, it is unlikely that activities on those lands have impacted lynx populations or meaningfully influenced the unit’s current capacity to support resident lynx.

Overall, although naturally fragmented and patchily-distributed, potential lynx habitat in this geographic unit appears to be largely intact relative to historical conditions and disturbance regimes, with only a small proportion apparently impacted by past management (timber harvest and precommercial thinning) activities (65 FR 16072). Despite some likely localized impacts of past timber management and infrastructure (e.g., highway, railroad) development, past management activities do not appear to have diminished this unit's ability to support resident lynx or to have created barriers to lynx movement, or to have had other landscape- or population-level effects.

In summary, much of this geographic unit occurs in national parks, designated wilderness and roadless areas, or other nondevelopmental land-use allocations, where management activities with the potential to adversely affect lynx habitat generally do not occur. Almost all lands with developmental land-use allocations in this unit are managed by the USFS to conserve and maintain lynx and hare habitats under management plans that were formally revised in 2007 in accordance with the NRLMD and based on the scientific findings and conservation recommendations of the LCAS. A small proportion of lands with developmental allocations occurs on BLM lands where management plans also were revised recently (2008 and 2010) to adopt conservation measures identified in the LCAS. Implementation of these USFS and BLM plans likely precludes landscape-level management-related adverse impacts to the vast majority of existing lynx and hare habitats in this unit. Nonetheless, past management activities that occurred prior to implementation of current regulations and other conservation efforts may exert continuing influence on current habitat quality in some places. Additionally, because lynx habitats in this unit are naturally highly-fragmented and, in most places, support low landscape-level hare densities, relatively minor impacts, especially to hare and lynx winter foraging habitats, may strongly influence lynx persistence in some parts of this unit.

Lynx Status: There are no reliable estimates of the historical or current number of resident lynx in this unit. As described in section 2.3.2.2 above, the historical record and recent research show that the GYA has supported resident lynx, but it is unclear whether the area consistently supported a persistent resident population over time or whether it naturally supported resident lynx only intermittently. Most historical and recent verified lynx records are from the southern portion of this unit in the Gros Ventre, Salt River, Wind River, and Wyoming mountain ranges in the Bridger-Teton National Forest. Eighteen lynx were reported to have been trapped from a small area in the Wyoming Range in 1971-72 (Squires and Laurion 2000, p. 338), but it is unknown whether any of those lynx were residents (and if so, how many) or if some or all of them were dispersers associated with the “explosion” (irruption) of lynx documented in several places in the contiguous U.S. in the early 1970s (McKelvey *et al.* 2000a, pp. 235-242). However, two resident lynx, a male and a female, were trapped, radio-marked, and monitored in the Wyoming Range over several years beginning in 1996. The female produced four kittens in 1998 and two in 1999, though none of the kittens survived to independence, and the female died of starvation in March 2000 (Squires and Laurion 2000, p. 346; Squires *et al.* 2001, pp. 9, 26). The female’s home range averaged 50 km^2 (19 mi^2) over the 3 years she was monitored, and the male’s averaged 824 km^2 (318 mi^2) over five years (Squires *et al.* 2003, pp. 12-13). The male also made multiple long-distance exploratory movements (up to 728 km [452 mi], including multiple highway crossings) over 3 successive years (Squires *et al.* 2003, pp. 13-16; Squires and Oakleaf 2005, entire).

Other surveys also detected lynx in the southern portion of this unit from 1999-2009, with records most consistent in the Wyoming Range, Togwotee Pass, Union Pass, the Bondurant Corridor, and in the Gros Ventre Range (Squires *et al.* 2001, pp. 9-14; Squires *et al.* 2003, pp. 9-11, 29-31; Endeavor Wildlife Research 2008, 2009, entire; Berg 2016, *pers. comm.*; Squires *in* Lynx SSA Team 2016, pp. 20-21). Additionally, 10 radio-marked lynx released in Colorado subsequently moved into or through this portion of the GYA unit from 2004-2010, with locations concentrated in areas used previously by native Wyoming lynx (Devineau *et al.* 2010, p. 526; Hanvey 2016, *pers. comm.*). Several of the Colorado-released lynx occupied home ranges (including overlapping male and female home ranges) in areas of the Wyoming Range previously occupied by “native” resident lynx (Squires *in* Lynx SSA Team 2016, p. 21), but there is no evidence of reproduction among these lynx. On the Shoshone National Forest in the northeastern part of this unit, seven lynx snow tracks were confirmed by DNA analysis in winter 2005/06, and a single track was verified the following winter (Endeavor Wildlife Research 2008, p. 2; Berg 2016, *pers. comm.*). During the winters of 2004-05 through 2007-08, 26 snow tracks on the Bridger-Teton and Shoshone national forests were confirmed by DNA analyses to be from five individual lynx (3 males, 2 females). One of the males had previously been documented in Yellowstone National Park (see below). The other two males and both females were lynx that had been released in Colorado (Pilgrim 2016, *pers. comm.*).

Verified records of lynx are less common elsewhere in this unit, including in Yellowstone and Grand Teton national parks and the Custer-Gallatin National Forest. There were no verified records of lynx in Yellowstone National Park from 1920-1999 (McKelvey *et al.* 2000a, p. 230); however, surveys in 2001-2004 documented at least 3 individual lynx, including two kittens, in the eastern part of the park (Murphy *et al.* 2006, entire). Several Colorado-released lynx also traveled through the park (Devineau *et al.* 2010, p. 526), and two possible (unconfirmed) lynx tracks were recorded in the park during winter 2008/2009 (Endeavor Wildlife Research 2009, pp. 4, 12). On the Custer-Gallatin National Forest in Montana in the northern part of the unit, a single female was detected over six consecutive winters (2003/2004 - 2008/2009) but not subsequently (Gehman *et al.* 2010, pp. 2-4), and it appears that she did not encounter a male or produce kittens during the six years she was detected (Gehman *et al.* 2010, p. 4).

Recent surveys and research-related trapping efforts have failed to detect lynx in this unit after 2010 (79 FR 54791; Squires *in* Lynx SSA Team 2016, pp. 20-21, 45; Hanvey 2016, *pers. comm.*). As discussed above and in section 2.3.2.2, it is uncertain whether this unit historically supported a small but persistent resident population that was recently extirpated, or if it historically and recently has supported resident lynx only intermittently. Given the protected conservation status of millions of acres in this unit, its apparent recent inability to support resident lynx may be a reflection of naturally marginal and patchy habitats and relatively low hare abundance in much of the unit, resulting in only an intermittent ability of this unit to support resident lynx (Lynx SSA Team 2016, p. 57). Conversely, the characteristics described above suggest that relatively small impacts could tip this unit from just barely able to support a persistent resident population to incapable of doing so. Further, the available evidence suggests that if this unit did support a persistent population, it was very likely a very small one, which would be more vulnerable to extirpation as a result of demographic, environmental, and genetic stochasticity, and to catastrophic events (McKelvey *et al.* 2000b, pp. 23-29), or to a combination of these factors.

<u>Factors Affecting Current Conditions</u>

Regulatory Mechanisms - As described above for Unit 3, Federal management activities (e.g., timber harvest and precommercial thinning, perhaps fire suppression) that occurred prior to listing and before implementation of current Federal regulatory mechanisms likely impacted some lynx and habitats by altering the distribution and quality of hare and lynx habitats. However, because these activities occurred in low proportions of lynx habitat on Federal lands and impacts appear to have been localized, they were deemed a low-level to threat to lynx at the time of listing (65 FR 16072-16076; 68 FR 40091-40095). Nonetheless, past Federal management activities may continue to influence the current quality and distribution of lynx habitats in some parts of this unit. Current regulatory mechanisms and conservation measures associated with recently amended or revised Federal management plans are intended to conserve and restore lynx and hare habitats across large landscapes. Although their effectiveness has not been quantitatively evaluated, they have almost certainly reduced significantly the potential for adverse management-related impacts to lynx habitats in this unit.

Lynx trapping has been prohibited in Wyoming since 1973 (79 FR 54794) and in Montana since 1999 (MTFWP 2016, p. 7) and, as described in section 3.1.2, above, both states require measures to reduce the likelihood of trapping lynx incidentally when legally trapping other species. Since the DPS was listed in 2000, no lynx are documented to have been incidentally trapped in the Montana portion of this unit (MTFWP 2016, pp. 5-10) and we are aware of no incidental captures in northwestern Wyoming since listing.

Climate Change - As elsewhere, increased temperatures, reduced snowpack, earlier snowmelt, and increased drought leading to increased fire all have been documented in this geographic unit (e.g., Mote *et al.* 2005, entire; Pederson *et al.* 2013; Riley *et al.* 2013; Dennison *et al.* 2014, entire; USEPA 2015, entire; Harvey *et al.* 2016, entire; Siren *in* Lynx SSA Team 2016, pp. 14-15; Westerling 2016, entire). A number of potential impacts to lynx have been described, and climate projections suggest these impacts are likely to result in future loss and increased fragmentation and isolation of lynx and hare habitats and declining lynx populations in the DPS (Carroll 2007, entire; Gonzalez *et al.* 2007, entire; ILBT 2013, pp. 69-71; 79 FR 54810-54811; Lawler and Wilsey *in* Lynx SSA Team 2016, pp. 15-16; Siren *in* Lynx SSA Team 2016, p. 15; see also section 3.2, above, and 5.1.3, below). Although climate change has probably already had some impact on lynx habitats in this geographic unit, and such impacts are likely to continue to occur, there currently is no evidence that climate change has had population-level effects or has reduced the ability of this unit to support persistent resident lynx populations. However, such impacts would be difficult to document and, as described under *Habitat Status*, above, because lynx habitats in this unit are naturally highly-fragmented and hare densities low in some places, relatively minor impacts, especially to hare and lynx foraging habitats, may strongly influence lynx persistence in some parts of this unit. Modeling vegetation and snow suitability for lynx across North America, Gonzalez *et al.* (2007, pp. 12, 15) indicated that boreal and temperate conifer forest biomes were broadly distributed across this geographic unit and that snow conditions suitable for lynx occurred with 95 percent probability from 1961-1990. (Future conditions based on this modeling are described in section 5.1.3, below). As described in section 3.2, above, climate change has also been implicated in recent increases in the frequency and intensity of outbreaks of boreal forest insect pests, with warmer winters resulting in increased insect survival and drought increasing conifer vulnerability to insects. This trend is expected to continue through the end of the century with continued climate warming (Bentz *et al.* 2010. pp. 607, 609).

Vegetation Management - The influence of vegetation management on the current condition of lynx and habitats in this unit is described above under <u>Habitat Status</u> and *Regulatory Mechanisms*, above.

Wildland Fire Management - As described above in section 3.4, wildfire suppression in this unit, as elsewhere in the West, has likely had little impact on lynx habitats (65 FR 16074; 68 FR 40093-94; USFS 2007, pp. 18, 20; USFS 2008, p. 11; ILBT 2013, p. 76). Also as described in that section, wildfire frequency, size, and intensity have increased in this geographic unit, likely in response to climate warming and related increases in drought conditions (e.g., Dennison *et al.* 2014, entire; Harvey *et al.* 2016, entire; Westerling 2016, entire), with most large, stand-replacing fires having occurred in the northern part of the unit, in Yellowstone National Park (see

Harvey *et al.* 2016, Fig. 1). Despite this increase, we are aware of no evidence that increased fire activity in the unit has thus far impacted resident lynx populations or reduced this unit's ability to continue to support resident lynx.

Habitat Loss and Fragmentation - As described above, the dominant land use in this unit, and that most likely to result in habitat loss and fragmentation, is timber harvest and associated vegetation management (e.g., precommercial thinning) and road construction on lands with developmental allocations. Much of this unit occurs in national parks, designated wilderness and roadless areas, or other nondevelopmental allocations. Even in areas with developmental allocations, the moist subalpine forests important to lynx have had less timber harvest, road construction, and have been modified much less than other drier forests (65 FR 16073), and these activities appear not to have had population-level impacts on lynx or to have measurably reduced the ability of this geographic unit to support resident lynx. Few highways intersect lynx habitats in the Northern Rockies (ILBT 2013, p. 63) and there are few records of lynx killed by vehicle collisions in Montana (5) and Wyoming (1; a Colorado-released lynx) (Broderdorp, unpubl. data; MTFWP unpubl. data). Other potential sources of habitat loss and fragmentation include recreation, minerals/energy development, and forest/ backcountry roads and trails; these are all considered second tier anthropogenic influences (ILBT 2013, pp. 78-85) that are unlikely to exert population-level influences, despite potential impacts to individual lynx.

Other Factors - Connectivity/Immigration - As elsewhere in the range of the DPS, resident lynx populations in this geographic unit are thought to be influenced by connectivity with, and immigration of lynx from, populations in Canada (see section 2.2, above). However, whether and, if so, to what the extent the persistence of populations in this geographic unit may depend on regular or intermittent immigration of lynx from Canada remains uncertain, and historic, recent, and current immigration rates of are unknown. Although this unit is not directly connected to lynx habitats and populations in Canada or elsewhere in the contiguous U.S., no barriers to lynx dispersal from the north have been identified, and 10 lynx released in Colorado are known to have dispersed northward into and through this unit (Devineau *et al.* 2010, p. 526; Hanvey 2016, *pers. comm.*), demonstrating that dispersal between the southern and northern Rockies is possible. As described above in Lynx Status, the large number of lynx reportedly trapped from a small area of the Wyoming Range in the early 1970s (Squires and Laurion 2000, p. 338) may suggest dispersers associated with the irruption of many lynx from Canada into the northern contiguous U.S. documented at that time (McKelvey *et al.* 2000a, pp. 235-242). No subsequent pulses of lynx dispersing from the north have been documented, and lynx trapping records suggest that the magnitude of lynx populations cycles in Alberta and British Columbia, the most likely source of lynx dispersing southward into this unit, dampened dramatically after the early 1980s (McKelvey *et al.* 2000a, p. 226; Bowman *in* Lynx SSA Team 2016, p. 13; also see Appendix 5, 2015 10 13 - 5, pp. 4-5 [https://www.fws.gov/mountain-prairie/es/species/mammals/lynx/SSA2016/Appendices/Appendix%205%20Presentation%20PDFs/2015%2010%2013%20-%205%20-%20Bowman%20Lynx%20Southern%20Canada.pdf]).

As described in section 3.2, above, a number of climate-mediated factors have been suggested as contributing to changes in the periodicity and amplitude of northern lynx and hare population cycles, which could alter the timing and magnitude of irruptions of lynx from Canada into the contiguous U.S. If lynx populations in this geographic unit are reliant on immigration from Canada which is no longer occurring or has been substantially reduced relative to historical conditions, population declines and a reduced probability of persistence among resident populations would be expected. Although the extent to which this factor has influenced the current condition of lynx populations in this unit is unknown, it is possible that it has contributed to the recent apparent loss of resident lynx from this unit.

4.2.6 Unit 6 - Western Colorado

Unit Description - This geographic unit includes the Southern Rocky Mountains of western Colorado. Small areas of similar potential lynx habitat extend into south-central Wyoming and north-central New Mexico, and some lynx released in Colorado traveled into or through those areas. However, there is no evidence that either area supports resident lynx, and we question their ability to do so. Potential lynx habitat in Colorado totals approximately 25,294 km^2 (9,766 mi^2), and is distributed west of US Interstate 25. We excluded the northwest part of the State, bounded on the south by US Interstate 70 and the east by Colorado State Highway 13, because this area lacks sufficient habitat to support lynx. Lynx habitat in this unit occurs within the following land ownerships: USFS (85 percent), BLM (3 percent), NPS (2 percent), private (9 percent), and State (< 1 percent).

The Southern Rockies are separated from the rest of the Rocky Mountain chain, and thus from lynx habitat in northwestern Wyoming, by sagebrush and desert shrub communities in the Wyoming Basin and the Red Desert of southern and central Wyoming, and the arid Green and Colorado River plateaus of western Colorado and eastern Utah. Connectivity of lynx habitat has been identified as an important consideration for the Southern Rockies, because of the extreme topographic relief juxtaposed with human developments such as highways and residential communities.

Habitat Description - Lynx habitat in the Southern Rockies is found within the subalpine and upper montane forest zones, generally above 2,900 m (9,514 ft) elevation (Shenk 2009, p. 10). In the upper elevations of the subalpine zone, forests are typically dominated by subalpine fir and Engelmann spruce. As the subalpine zone transitions to the upper montane, spruce-fir forests begin to give way to lodgepole pine and aspen. On cooler, mesic mid-elevation sites, Engelmann spruce may retain dominance, intermixed with aspen, lodgepole pine, and Douglas-fir. Lodgepole pine reaches its southern limits in the central part of the geographic unit, while southwestern white fir occurs only in the San Juan Mountains. The lower montane zone is dominated by ponderosa pine and Douglas-fir, with pines typically dominating on lower, drier, more exposed sites, and Douglas-fir occurring on the more sheltered sites. Lower montane forests do not support snowshoe hares and seldom would be used by lynx.

Mature Engelmann spruce/subalpine fir forests with total canopy cover of 42–65 percent, of which 15–20 percent was contributed by conifer understory tree canopies, were the most commonly used areas, followed by mixed forests of Engelmann spruce/subalpine fir/aspen (Shenk 2008, p. 15). Riparian and riparian-mix was the third most-used cover type, with a pattern of increasing use beginning in July, peaking in November, and dropping off in December. Large or medium willow/alder carrs and willow riparian communities provided important habitat for snowshoe hare, grouse, ptarmigan (winter), and other prey species that could be utilized by lynx.

Ivan *et al.* (2012, p. 5) confirmed some relationships that were already known (e.g., lynx are strongly associated with high-elevation spruce/fir and mixed spruce/fir forests but avoid lower-elevation montane forests and montane shrublands). We recognize that all spruce-fir forest does not support lynx equally based on the low detection rate (28 percent) reported during the ongoing lynx study in the San Juan Mountains within predominantly spruce-fir forest (Ivan *in* Lynx SSA Team 2106, p. 14), thus not all areas of spruce-fir forest are used by lynx.

Dolbeer and Clark (1975, p. 539) estimated a density of 0.73 hares/ha (0.3 hares/ac) within their study site in Colorado, with the highest densities of snowshoe hare in mature and late-successional spruce-fir forests. However, this study was conducted in a very limited area and did not sample younger sapling-stage stands (15-40 years post-disturbance) to compare hare densities with those reported for mature and late-successional spruce-fir forests (USFWS 2008b, p. 32).

Habitat that supports snowshoe hares is patchily distributed in the Southern Rocky Mountains, including the Western Colorado Geographic Unit, which limits their abundance. Zahratka and Shenk (2008, entire) found densities of snowshoe hares to be greatest in mature Engelmann spruce-subalpine fir stands when compared to mature lodgepole pine stands in Taylor Park, Colorado. Their density estimates were 0.08±0.03 to 1.32±0.15 hares/ha (0.03–0.5 hares/ac) in Engelmann spruce-subalpine fir habitats, and 0.06±0.01 to 0.34±0.06 hares/ha (0.02–0.14 hares/ac) in lodgepole pine habitats (Zahratka and Shenk 2008, pp. 910-911).

Ivan (2011*a in* ILBT 2013) compared snowshoe hare density, survival, and recruitment in mature uneven-aged spruce/fir stands, small-diameter lodgepole pine (2.54–12.7 cm [1–5 in]) stands (20–25 years old), and medium-diameter (12.7–22.9 cm [5–9 in]) previously-thinned lodgepole pine stands (40–60 years old) in Colorado. During summer, Ivan (2011*a* in *ILBT 2013*) recorded densities of 0.2+0.01 to 0.66+0.07 hares/ha (0.08–0.27 hares/ac) in small lodgepole pine forest, 0.01+0.04 to 0.03+0.03 hares/ha (0.004–0.01 hares/ac) in medium lodgepole forest, and 0.01±0.002 to 0.26±0.08 hares/ha (0.004–0.1 hares/ac) in spruce/fir forest; densities were more similar across the 3 forest types during the winter months. He concluded that “hares reached their highest densities and recruited juveniles most consistently in stands of small lodgepole, followed closely by spruce/fir, but survival was highest in spruce/fir stands.”

<u>Habitat Status</u> - At the time of the 2000 listing, we identified 26,305 km^2 (10,156 mi^2) of potential lynx habitat in the Southern Rockies (i.e., western Colorado and southern Wyoming; [65 FR 16052]). In 2003, we estimated 31,027 km^2 (12,419 mi^2) of potential habitat within the Southern Rockies (68 FR 40076). As stated above, our focus here is limited to the State of Colorado. In 2008, the USFS reported that most of their LAUs in the Southern Rockies fell within a range of

3-8 percent in a currently unsuitable condition, with only one LAU exceeding 30 percent unsuitable (USFS 2008, p. 19). Currently, the USFS reports 51 out of 202 (25%) LAUs currently exceed the 30 percent unsuitable condition (P. McDonald 2016, *pers. comm.*). These changes are mostly in response to the ongoing bark beetle infestations, as well as wildfire events that have occurred since 2008.

Ivan (2011e, entire), developed a predictive map of lynx habitat use by using lynx location data collected during CPWs reintroduction monitoring, then estimated the amount of habitat associated with a high probability of detecting lynx. Our review of the vegetative characteristics of CPW's predictive map detected large areas of spruce-fir habitats that were excluded by their presentation of the habitat associated the top 20 percent of predicted use (Ivan 2011e, p. 26). Therefore, we selected the top 30 percent of the Ivan (2012, entire) predictions and the associated habitat to represent the amount of potential lynx habitat in Colorado totaling 25,294 km^2 (9,766 mi^2). This habitat estimate falls between the Ivan (2011e, p. 26) estimate and the USFS's habitat estimate of 30,664 km^2 [11,839 mi^2] (USFS 2008, p. 18), while retaining a greater than 60 percent probability of detecting lynx as described by Ivan (2011e, pp. 32-33).

Regulatory mechanisms in Colorado are largely provided through Forest Service planning documents. All USFS land management plans within the unit were amended in 2008 to provide for the conservation of lynx. Three BLM plans in Colorado have been amended or revised to conserve lynx following the 2013 LCAS on lands totaling approximately 126 km^2 (49 mi^2) of potential lynx habitat. One additional plan provides conservation measures for timber management actions only, but the FO contains only about 1 km^2 (0.39 mi^2) of potential lynx habitat. The remaining FOs currently have not amended or revised their plans specifically to provide conservation for lynx (these plans combined guide management of approximately 645 km^2 (298 mi^2) of potential lynx habitat. Since the 2000 listing, however, all BLM Field Offices in Colorado have been conserving lynx discretionarily through application of conservation measures provided in the Lynx Conservation Assessment and Strategy (Ruediger *et al.* 2000, entire; ILBT 2013, entire). Rocky Mountain National Park has a fire management plan that includes conservation measures for lynx. We are not aware of any specific conservation planning guiding activities on non-Federal lands (M. Wrigley 2016, *pers. comm.*; M.K. Watry 2016, *pers. comm.*).

<u>Lynx Status</u> - As of 2016, the current distribution of lynx is somewhat uncertain within Colorado. However, we believe it is reasonable that lynx continue to occupy all National Forests within the State of Colorado (Odell 2016, undocumented *pers. comm.*), and Rocky Mountain National Park (Shenk 2008, p. 3). The CPW is developing a minimally-invasive, long-term, statewide monitoring program to track the distribution, stability, and persistence of lynx in Colorado (Ivan 2011e, entire).

As of 2015, evidence of recent lynx reproduction is provided through kittens captured on game cameras accompanying adult females at three locations during 2014-2015 monitoring effort (Ivan *in* Lynx SSA Team 2016, p. 17). In addition 38 percent of lynx captured during recent (2010-2015) USFS Rocky Mountain Research Station research projects in Colorado have been young and/or unmarked cats (Ivan *in* Lynx SSA Team 2016, p. 17), suggesting continued reproduction within Colorado. However, reproductive rates are currently unknown.

As of 2007, the average probability of survival for reintroduced lynx was 0.9315±0.0325 within the study area in the San Juan Mountains and 0.8219±0.0744 outside the study area boundary (Devineau *et al.* 2010, p. 5). Although 30 percent of known mortalities were due to human causes (being shot or hit by a vehicle), the estimate of survival within the study area was higher than those reported for natural, lightly trapped populations of Canada lynx in the Yukon (0.75–0.90; Slough and Mowat 1996, entire; O'Donoghue *et al.* 1997, p. 155) or in the Northwest Territories (~0.90; Poole 1994, p. 612). Successful reproduction, including by females born in Colorado, has been documented (Shenk 2008, p. 2), and kitten survival was 0.2260 (Ivan 2016b, *pers. comm*. March 9, 2016).

<u>Factors Affecting Current Conditions</u>

Colorado is currently experiencing major bark beetle epidemics in lodgepole pine and spruce-fir forests. Although bark beetles are native insects, and forests in the western U.S. have experienced regular insect infestations throughout their history, the current bark beetle epidemic is notable for its intensity and extensive geographic range. The causes of this epidemic include: relatively even-aged, dense, and homogenous forest conditions, which are highly susceptible to beetle attack, and which were created by large-scale logging in the late 1800s and subsequent fire suppression efforts; warmer winters as a result of climate change (cold winters typically reduce beetle populations); and a multi-year drought that occurred in the mid-1990s through early 2000s, stressing the trees and making them more susceptible to beetle attack (USFS 2011, p. 4).

In lodgepole pine forests, a mountain pine beetle epidemic typically kills the entire overstory and results in a stand-replacing disturbance event. In Colorado, more than 1,375,931 ha (3,400,000 ac) has been affected by mountain pine beetle, and 639,000 ha (1,579,000 acres) affected by spruce beetle since 1996 (USFS 2015, p. 3), a portion of which overlaps with lynx habitat.

Even-aged mature and "dry" lodgepole pine stands characteristically have depauperate understory vegetation and are not capable of supporting dense populations of snowshoe hares. On moist sites, regeneration of beetle-killed lodgepole pine stands is expected to be relatively rapid 20-30 years, and the new stands will be dominated by resprouting aspen or by a new cohort of lodgepole pine. If these newly-established stands grow tall and dense enough to provide horizontal cover above the snow layer, they may produce excellent habitat for snowshoe hares and lynx for several decades, until the crowns again lift above the reach of snowshoe hares.

A spruce beetle epidemic kills the larger-diameter trees and can also result in a stand-replacing disturbance event. Because of the importance of spruce-fir forests for production and survival of snowshoe hares (Ivan 2011a *in* ILBT 2013), widespread mortality of mature spruce/fir forests could impact lynx habitat for a long duration. By 2015, the spruce beetle outbreak influenced approximately 95 percent of the mature spruce component of the subalpine cover types on the

Rio Grande National Forest (Squires *et al.* unpublished report 2016, p. 1). Despite the large scale, and almost complete mortality of the mature spruce component within their study area, lynx continue to use and reproduce in the beetle-infested forests (Squires *et al.* unpublished report 2016, p. 2). Since the majority (88 percent) of lynx habitat in Colorado is under Federal land management, actions occurring on other ownerships are unlikely to result in significant losses of lynx habitat within Colorado. However, habitat connectivity may be negatively affected by intense recreational use or development within strategic areas that are important for habitat connectivity.

ILBT (2013 p. 57; 61-62) states:

> *Plague, a flea-borne disease caused by the bacterium Yersinia pestis, which is not native to North America, was reported for the first time in lynx in Colorado (Wild et al. 2006). Pneumonic plague appeared to be the direct or indirect cause of death of 6 reintroduced lynx between 2000 and 2003. When translocated from Canada and Alaska, none of the lynx had antibody titers to Y. pestis; it appears likely that lynx were exposed to plague by infected prey after their release in Colorado.*
>
> *Vehicular collisions are a potentially important cause of mortality for lynx in portions of the southern Rockies. Thirteen of 102 mortalities documented for lynx translocated into Colorado were from vehicle collisions (Devineau et al. 2010). Brocke et al. (1990) suggested that translocated animals might be more vulnerable to highway mortality than resident lynx and this could have been a factor in Colorado at the time of listing. Currently, the majority of lynx mortalities caused by vehicle collision (13 of 16) occurred during the reintroduction period (1999-2006). Since early 2007, one year after the final reintroductions occurred, only 3 hit by vehicle mortalities have been reported, and only two of those occurred in Colorado (Broderdorp unpublished data 2016). A number of highways with high speed and high traffic volume pass through lynx habitat, such as I-70, I-80, US 50, US 550 and US 160. These highways are not a barrier to lynx movement, as repeated successful crossings by radio-telemetered lynx have been documented on I-70 and Highways 9, 40, 50, 91, and 114 (Ivan 2011b, c, 2012; J. Squires, personal communication 2012). At this time, it appears that hit by vehicle mortality may be a less significant mortality factor for lynx in Colorado.*
>
> *As compared with other portions of the range of lynx, in Colorado more winter recreation and associated development overlaps with lynx habitat. Preliminary information from a study in Colorado indicates that some winter recreation uses may be compatible, but lynx may avoid some developed ski areas (J. Squires, personal communication 2012). It is possible that ski areas and 4-season resorts may reduce the amount and availability of lynx habitat within localized areas, in part by influencing the distribution or abundance of prey resources within the developed area. However, there is also considerable anecdotal evidence of lynx using ski areas.*

Leg-hold trapping is currently prohibited under the state constitution of Colorado as a means of predator control or for commercial and recreational trapping. If a landowner can prove that all other non-lethal methods have been ineffective, a 30-day exemption may be granted for depredation cases. Incidental trapping mortality of lynx may be a minor risk during trapping seasons in southern Wyoming and surrounding states.

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. The majority of sheep grazing occurs on arid rangelands, but some grazing does occur during summer at the higher elevations, especially in south-central Colorado. Incidental capture of lynx is possible, but unlikely.

Chapter 5: Future Conditions

In this chapter, we present our assessment, based on the best available scientific information, including our analysis of input from lynx experts, of the future condition of the lynx DPS in terms of redundancy, representation, and resiliency. We then provide brief summaries of the possible future conditions in each geographic unit, followed by a more detailed evaluation of the factors likely to influence lynx populations and habitats in each unit. We elicited expert input on the probabilities that resident lynx populations will persist because we lack reliable estimates of the sizes and trends of lynx populations in each geographic unit and in the DPS, and because existing demographic data are inadequate to construct empirical models to project population sizes, trends, and viability into the future. We present and summarize the professional judgments and opinions of a panel of 10 lynx experts regarding the factors likely to influence the persistence of resident lynx populations in each of the six geographic units. We also present and summarize the experts' projections, based on consideration of those influencing factors, of the probability that each of the geographic units will continue to support resident breeding populations of lynx into the future (at years 2025, 2050, and 2100), and the sources of uncertainty that influenced their confidence in their predictions.

We then present our evaluation of the scientific literature regarding how certain anthropogenic factors may influence future conditions for resident lynx in each geographic unit. The factors we consider for each geographic unit include regulatory mechanisms (the factor for which the DPS was originally listed under the ESA) and the anthropogenic influences identified by the Interagency Lynx Biology Team (ILBT) as having the potential for population-level impacts to lynx in the DPS (climate change, vegetation management, wildland fire management, and habitat loss/fragmentation; ILBT 2013, pp. 68-78; see also Chapter 3, above). Other factors were also evaluated for some geographic units if the Core Team member most familiar with that unit felt those factors could pose meaningful, even if less likely, risks to the unit's continued ability to support resident lynx. After considering all of the above, we present our conclusions regarding the future conditions for resident lynx populations in each geographic unit and we discuss the extent to which our conclusions agree with or differ from the projections provided by the lynx expert panel we consulted and, if they differ, why.

Implicit in our evaluation of the future for lynx in the contiguous U.S. is our recognition and consideration of a future in which the DPS is not listed under the ESA. However, given the DPS's listing history and the ESA's requirements for delisting, we do not evaluate the unlikely hypothetical future in which the DPS is not listed and all protections and conservation efforts disappear. Rather, we assume that although some protections could be relaxed (e.g., less stringent analyses of project-related impacts, potential for some states to reinstitute limited trapping/hunting harvest), that conditions for delisting would include requirements and incentives to continue to conserve lynx and its habitats and to assure persistence of resident lynx populations in those places that can support them on Federal, State and Tribal lands (perhaps some private lands as well). Our evaluation, therefore, considers the possibility of the future relaxing of some lynx conservation measures and efforts, but not the complete absence of all protections for lynx. Some of the experts we consulted indicated that their projections assumed the status quo (i.e., continued protections under the ESA and current Federal and State land management policies). Others indicated their persistence probabilities were not influenced by regulatory considerations but that doing so would not have altered their projections; they felt that factors influencing lynx persistence on the landscape are independent of ESA listing status (Lynx SSA Team 2016, p. 52).

Additionally, we do not to define and evaluate specific and explicit climate change/ greenhouse gas emissions scenarios or attempt to quantify differences in DPS viability or the persistence of resident lynx populations in individual geographic units based on differences in the rate and extent of potential impacts associated with projected continued climate warming. This is because of the limited resolution and inherent uncertainty of available climate models and the inadequacy of existing demographic data for projecting lynx populations in the DPS over time, including their potential responses to a range of climate-mediated potential future habitat conditions. Therefore, this SSA does not constitute or include a formal climate change vulnerability assessment (Glick *et al*., editors, 2011, entire) for the lynx DPS. Instead, underlying our evaluation in this SSA is the recognition that the lynx, as a broadly-distributed boreal forest- and snow-reliant predator that relies heavily on a single, similarly-specialized prey species, and whose habitats are naturally influenced by climate-mediated disturbance factors (e.g., wildfire, forest insects, wind/ice storms, etc.), is likely highly sensitive and broadly exposed to the impacts of climate change and has limited adaptive capacity to respond to it. Therefore, we (along with the experts we consulted and the ILBT) consider lynx populations in the DPS vulnerable to the projected impacts of continued climate warming. While we recognize that the pace and extent of impacts would be expected to differ under specific emissions or modeling scenarios, the limitations described above preclude us from quantifying those differences and their potential influence on the probabilities that resident lynx will persist in the DPS or in individual geographic units.

5.1 Summary of Future Conditions DPS-wide

Given the irresolvable uncertainty about the historical distribution of resident lynx in the contiguous U.S. and the current lack of reliable estimates of the sizes, trends, and many demographic parameters for most DPS populations, it is difficult to confidently predict the future condition of the DPS or the likelihood that any given geographic unit will support resident lynx in the future. We lack data to build rigorous empirical population models for lynx in the DPS, and uncertainty regarding the timing and magnitude of potential impacts to lynx from continued climate warming also limits our ability to predict the future condition of the DPS. Therefore, our assessment of the future condition of the DPS is based on our evaluation of the available scientific information regarding the factors identified by the ILBT as the most likely to have population-level impact to lynx in the DPS (ILBT 2013, pp. 68-78), including the best professional judgments and opinions of lynx experts.

Overall, our evaluation of the scientific literature and expert input suggests that resident lynx populations in each of the geographic units and, therefore, in the DPS as a whole, are likely to be smaller and their distributions reduced in the future. These anticipated declines are likely to be most influenced by projected loss and increasing fragmentation and isolation of boreal forests and favorable snow conditions resulting from continued climate warming and related impacts (e.g., increased wildfire and forest insect activity, diminished hare populations; Lynx SSA Team 2016, p. 58). This outcome seems likely regardless of which climate emissions scenario is used to model future conditions, although the timing, extent, and magnitude of impacts is uncertain and will likely vary by scenario.

In addition to climate change, forest management also has the potential to influence (negatively or positively) hare and lynx habitats in the DPS range. Forest management on private lands that lack lynx conservation commitments may contribute to future declines in the amount and quality of lynx habitats, particularly in Maine and perhaps also in Minnesota (private lands contribute minimally to lynx habitats in the other geographic units – see Table 2, above). Uncertain future forest ownership and markets for forest products, shifts in silvicultural practices, and development pressures on private lands all may affect the resiliency of future lynx populations and thus the units. The lack of evaluation of the effectiveness of forest management plans for lynx on Federal lands is of concern for western units.

In each geographic unit, the experts we consulted expect the probability that resident lynx populations will persist will decline in the future, although uncertainty about persistence probability increases with time from the present (Lynx SSA Team 2016, pp. 36-49; also see 5.2, below). Although all five geographic units that currently support resident populations (all units except the GYA) are expected by lynx experts to continue to do so through mid-century, only one (Northwestern Montana/ Northeastern Idaho) had an expert-estimated probability of persistence greater than 50 percent (i.e., persistence more likely than not) by the end of the century. Expert input suggests that all other geographic units individually have a 50-percent or greater probability of functional extirpation (i.e., no longer capable of supporting resident lynx populations) by the end of the century (Lynx SSA Team 2016, pp. 36-49; also see 5.2, below), and a cumulative likelihood that resident lynx will be lost from two or three of the five units that currently support them by the end of the century (Figure 7).

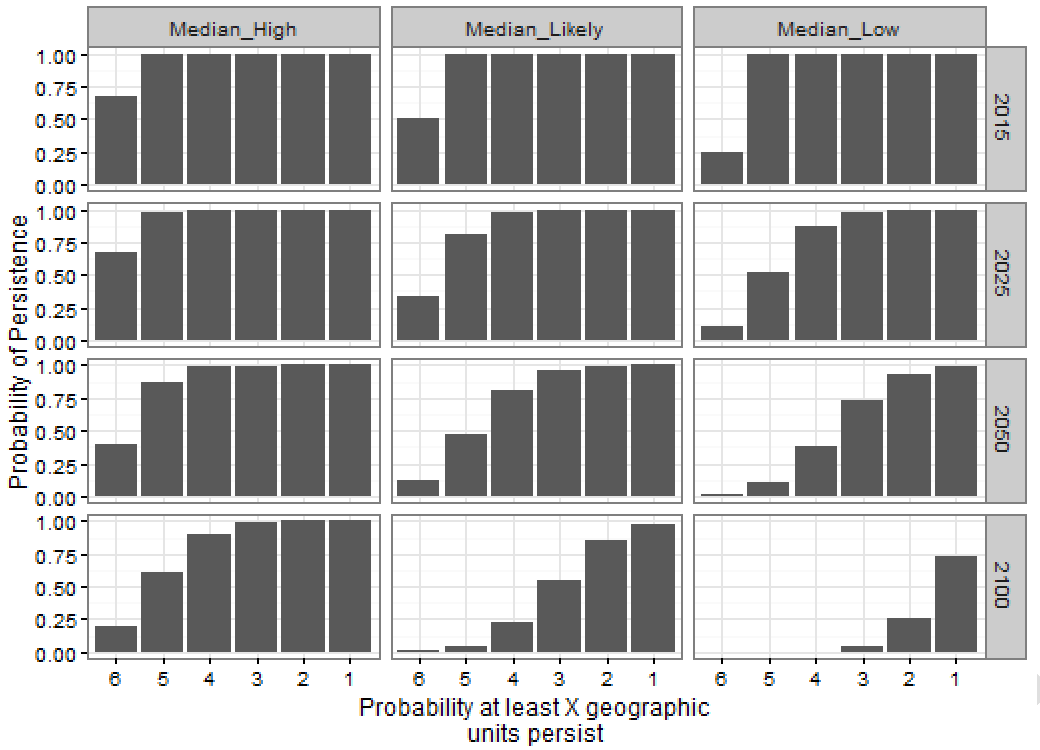


Figure 7. Summary of lynx experts' predictions regarding the probability of persistence of at least a given number of geographic units given the probability of persistence for each individual geographic unit. The y axis of each grid in Figure 7 is the probability that at least the number of geographic units indicated by the x axis of the grid persist. The probability in a bar reaches 1 when there is no probability of fewer geographic units persisting. Moving from top to bottom the grids show the probabilities by time period (2015, 2025, 2050, and 2100). Moving from left to right the grids show the range of expert responses by summary selection type and probability response. Therefore, looking down a column of grids provides a view of the trend in persistence through time and looking across a row of grids provides a view of the range of uncertainty in persistence for a given time period.

Our evaluation generally concurs with the expert input we received. We believe that lynx populations and habitats in the DPS will decline over time largely as a result of continued climate warming and associated impacts, which are likely to exacerbate the potential adverse effects of other factors (e.g., forest management, competition from other hare predators). We conclude that, at mid-century, resident lynx populations are likely to persist in most geographic units that currently support them. However, we conclude it is very unlikely that resident lynx populations will persist through the end of this century in all five of the geographic units that currently support them. That is, we believe it is more likely than not that resident lynx will be functionally extirpated by the end of the century from one or more of the five geographic units that currently support them.

We acknowledge that under a "worse case" climate modeling scenario the boreal and subalpine forests and snow conditions lynx need could completely disappear from some units and be substantially reduced in the remainder by the end of the century (we are aware of no climate modeling that suggests the complete disappearance of potential lynx habitat from the entire contiguous U.S. by the end of the century). Complete loss of lynx habitat is perhaps more likely in the Northern Maine and Northeastern Minnesota units where there is little potential for elevational refugia compared to the more topographically diverse units (3 through 6) in the western U.S. Under such a scenario, resident lynx would be unable to persist in some units and severely restricted in number and distribution in others, with any remaining resident populations more vulnerable to demographic, environmental, and genetic stochasticity and to catastrophic events than is currently the case.

Conversely, under a "best case" climate scenario (perhaps combined with a "best case" future forest management scenario), it is possible that resident lynx could continue to persist through the end of the century in all five geographic units that currently support them. Even under this scenario, however, we would expect smaller population sizes and reduced distributions in each unit resulting from the impacts of even moderate continued climate warming (we are aware of no models that predict climate cooling or climate-mediated improvement in lynx habitat conditions in the contiguous U.S. over the next century). We cannot quantify the likelihoods of either of these extreme scenarios nor improve the precision of, or our confidence in, the experts' predictions regarding persistence. Nonetheless, we believe the most likely future condition of the DPS is that resident lynx populations will continue to persist at the end of the century in two or three of the five units that currently support them (i.e., they will be functionally extirpated from two or three of the units) and that even where populations persist, they will be reduced in number and distribution and, therefore, resiliency.

The loss of viable resident lynx populations from one or more geographic units would represent reduced future redundancy, representation, and resiliency within the lynx DPS. With regard to redundancy, however, our evaluation of the scientific literature and expert input indicates that no individual geographic unit that currently supports resident lynx is vulnerable to extirpation from a single catastrophic event. Given that, we conclude that the DPS as a whole is not vulnerable to extirpation from a catastrophic event (i.e., we find that there is a zero probability that a single catastrophic event could result in extirpation of resident lynx from any of the five geographic units that currently support them and, therefore, a zero probability of catastrophic extirpation of the entire DPS). As described above (section 1.3), we do not consider continued anthropogenic climate warming a catastrophic event; rather, we consider it a separate, ongoing, and pervasive stressor, not a single temporally- and spatially-discrete event. We recognize that a sequence of discrete but spatially-clustered catastrophic events in lynx habitats over a short time could increase the potential for functional extirpation in one or more of the individual geographic units (especially the possibility of additional large wildfires in north-central Washington), thereby reducing redundancy within the DPS. However, as long as resident lynx remain geographically well-distributed in one or more units within the DPS, extirpation of the DPS from a single catastrophic event is very unlikely.

With regard to representation, although some lynx populations in the DPS units are demographically isolated from each other and the level of interaction between others is uncertain, there seems to be little risk of significant genetic drift. This is because of the currently observed and likely future high level of gene flow across most of the lynx's continental range, the species' well-documented dispersal capability, and the current and likely future connectivity and absence of significant barriers to dispersal between Canada and most DPS geographic units. Based on these factors and expert input, we find that is there is no indication that the relatively low level of genetic diversity currently observed among lynx populations is likely to reduce DPS viability in the future (USFWS 2016, p. 51) and no indication that future gene flow is likely to be substantially reduced (79 FR 54793). This information suggests the current and likely future relative genetic health of the DPS.

How the potential loss of resident lynx from one or more geographic units may affect representation within the DPS in terms of ecological diversity is uncertain. Despite similarities in the fundamental components (vegetation, snow conditions, and hares) that define the ecological niche of lynx DPS-wide, differences in habitats and how lynx use them are apparent. For example, snow depth that seems to demarcate a boundary between lynx and bobcat occupancy in Maine (270 cm/yr) is almost twice that observed in Minnesota (140 cm/yr]), and lynx in some parts of the West select mature forest stands, particularly in winter, while in other parts of the DPS, young regenerating stands are most important. The loss of resident lynx from any of the geographic units could result in the loss of behavioral and potential future genetic adaptations to the climate-mediated changes now occurring and likely to continue into the future at the southern edge of the lynx range. Such potential adaptability to diminished snow conditions, increasingly patchy and isolated boreal forests, and reduced hare abundance may be important to the taxon as a whole faced with a rapidly changing climate.

Because resident lynx populations in all geographic units that currently support them are expected to be smaller and more fragmented and isolated in the future, each geographic unit and the DPS as a whole will be less resilient in the future. Our analyses and expert input suggest that resiliency will likely be adequate to foster persistence of resident lynx in most units through mid-century but that it will be substantially diminished after that time, with resulting extirpation of resident populations from two to three (of five) units by the end of the century. Projected climate warming is expected to exert the greatest influence on the resiliency of individual populations, and thus continued presence of resident lynx in each geographic unit. Climate models project that boreal forests and snow conditions favorable for lynx at the southern periphery of the range will retreat northward and upslope with continued warming, further fragmenting and diminishing the quality of lynx and hare habitat within the DPS. Although uncertainty remains regarding the timing, extent, and biological consequences of such impacts, as habitat conditions decline, hare populations will decline and lynx mortality rates are likely to increase and reproductive rates decrease. As snow conditions become less favorable, competitors (e.g., bobcats) are likely to outcompete and displace lynx. This in turn will reduce lynx abundance and density within populations, making populations more susceptible (i.e., less resilient) to stochastic events.

5.1.1 Summaries of Future Conditions in Each Geographic Unit

Unit 1 – Northern Maine: Although the Northern Maine geographic unit currently has extensive lynx habitat, it may be one of the units in the DPS at greater risk. Forestry practices, climate change, habitat loss and fragmentation, and development will be the greatest future drivers of hare and lynx habitat in this unit. Lynx habitat and numbers are expected to decline by 50 to 60 percent by 2032 in response to aging of the budworm-era clearcuts and the effects of 27 years of extensive partial harvesting. In the next few decades, high quality hare habitat will drop from about 10 percent to 5 percent of the landscape. High quality habitat patches will become more fragmented, smaller, and more isolated, thus making the landscape less suitable for lynx. For the next few decades the best habitat will occur in the southern portion of the range where effects of climate change and competition with bobcats are likely to be greatest. Absent long-term lynx management agreements, the future of lynx habitat is uncertain. Wood products markets will continue to change, and could be affected by interest in carbon sequestration in response to climate change. Rapid changes in private forest land ownership are likely to continue resulting in subdivision of large ownerships. Non-forestry land uses (wind energy development, transmission line corridors, residential and resort land development, and unmanaged, conservation lands) will compete with forest management as the primary land use. Conservation easements will help reduce development pressures and keep some lands as working forest, but forest practices (e.g., partial harvesting, northern hardwood management) may not be conducive to creating new lynx habitat. Climate change is expected to affect the Maine unit more than others in the DPS because snow depth and duration already seem to be at thresholds for lynx and there are few potential elevational refugia. In the near term and to mid-century, snow quantity and quality will continue to deteriorate, likely causing the range of lynx to begin contracting northward.

Our review of the published literature and input from lynx experts lead some members of the SSA Core Team to conclude that lynx could become extirpated from the unit by mid- to late-century. Climate change, increasing demand for hardwood forest products, a pending spruce-budworm outbreak, and frequent disturbance of the forest all will contribute toward the trend in the loss of spruce-fir forest and expansion of northern hardwoods, although the timeframe for conversion is uncertain. The lynx experts we consulted indicate the probability of persistence will decline to about 50% by the end of the century, although there was wide variation in opinions. After reviewing the scientific literature concerning climate change projections (diminishing snow conditions, lack of elevational refugia), some members of the Core Team were more pessimistic about the future of lynx in Maine than the lynx expert panel. In particular, we observed that there is great uncertainty about the future of forest management and future development on private forest lands. We also note that the threat for which the lynx DPS was listed, the lack of specific conservation direction in Federal forest planning and management regulations and direction, has not been addressed on private lands. There are no long-term management plans in place, State forest regulations have greatly influenced harvesting practices that have (and will continue to) reduce landscape hare densities, markets for forest products are depressed, and projections (under current harvest scenarios) are that habitat will diminish and shift southward in the near term because of post-harvest succession and recede northward over the longer-term because of continued climate warming.

Unit 2 - Northeastern Minnesota: The direct and indirect effects of climate change are expected to affect lynx into the future in Minnesota. Specifically, the quantity, quality, and duration of snow are projected to decline; competition and hybridization with bobcats are likely to increase as snow conditions favorable to lynx are diminished; boreal conifer forests are projected to contract northward, resulting in increased habitat loss and fragmentation and increased isolation of Minnesota lynx is anticipated with diminishing forest conditions in Ontario. The probability of persistence of the lynx population in Minnesota is projected to decrease over time with increasing uncertainty through the end of the century, driven in the near term by the quality, quantity and persistence of snow, competition, disease, and forest insects, and over the long term from some of the same factors with the addition of climate change, loss of spruce-fir forests, and (projected increases in?) wildfires. If the SNF in Minnesota continues to follow vegetation management and other recommendations under the LCAS in their Forest Plan, we expect that several risk factors will continue to be minimized and managed to promote the conservation of lynx within the SNF into the future. It is not clear if the Forest will maintain that commitment into the long term. If the DPS is de-listed, the species would be placed on the Forest's Regional Forester Sensitive Species list for at least 5 years, which gives it a higher priority than other species for monitoring and management during that time. It is expected that the MFRC guidelines will remain in place into the future and that voluntary actions will continue on State and private lands. However, it is unclear on what proportion of State and private lands these voluntary actions will be implemented into the future. Further, these guidelines are generalized for listed species and give no specific direction for lynx. Taking all factors into consideration (i.e., loss of boreal forest, increased competition, potential disease and insect outbreaks, loss of snow), lynx experts projected the mean probability persistence of lynx in Minnesota to the year 2025 was greater than 90 percent, to 2050 was 80 percent, and would decline to approximately 35 percent by 2100. After reviewing the scientific literature concerning climate change projections (diminishing snow conditions, loss of boreal forest, lack of elevational refugia, increased competition, potential disease, and insect outbreaks), some members of the SSA Core Team were slightly more pessimistic about the future of lynx in Minnesota than the lynx expert panel. The Core Team concluded that the climate-mediated conversion of boreal forest to temperate forest and the loss of favorable snow conditions could occur at a rate and extent that would result in a lower probability of persistence than the median most likely estimate provide by experts, including the possibility that resident lynx could be extirpated from this unit by the end of the century.

Unit 3 - Northwestern Montana/Northeastern Idaho: As in other units, climate change is projected to reduce the future amount, distribution, and quality of lynx habitats in this unit via northward and upslope contractions in favorable snow and forest vegetation conditions. This will result in increased fragmentation and isolation of habitats and smaller and more isolated lynx populations. Increased wildfire frequency and extent and perhaps other climate-mediated factors (forest insect outbreaks, changes in northern hare/lynx cycles that may influence immigration into this unit) could also reduce future lynx habitats and populations in this unit. Fire- and insect-related habitat losses would likely be temporary, resulting subsequently in improved habitat conditions when impacted areas regenerate the dense vegetative structure conducive to hare abundance. Continued forest management to conserve and maintain the vast majority of lynx habitats in this unit will benefit resident lynx in the future, though it is unlikely to offset the projected adverse consequences of continued climate warming. Lynx experts felt that future extirpation of lynx from this unit from reduced genetic health or a catastrophic event is unlikely. However, the extent to which the future demographic and genetic health of lynx populations in this unit may be influenced by immigration is unknown. Considering the factors above, lynx experts felt this geographic unit has the highest likelihood of continuing to support resident lynx into the future in the near term (year 2025; median probability of persistence > 0.95), at mid-century (median = 0.90), and end-of-century (median = 0.78), despite a declining probability of persistence and greater uncertainty with increasing time from present, as in all units. After reviewing the scientific literature and evaluating the factors that may influence lynx persistence in this unit, we concur with the experts' conclusion that this geographic unit is likely the most secure in the DPS. We conclude that it is very likely to continue to support resident lynx in the short term (through 2025) and through mid-century, although the number of lynx, the amount and distribution of high-quality habitat, and landscape-level hare densities are all likely to decline by mid-century as a result of continued climate warming and associated impacts. We also agree that this unit is more likely than not to support some resident lynx at the end of this century, although at that time we expect lynx numbers and distribution would be substantially reduced from the current condition and would, therefore, be more vulnerable to demographic, environmental, and genetic stochasticity and to catastrophic events, resulting in diminished resiliency.

Unit 4 - North-central Washington: Recent wildfires have temporarily eliminated or reduced the quality of greater than 50 percent of lynx habitat within north Cascades, which has significantly affected the status of and current viability of the lynx population within this geographic unit. Similar to the other geographic units, continued climate warming is anticipated to reduce the future quality and distribution of lynx habitat in Washington, potentially further exacerbating the recent temporary losses of lynx habitat from wildfires. Projected warming may increase wildfire frequency and severity, which may result in further temporary losses of lynx habitat. Climate change is also expected to reduce the quantity and quality of snow, potentially resulting in permanent reductions in the quantity and distribution of lynx habitat in Washington State. These potential climate-driven reductions of lynx habitat may serve to further isolate lynx populations within this unit as well as between neighboring lynx populations in the other geographic units and Canada. Continued forest management on both Federal and State lands will benefit lynx populations in Washington, but this may not completely ameliorate the potential negative effects related to climate change. Considering the recent reduction in lynx habitat and the projected impacts of climate change, experts predicted near-term (year 2025) persistence probabilities of 60% to 90% (median = 80%), mid-century persistence at 30% to 80% (median = 70%), and end-of century (year 2100) persistence probabilities less than 50% (median = 38%) for lynx populations within this geographic unit. After considering the best available scientific information and input from lynx experts summarized above, the Core Team is generally in agreement with the experts regarding the probability of long-term persistence of Canada lynx in this geographic unit. We expect this unit will continue to support a small resident lynx population through mid-century but that its ability to do so beyond then is questionable, and that functional extirpation of lynx from this unit by the end of the century is more likely than not.

Unit 5 - Greater Yellowstone Area (GYA): As elsewhere, climate change is projected to reduce the future amount, distribution, and quality of lynx habitats in this unit via northward and upslope contractions in favorable snow and forest vegetation conditions. This will result in increased fragmentation and isolation of habitats and smaller and more isolated lynx populations. Because potential habitats in much of this unit already are naturally highly fragmented and perhaps only marginally capable of supporting resident lynx, and because it appears to have never supported more than a small number of residents, its ability to do so in the future is tenuous. Lynx experts felt that the small number of lynx this unit appears capable of supporting and its relative isolation from other lynx populations make it more vulnerable to genetic drift and extirpation from catastrophic events or demographic or environmental stochasticity. However, the extent to which the future demographic and genetic health of lynx populations in this unit may be influenced by immigration is unknown. Increased wildfire frequency and extent and perhaps other climate-mediated factors (forest insect outbreaks, changes in northern hare/lynx cycles that may influence immigration into this unit) could also reduce future lynx habitats and populations in this unit. Continued forest management to conserve and maintain the vast majority of lynx habitats in this unit will benefit resident lynx in the future, though it is unlikely to offset the projected adverse consequences of continued climate warming. Considering the factors above, lynx experts felt this geographic unit has the lowest likelihood of supporting resident lynx into the future in the near term (year 2025; median probability of persistence = 0.52), at mid-century (median = 0.35), and end-of-century (median = 0.15), with a declining probability of persistence and greater uncertainty with increasing time from present, as in all units. After reviewing the scientific literature and evaluating the factors that may influence lynx persistence in this unit, we concur with the experts' conclusion that this geographic unit is the least secure in the DPS. We find that conditions for lynx in this unit are naturally marginal, both its historical and current ability to support a persistent resident lynx population are questionable, and that continued climate warming and associated impacts are likely to further diminish its already limited ability to support resident lynx. We conclude, based on the protected status (national park, designated wilderness, and non-developmental land use allocations) of vast areas and climate models that project some areas of adequate vegetation and snow conditions through the end of the century, that this unit may continue to occasionally/ intermittently support a small number of resident lynx and some reproduction throughout the remainder of the century. However, we conclude that it is very unlikely to support a persistent resident population over the short-term (through 2025), even less likely that it will do so at mid-century, and it is highly improbable that this geographic unit will support resident lynx by the end-of-century.

Unit 6 - Western Colorado: Regulatory mechanisms that provide for the conservation of lynx in Colorado consist of State regulations prohibiting unauthorized take of lynx and amendments of USFS and BLM management plans, which limit vegetation management (among other things) covering approximately 85-90 percent of the lynx habitat within this geographic unit, and provide guidance to limit habitat fragmentation. Climate change is expected to negatively affect vegetation and influence snow conditions within the Western Colorado unit. The elevation gradient in Colorado may provide refugia from deteriorating snow quality, depth, and duration throughout the period. However, climate models suggest a 40 percent decline in snow persistence. Assuming that snow levels will increase in elevation, lynx habitat is likely to become more fragmented by areas that no longer retain appropriate snow conditions and vegetation. However, we anticipate large areas of snow persistence to remain through the end of the century. Beetle kill and wildland fire will result in temporary nonfunctional habitat conditions. However, affected areas are likely to regenerate and provide excellent habitat conditions to support hares and lynx. A caveat to future habitat conditions in light of climate warming is that some areas that currently support snowshoe hare populations may experience vegetation type conversion that may not support snowshoe hares. Our conclusion, based on the information available to us, is that lynx are likely to persist in western Colorado to the end of the century. Our conclusion is not without uncertainty, stemming primarily from the historical lack of evidence of consistent lynx presence within Colorado prior to the reintroduction effort. Our conclusion is generally consistent with that of the experts.

Table 5, below, summarizes expert predictions of future lynx persistence and Core Team summary of factors thought likely to influence the future resiliency of lynx populations in each geographic unit.

Table 5. Expert-predicted future (2050 to 2100) persistence of lynx populations in individual geographic units of the Canada lynx DPS and supporting evidence and uncertainties.

Lynx population	Lynx expert probability of persistence	Key evidence	Uncertainties
Unit 1 Maine	2050 median 80% (range 20 to 100%) 2100 median 50% (range 0 to 100%)	• 50% decline in habitat expected by 2032, habitat will shift to the south edge of range • Slight recovery of habitat by end of century depending on forestry trends • Continued demographic and genetic connectivity to southern Quebec, New Brunswick populations • Climate models predict deteriorating snow quality, depth and duration below thresholds for lynx; more severe than other units • Little elevation refugia	• Future forest management trends and habitat conditions on private forest lands in Maine and Canada • Future shifts in land ownership, forest products markets, and development • Extent and pace of deteriorating snow conditions • Response of hares (pelage mismatch), bobcat and fisher to changing snow regime • Extent and pace of loss of spruce-fir • Future trends in hare populations • Disease and parasites in lynx • Effects of lynx trapping in Quebec
Unit 2 Minnesota	2050 median 80% (range 35 to 100%) 2100 median 35% (range 0 to 100%)	• Smaller population could be susceptible to stochastic effects • Habitat conditions on national forests will remain stable or improve if managed for softwoods • Continued demographic and genetic connectivity to southern Ontario populations	• Future forest management trends and habitat conditions on private forest lands in Minnesota and Ontario • Extent and pace of deteriorating snow conditions • Response of bobcat and fisher to changing snow regime

		• Climate models predict deteriorating snow quality, depth and duration below thresholds for lynx • Little elevation gradient: lake-effect snow may retain refugia to 2050 but not 2100	• Rate of decline of spruce-fir • Future trends in hare populations • Disease and parasites in lynx
Unit 3 Northwestern Montana	2050 median 90% (range 40 to 100%) 2100 median ~78% (range 10 to 100%)	• Some habitat loss from increased wildfire, otherwise habitat will remain stable with USFS management • Continued demographic and genetic connectivity to southern British Columbia populations • Potential high elevation buffer against climate change • Recent loss of small sub-metapopulation in Garnet Range • Increasing fire frequency	• Extent and frequency of fire in hare-lynx habitat • Extent and frequency of insect outbreaks • Extent and pace of deteriorating snow conditions • Response of bobcat, pumas, coyotes to changing snow regime • Extent and pace of elevational migration of spruce-fir • Mismatch in elevation between appropriate snow regime for lynx and spruce-fir • Future trends in hare populations
Unit 4 North-central Washington	2050 median 70% (range 10 to 100%) 2100 median ~38% (range 0 to 90%)	• Habitat and population low because of recent fires; could be susceptible to stochastic effects • Continued demographic and genetic connectivity to southern British Columbia populations • Elevation is not sufficient to provide long-term refugia from deteriorating snow quality, depth, and duration	• Extent and frequency of fire in hare-lynx habitat • Extent and frequency of insect outbreaks • Extent and pace of deteriorating snow conditions • Response of bobcat, pumas, coyotes to changing snow regime • Extent and pace of elevational migration of spruce-fir • Future trends in hare populations
Unit 5 Greater Yellowstone	2050 median 35% (range 0 to 90%) 2100 median 15% (range 0 to 90%)	• Habitat loss from 1980s wildfire, otherwise habitat will remain stable with USFS and NPS management • No connectivity with Canada populations; little immigration from DPS populations • Elevation may provide refugia from deteriorating snow quality, depth and duration • Low quality habitat; dry; low hare populations • Smaller population could be susceptible to stochastic effects	• Will habitat support adequate landscape hare densities to support lynx? • Extent to which GYA remains demographically isolated from other DPS populations; immigration from Colorado population • Extent and frequency of insect outbreaks • Extent and pace of deteriorating snow conditions • Response of bobcat, pumas, coyotes to changing snow regime • Extent and pace of elevational migration of spruce-fir • Future trends in hare populations • Extent to which high elevation may provide climate and snow refugia • Extent to which area will be

			repopulated by the north and/or the south
Unit 6 Western Colorado	2050 median 80% (range 20 to 100%) 2100 median 50% (range 0 to 100%)	● Habitat loss from increased wildfire and insect outbreaks, otherwise habitat will remain stable with USFS management ● Isolation from other lynx populations ● Elevation may provide refugia from deteriorating snow quality, depth and duration ● Uncertainty about stability of recently-reintroduced lynx population	● Demographic and genetic effects of isolated population ● Extent and frequency of fire in hare-lynx habitat ● Extent and frequency of future insect outbreaks ● Extent and pace of deteriorating snow conditions ● Response of bobcat, pumas, coyotes to changing snow regime ● Extent and pace of elevational migration of spruce-fir ● Mismatch in elevation between appropriate snow regime for lynx and spruce-fir ● Future trends in hare populations

5.2 Future Conditions - Detailed Descriptions by Geographic Unit

5.2.1 Unit 1 - Northern Maine

Expert Projections of Lynx Persistence

Most of the experts that we consulted indicated an initially high and subsequently declining probability of persistence of resident lynx in Maine through the end of the century, with uncertainty (range between lowest and highest probabilities) also increasing over time (Lynx SSA Team 2016, pp. 33-36 and Fig. 8, below). Climate change was an overriding near- and long-term stressor for lynx expressed by lynx experts.

Increased winter precipitation in the form of rain, reduced snow depth, and reduced snow durations were discussed by the experts. Experts believed that the effects of climate change would continue to increase as a stressor that would reduce lynx populations by mid- to the end of the century (2050, 2100). Snow conditions would continue to deteriorate (especially in the Northern Maine Unit compared to other areas in the DPS), likely resulting in increased competition with bobcats and increased predation by fisher. We heard varying prognoses from experts regarding the speed at which climate-induced loss of spruce-fir forest will occur. The scientific literature suggests that loss of spruce-fir could occur relatively quickly in the Northeast (but possibly more slowly elsewhere in the DPS) and all noted that an increase in northern hardwood composition of the forest is already occurring. One expert provided information that suggests that balsam fir could actually increase in the short term (next few decades), but that the long-term prognosis is not favorable for natural spruce-fir regeneration. Decline or loss of spruce-fir could be accelerated by forest disturbance (budworm outbreak, forest management affecting large acreages of lynx habitat annually).

In addition to climate change, the lynx experts that we consulted expressed a number of near-term stressors (in the next 15 years) related to forest management in northern Maine. Land management objectives were uncertain because of frequent changes in private forest land ownership. Changes in forestry management because of the Maine Forest Practices Act (shift to partial harvesting, increasing acreage harvest, habitat shifting to south) would result in increased fragmentation and declining lynx and snowshoe hare habitat (succession of previous clearcuts from young, dense regenerating stands to mature stands less conducive to high hare densities).

Both the Core Team and experts that we consulted acknowledge uncertainty concerning the severity and response by new landowners to the next spruce budworm outbreak. Experts believed that investment landowners would not respond to the pending spruce budworm outbreak like they did in the 1970s (extensive clearcuts, herbicide application). Experts also acknowledged concerns about the effects of the current clearcuts aging past conditions that support hares and lynx. The Core Team echoes these concerns. We conclude that it is unlikely that the response to the coming spruce budworm outbreak will create extensive hare and lynx habitat as it did in the past.

The best available science indicates that hare populations have declined by about half across all stand types (and in adjacent Quebec) since 2006 and apparently have not rebounded. In response, lynx initially had lower reproduction (lower proportion of females breeding, slightly lower litter sizes), but this has not affected home range sizes. Lower landscape hare densities are likely to eventually result in lower lynx populations. The lynx experts that we consulted were uncertain about how hare numbers will cycle or fluctuate in the future.

Although uncertainty increases with time from the present, experts generally agreed that climate-related loss of favorable snow conditions (amount, consistency, and duration), loss of spruce-fir, and bobcat competition are likely to reduce the probability of lynx persistence in this unit. Modeling of current lynx habitat and future habitat trends was more advanced for the Northern Maine Unit than other units. Models indicate that aging of past clearcuts and changes in forest practices to partial harvesting will diminish the current lynx habitat by half in coming decades. Experts and the Core Team expressed uncertainty about the severity of a pending spruce budworm outbreak, forestry response by investment company landowners, and how this will affect future lynx habitat. More is known about long-term trends in snowshoe hare populations in this unit than others. Hares seem to have declined by half since about 2006 and have remained low. Experts and the Core Team were uncertain about whether hare numbers would rebound or remain at this lower level, but lower hare densities are affecting demographics (especially percentage of females breeding), which could contribute to population declines. Taking all of these factors into consideration, the median probability of persistence projected by the experts to the years 2025 was greater than 95 percent, to 2050 was about 80 percent (range from 20 to 100 percent), and to 2100 was about 50 percent (range from 0 to 100 percent;

Lynx SSA Team 2016, pp. 33-34, Fig. 8). The USFWS lynx Core Team generally agreed with this prognosis with the exception that some were less optimistic about the persistence of this population, especially after reviewing the literature pertaining to climate change in this region.

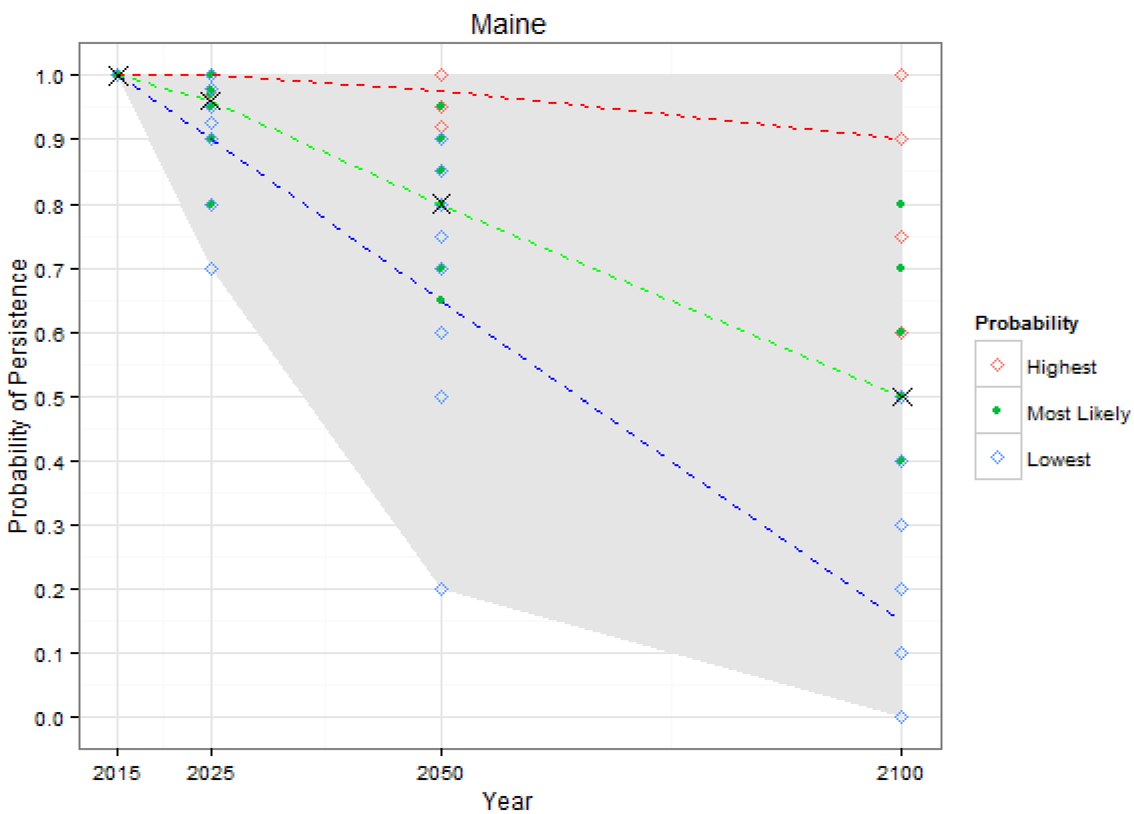


Figure 8. Lynx expert estimates of the probability that the Northern Maine Geographic Unit will continue to support resident lynx in the future (at years 2025, 2050, and 2100).

Note: In Figure 8, above, and similar figures for the other geographic units, below, points for each of the 10 expert responses, for each of the three probability-of-persistence levels, i.e., highest, most likely, and lowest probabilities of persistence, are represented by the hollow red, filled green, and hollow blue points respectively. The black x mark is the median of the most likely responses across the experts in each response year. The red, green, and blue dashed lines connect the median of the highest, most likely, and lowest probability of persistence responses across the experts in each response year. The edges of the grey area were defined by the extreme responses, i.e., the range from the largest of the highest probability of persistence responses to the smallest of the lowest probability of persistence responses. The median lines and grey area are provided as a summarizing visualization to aid comprehension of the experts' responses and their range, and should not be viewed as a substitute for individual responses or presented outside the context of the accompanying discussion.

<u>Service Evaluation of Factors Potentially Influencing Future Conditions</u>

Regulatory Mechanisms - In response to public concern about widespread clearcutting in northern Maine, in 1989 the Maine Legislature passed the Maine Forest Practices Act (MFPA). The MFPA regulates maximum size of clearcuts (250 acres), separation zones between clearcuts, harvest plans, and notification to the Maine Forest Service. Clearcuts are not banned, but require varying levels of State permits depending on their size. As a result of these regulatory requirements, the number and acreage of clearcuts completed annually has declined substantially and have been replaced by various forms of partial harvesting (Sader *et al.* 2003, p. 349-350; McWilliams *et al.* 2003, p. 35). In the first decade following passage of the MFPA, the percentage of acreage clearcut annually in Maine declined from 40 percent to four percent (Simons 2009, pp. 45-46). The average size of clearcuts has been reduced from >125 acres (Maine Forest Service 1995, entire) to <25 acres (Maine Forest Service 2003, entire; 2005, entire; 2007, entire). Currently, partial harvesting comprises about 94 percent of acres cut annually in Maine (Simons 2009, p. 50). The total volume harvested, however, changed relatively little. The partial harvest that replaced clearcuts include a variety of silvicultural treatments, including both even-aged (e.g., shelterwood) and uneven-aged (e.g., selection) management that result in a wide range of residual stand conditions (Robinson 2006, pp. 5-37), which have important implications for lynx conservation. Foremost, snowshoe hare densities in partially harvested forests are on average about 50 percent lower (but range from 20 to 90 percent lower) than in regenerating conifer stands created by clearcutting (Robinson 2006, pp. 5-37; Scott 2009, p. 109, Simons 2009 p. 83), thus reducing landscape hare density and presenting a challenge for future lynx conservation (Simons 2009, pp. 206, 209, 217; Simons-Legaard *et al.* 2016, p. 7-8; Simons-Legaard 2016, entire).

To harvest the same volume of wood annually, landowners must partial harvest many more acres than they would under former clearcutting silvicultural systems. The acres of forest harvested annually in Maine have increased from about 250,000 acres pre-MFPA to 550,000 acres post-MFPA (McWilliams *et al.* 2003, p. 35). Currently, 27 years after implementing the MFPA, much of the 10 million-acre northern Maine landscape has been partially harvested – some areas being partially harvested on multiple occasions. Extensive partial harvesting and aging of the spruce budworm-era clearcuts have and will continue to reduce landscape hare densities (Simons-Legaard *et al.* 2016, 9-10). If the current landowners continue to harvest using similar methods at and similar rates, habitat for lynx will diminish by about 50 percent by 2030 (Simons-Legaard 2016, pp. 9-10). After 2030, projected outcomes for lynx habitat become more uncertain and depend on assumptions about habitat definitions and harvest rates. Lynx in Maine selected for regenerating, conifer-dominated forest (>75 percent conifer, Vashon *et al.* 2008b, pp. 1490, 1492-1494). If one defines lynx habitat as stands having greater than 75 percent spruce-fir, then habitat will decline by about 50 percent by 2030 and remain at about at this level through 2060 (Simons-Legaard 2016, pp. 9,16).

These projections do not consider the effects of the next outbreak of spruce budworm. After being low for the last 20 years, spruce budworm numbers are again building toward epidemic levels in Maine, southern Quebec, and northern New Brunswick. Significant defoliation in Maine is expected in the next few years and the outbreak may last for about a decade (Wagner *et al.*

2016; pp. 12-16). Although Maine research has clearly demonstrated that landowner response to the last outbreak resulted in unintended, positive benefits for lynx from one to three decades later, our ability to project what effects the next outbreak will have on lynx habitat is still limited. Land ownership has changed dramatically since the last outbreak. To reduce risk from spruce budworm, some financial investment owners may cut younger spruce-fir stands that still support elevated hare populations. Some may be less inclined to intensively manage for spruce-fir and may switch to an emphasis on northern hardwoods. It is unlikely that current landowners will use widespread use of pesticides to control spruce budworm and herbicides to promote spruce-fir regeneration after stands are defoliated. The MFPA may serve as an additional constraint on motivation to clearcut infested stands, even with recently-enacted changes intended to reduce the regulatory burden for landowners. Landowner response to the pending outbreak will have important implications for the short- and long-term persistence of lynx habitat in the northern Maine unit (Simons-Legaard 2016, pp. 16-17).

Nor do these projections consider a substantial decline in snowshoe hare densities that has occurred in Maine. Snowshoe hare density declined by 69.3 percent from a period of high hare density in 2001-2006 (average of 2.1 hares/ha in regenerating conifer) to a period of lower hare density 2007-2009 (average of 1.0 hares/ha). This decline occurred across all forest stand types and across a broad geographic area of Maine (Scott 2009, p. 36) and the adjacent Gaspe region of southern Quebec (Assells *et al.* 2007 *in* Scott 2009, p. 41-42). Hares remained at these lower numbers through 2013 (D. Harrison, University of Maine, unpublished data). If future hare populations remain low, then Maine habitats will have a lower capacity for supporting lynx.

<u>Climate Change - </u>The northern Maine unit is more vulnerable to snowpack loss because of the lack of elevational refugia (Siren *in* Lynx SSA Team 2016, pp. 15 and experts p. 37) and changes in snow conditions could further restrict their range (Hoving 2002, pp. 27-28; Hoving *et al.* 2005, p. 749; Carroll 2007, entire). Wildlife experts in Maine ranked lynx as highly vulnerable to climate change (>66 percent loss in species range/population and extirpation within 50 to 100 years; Whitman *et al.* 2013, pp. 19, 74). Similarly, Carroll (2007, entire) modeled Maine lynx population assuming non-cycling hare populations and snow conditions expected under intermediate to high emissions climate models (Kiehl and Gent 2004, entire). He predicted a 59 percent decline in the lynx population (the non-cycling hare population model) by mid-century because of climate change alone. Maine lacks elevational refugia for lynx under reduced snow scenarios (Carroll 2007, p. 1102), except for the mountains in western Maine where snow refugia may only persist as very small, isolated “sky islands” that would be unlikely to support lynx.

Climate change is already affecting the Northeast, and the rate of change is faster than expected with large changes observed since 1970 (Rustad *et al.* 2014, p. 6). Rapid winter warming in recent decades is believed to be caused by reduced albedo feedback caused by the diminished persistence of snow in winter (Hayhoe *et al.* 2006, p. 25). Average winter temperatures are increasing 0.42-0.46^{o} C/decade with the greatest warming occurring in the coldest months of winter (January, February; Burakowski *et al.* 2008, p. 1). Northeast climate models predict average winter temperature increasing 2.0^{o}C (low emission) to 2.9^{o}C (high emission) by mid-century and 3.1^{o}C (low emissions) to 5.3^{o}C (high emissions) by late century (Notaro *et al.* 2014, p. 6529). Largest increases in temperature are expected in northern Maine (A. Siren *in* Lynx SSA Team 2016, Appendix 3; Rawlins *et al.* 2012, p. 9) where temperatures may increase 4.5 to 5.0^{o} F by 2050 (Fernandez *et al.* 2015, p. 3). In response to climate change, interest in wind development has grown in northern and western Maine, increasing threats to high elevation and potential spruce-fir refugia (Publicover 2013, p. 2). Climate conditions are currently at or falling below threshold values needed to support lynx in Maine.

If future trends in increasing temperature and decreasing snow occur, then lynx are unlikely to persist in Maine. Gonzalez *et al.* (2007, entire) modeled distribution of boreal forest and future snow conditions under nine different low, medium, and high emission scenarios (IPCC 2007) and predicted loss of forest and snow conditions able to support lynx in Maine by the end of the century. Although there are uncertainties about future climate warming, lynx populations in Maine are expected to recede northward and decline substantially this century (Vashon *et al.* (2012, p. 60).

Snow Duration - The current average snow duration in Maine is at or below the 4-month snow persistence threshold believed necessary to support lynx (section 4.1.1; Gonzalez *et al.* 2007, entire) and is projected to decline. Snow duration is projected to continue to deteriorate. Snow duration declined by 16 days in the Northeast from 1970 to 2001 (Wake 2005, p. 15) and is expected to diminish by another two weeks in Maine by mid-century (Fernandez *et al.* 2015, p. 10). Snow duration is expected to diminish by 25 percent (low emissions) to 50 percent (high emissions) from current conditions by the end of the century (Hayhoe *et al.* 2006, pp. 21-25). Similarly, Notaro *et al.* (2014, p. 6543) projected an average decrease of 28 days (low emission) to 47 days of snow cover (high emissions) by the end of the century.

Snow Depth - The current average snow depth in northern Maine is at or below the 270 cm/yr. (106 in/yr) thresholds believed needed to support lynx (section 4.1.1; Hoving *et al.* 2005, p. 749) and is expected to decline. By the end of the century, large areas of the Northeast will experience 15-percent (low emission) to 25-percent (high emissions) reduced snowfall (Ning and Bradley 2015, p. 6). Northeast winter snowfall has decreased by about 4.6 cm/decade, with the greatest decreases occurring in December and February (Hayhoe et al. 2006, p. 1). By the end of the century Notaro *et al.* (2014, p. 6529) projected average snow declines in the North Atlantic Landscape Conservation Cooperative of 59 cm (31 percent) (low emissions) to 92 cm (48 percent) (high emissions) because a higher proportion of winter precipitation will fall in the form of rain rather than snow.

Snow Quality - Winter precipitation in Maine is likely to increase by 10 to 15 percent by the end of the century (Hayhoe *et al.* 2006, p. 28) with a greater proportion of winter precipitation falling as rain (Huntington *et al.* 2004, entire; Hayhoe *et al.* 2006, p. 23; Ning and Bradley 2015, entire). Snow density and compaction (caused by wet, heavy snow or rain on snow events in winter) will continue to increase in the region in the future (Karl *et al.* 1993, entire; Dudley and

Hodgkins 2002, pp. 8-10, 19-20; Huntington *et al.* 2004, p. 2632; Huntington 2005, entire; Hodgkins and Dudley 2006, entire).

Loss of Boreal Forest - Climate change is projected to cause a northward contraction of spruce-fir forest in the Northeast with potential negative consequences for both lynx and snowshoe hares (Gonzalez *et al.* 2007, entire). Spruce-fir forest is expected to decline substantially in Maine and the Northeast (Ollinger *et al.* 2008, p. 17; Beckage *et al.* 2008, entire; Jacobson *et al.* 2009, p. 27; Tang and Beckage 2010, entire; Whitman *et al.* 2010, p. 12) or disappear (Iverson and Prasad 2001, pp. 192-193; Prasad *et al.* 2007, entire) because of climate change. Climate change is anticipated to increasingly fragment the boreal forest in northern New England (Iverson *et al.* 2008, pp. 400-405). Lynx habitat will decline as boreal forest diminishes (Simons 2009, pp. 221-222). Even under the lowest emissions scenarios, spruce-fir forest would be reduced by 2100 (Williams and Liebhold 1997, pp. 210-214; Prasad *et al.* 2007, entire; Mohan *et al*. 2009, pp. 221-222), although some spruce-fir may persist at highest elevations (Tang and Beckage 2010, pp. 148-156) and along the eastern coast (Jacobson *et al.* 2009, pp. 26-29) where cooler conditions will prevail. Recent shifts of northern hardwoods to higher elevations formerly occupied by boreal forests have also been attributed to regional warming over the last century (Beckage *et al*. 2008, entire).

The spruce-fir forest type has come and gone from New England during the post-glacial period. It nearly disappeared from the Northeast during the interglacial warming period 1000 years ago, then moved south into New England only in the past few centuries during the “Little Ice Age” (Schauffler and Jacobson 2002, entire; DeHayes *et al.* 2000, entire). Because of its sensitivity to climate and mobile nature, Iverson *et al.* (2008, p. 403) predicted a significant decline (low emissions) or the disappearance (high emissions) of the spruce-fir forest type in northern Maine in response to climate change.

Spruce (red, black, white) and balsam fir are the most important boreal forest conifer tree species in the Northeast and will be affected by climate change in different ways. Mechanisms of injury to spruce-fir include winter injury from freeze-thaw cycles, spring drought (because of reduced snowpack), and reduced seed germination (Auclair *et al.* 2010, pp. 694-695). Thus, the range of spruce-fir is limited by summer heat and drought. Mohan *et al.* (2009) projected that suitable area for balsam fir would decline by 80 percent in 2100 under an average to high emissions scenario. In contrast, Ollinger *et al.* (2008, p. 8) projected increasing growth rates for balsam fir and red spruce to mid-century, after which they would decline.

The timescale of the spruce-fir decline in the Northeast is difficult to predict because of the many variables that influence shifting of the forest species composition (emissions scenarios, the long lifespan of trees, slowness of tree dispersal, frequency of disturbance, competition from advancing hardwoods and invasive tree species, complex interactions with moisture, and synergistic effects with other pollutants). Arguments in favor of an accelerated decline include evidence that spruce-fir is already in decline and is being replaced in Maine by northern hardwoods (oak, pine, red maple). Since 1995, the area of forest land classified as the northern hardwoods type in Maine has increased 8.9 percent (by about 2,400 km^2 [927 mi^2]) and the area in the spruce/fir forest type group has decreased 8.5 percent (1,987 km^2 [767 mi^2]) (McCaskill *et al*. 2016, p. 2).The decline of the spruce-fir forest type may be accelerated by forest disturbances when northern hardwoods replace areas formerly occupied by spruce-fir. In some situations, disturbance may favor persistence of balsam fir and help it persist longer in a warming climate (Scheller and Mladenoff 2005, p. 318). A pending spruce budworm outbreak and frequent disturbance from forest management could accelerate conversion to northern. Other climate-related forest disturbances (forest pests, diseases) could further accelerate conversion to northern hardwoods (Iverson *et al.* 2008, p. 404).

In contrast, some authors note that trees migrate slowly in response to a changing climate and are long-lived. Therefore, a time lag may occur in shifting forest composition from spruce-fir to northern hardwoods (Mohan *et al.* 2009, p. 221; Zhu *et al.* 2012, pp. 1048-1051). Some northern Maine industrial forest landowners could “adapt” to climate change by intentionally favoring spruce-fir (e.g., by plantations and use of herbicides).

Finally, there is uncertainty concerning the influence of climate change on balsam fir, a short-lived, shade-tolerant, conifer that dominates much of the understory in the Acadian forest and is an important component of lynx habitat in the Northern Maine Unit. McWilliams *et al.* 2005 (p. 8) noted that balsam fir increased in Maine’s forest inventory in the early 2000s because this species seems to respond favorably to frequent disturbance. Forest models projected increases in spruce-fir biomass over the next century because of partial harvesting and periodic budworm outbreaks, but did not take climate change into consideration (Simons-Legaard *et al.* 2013, entire). In contrast, Iverson *et al*. 2008 (p. 400) identified balsam fir as the most sensitive tree species in Maine to a warming climate, and they projected large declines, with only 29 percent (low emissions) to 16 percent (high emissions) persisting by the end of the century. Climate change will influence precipitation and temperature, forest management strategies, and forest disturbance (fire frequency and spruce budworm), all of which will interact in complex ways to influence balsam fir at the southern edge of its range. Carter (1996, pp. 1092-1093), Iverson *et al.* (1999, pp. 400, 403), and Goldblum and Rigg (2005, p. 2714) documented balsam fir growth rates and growth potential would decline under likely climate warming scenarios (~4 to 5 F degree temperature increase by the end of the century and reduced snow conditions). Some have projected the extirpation of spruce-fir forest types in the Great Lakes States (Scheller and Mladenoff 2005, entire) and New England (Iverson and Prasad 2000, p. 403). Balsam fir has prolific seed production following forest disturbance such as harvesting (Seymour 1992, p. 217), and has proliferated under the current climate and forest management regime dominated by partial harvesting (Olson *et al.* 2013, entire). Balsam fir is a relatively short-lived tree (~100 years), and is unlikely to persist long if climate change affects seed and germinations rates. Given, anticipated climate changes, especially early snow melt and low spring precipitation, fir may increase for the next few decades but is unlikely to regenerate in a the future Maine forest (E. Simons-Legaard, University of Maine, *pers. comm.* May 31, 2015).

<u>Vegetation Management</u> - Habitat suitable for lynx is expected to decline in the future (see Regulatory Mechanisms section above). By 2020, all of the extensive areas that were clearcut in the 1970s and 1980s will be greater than 35 years of age and no longer support high hare

densities. For the foreseeable future, partial harvesting will continue as the primary means of forest management. Although partially harvested forests with well-developed understory structure may provide foraging opportunities via increased prey access (Fuller *et al.* 2007, 1984-1985), snowshoe hare densities are approximately 50 percent less in landscapes dominated by partially harvested stands (Robinson 2006, pp. 5-37; Fuller and Harrison 2010, p. 1276). Thus changing forest management practices have and will continue to reduce landscape hare density possibly below levels that can support lynx.

Sources of uncertainty concerning future habitat conditions in northern Maine include changes in forest policy, timber harvesting methods, changing timberland ownership, response to budworm outbreaks, and timber markets - all of which have occurred in the recent past and will undoubtedly shape forest management in the future (Simons-Legaard *et al.* 2016, p. 8). Currently, the landscape is owned primarily by financial investors who may be less inclined to intensively manage for spruce and fir after the next outbreak of the spruce budworm (Wagner *et al.* 2016, p. 4).

The dramatic shift from clearcutting to partial harvesting presents a challenge for lynx conservation in this unit for the next several decades. Lynx, habitat is expected to peak and then remain stable through about 2012-2020 then decline (Simons 2009, pp. 153-165, 202-220; Simons-Legaard *et al.* 2016, p. 6). After 2020, aging of the former clearcuts and extensive partial harvesting are projected to result in a 50 to 65 percent decline in lynx habitat by 2032 (Simons 2009, p. 217). Lynx habitat will decline from about 9.5 percent of the landscape (current condition) to about 5.0 percent of the landscape (Simons-Legaard 2016, Fig. 8, p. 10). By 2032, the Northern Maine Unit may support less than half the number of resident lynx that it does today (Simons 2009, pp. 209, 217).

In the future, lynx habitat will be fragmented into smaller, isolated parcels, and will shift southward into areas occupied by bobcats and fishers where snow conditions are unlikely to favor lynx (Simons 2009, pp. 153-165; Simons-Legaard *et al.* 2016, pp. 1, 6; Simons-Legaard 2016, p. 8). By 2022, the number of patches of high quality hare habitat will increase by 57 percent, but the average size of patches will decline by 87 percent, and patches will become more isolated (Simons-Legaard *et al.* 2016, pp. 5-6). The proximity index of high quality habitat patches will decline by 78 percent within lynx home ranges. Although lynx habitat is peaking, fragmentation may diminish its ability to support lynx (Simons-Legaard *et al.* 2016, p. 8).

Beyond 2030 assumptions concerning future climate change, land ownership, and harvest rates introduce greater uncertainty. The most optimistic forest management models (greatest harvest rates, no climate change, no spruce budworm) project that lynx habitat will decline over the next few decades then gradually increase to about 10 percent of the landscape by 2060 (Simons-Legaard 2016, Fig. 8, p. 9). The most pessimistic models (lowest harvest rates, no climate change, no spruce budworm) project about 5 percent of northern Maine will have high quality hare habitat from 2030 to 2060 (Simons-Legaard 2016, Fig. 8, p. 9), although the habitat will be much more fragmented and have smaller patch sizes (Simons-Legaard *et al.* 2016, entire).

Softwood plantations could offset losses in spruce-fir and become a form of adaptation to climate change effects of reducing spruce-fir forest types. Jack pine plantations are extensive in adjacent New Brunswick (Etheridge *et al.* 2005, p. 1966). A forest company that has planted extensive spruce plantations in New Brunswick recently purchased nearly 1 million acres (4,047 km^2 [1,563 mi^2]) of forestland in northern Maine where it is doing the same. Spruce plantations are becoming more common on this ownership in Maine, but not others. Stand structure and intensive management of plantations are highly variable (e.g., pruning, thinning, herbicide treatments), thus hare density and use by lynx vary (Roy *et al.* 2010, entire). Hares can achieve higher densities in plantations depending on the amount of lateral cover, but for shorter periods of time; ~10 to 17 years after cutting and planting in New Brunswick (Parker 1984, p. 163) and 15 to 25 years in Quebec (Roy *et al.* 2010, p. 585). This is in contrast to ~15 to 35 years in naturally regenerating spruce-fir stands after harvest (Simons-Legaard *et al.* 2016, p. 4). The future of plantations in the northern Maine unit is uncertain. Most investment landowners have short-term investment horizons and are unlikely to invest in plantations.

Natural stand-replacing disturbances are rare and infrequent and, other than spruce budworm outbreaks, are unlikely to significantly affect future habitat conditions (Hoving *et al.* 2004, p. 292). A spruce budworm outbreak is projected to reach epidemic proportions in Maine in 2018 to 2021. The epidemic has already affected 10 million acres (40,470 km^2 [15,630 mi^2]) of spruce-fir in southern Quebec, immediately north of Maine (Wagner *et al.* 2014, entire). The last outbreak in the 1970s and 1980s killed millions of acres of spruce and fir forests in the Northern Maine Unit. Maine's 5.8 million acres (23,472 km^2 [9,063 mi^2]) of spruce-fir stands across the State are at risk of defoliation. Although the outbreak has caused severe defoliation thus far over 15 million acres (60,703 km^2 [23,438 mi^2]) of spruce-fir forests in southern Quebec, some project a weaker outbreak in Maine because spruce and fir trees are younger and less susceptible and there is a higher hardwood component in northern Maine forests (Wagner *et al.* 2016, p. 18-22). A typical outbreak lasts for a decade.

Forest management strategies for addressing the coming outbreak vary and include applying insecticides (although land area sprayed is expected to be small compared to the previous outbreak), pre-emptive cutting of mature spruce-fir before defoliation, stop precommercial and commercial thinning, and salvaging dead and diseased trees (Wagner *et al.* 2016, pp. 38-48). An aggressive forest management response (or not) will greatly affect future outcomes for lynx habitat (see section 5.2.1). The next budworm outbreak and subsequent forestry response is a disturbance agent that may accelerate changes in forest composition influenced by climate change, especially toward increased northern hardwood and reduced spruce-fir. The nature of land ownership is greatly changed from the 1970s and 1980s, and landowner response is expected to be diverse depending on their objectives and investment horizons. The pending budworm outbreak cast additional uncertainty on the status of lynx habitat beyond 2030.

Climate change, forest management and budworm outbreaks will interact to influence the future trajectory of spruce-fir forest in Maine. All three variables have yet to be modeled simultaneously (K. Legaard 2016, *pers. comm*.). Assuming current forest management trends persist to the end of the century, spruce-fir dominated forest is expected to continue to decline

(Legaard *et al.* 2013, entire). The combination of budworm-induced mortality and salvage harvesting will have a negative effect on spruce-fir (Legaard *et al.* 2013, entire). However, after a budworm outbreak the biomass and area of mixed-hardwood/softwood forest would be expected to increase through this century primarily because of the proliferation of regenerating balsam fir (see discussion above) (Legaard *et al.* 2013). Mixed forests having a high (greater than 50%) hardwood component are not believed to support high hare densities (Scott 2009, p. 109) or be preferred by lynx (Vashon *et al.* 2008b, pp. 1492-1493). It is uncertain whether lynx can adapt to lower landscape hare densities associated with mixed hardwood-softwood forest. They may persist, but at lower densities as they currently do in the western units of the DPS. However, the probability of persistence is further diminished by deteriorating snow conditions and increased populations of bobcats and other competitors.

Wildland Fire Management - Susceptibility of the northern Maine unit to fire may be enhanced by a severe spruce budworm outbreak because of the amount of dead and dying spruce-fir (Stocks 1987, entire), although there were no large fires after the last outbreak. Fire risk is currently very low in this unit and a continuous decrease in fire frequency is predicted with climate change in eastern Canada because of increased precipitation and decreased drought (Bergeron and Flannigan 1995, entire; Flannigan *et al.* 1998, entire). Climate is expected to become more variable (i.e, wider extremes of summer drought and precipitation) during the next century (Gregory & Mitchell 1995, entire; Gregory *et al.* 1997, pp. 684-685), which could create fire conditions in unusually dry years (Flannigan *et al.* 1998, p. 475). Maine's policy is to immediately suppress wildfire, thus large, stand-replacing fires are expected to be infrequent in this region. Notable large fires in Maine include a 3 million-acre (12,141 km^2 [4,688 mi^2]) fire in 1825 and a 200,000-acre (809 km^2 [313 mi^2]) fire in 1947.

Habitat Fragmentation - The future of the 10 million-acre (40,470-km^2 [15,630-mi^2]), sparsely populated "North Woods" of Maine is highly uncertain and has been the subject of intense public debate (Baldwin *et al.* 2007, entire). Land use and zoning in the state's "unorganized townships" are the responsibility of the Land Use Planning Commission (LUPC) in the Maine Department of Conservation. The LUPC revised its Comprehensive Land Use Plan (Maine Land Use Regulation Commission 2010, entire), and described principal values in guiding future land management decisions: maintaining working forests, provide for traditional recreational opportunities, protect high-value natural resources, and encourage long-term conservation. The North Woods has long been considered a public resource or "commons," even though privately owned (Judd 2007, p. 9). This land was traditionally owned by a few large timber companies, but since the 1980s there has been rapid turnover in ownership largely by investments companies and subdivision of large parcels (Hagan *et al.* 2005). Financial investors, primarily Real Estate Investment Trusts (REITS) and Timber Investment Management Organizations (TIMOs), focus on maximizing the asset value of timberlands and are increasingly likely to seek revenue from non-timber resources if they generate a higher return. These new owners operate over relatively short time horizons (e.g., 5 to 15 years) and are willing to consider multiple means of monetizing their asset, including development and real estate sales (Legaard 2013, entire). If left unchecked, these pressures may continue to promote dispersed development throughout this region. Parcelization and subdivision has increased, particularly in the southern third of the jurisdiction (Maine Department of Conservation 2010, p. 72-73). The LUPC has limited ability to address stressors on Maine's North Woods, including resale and subdivision trend. This trend is likely to continue into the foreseeable future and will make management of large, forested landscapes for Canada lynx even more difficult.

Historically, development has stayed mostly on the edges of the North Woods jurisdiction with exception of scattered seasonal dwellings and sporting camps in the interior, but this could change in the future. Between 1971 and 2005, the LUPC permitted 8,136 new dwellings in unorganized townships — an increase of 66 percent in the number of residences during this time period (Maine Land Use Regulation Commission 2010, p.80). Between 1971 and 2005, the LUPC issued 1,353 development permits for new uses scattered throughout the unorganized townships (Maine Land Use Regulation Commission 2010, pp. 97-99); most (42 percent) being recreational facilities (boat launches, campsites, gatehouses, recreational lodges). Most development has occurred in areas that abut organized communities and near public roads. Within the interior most development has occurred on long lakeshores and waterfront. However, the amount of hillside and ridge development is growing and this trend is likely to continue (Maine Land Use Regulation Commission 2010, p. 136), which will further fragment lynx habitat.

We have an incomplete understanding of the effects of outdoor recreation on lynx and their habitat (ILBT 2013, p. 80). Future trends in outdoor recreation in northern Maine are also uncertain (Vail 2007, entire). A portion of the North Maine Woods is a gated road system that encompasses about 3.5 million acres. Visitation by outdoor recreationists is currently about 175,000 per year and declining. Likewise, visitors to Baxter State Park and the Allagash Wilderness Waterway have declined (Vail 2007, p. 107). Aside from a vigorous discussion of the recently-designated Katahdin Woods and Waters National Monument or a master tourism plan for the area (Vail 2007, pp. 112-113), there could be stagnant or declining participation in traditional outdoor recreational activities in the future (Vail 2007, p. 107). Alternately, increased numbers of second homes and resorts could increase visitor numbers in the future. Snowmobiling may be an exception and has risen in popularity in northern Maine, but it too may decline because of declining snow (see climate change section, above). The effects of new or expanded downhill ski development on fragmentation of lynx habitat are expected to be minimal. Three alpine ski resorts occur within the unit on the southern margin of lynx habitat: Saddleback Mountain Ski Area in Sandy River Plantation near Rangeley, Sugarloaf Mountain Ski Area in Carrabassett Valley, and Sunday River Skiway in Newry and Riley Township. Further development of ski areas is unlikely in the Western Maine Mountains. Future trends in outdoor recreation and associated effects on lynx, hares, and their habitat are uncertain in the northern Maine unit

Within the last five years, two landowners developed concept plans for rezoning for large-scale development of hundreds of house lots and resort development within designated lynx critical habitat. Under one concept plan, 975 houses and two resorts would be constructed on about 14 km^2 (5.5 mi^2) and a 1,469-km^2 (567-mi^2) conservation easement would be established. A second concept plan would allow development on about 8 km^2 (3 mi^2) of land and establishment of a 59-km^2 (23-mi^2) conservation easement. Although these developments have not been built, they may portend future trends in land use.

Energy production is emerging as a potentially significant economic factor in this unit, with grid-scale industrial wind power, solar power, biomass, biofuels, and other energy sources offering new opportunities to utilize natural resources. Wind energy resources are high within the lynx critical habitat (National Renewable Energy Laboratory 2010, http://apps2.eere.energy.gov/wind/windexchange/wind_resource_maps.asp?stateab=mecitation ; last accessed 5/25/2016), and wind development in the lynx critical habitat are likely to accelerate in the foreseeable future. Two large wind energy projects are being considered in designated lynx critical habitat in this unit; if built, each would cover about 450-650 km^2 (180-250 mi^2) and become two of the largest such projects in Maine. Mining is not a traditional land use in this unit, but a large mining operation is being considered at one location in designated lynx critical habitat. Extraction operations for gravel (for road building) are widely-scattered throughout the unit.

The area designated as lynx critical habitat is heavily-roaded, particularly with forestry roads. While accurate numbers are difficult to obtain, approximately 1,500 miles of public roads and over 20,000 miles of private roads exist within unorganized areas of Maine (Maine Department of Conservation 2010). There has been discussion of an east-west limited access highway through northern Maine and extending Interstate 95 north from Houlton to Presque Isle, which, if constructed, would further fragment habitat (Maine Department of Transportation 1999, Beck *et al.* 2012, p. 38).

An increasing area of the designated lynx critical habitat in this unit is likely to be placed under conservation easements that will limit future development and fragmentation of lynx habitat. Maine has the largest amount of land under easement of any state, and there are about 8,094 km^2 (3,125 mi^2) of conservation easements in lynx habitat in northern Maine (Pidot 2011). Continued expansion of areas under conservation easement is uncertain and will depend on willing landowners and funding available for purchase of easements. Conservation easements often purchase development rights, but they may allow for wind power development and other land uses that may not be compatible with lynx conservation. Easements in Maine allow forest management, but they rarely prescribe specific management that would benefit lynx and other species of conservation concern.

The Core Team believes that all development trends portend increased loss and fragmentation of lynx habitat in the Northern Maine Unit. As habitat is lost and fragmented as a result of development, it will become increasingly difficult to influence landscape-scale forest management that could benefit lynx.

Conclusion

After reviewing the scientific literature concerning snow and climate change and acknowledging other threats unique to this unit (e.g., lack of forest planning for lynx, rapid land ownership turnover and development pressures), the Core Team also believed that the population status of lynx in Maine will diminish substantially in the future. The Core Team believed that lynx populations in Maine are at an artificially (historically) high level and will decrease to lower populations. The Core Team believed that given current trends (diminishing snow conditions, extensive partial harvesting of the forest, forest fragmentation, possible pelage mismatch for hares, increasing populations of bobcat and fishers in a lower snow environment) landscape hare densities have, and will continue to decline in northern Maine. Extended periods of lower hare numbers (as seems to be occurring now), would be expected to exacerbate these declines.

The Core Team concurred with expert assessments concerning trends in forest management, but we also note that development pressures in northern Maine did not receive much discussion at our expert elicitation workshop. We believe that development pressures (residential and commercial development, energy development, transmission lines, roads, mining) will increasingly become competing land uses on private lands in northern Maine. We also expect the rapid turnover and subdivision of private forest lands in northern Maine to continue, which will accelerate opportunities for non-forestry land uses. Turnover in land ownership have provided opportunities to conserve some areas of the north Maine woods through purchase of conservation easements and fee title acquisitions, including a new Katahdin Woods and Waters National Monument. However, conservation easements do not fully protect these lands from some kinds of development that could adversely affect lynx and their habitat. For example, many conservation easements allow large-scale, industrial wind power development. We conclude that various forms of development in northern Maine will continue in the future.

The Core Team believes Maine lynx populations would be expected to decline more rapidly in a future scenario without Federal listing. The lynx is not State-listed in Maine and there is currently little consideration of lynx in the review of projects requiring state permits. There is a closed season on lynx, so intentional take would continue to be prohibited. There is rarely a nexus for Service review of forestry projects under section 7 of the ESA (i.e., no Federal funding or permits are typically required for forest management on private lands). Nevertheless, because of their Federal listing, Canada lynx are a priority species for planning by Federal, Tribal, State, and private forest landowners. Although few private landowners have thus far made formal commitments to intentionally manage their forests for lynx, by virtue of their Federal listing status they at least consider the possibility of doing so in the future. This is particularly true of landowners who must plan for Federal listed species as a requirement of their enrollment in green certification programs. Without Federal listing, there would be no incentive or motivation for private forest landowners to change the current paradigm of partial harvesting and intentionally engage in forest management to benefit lynx. With current Federal listing, there is a nexus for the Service to review other projects in northern Maine (e.g., Army Corps of Engineers permits for wetland impacts); for new highways, transmission lines, large-scale energy development, mining, and residential and commercial development. Without Federal listing, few of these projects would consider lynx. Critical habitat has been an important consideration in the Federal review of the aforementioned kinds of development projects. Critical habitat also has had a positive influence on land conservation in northern Maine, with land trusts and nongovernmental organizations using the lynx and their critical habitat as justification for seeking funds for conservation easements. This justification for habitat protection would no longer be valid in a future scenario without lynx being Federally-listed. The Core Team concludes that a future scenario without Federal listing would result in increased habitat loss and fragmentation and would result in reduced justification for habitat protection initiatives in northern Maine.

Lynx would be at greater risk without ESA section 9 prohibitions against take. In a future scenario without Federal listing, Maine's incidental take plan for trapping would be rescinded, and it is likely that many protective measures to minimize injury, take, and mortality of lynx would cease or diminish. It is unlikely that lynx would become a legally trapped furbearer in Maine (although some Maine trappers have suggested that). Habitat mitigation for lethal take of lynx associated with the Maine trapping HCP would cease. About 10 lynx have been illegally shot and reported or otherwise discovered since listing. Illegal shooting and non-reporting would likely increase without Federal protection. We believe several high-profile Federal law enforcement cases have helped to reduce illegal shooting of lynx. With a diminished snow regime, populations of bobcats would be expected to increase and expand northward into areas currently occupied by lynx. Incidental take of lynx from bobcat trapping, running with dogs, and hunting activities would likely increase without Federal listing. Similarly, increased fisher populations and trapping would be expected to occur in northern Maine in a diminished snow regime that would lead to greater incidental (lethal) take of lynx. There have been a few situations where lynx have destroyed livestock, but lethal actions to remove lynx were avoided because of Federal listing. Without Federal listing, justification for shooting lynx in these situations would likely increase. We believe that despite a closed hunting and trapping season, incidental take would continue and possibly increase and could become a significant threat to a population of lynx that will likely be significantly diminished by mid- to late-century.

After considering the lynx expert opinion and the best available scientific information, the Core Team was more pessimistic than the experts about the probability of persistence of Canada lynx in the northern Maine unit. All threats – forest management, climate change, habitat loss and fragmentation, and development – are increasing in frequency, intensity, and extent. The amount of high quality hare and lynx habitat created by clearcutting in the 1970s and 1980s recently peaked at unprecedented high levels that are unlikely to be achieved again. Because of state regulations, forest management has shifted dramatically away from clearcutting to many forms of partial harvesting, which on average support less than half the hare densities. Forest land ownership has, and continues to rapidly change, further subdividing private forest lands. Furthermore, hare densities have declined by half and have remained at these lower levels. Lynx habitat in the next few decades will shift south to areas that will be more influenced by climate change and northward range expansion by bobcats. Thus, we conclude that the carrying capacity to support lynx is diminishing, and the lynx population will decline as the quantity and quality of boreal forest habitat declines. In contrast to other units, there are no commitments by private forest landowners to management plans to ameliorate this stressor. After reviewing the best available scientific information, we believe that climate change is a significant threat to lynx in the Maine unit; more so than expressed by experts. Deep, fluffy snow is critical to the existence of hare and lynx, and snow depth and duration are currently at or below the thresholds believed necessary to support lynx. Unlike other units, as snow condition decline there is little elevational refugia for lynx in Maine. Spruce-fir is being replaced by northern hardwoods because of climate change. Frequent forest cutting and disturbance, including a pending spruce budworm outbreak, could accelerate conversion to northern hardwoods. We acknowledge that the rate of spruce-fir decline is uncertain, but note that some of the science reviewed indicates the spruce-fir forest type could nearly disappear from Maine by late-century under both low and high emissions scenarios. Climate change models portend declining snow conditions from low- to high-emissions. Because increases in temperature are thus far tracking high emissions scenarios we are less optimistic for snow conditions that favor lynx by mid- to late-century. In the past decade, interest in development has increased in lynx critical habitat, especially proposals for large-scale residential and resort development and extensive wind energy development that could cover hundreds of square miles. We conclude that these threats, individually and cumulatively, indicate diminished populations of lynx and their habitat. If these threats are not abated, we believe that the probability of persistence will be lower than projected by experts by mid-century and that lynx will have a greater likelihood of extirpation by the end of the century.

5.2.2 Unit 2 - Northeastern Minnesota

<u>Expert Projections of Lynx Persistence</u>

The experts that we consulted indicated an initially high and subsequently declining probability of persistence of resident lynx in Minnesota, with increasing uncertainty through the end of the century (Lynx SSA Team 2016, pp. 37-38 and Figure 9, below). Near term drivers of the projected decline were reduced quality, quantity, and persistence of snow, competition from bobcats, disease (*e.g.*, lungworm, liver fluke, feline leukemia), and forest insects. Long term drivers of the projected decline were reduced the quality, quantity, and persistence of snow, competition from bobcats, loss of spruce-fir forests, wildfires, and climate change.

Climate change was primarily associated with loss of boreal forest but could potentially also increase disease or insect outbreaks, and is likely to affect the amount of precipitation falling as good quality snow in the area of the state supporting lynx habitat. We heard varying prognoses from experts on the speed at which climate-induced loss of boreal forest will occur. The scientific literature suggests and one of the climate change experts indicated that loss of spruce-fir could occur relatively quickly in the Midwest and Northeast (but possibly more slowly elsewhere in the DPS because of elevational refugia) and all noted that an increase in northern hardwood composition of the forest is already occurring. The connection to lynx in Ontario reduces the likelihood of local extirpation in this geographic unit, but the likelihood would increase if connectivity was compromised.

Although uncertainty increases with time from the present, experts generally agreed that climate-related loss of favorable snow conditions (amount, consistency, and duration), loss of boreal forest, and increased bobcat competition and hybridization are likely to reduce the probability of lynx persistence in this unit. Experts expressed uncertainty about the severity of a pending insect outbreak (and how this will affect future lynx habitat) and the potential introduction and spread of diseases. Less is known about long-term trends in snowshoe hare populations in this unit than other units (e.g., the Maine unit).

Taking all factors into consideration (i.e., loss of boreal forest, competitions, disease and insect outbreaks, loss of snow), the experts projected the mean probability persistence to the year 2025 was greater than 90 percent, to 2050 was 80 percent (ranging from 60 to 90 percent), and would decline to approximately 35 percent (ranging from 10 to 60 percent) by 2100 (Lynx SSA Team 2016, pp. 37- 38).

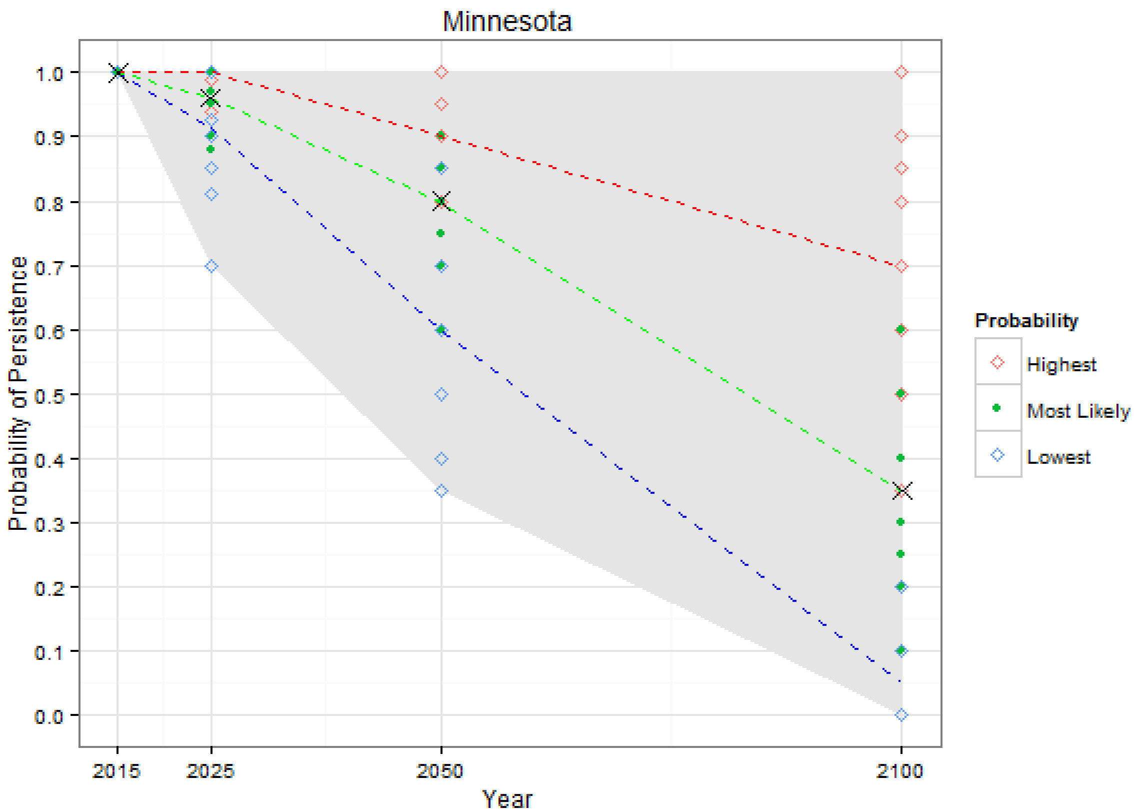


Figure 9. Lynx expert estimates of the probability that the Northeastern Minnesota Geographic Unit will continue to support resident lynx in the future (at years 2025, 2050, and 2100).

Service Evaluation of Factors Potentially Influencing Future Conditions

Regulatory Mechanisms - In Minnesota, the vast majority of lynx habitat that supports a long-term persistent lynx breeding population is administered by the SNF. This area includes designated critical habitat (79 FR 54782). The SNF is currently implementing the 2004 SNF Plan (USFS 2004a, entire), which has direction based on the LCAS (Ruediger et al. 2000, entire) and the Canada Lynx Conservation Agreement (CA) between the Forest Service and the Service (USFS and USFWS 2000, entire), for all forest activities that occur within LAUs. Active management of forest lands can maintain, restore, or create lynx habitat, and the SNF has a long-term commitment to doing so. If the SNF continues to follow vegetation and wildland fire management and other applicable recommendations under the 2000 LCAS (or the updated 2013 LCAS or subsequent updates) in its Forest Plan, we expect that several risk factors will continue to be minimized and managed to promote the conservation of lynx within the SNF into the future. Management of lynx and its habitat on SNF land will remain in place until the forest amends or revises its LRMP. We expect that management direction for lynx addressing vegetation management, wildland fire management, and habitat fragmentation on national forest system lands will be incorporated into the revised or amended Forest Plans (LRMPs). It is unclear if the SNF will continue to implement lynx direction in the absence of the DPS listing. Once if the DPS is de-listed, the species would be placed on the Forest's Regional Forester Sensitive Species list for a minimum of 5 years, which gives it a higher priority than other species for monitoring and management during that time. The SNF consults with the FWS to consider the effects of any projects to lynx and its critical habitat and is anticipated to do so as long as the species is listed under the ESA.

The Chippewa and the Chequamegon-Nicolet national forests occur outside the Northeastern Minnesota geographic unit and the area considered to be core lynx habitat (i.e., where lynx are persistent and are reproducing) in the Great Lakes Region. However, because lynx occasionally occur on these forests, the Forest Plans for both also include direction based on the LCAS and Canada Lynx Conservation Agreement (CA) between the Forest Service and the Service (Ruediger et al. 2000, entire; USFS and USFWS 2000, entire), for all forest activities that occur within LAUs (USFS 2004b, entire; USFS 2004c, entire). These two forests consult with the FWS to consider the effects of any projects to lynx and are anticipated to do so as long as the species is listed under the ESA. It is unclear if these national forests outside of the lynx core area would continue to implement lynx direction in the absence of the DPS listing.

Additionally, the Minnesota Department of Natural Resources (MN DNR) manages approximately 36 percent of the lynx habitat in this unit, and privately-owned lands make up about 16 percent of the unit. Under the Sustainable Forest Resource Act of 1995 (revised in 2014), the Minnesota Forest Resources Council (MFRC) has developed guidelines for site-level timber harvesting and forest management (MFRC 2013, entire; MFRC 2014, entire). These voluntary guidelines are intended for private and State landowners and include some general recommendations for wildlife but are not specific to lynx (MFRC 2014, pp. 4-5). It is expected that the MFRC guidelines will remain in place into the future and that voluntary actions will continue. Private landowners, however, do not have an official commitment to land management. We cannot say with any certainty what proportion of privately owned land will follow those guidelines into the future, because following the guidelines is voluntary. The MFRC guidelines are less comprehensive and are not specific to lynx, and therefore may not be as beneficial to lynx and lynx habitat as the lynx and hare specific direction followed by the Forests.

The NPS manages Voyageurs National Park, which is also within the Minnesota unit. Voyageurs National Park protects an area of 882 km^2, of which 534 km^2 (62 percent) is covered by forests and other uplands (Moen *et al.* 2012, p. 348), but does not have lynx specific direction in its management plan (NPS 2002, entire). The National Park consults with the FWS to consider the effects of any projects to lynx (NPS 2002, p. 26) and is anticipated to do so as long as the species is listed under the ESA. Lynx documented on and near Voyageurs National Park are probably transient animals (Moen *et al.* 2012, p. 348).

Approximately 1 percent of the Minnesota unit is managed by the Grand Portage Band of Chippewa, who has been actively working on lynx conservation since 2004. On-reservation timber sales and harvest practices follow an integrated management plan for priority wildlife management, sustainable economic development, and recreational uses. The Band's timber management practices benefit populations of snowshoe hares, the lynx's primary prey (Deschampe 2008, entire) and are expected to continue into the future.

In response to a 2008 court ruling, the MN DNR began to draft a plan to address incidental take of lynx that may result from otherwise legal trapping in Minnesota. This plan is still under development by the MN DNR and will be designed to reduce the likelihood of incidental take from trapping (ILBT 2013, p. 49). If the DPS was not listed, the State would likely still try to reduce incidental take of lynx from trapping; however, it also is possible that State-managed trapping of lynx could resume.

<u>Climate Change</u> - The direct and indirect effects of climate warming are expected to affect lynx in Minnesota (Siren *in* Lynx SSA Team 2016, pp. 15 and Moen *in* Lynx SSA Team 2016, p. 19) and could further restrict their range. Since the DPS was listed in 2000, new information on regional climate changes and potential effects to lynx habitat has been developed (e.g., Danby & Hik 2007; Gonzalez *et al.* 2007; Knowles *et al.* 2006, Notaro *et al.* 2015), and this new information suggests that climate change may be an issue of concern for the future conservation of lynx because lynx distribution and habitat is likely to shift upward in elevation within its currently occupied range as temperatures increase (Gonzalez *et al.* 2007, entire). Greatest stressors of climate change include diminishing snow depth, quality and duration; competition from bobcats and other carnivores; hybridization with bobcat (Schwartz *et al.* 2004, p. 354); loss of spruce-fir to northern hardwoods; and potential future isolation of resident lynx in this unit because of diminishing forest conditions in Ontario.

Gonzalez *et al.* (2007, entire) modeled distribution of boreal forest and future snow conditions under nine different low, medium, and high emission scenarios (IPCC 2007, pp. 44-47) and predicted loss of forest and snow conditions able to support lynx in Minnesota by the end of the century. Notaro *et al.* (2015, pp. 1668-1669) projected changes in lake effect snowfall using downscaled climate models (Abdus Salam International Centre for Theoretical Physics (ICTP) Regional Climate Model version 4 (RegCM4; Elguindi *et al.* 2011 and Giorgi *et al.* 2012 as cited in Notaro *et al.* 2015) for the Great Lakes Basin. Siren (*in* Lynx SSA Team 2016, p. 15) stated that climate models show an increase in lake effect snow in the eastern Great Lakes until 2050, with a decline later in the century, with an overall decline in the amount and duration of pack in the Midwest. Although there are uncertainties about future climate warming, lynx populations in Minnesota are expected to recede northward and decline over the next century (Lynx SSA Team 2016, pp. 37-38).

Lynx require at least four months (120 days) of continuous snow coverage (Gonzalez *et al.* 2007, p. 7). Snow cover days of 1 inch or greater in northern Minnesota (1959 -1979) ranged from 130-160 days, of 6 inches or greater ranged from 85 to 130 days, of 12 inches or greater ranged from 50 to 100 days, of 24 inches or greater ranged from 10 to 30 days (Kuehnast *et al.* 1982, pp. 7-9). In the future, Notaro *et al.* (2015, p. 1675) projected a general reduction in the frequency of heavy lake-effect snowstorms during the twenty-first century, with the exception of projected mid-century increases around Lake Superior when local air temperatures are expected to remain low enough for precipitation to largely fall in the form of snow. The snow season in the Great Lakes basin is likely to become substantially compressed during the twenty-first century with dramatic increases in rainfall (Notaro *et al.* 2015, pp. 1676-1678). The Minnesota unit may be more vulnerable to snowpack loss due to lack of elevational refugia (Siren *in* Lynx SSA Team 2016, p. 15).

Normal annual snowfall from 1981-2010 in northeastern Minnesota ranged from 140 to 241 cm per year (55 to 95 in/yr.) http://www.dnr.state.mn.us/climate/summaries_and_publications/normals_snow_1981_2010.html, accessed 24May2016) and is projected to decline across the Great Lakes Basin (Notaro *et al.* 2015, p. 1675). Snow quality ('fluffiness") is projected to deteriorate in the Great Lakes. Notaro *et al.* (2015, pp. 1671-1674) projected a dramatic decline of Great Lakes ice cover that will become confined to the northern shallow lakeshores during mid-to-late winter by the end of the century. Ultimately, this leads to increased rainfall, not snowfall, as these projected reductions in ice cover and greater dynamically induced wind fetch lead to enhanced lake evaporation and total lake-effect precipitation (Notaro *et al.* 2015, pp. 1674-1678).

Climate change is projected to cause some northward contraction of boreal conifer forest in Minnesota (Gonzalez *et al.* 2007, p. 16, 18) with some potential loss of habitat at the southern portion of lynx habitat in the State (Gonzalez *et al.* p. 2007, p. 19). According to Frelich (*in* Lynx SSA 2016, p. 14), Minnesota could lose the boreal biome completely, possibly within the next 60 to 70 years, with unmitigated climate change. Gonzalez *et al.* (2007, pp. 8, 13) projected that northeastern Minnesota, including the SNF, would continue to have snow conditions suitable for lynx at the end of the century, and may serve as a refugium for lynx in the Lower 48 States. However, Moen (*in* Lynx SSA Team 2016, p. 19) questioned this result, noting that the Gonzalez *et al*. model predicted a much larger distribution of suitable snow conditions than currently exists in Minnesota. Moen presented preliminary snow modeling results that project snow conditions suitable for lynx will shrink significantly by 2055, be limited to extreme northeastern Minnesota by 2070, and may be entirely absent from the state by 2095 (Moen and Catton *in* Lynx SSA Team 2016, p. 19). If a refugium for lynx does persist in this unit in the future, it would likely only consist of the small area in Cook County (the extreme northeastern corner of the unit) with slightly higher elevations (518-701 m [1700-2300 ft) than the majority of the area that is now considered lynx core habitat and would, therefore, support a much smaller number of resident lynx than likely occur in the unit now.

<u>Vegetation Management</u> - Vegetation management similar to that conducted under current Forest Plans will likely continue into the future on Forest Service lands in Minnesota as long as

the DPS is listed. These activities include timber harvest, such as thinning, clear-cutting, shelterwood, partial cut, and uneven-aged cutting; wildlife restoration projects that involve tree cutting, shearing, burning, seeding, and planting; prescribed burning for ecological purposes, hazardous fuel reduction, and site preparation; mechanical site preparation. If the DPS is de-listed, the species would be placed on the Forest's Regional Forester Sensitive Species list for a minimum of five years, which gives it a higher priority than other species for monitoring and management during that time; however, it is unclear what the forest management would entail during or after that period of time.

Vegetation, timber, and minerals management authorized under current Forest Plans in Minnesota have the potential to adversely affect lynx and lynx critical habitat by reducing habitat quality for denning, foraging, and dispersal; disrupting travel, resting, and foraging patterns; disturbing denning females; and reducing habitat quality for lynx prey species, especially snowshoe hares. Depending on the timing, frequency, intensity, extent, amount, or other conditions, impacts may be variable among similar projects. Using the LCAS as a basis, the Forest Plans have incorporated a number of components that would reduce the risk of those impacts into the future. We expect that management direction for lynx addressing vegetation management on National Forest System lands in the future will be incorporated into revised or amended forest plans, using LCAS as a basis. Future Forest Plan revisions will likely maintain broad direction to design and implement vegetation management projects to maintain or restore conditions for lynx foraging and denning habitat and to maintain or improve juxtaposition of required habitat types and connectivity.

Over the long term, the Forest Plan will alter vegetation patterns on the landscape. Suitable hare habitat was predicted to decrease over time with implementation of the Forest Plan, but has actually increased since 2004 (USFWS 2011, p. 51). Management activities that create unsuitable conditions for hare generally include clear-cut and seed tree harvest, and might include management-ignited fire, mechanical site preparation, salvage harvest, and shelterwood and commercially-thinned harvest, depending on unit size and remaining stand composition and structure. Suitable hare habitat is predicted to remain above the range of natural variation, which is essentially a description of conditions that existed prior to European settlement (1600 – 1900 A.D.) of the area (USFS 2004a, p. 105). Further, unsuitable habitat for lynx would vary only slightly with continued implementation of the Forest Plan and would remain distinctly below the maximum of 15 percent unsuitable in a decade prescribed in the LCAS and incorporated into the Forest Plan. Current (2010) unsuitable habitat levels are below what was predicted in the 2004 (USFWS 2011, pp. 51-52). Because suitable habitat on National Forest lands alone is such a high percentage within LAUs and the SNF is the majority landowner within most LAUs, we expect that in the future, the Forest would not approach the LCAS maximum of 30 percent of lynx habitat on all ownerships in an unsuitable condition within an LAU at any time, which would be ensured by corresponding guidance in the Forest Plan.

Wildland Fire Management - Unlike the Maine unit, the susceptibility of the Minnesota unit to fire may be reduced by periodic spruce budworm outbreaks. Measurable defoliation from spruce budworms has occurred in Northeastern Minnesota continuously since 1954 (MN DNR http://www.dnr.state.mn.us/fid/july2014/articles.html) and is expected to continue into the future. Modeling to evaluate the relative strength of interactions between spruce budworm outbreaks and fire disturbances in the BWCA showed that budworm disturbance can partially mitigate long-term future fire risk by periodically reducing live ladder fuel within the forest types of the BWCA but will do little to reverse the compositional trends caused in part by reduced fire rotations there (Sturtevant *et al.* 2012, pp. 1286-1292).

The SNF manages for wildfires through preventative measures such as fuels reductions, but does not manage for wildfires in the BWCAW. Natural successional changes and those associated with natural phenomena, such as wildfire or windstorms, are and are expected to continue to be the dominant force in ecosystems on the BWCAW.

<u>Habitat Fragmentation</u> - Ravenscroft *et al.* (2010, p. 329) considers northeastern Minnesota forest landscape as largely un-fragmented. The BWCAW remains intact and contiguous with Canada. Within the SNF, natural disturbances and vegetation management activities make up most of the annual human-caused fragmentation in actively managed portions of the Forest. These areas typically re-vegetate within three to five years, depending on the forest type and number and type of activities (USFS 2011, p. 119). The SNF’s Forest Plan (USFS 2004a, Appendix E) provides direction on limiting lynx habitat fragmentation and the Forest actively consolidates habitat through land acquisitions and exchanges. The Forest direction limiting habitat fragmentation is expected to continue as long as the DPS is listed.

Fragmentation, Development, and Human Access - Throughout the SNF and northern Minnesota, human activities have reduced connectivity between patches of suitable lynx habitat. Development for residential and commercial uses, as well as roads, railroads, and utility corridors have all interrupted linkage corridors. Still, much of the land within the Forest remains undeveloped and lynx habitat remains relatively intact and well connected. This is particularly true on the SNF, which has a “high standard” (OML 3, 4 and 5) road density of roughly 0.45 mi/mi^2 outside the BWCAW.

Human access to lynx areas occurs by foot and motorized vehicle, including RMVs and off-road vehicles, and generally occurs on trails, low standard roads, and temporary roads developed for management operations, particularly timber harvests, and more recently, minerals exploration. While open, these roads provide access to lynx habitat. As northern Minnesota has become more developed and the human population has increased, the SNF has sustained increased visitation in recent years (USDA 2011) which increases the opportunity for human-lynx encounters, especially by trappers. Lynx are likely to continue to be incidentally trapped at the current rate as a result of continued access via low standard roads and trails on the Forest. Any corridor open to RMVs provides the potential for Forest visitors to incidentally trap, shoot, or collide with lynx. Temporary road construction for minerals exploration projects may have significant contributions to temporary road densities and increase human access during the time the roads are being used. Temporary roads in mineral exploration projects may stay open for more years (1-15 years) than those predicted by the Forest Plan EIS for resource management (1-5 years). If these sites are left accessible to the public, then human-lynx conflicts may increase. Furthermore, intersections of new roads, closed temporary roads and/or roads open to the public are likely to become parking areas for cars, which would indirectly increase public access. Further, these corridors increase potential competition through increased snow compaction. Effective road closures, however, may reduce the potential effects to lynx and their habitat.

Energy and Mineral Development - Mining (e.g., iron ore and taconite mining) is occurring at several locations in or near the lynx core habitat area in northeastern Minnesota (MN DNR 2016, p. 1). Large-scale mining operations on non-Forest land could result in irreversible or irretrievable loss of lynx and hare habitat. Minerals exploration has increased and is occurring at many locations in northeastern Minnesota, which may lead to more large-scale mining projects. Vegetation clearing for minerals exploration projects may have temporary impacts to lynx and hare habitat at drill pad sites, although impacts from pad sites are expected to be minimal and temporarybecause the foot print of individual drill pads is typically small and the cleared land is expected to re-vegetate. Drill pad site preparation includes vegetation clearing on small patches of land (average of approximately 1.6 acres). This cleared land may provide snowshoe hare habitat after it has time to revegetate. Mineral exploration activities use existing Forest roads but also may require construction of new roads and may potentially add a significant number of road miles. Land exchanges associated with proposed mining sites could result in a loss of lynx and hare habitat under Forest management, but may also result in consolidation or gain of habitat with newly acquired lands (*e.g*, the Forest may able to consolidate lands that they can then manage for lynx). Stone quarry extraction operations are also scattered throughout the unit (MN DNR 2016, p. 1) and may impact lynx and hare habitats.

<u>Conclusion</u>

After reviewing the scientific literature concerning climate change projections (diminishing snow conditions, loss of boreal forest, lack of elevational refugia, increased competition, potential disease, and insect outbreaks), some members of the Core Team were slightly more pessimistic about the future of lynx in Minnesota than the lynx expert panel. The Core Team concluded, with slightly more certainty than the expert panel, that the lynx may be extirpated at the end of the century. The experts predicted the probability of persistence to decline to approximately 35 percent by 2100 while the Core Team thought the probability of persistence would be lower at that time. The threat for which the lynx was listed, lack of specific conservation direction, associated regulations, and lynx forest management planning has not been addressed on private lands in Minnesota, except through voluntary guidance. There is some uncertainty about the future of forest management and future development on private forest lands in Minnesota and in adjacent lands in Ontario, although there are some basic voluntary management guidelines for private lands in Minnesota. Further, if the DPS is de-listed, there is uncertainty whether the lynx direction on Forest lands would continue into the future. It is projected that habitat will diminish and recede northward over the mid- to longer-term because of continued climate warming. Furthermore, hybridization and competition with bobcat may increase with diminishing snow conditions because of continued climate warming and there are uncertainties how insect outbreaks or disease may affect the species or its habitat.

The Core Team believes the Minnesota lynx populations would be expected to decline more rapidly in a future scenario without Federal listing. The lynx is state listed, however, and Minnesota's Endangered Species Statute and the associated Rules impose a variety of restrictions, a permit program, and several exemptions pertaining to species designated as endangered or threatened. Under the state statute, a person may not take, import, transport, or sell any portion of an endangered or threatened species. However, these acts may be allowed by permit issued by the DNR. There is a closed season on lynx, and it is expected that intentional take would continue to be prohibited until the population reached sustainable levels defined by the state. In Minnesota, the large proportion of lynx core area owned by the Forest Service provides a nexus for USFWS review of Forest projects under section 7 of the Endangered Species Act (i.e., there is rarely federal funding spent on forestry and no federal permits required for forest management on private lands), which would be lost post de-listing. Because of their Federal listing, Canada lynx are recognized as a priority species for planning by federal, tribal, state, and private forest landowners. Voluntary guidelines that consider the Federal listing status may guide private landowners to at least consider measures to help conserve listed species in the future. Without Federal listing driving voluntary conservation guidelines, however, there would be little or no motivation for private forest landowners to intentionally engage in forest management to benefit lynx. With current Federal listing, there is a nexus for the USFWS to review other projects in northeastern Minnesota (e.g., Army Corps of Engineers permits for wetland impacts); for new highways, transmission lines, large-scale energy development, mining, and residential and commercial development. Without Federal-listing, these projects would not consider impacts to lynx critical habitat. The Core Team concludes that a future scenario without Federal listing would result in increased habitat loss and fragmentation and would result in reduced justification for habitat protection initiatives in northeastern Minnesota.

Lynx would be at greater risk without Endangered Species Act section 9 prohibitions against take. In a future scenario without Federal listing, Minnesota's incidental take planning effort for trapping may be further delayed or halted and may result in the diminishment of protective measures to minimize injury, take, and mortality of lynx. As it is, approximately 16 lynx have been reported to be incidentally trapped in Minnesota since listing, resulting in at least 6 mortalities. It is unlikely that lynx would become a legally trapped furbearer in Minnesota (although a legal wolf hunt was reinstated post-delisting of that species in Minnesota, so it may also be suggested for lynx). Seven lynx have been illegally shot and reported or otherwise discovered since listing. Illegal shooting and non-reporting would likely increase without federal protection. High-profile law Federal enforcement cases may have helped to reduce illegal shooting of lynx. With a diminished snow regime, populations of bobcats would be expected to increase and expand north and eastward into areas currently occupied by lynx. Incidental take of lynx from bobcat trapping and hunting activities would likely increase without Federal listing. Similarly, fisher, fox, and coyote populations may increase in a diminished snow regime in northern Minnesota and trapping would be expected to occur there that may lead to greater incidental take of lynx. Without federal listing, shooting lynx may increase. We believe that despite a closed hunting and trapping season, incidental take would continue and possibly increase and could become a significant threat to a population of lynx that will likely be significantly diminished by mid- to late-century.

After considering the best available scientific information, including the opinions of lynx experts summarized above, the Core Team was more pessimistic than the experts about the probability of persistence of Canada lynx in the Minnesota unit. All threats –climate change, habitat loss and fragmentation, mining and development – are increasing in frequency, intensity, and extent. Lynx habitat in the next few decades will likely shift north to areas that will be more influenced by climate change and northward range expansion by bobcats. Thus, we conclude that the carrying capacity to support lynx is diminishing, and the lynx population will likely decline as the quantity and quality of boreal forest habitat declines. Although there are voluntary measures to consider listed species on private land forest management, there are no commitments by private forest landowners to management plans to ameliorate this stressor. After reviewing the best available scientific information, we believe that climate change is a significant threat to lynx in the Minnesota unit; slightly more so than expressed by most of the experts. Deep, fluffy snow is critical to the existence of hare and lynx, and snow depth and duration are currently at or below the thresholds believed necessary to support lynx. Unlike most other units, as snow condition decline there is little potential for elevational refugia for lynx in Minnesota except, perhaps, a small area of slightly higher elevation in extreme northeastern Minnesota in Cook County. The boreal forest in this unit is already being replaced by northern hardwoods because of climate change. Frequent forest cutting and disturbance, including a potential insect outbreak, could accelerate conversion to northern hardwoods. We acknowledge that the rate of boreal decline is uncertain, but note that some of the science reviewed indicates the spruce-fir forest type could nearly disappear from Minnesota by late-century under both low and high emissions scenarios. Climate change models portend declining snow conditions from low- to high-emissions. Because increases in temperature are thus far tracking high emissions scenarios, we are less optimistic for snow conditions that favor lynx by mid- to late-century. In the past decade, interest in development has increased in lynx critical habitat, especially proposals for large-scale mining developments. We conclude that these threats, individually and cumulatively, indicate diminished populations of lynx and their habitat. If these threats are not abated, we believe that resident lynx in this unit will have a slightly greater likelihood of extirpation by the end of the century than was predicted by lynx experts.

5.2.3 Unit 3 - Northwestern Montana/Northeastern Idaho

Expert Projections of Lynx Persistence

Because of its connectivity to lynx populations and habitats in Canada, its large geographic extent, and the relatively large number and broad distribution of resident lynx it is thought to support, future extirpation of lynx from this unit from either reduced genetic health or a catastrophic event is unlikely (Lynx SSA Team 2016, pp. 25-34). When considering the probability that this unit would continue to support resident lynx in the future, experts noted that despite projected losses of favorable forest and snow conditions, climate models project that some boreal forest will persist in this unit and that it will maintain some areas of suitable snow into the future. Experts also noted that lynx in this unit primarily occupy public lands, which are actively managed for lynx into the future. Experts also considered recent and projected future increases in wildfire frequency, size and intensity.

As for most other geographic units, all experts indicated an initially high and subsequently decreasing probability of the persistence of resident lynx in this unit, with increasing uncertainty over time, but a higher probability of persistence at all time frames than other units. All experts predicted near-term (year 2025) persistence probability >= 95%, mid-century persistence at 70% to 100% (median = 90%), and end-of-century persistence probabilities >= 50% (median = 78%) (Figure 10, below).

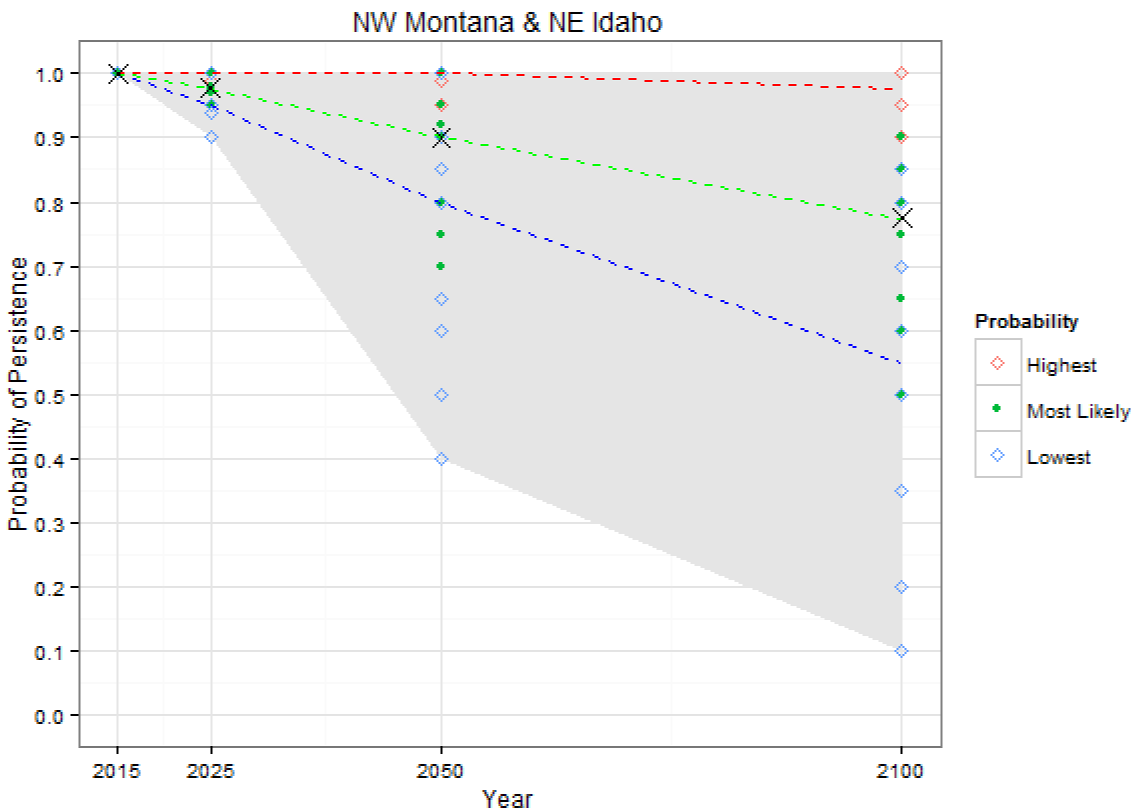


Figure 10. Lynx expert estimates of the probability that the Northwestern Montana/Northeastern Idaho Geographic Unit will continue to support resident lynx in the future (at years 2025, 2050, and 2100).

Overall, experts assigned a higher probability of persistence in this unit compared to the other geographic units. Most lynx habitats in this unit occur on Federal lands that are managed for lynx conservation, but one expert noted that little has been done to document whether lynx are responding to this management. The recent sale of large tracts of private commercial timberlands in the central part of this unit to The Nature Conservancy has increased protection for lynx via conservation easements managed for lynx. Habitats in some areas should improve in the near future as previously cut or burned areas mature into dense stands. Unlike the Maine and Minnesota geographic units (but similar to most other western units), high elevations in this unit could buffer the effects of climate change by providing for the upslope migration of lynx habitats and snow conditions that climate models predict. However, this would result in even patchier and more isolated islands of habitat in high elevation areas that would be more prone to extirpation from catastrophic or stochastic events. Competition from coyotes and bobcats seem to be less of a concern for this unit.

This unit has unimpeded connectivity with Canada, but some experts questioned whether this geographic unit depends on intermittent immigration of lynx from Canada, and whether the historical lynx population cycles in Canada believed to have fueled such immigration are still occurring or will into the future. There doesn't appear to be much demographic input from recent cycles. There is evidence of lynx from this unit moving north into Canada, but little evidence of demographic interactions among the three subpopulations (Purcell Mountains, Seeley Lake, and Garnet Mountains) in this unit. Experts noted that the Garnets Mountains subpopulation at the southern end of this unit may have recently become extirpated.

Discussion among experts indicated that fire was more of a concern for this area. Increased fire extent and severity or other catastrophic events and small subpopulation effects in separated mountain ranges could affect lynx persistence in the future in some parts of this unit. Fire exclusion in this area for the last 100 years likely resulted in the accumulation of fuels; however, this unit may have a reduced probability of a catastrophic fire over time because of recent changes in management and recent fires that may have reduced fuels. Out to the year 2050 and beyond, some experts felt there may be more pressure on lynx populations in this unit from continued increases in fire extent and severity. Other experts expressed a different opinion of the overall effect of fire in this unit, indicating that it may actually improve habitat over time, and that whether fires improve or degrade habitat depends on the frequency, intensity, size and spatial extent of future fires.

Experts discussed the possibility for increased precipitation and warmer temperatures in this unit because of climate change, and how this might affect lynx habitats. Boreal/subalpine forest may move up in elevation as described above; however, experts expected a shift in forest composition and diminished lynx habitat quality in future with climate change. It is unknown how much the distribution of dry ponderosa pine (non-habitat for lynx) will increase with climate change, but it is likely to happen at some level. One expert cautioned that some climate modelers estimated that vegetation will lag about 50 years behind the projected changes in temperature and precipitation. Snow levels in lower elevation areas are already decreasing in some areas, which could lead to smaller areas for lynx to use in winter in the future.

<u>Service Evaluation of Factors Potentially Influencing Future Conditions</u>

<u>Regulatory Mechanisms</u> - Federal, State, and Tribal regulations and land management direction could change in the future, but such changes and their potential impacts on lynx populations and habitats are difficult to predict. Because most (84 percent) of this geographic unit consists of Federal lands, the regulations and guidance that govern management of those lands have

the greatest potential to influence future lynx habitats and populations in this unit. When Forest Service, Park Service, and BLM management plans are revised or amended, they require opportunities for public participation in accordance with several statutes (e.g., the National Environmental Policy Act [NEPA], National Forest Management Act [NFMA], National Parks and Recreation Act, Federal Land Policy and Management Act [FLPMA]) (USFWS 2014 pp. 26-34, also see 3.1, above). If plan amendments or revisions may affect listed species, management agencies must consult with the Service in accordance with section 7 of the ESA. If in the future the lynx DPS is determined by the Service to be recovered and the protections of the ESA no longer necessary (i.e., if the DPS is removed from the *Federal Lists of Endangered and Threatened Wildlife and Plants*), the ESA requires the Service, in cooperation with the States, to monitor the DPS for a minimum of five years to assess its ability to sustain itself without the ESA's protective measures. If, within the designated monitoring period, threats to the DPS change or unforeseen events affect its stability, then the DPS may be relisted or the monitoring period extended. Given these requirements, we expect that future Federal management direction will continue to include regulations and guidance protective of lynx, although specific measures may change as new information becomes available.

We anticipate that future Federal management direction will include continued management of national parks, designated wilderness and roadless areas, and other areas with nondevelopmental land-use allocations to maintain natural ecological processes, which should maintain natural disturbance regimes and landscape-level habitat mosaics to which lynx are adapted (although continued climate warming [see below] may preclude maintenance of historical disturbance and landscape patterns). Regardless of the future listing status of the DPS, these lands will continue to be managed in accordance with the acts described above, as well as the National Park Service Organic Act and the Wilderness Act.

We also expect that Federal management into the future will include continued management of lands with developmental allocations to avoid or minimize potential impacts of vegetation management (timber harvest, thinning, salvage logging, other silvicultural prescriptions), wildland fire management (fire suppression, fuels reduction, prescribed fires), energy exploration and development, recreation, or other management activities with the potential to affect lynx. Current and likely future objectives include (1) managing vegetation to mimic or approximate natural disturbance and succession processes while maintaining habitat components necessary for lynx conservation; (2) providing a mosaic of habitat conditions through time that supports dense horizontal cover, high hare densities, and winter hare habitat in both young regenerating and mature multistoried forest stands; (3) using fire (natural and prescribed) to restore ecological process and maintain or improve lynx habitat, and (4) focusing vegetation management in areas with potential for improving winter hare habitat (BLM 2004a, pp. 2-3; USFS 2007, Attachment 1, p. 2). Although specific standards and guidelines may change as new scientific information and management techniques become available, we anticipate continued Federal management designed to conserve or restore the capacity of the areas that historically or recently supported resident lynx populations, including the Northwestern Montana/Northeastern Idaho Geographic Unit, to continue to do so in the future.

On non-Federal lands (about 16 percent of this unit), as described above (sections 3.1.1 and 4.2.3, Habitat Status), recent acquisitions and conservation easements on some of the private lands in this unit will also reduce the likelihood of future adverse impacts to important lynx habitats. Similarly, the MTDNRC HCP includes a 50-year commitment to manage most (64 percent) State lands in this unit to conserve lynx foraging, denning, and connectivity habitats. Additionally, the Confederated Salish and Kootenai Tribe's objective to manage wildlife and habitats on the Flathead Reservation for future generations (section 3.1.2, Tribal Management, above) suggests continued management to conserve lynx habitats on Tribal lands.

Given the commitments and management objectives and practices described above, implementation of current and future regulatory mechanisms will likely continue to support conservation and restoration of lynx habitats in this unit and improve the likelihood that it will continue to support resident lynx into the future.

If the DPS was not listed, it is possible that State-managed trapping could resume in this and perhaps other geographic units. We expect that would only occur if scientific evidence strongly suggested the presence of a harvestable surplus of lynx and that harvest quotas would be carefully managed to ensure that the viability of resident lynx populations would not be diminished or that potential recovery objectives were not otherwise compromised.

Climate Change - The recent evidence of climate change and the numerous mechanisms by which continued warming may affect future conditions for lynx and the potential consequences for the DPS and specific geographic areas are described in detail in section 3.2, above. Also, as noted above in section 4.2.3, evidence of warming and related impacts (increased temperatures, reduced snowpack, earlier snowmelt, and increased drought leading to increased fire) have already been documented in the Northern Rocky Mountains, including this geographic unit. Climate projections suggest these impacts are likely to continue and to result in future northward and upslope contractions in the snow conditions and boreal/ subalpine vegetation communities that support lynx. This is expected to cause loss and increased fragmentation and isolation of lynx and hare habitats and, therefore, declining and more vulnerable lynx populations in the DPS and in this geographic unit (Carroll 2007, entire; Gonzalez *et al.* 2007, entire; ILBT 2013, pp. 69-71; 79 FR 54810-54811; Lawler and Wilsey *in* Lynx SSA Team 2016, pp. 15-16; Siren *in* Lynx SSA Team 2016, p. 15).

Snow conditions in this unit are projected to become less favorable, with an overall decrease in snowpack after mid-century as a result of a shorter snowfall season, fewer days with snowfall, and a lower proportion of winter precipitation in the form of snow (more as rain; Siren *in* Lynx SSA Team 2016, p. 15). In this unit, the probability of suitable snow conditions is modeled to decline from 90-95 percent from 1961-1990 to 50 percent across much of the unit by the end of this century (years 2071-2100), although some parts of this unit are projected to retain adequate snow (Gonzalez *et al.* 2007, pp. 12-14; Lynx SSA Team 2016, pp. 15, 41). There will likely be a lag time between the loss of favorable snow conditions and an eventual shift/ contraction in vegetative communities (Lynx SSA Team 2016, pp. 43, 59; also see 3.2, above), but continued warming is projected to convert much of the boreal forest in this unit to temperate conifer forest by the end of the century (Gonzalez *et al.* 2007, pp. 15-17). The ability of lynx and hare populations to persist during this lag and to adjust to future habitat distributions is uncertain, but habitat quality, quantity, distribution, and connectivity are expected to decline, likely compromising this unit's continued ability to support resident lynx populations.

Climate change has also been linked to increased wildfire size, frequency, and intensity in this geographic unit, and to increased frequency and extent of forest insect outbreaks in other parts of the DPS. These factors are likely to have temporary impacts on future lynx habitat, with regeneration to hare and lynx foraging habitat 20-40 years post-disturbance, depending on local climate, elevation, and topography. However, if extensive areas are affected, the ability of these landscapes to continue supporting resident lynx may be compromised, and lynx populations may be unable to persist until favorable vegetation conditions return. This is especially true where habitats and populations are naturally fragmented and patchily-distributed, and where landscape-level hare densities are already marginal, which appears to be the case for much if not all of this geographic unit.

Climate change has also been implicated in observed declines in the amplitude of northern hare and lynx population cycles (Yan *et al.* 2013, p. 3269). If lynx populations in this geographic unit are influenced (as is suspected) by intermittent immigration from the north, and if climate change diminishes the likelihood of future immigration via muted northern lynx population cycles, the future persistence of resident lynx in this unit is uncertain (see also <u>Other Factors</u>, below).

Given the factors described above, recent and projected future climate warming will reduce this geographic unit's ability to continue to support resident lynx into the future. The timing and magnitude of climate-driven impacts are uncertain; however, all are anticipated to adversely affect, and none are expected to benefit, lynx populations in this geographic unit. Climate model uncertainties and resolution limits, combined with our imperfect understanding of historical and current lynx numbers and habitat distributions, preclude quantifying future habitat quality/ distribution or lynx population dynamics in this unit. Nonetheless, it appears likely that continued climate warming will reduce future habitat quality and quantity and, therefore, the likelihood that this geographic unit will support resident lynx in the future.

<u>Vegetation Management</u> - Future vegetation management and, therefore, its implications for future lynx habitats and populations in this unit, are closely linked to the current and future regulatory mechanisms described above. As noted, we expect future vegetation management on all Federal and most non-Federal lands in this unit to continue to focus on maintaining and restoring lynx habitats by implementing standards, guidelines, and BMPs based on the best available scientific information. We expect these measures to continue to benefit lynx by limiting detrimental effects of timber harvest, thinning, fuels management, etc., and encouraging the use of these activities to restore, improve, or create high quality hare and lynx foraging habitats where feasible.

Wildland Fire Management - As noted in sections 3.4 and 4.2.3, above, past wildfire management, including fire suppression, does not appear to have altered the historical fire regime in lynx habitats in the western contiguous U.S., including this geographic unit. Also as noted there and in sections 3.1.1 and the Regulatory Mechanisms section of this chapter, current Federal management restricts, with few exceptions, fire management (fuels reductions, prescribed fires, etc.) impacts to lynx habitats, and it promotes the use of such activities and wildfire response to conserve and restore lynx and hare habitats. We expect such conservation-focused fire management to continue and, therefore, to benefit lynx rather than to affect them detrimentally in the future.

However, as also noted in section 4.2.3, increased wildfire frequency, size, and intensity have been documented in this geographic unit, and that pattern is anticipated to continue in the future with continued climate warming. Although this increased wildfire activity does not appear to have diminished this unit's current ability to support resident lynx, it could do so in the future depending on the timing and extent of future fires. As described in section 3.4, increases in fire frequency and size could rapidly convert large areas to the temporarily unsuitable stand-initiation successional stage, thus reducing the amount and altering the distribution of higher-quality habitats and potentially compromising this unit's ability to support a resident lynx population until burned habitats recover. Because lynx habitats are naturally patchily-distributed and landscape-level hare densities already marginal in many parts of this unit, it is possible that very large wildfires or many over a short time period could tip some parts of this unit from just barely capable of supporting resident lynx to incapable of doing so in the future. Although fire suppression was considered a potential risk factor for lynx in the DPS range, given the trends discussed above and the likely continued increase in future fire activity resulting from continued climate warming and drying, it may be necessary to reconsider whether fire suppression in some lynx habitats could benefit lynx by reducing the potential for extirpation of resident populations, especially in places already apparently only marginally capable of supporting them.

Habitat Loss/Fragmentation - As described above in section 4.2.3, lynx habitats in this unit are naturally fragmented but otherwise appear to be largely intact relative to historical conditions in most of this geographic unit. Although some localized impacts of past timber harvest and related activities have likely occurred, anthropogenic habitat loss or fragmentation does not appear to have broadly diminished this unit's ability to support resident lynx. Current and probable future management for conservation of lynx habitats suggests that broad-scale habitat loss or fragmentation resulting from timber harvest and other development activities are unlikely. The most likely sources of future habitat loss and fragmentation in this unit are the climate-mediated influences discussed above: increased wildfire activity and the projected contraction in vegetation and snow conditions favorable for lynx. Increased frequency, size, and severity of forest insect outbreaks, also driven by climate warming, has been documented in other geographic units and could occur in this unit in the future, too, resulting in temporary habitat loss and increased (though also temporary) fragmentation.

Additional highway construction and other transportation developments are likely in this unit, but the future locations, size, and potential impacts of such projects are difficult to predict. We are not currently aware of plans for specific major highway/road projects in this unit that would potentially impact lynx habitats and increase future habitat loss or fragmentation. Other potential sources of future habitat loss and fragmentation include recreation, minerals/energy development, and forest/ backcountry roads and trails; these are all considered second tier anthropogenic influences (ILBT 2013, pp. 78-85) that are unlikely to exert population-level influences, despite potential impacts to individual lynx.

<u>Other Factors</u>: *Connectivity/immigration* – As described above and in section 4.2.3, maintaining connectivity between this geographic unit and lynx populations in Canada is thought to be important, although it is uncertain if or to what degree immigration of lynx from Canada is essential to the persistence of lynx in this unit. A number of climate-mediated factors have been suggested as contributing to changes in the periodicity and amplitude of northern lynx and hare population cycles (see section 3.2, above), which could alter the timing and magnitude of irruptions of lynx from Canada into the contiguous U.S. If lynx populations in this unit rely on immigration from Canada which is no longer occurring or has been substantially reduced relative to historical conditions, population declines and a reduced probability of persistence among resident populations would be expected.

Although the extent to which this factor may influence lynx populations in this unit is unknown, the population growth rate estimated for the Seeley Lake area (λ = 0.92, declining trend 1999-2007; Squires *in* Lynx SSA Team 2016, p. 20) may reflect a gradual decline of a resident lynx population that needs but is not receiving adequate immigration. If this growth rate was applied continuously to a hypothetical resident population of 250 lynx (the midpoint of the range in the number of resident lynx this geographic may support based on expert opinion [Lynx SSA Team 2016, p. 41]), the population would decline to 100 lynx after 11 years, about 50 lynx after 20 years, and roughly 20 individuals after 30 years. Vulnerability to demographic, environmental, and genetic stochasticity would increase as lynx numbers decreased, resulting eventually in an increased likelihood of functional extirpation of lynx from this unit (i.e., a lower probability that the unit would continue to support a persistent resident lynx population). However, as noted above, the lynx population in the Purcell Mountains in the northwestern part of this unit was estimated to be increasing (λ = 1.16, 2003-2007; Squires *in* Lynx SSA Team 2016, p. 20) over the last four years of the period for which the Seeley Lake population was estimated to be declining. In the absence of information on historic, recent, and likely future rates of immigration and its contribution to the persistence of lynx populations in this geographic unit, impacts of potentially reduced future immigration are difficult to project and are largely speculative at this time.

<u>Conclusion</u>

After reviewing the scientific literature and evaluating the factors that may influence lynx persistence in this unit, we concur with the experts' conclusion that this geographic unit is likely the most secure in the DPS. We conclude that it is very likely to continue to support resident lynx in the short term (through 2025) and through mid-century, although the number of lynx, the amount and distribution of high-quality habitat, and landscape-level hare densities are all likely to decline by mid-century as a result of continued climate warming and associated impacts. We also agree that this unit is more likely than not to support some resident lynx at the end of this century, although at that time we expect lynx numbers and distribution would be substantially reduced from the current condition and would, therefore, be more vulnerable to demographic, environmental, and genetic stochasticity and to catastrophic events, resulting in diminished resiliency. We acknowledge that under a *status quo* or increasing greenhouse gas emissions scenario the rate of climate-mediated loss, fragmentation, and isolation of habitat could, perhaps in concert with other factors (e.g., decrease in or complete loss of immigration from Canada), result in the functional extirpation of resident lynx from this unit before the end of the century.

5.2.4 Unit 4 - North-central Washington

Expert Projections of Lynx Persistence

Compared to the previous units, most expert graphs showed a lower probability of persistence for this unit over the short term, and then lower probability of persistence along with increasing uncertainty by 2100, reflecting a more pessimistic outcome for this unit compared to previous units (Figure 11). Experts predicted near-term (year 2025) persistence probabilities of 60% to 90% (median = 80%), and mid-century persistence at 30% to 80% (median = 70%). All experts predicted end-of-century persistence probabilities less than 50%, with a median of 38%, by 2100 (Figure 11). However, one expert predicted an increase in persistence probability by mid-century as habitats impacted by recent large-scale fires regenerate into optimal hare-lynx habitat.

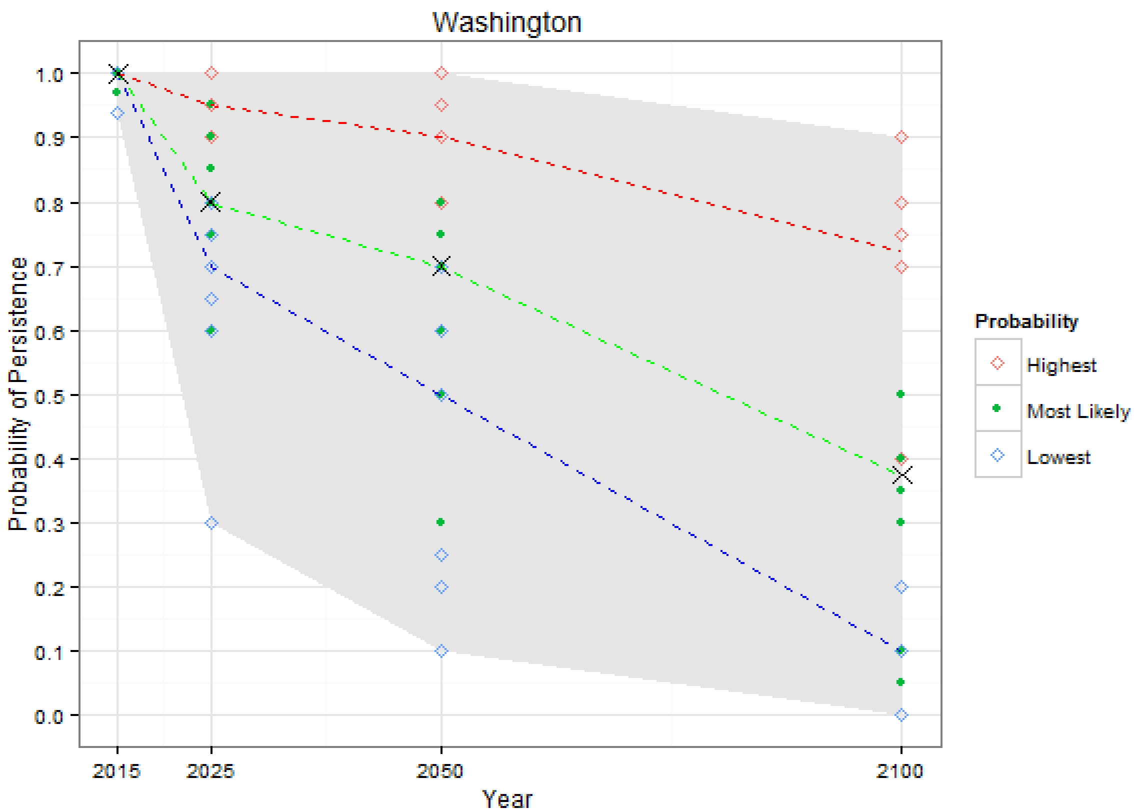


Figure 11. Lynx expert estimates of the probability that the North-central Washington Geographic Unit will continue to support resident lynx in the future (at years 2025, 2050, and 2100).

The probability of lynx persistence in this unit could decrease sharply over the next 10-20 years because of extensive recent fires in lynx habitats and the time needed for these areas to regenerate back to good hare/lynx habitat. After that, the probability could rebound (or decline more slowly) over the longer term as these large areas return to prime habitat providing high hare densities. The current small population is likely at greater risk of extirpation because of stochastic events, particularly if large fires in lynx habitat continue to occur in the near future as they have in the recent past. A small population also could be more susceptible to disease, though none has been documented among lynx in this unit. Experts discussed the extent to which small lynx populations could be reduced before they would become highly susceptible to stochastic demographic effects. It was suggested that 15-20 breeding individuals might be the minimum needed to avoid such susceptibility. Unimpeded connectivity between Canada and the Okanogan area of this unit could allow lynx to repopulate currently-unsuitable areas after the habitat recovers. Lynx in this unit are likely the southern portion of a larger population in Canada, not really a separate, isolated small population. Factors that influenced expert persistence probabilities for this unit included fire, habitat loss, and the future loss of favorable snow conditions predicted by climate change models.

Service Evaluation of Factors Potentially Influencing Future Conditions

Regulatory Mechanisms - As stated previously, it appears that, currently, adequate protective regulatory mechanisms are in place in this geographic unit. Looking to the future, relative to the regulatory risks to lynx, we do not anticipate the existing regulatory protections for lynx to diminish. We anticipate that either the CA will remain in place (and/or be extended), or the OWNF and CNF will revise or amend their respective LRMPS incorporating direction for lynx management similar to what has occurred with other 18 National Forests in Idaho, Montana, Utah, and Wyoming. These 18 National Forests amended their respective LRMPs with lynx management direction known as the Northern Rockies Lynx Amendment (NRLA) in 2007. The NRLA incorporated management recommendations from the LCAS, with modifications based on the advent of new information pertaining to the management of lynx. Currently, both the OWNF and CNF are in the process of amending or revising their LRMPs. We expect that management direction for lynx addressing vegetation management, wildland fire management, and habitat fragmentation on national forest system lands will be incorporated into the revised or amended LRMP. Also, as discussed previously, the WADNR has developed and is implementing its 2006 Lynx Plan. The WADNR commits to implementing the 2006 Lynx Plan until lynx are delisted or until 2076, whichever is shorter (WADNR 2006, p. 6). Thus, it appears the regulatory future of lynx management, and thus, lynx habitat management, is largely secure on both Federal and State managed lands within Washington State.

Further, should lynx be delisted, the management for and status of lynx in this geographic unit should be largely secure (insofar as we can affect their status [i.e., notwithstanding effects of climate change)] as greater than 90 percent of lynx habitat in this unit consists of Federal ownership on the OWNF and CNF. We expect that both the OWNF and CNF will be required to manage for lynx and their habitat into the future because both forests will have incorporated lynx management direction into their respective LRMPs. We acknowledge that LRMPs can be amended or revised. However, LRMPS are typically in place for 15 years or longer, and the Service, other Federal and State agencies, and the public would have opportunities to comment on any proposed amendments or revisions to the OWNF and/or CNF LRMPs through the National Environmental Policy Act process. Therefore, we expect that both the OWNF and CNF will continue managing for lynx and their habitat into the future regardless of their listing status.

Climate Warming - The one risk factor identified by the LCAS which the Forest Service, or the WADNR for that matter, has little ability to control or influence is climate change. Climate change was identified by the panel of lynx experts convened during development of the Canada Lynx Expert Elicitation Workshop Report to potentially represent the greatest threat to the long-term persistence of lynx (Lynx SSA Team 2016, p. 56). Our review of the published literature on this subject leads the Core Team to conclude that climate change does indeed pose the greatest risk to the long-term persistence of lynx, including within this geographic unit.

Potentially further exacerbating the recent losses of lynx habitat from fires is climate change. Climate change may affect fire return intervals and severity as well as the quality and depth of snow within lynx habitat. Westerling *et al.* (2006, pp. 942-943) compiled information on large wildfires in the western U.S. from 1970-2004 and found that large wildfire activity has increased significantly from the mid-1980s with large-wildfire frequency, longer wildfire duration, and longer wildfire seasons. The greatest increases occurred in high elevation forest types including lodgepole pine and spruce fir in the northern Rockies (i.e., lynx habitat). They also found that fire exclusion had little impact on natural fire regimes. Rather, climate appeared to be the primary driver of increasing wildfire risk. As stated previously, Koehler's (1990, p. 847) estimated adult lynx density of 2.3 lynx/100 km^2 was obtained in an area supporting high quality lynx habitat in the Meadows area of north central Washington (at least relative to other lynx habitat in Washington). Much of the lynx habitat in the Meadows was impacted by the recent large, stand replacing fires in the Cascades, resulting in further fragmentation of lynx habitat in the northern Cascades. Thus, the lynx densities Koehler observed in his study area may not be currently supported, because as habitat becomes more fragmented and isolated (i.e., marginal), the carrying capacity for a particular species declines.

Additionally, relative to the persistence of Washington's lynx population, during the lynx expert elicitation workshop several of the lynx experts expressed concern that should more wildfires occur within the next 10 years and result in losses of lynx habitat similar to the impacts caused by the recent wildfires, such wildfires could result in the functional extirpation of lynx in Washington. The experts expressed heightened concern of functional extirpation of lynx in this geographic unit from wildfires because of its small size and current lynx population (Lynx Workshop Report 2016, p. 27). However, the experts felt the potential extirpation of lynx, should it occur from a large catastrophic wildfire(s) (or other mechanisms such as insect outbreaks), may be ameliorated to some extent because of Washington's juxtaposition and connectivity to Canadian lynx populations. The experts felt that lynx immigration from Canada may rapidly recolonize Washington as the habitat recovers from fires or other impacts (Lynx Workshop Report 2016, p. 43). Climate change, in addition to potentially affecting fire return intervals, fire severity (intensity, size), and insect outbreaks, is likely to affect the amount of precipitation falling as snow at elevations typically supporting lynx habitat in this geographic unit.

Lynx survive in areas with cold, snowy winters providing deep, fluffy snow (78 FR 59443) that gives lynx competitive advantages over other competitors and predators of lynx, as well as providing the conditions supporting the lynx's main prey, the snowshoe hare, which can comprise as much as 97 percent of their winter diet (Koehler and Aubry 1994, p. 75). Snowshoe hares are limited to environments with snowy climates (Ruggiero *et al.* 2000b, p. 448).

Climate change may impact the quantity, quality, and temporality of snow in the Cascades. Mote (2003b, pp. 272, 274), who evaluated temperature trends in the Pacific Northwest using data collected by weather stations from 1930 to 1995, determined that the temperature increased in the Pacific Northwest, and more precipitation fell in the spring and summer months, especially at elevations below 1,800 m (5,900 ft). Additionally, Mote (2003a, pp. 2-3) determined that an increasing temperature and precipitation trend from 1950 to 2000 is correlated with a 40 percent decrease in the snow water equivalent in the Cascades. Mote *et al.* (2005, p.45) determined that the Cascades are very sensitive to temperature changes, with large increases in temperature potentially resulting in significant declines in snowpack. Corroborating Mote's speculation, Stoelinga *et al.* (2010, p. 2474) determined that the Cascade snowpack has declined by up to 40 percent in the latter half of the twentieth century, which resulted from increased temperatures. Furthermore, predicted continued increasing temperature changes of 2° C to 5° C over the next century are expected to cause further and accelerated losses in snowpack in the Cascades (Mote *et al.* 2005, p. 48). Continued declines of snowpack in the Cascades through 2025 are predicted to range from 9 percent (Stoelinga *et al.* 2010, p. 2486) to 29 percent (Elsner *et al.* 2010 *cited in* Stoelinga *et al.* 2010, p. 2486), which may also affect lynx densities supported in the Cascades. Finally, some of the best lynx habitat in this geographic unit occurs on plateaus that may be more vulnerable to impacts of climate change because of the absence of higher elevation areas to which habitats and lynx could migrate in response to climate warming (Lynx Workshop Report 2016, p. 42). Thus, in addition to the recent losses of lynx habitat to large wildfires, coupled with increasing wildfire risk, the potential for the Cascades to support a viable lynx population may be further reduced because of projected climate-mediated decreases in snow quantity and quality.

Similar to the potential effects of wildfires on the persistence of the lynx population in this geographic unit, the lynx experts identified climate change relating to loss of favorable snow conditions as a significant factor potentially affecting the long-term persistence of this population (Lynx Workshop Report 2016, pp. 43-44). Taking all factors into consideration (i.e., catastrophic wildfire, insect outbreaks, loss of snow), the experts felt the probability of this population persisting to the year 2050 most likely ranged between approximately 60 percent to 80 percent, declining by the year 2100 to approximately 30 percent to 50 percent (Lynx SSA Team 2016, p. 43). The Core Team generally agrees with this prognosis.

<u>Conclusion</u>

After considering the best available scientific information and the opinions of lynx experts summarized above, the Core Team is generally in agreement with the experts regarding the probability of long-term persistence of Canada lynx in this geographic unit. As described above, the potential effects of climate change upon the quantity and quality of snow, as well as the northward and upslope movement of spruce-fir and subalpine fir forests are likely to result in further fragmentation and reduction of lynx habitat within this geographic unit by the end of the century. More fragmented and smaller habitat patches are likely to support fewer lynx as well within this geographic unit. A smaller and more isolated lynx population within this unit is likely to increase the population's vulnerability to stochastic environmental and demographic events. Recent wildfires have reduced lynx habitat within this geographic unit to approximately 1,600 km^2 (618 mi^2). Additional losses of lynx habitat resulting from wildfires (increasing risk of wildfires is related to climate change) may pose the greatest near-term threat to the persistence of this population. The Service's Recovery Outline (USFWS 2005, p. 5) suggests that landscapes of at least 1,250 km^2 (483 mi^2) are the minimum landscape size thought necessary to support a minimum population of at least 25 lynx. However, also as noted above, the lynx population in this geographic unit is connected to lynx populations in Canada. Currently, the connectivity of this population between the United States and Canada appears intact. Given that lynx are highly mobile and able to traverse large areas of non-lynx habitat, we do not anticipate that climate change, in and of itself, will significantly affect the connectivity of the lynx population within this geographic unit to the lynx population in Canada. In fact, it is likely that the lynx population in this geographic unit in the Cascades is an extension of the lynx population in Canada. This connectivity may contribute to maintaining a persistent, albeit smaller, lynx breeding population in this geographic unit.

5.2.5 Unit 5 - Greater Yellowstone Area

Expert Projections of Lynx Persistence

The expert graphs for this unit were widely variable and had different outcomes and high uncertainty at all time frames. Experts predicted near-term (year 2025) persistence probabilities of 10% to 70% (median = 52%), and mid-century persistence at 15% to 60% (median = 35%). All experts predicted end-of-century persistence probabilities less than 50% for this unit, with a median of 15%, by 2100 (Figure 12). This was the only unit for which most experts believed the present probability of persistence is low (i.e., that it is uncertain whether this area currently supports a resident lynx population). Some experts increased probability of persistence into mid-century as the 1980s-era fires regenerate into hare/lynx habitat, and with the possibility of continued immigration of lynx from Colorado. Other experts project a 10% to 20% probability of persistence by 2100. One reason given for wide variability in responses is because of the uncertainty whether a population currently exists. There were wide confidence intervals around the probabilities for all time periods for this area.

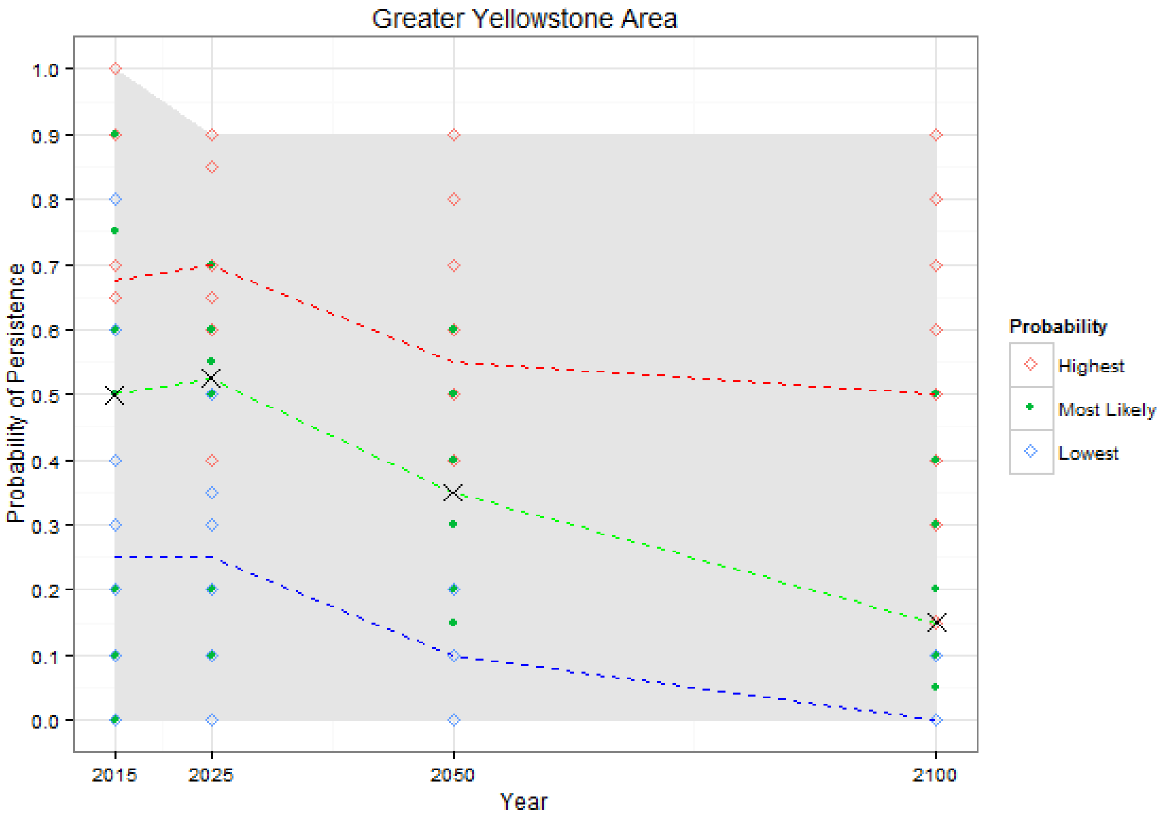


Figure 12. Lynx expert estimates of the probability that the Greater Yellowstone Area Geographic Unit will continue to support resident lynx in the future (at years 2025, 2050, and 2100).

Current and future factors expressed by experts as influencing probability of persistence for this unit included small population size, forest disease and insect pests, and fire. Some experts doubt that the GYA unit currently supports a resident breeding population of lynx. Experts indicated that climate models predict that some parts of the GYA unit could provide refuge from climate change impacts because of their high elevations and potential to maintain winter snow levels into the future. Summer conditions in this unit, however, could be drier in the future, resulting in increased fire frequency, extent and intensity, and additional temporary habitat loss. However, regeneration of these areas and the extensive areas that have burned in the recent past may provide good habitat over the next several decades. Lynx immigrating to this unit from Colorado could occupy such improved habitats in the near future. Colorado lynx have made exploratory movements into the GYA in summer months, and analysis of available data could improve our understanding of Colorado lynx movement into and use of the GYA. It is possible that lynx from Colorado are maintaining or could maintain lynx in GYA.

<u>Service Evaluation of Factors Potentially Influencing Future Conditions</u>

Regulatory Mechanisms - As noted above in section 5.2.3, Federal, State, and Tribal regulations and land management direction could change in the future, but such changes and their potential impacts on lynx populations and habitats are difficult to predict. Federal lands account for over 97 percent of this geographic unit; therefore, regulations and guidance that govern management of those lands have the greatest potential to influence future lynx habitats and populations. Also as described above, revisions or amendments to Federal management plans require opportunities for public participation in accordance with NEPA, NFMA, National Parks and Recreation Act, and FLPMA (USFWS 2014 pp. 26-34; also see 3.1, above) and consultation with the Service in accordance with section 7 of the ESA. If the DPS were to be recovered and delisted in the future, the ESA requires a minimum of five years of monitoring to assess its ability to sustain itself without the ESA's protective measures. If, during that time, threats to the DPS change or unforeseen events affect its stability, then the DPS may be relisted or the monitoring period extended. Given these requirements, we expect that future Federal management direction will continue to include regulations and guidance protective of lynx, although specific measures may change as new information becomes available.

We anticipate that future Federal management direction will include continued management of national parks, designated wilderness and roadless areas, and other areas with nondevelopmental land-use allocations to maintain natural ecological processes, which should maintain natural disturbance regimes and landscape-level habitat mosaics to which lynx are adapted (although continued climate warming [see below] may preclude maintenance of historical disturbance and landscape patterns). Regardless of the future listing status of the DPS, these lands will continue to be managed in accordance with the acts described above, as well as the National Park Service Organic Act and the Wilderness Act.

We also expect that Federal management into the future will include continued management of lands with developmental allocations to avoid or minimize potential impacts of vegetation management (timber harvest, thinning, salvage logging, other silvicultural prescriptions), wildland fire management (fire suppression, fuels reduction, prescribed fires), energy exploration and development, recreation, or other management activities with the potential to affect lynx. Current and likely future objectives include (1) managing vegetation to mimic or approximate natural disturbance and succession processes while maintaining habitat components necessary for lynx conservation; (2) providing a mosaic of habitat conditions through time that supports dense horizontal cover, high hare densities, and winter hare habitat in both young regenerating and mature multistoried forest stands; (3) using fire (natural and prescribed) to restore ecological process and maintain or improve lynx habitat, and (4) focusing vegetation management in areas with potential for improving winter hare habitat (USFS 2007, Attachment 1, p. 2; BLM 2008, pp. A18-10 - A18-15; BLM 2010, pp. A-9 - A-12). Although specific standards and guidelines may change as new scientific information and management techniques become available, we anticipate continued Federal management designed to conserve or restore potential lynx habitats in this geographic unit in the future.

Given the commitments and management objectives and practices described above, implementation of current and future regulatory mechanisms will likely continue to support conservation and restoration of lynx habitats in this unit and improve the likelihood that it will support resident lynx into the future. Because non-Federal lands make up such a small proportion of this geographic unit, we believe it is unlikely that regulatory mechanisms on those lands will influence this unit's future ability to support resident lynx.

If the DPS was not listed, State-managed trapping could resume in this geographic unit. We expect that would occur only if scientific evidence strongly suggested the presence of a harvestable surplus of lynx and that harvest quotas would be carefully managed to ensure that the viability of resident lynx populations would not be diminished or that potential recovery objectives were not otherwise compromised.

Climate Change - The recent evidence of climate change and the numerous mechanisms by which continued warming may affect future conditions for lynx and the potential consequences for the DPS and specific geographic areas are described in detail in section 3.2, above. Also, as noted above in section 4.2.5, evidence of warming and related impacts (increased temperatures, reduced snowpack, earlier snowmelt, and increased drought leading to increased fire) have already been documented in the Northern Rocky Mountains, including this geographic unit. Climate projections suggest these impacts are likely to continue and to result in future northward and upslope contractions in the snow conditions and boreal/ subalpine vegetation communities that support lynx. This is expected to cause loss and increased fragmentation and isolation of lynx and hare habitats and, therefore, declining and more vulnerable lynx populations in the DPS and in this geographic unit (Carroll 2007, entire; Gonzalez *et al.* 2007, entire; ILBT 2013, pp. 69-71; 79 FR 54810-54811; Lawler and Wilsey *in* Lynx SSA Team 2016, pp. 15-16; Siren *in* Lynx SSA Team 2016, p. 15).

Snow conditions in this unit are projected to become less favorable, with an overall decrease in snowpack after mid-century as a result of a shorter snowfall season, fewer days with snowfall, and a lower proportion of winter precipitation in the form of snow (more as rain; Siren *in* Lynx SSA Team 2016, p. 15). In this unit, the probability of suitable snow conditions is modeled to decline from 90-95 percent from 1961-1990 to 50 percent across much of the unit by the end of this century (years 2071-2100), though some parts of this unit are projected to retain adequate snow (Gonzalez *et al.* 2007, pp. 12-14; Lynx SSA Team 2016, pp. 15, 46). There will likely be a lag time between the loss of favorable snow conditions and an eventual shift/ contraction in vegetative communities (Lynx SSA Team 2016, pp. 43, 59; also see 3.2, above), but continued warming is projected to convert much of the boreal forest in this unit to temperate conifer forest by the end of the century (Gonzalez *et al.* 2007, pp. 15-17). The ability of lynx and hare populations to persist during this lag and to adjust to future habitat distributions is uncertain, but habitat quality, quantity, distribution, and connectivity are expected to decline, likely further compromising this unit's ability to support resident lynx populations, which is already questionable.

Climate change has also been linked to increased wildfire size, frequency, and intensity in this geographic unit, including the extensive fires in Yellowstone National Park in 1988, which burned over one-third of the park. Climate warming has also been linked to increased frequency and extent of forest insect outbreaks in other parts of the DPS. These factors are likely to have temporary impacts on lynx habitat, with regeneration to hare and lynx foraging habitat 20-40 years post-disturbance, depending on local climate, elevation, and topography. However, if extensive areas are affected, the ability of landscapes in the GYA to support resident lynx may be further compromised, and resident lynx may be unable to persist until favorable vegetation conditions return. This is especially true where potential habitats are naturally fragmented and patchily-distributed, and where landscape-level hare densities are already marginal, which appears to be the case for much of this geographic unit.

Climate change has also been implicated in observed declines in the amplitude of northern hare and lynx population cycles (Yan *et al.* 2013, p. 3269). If lynx populations in this geographic unit are influenced by intermittent immigration from the north, and if climate change diminishes the likelihood of future immigration via muted northern lynx population cycles, the future persistence of resident lynx in this unit is uncertain (see also Other Factors, below).

Given the factors described above, recent and projected future climate warming will further reduce this geographic unit's ability to support resident lynx into the future. The timing and magnitude of climate-driven impacts are uncertain; however, all are anticipated to adversely affect, and none are expected to benefit, lynx and habitats in this geographic unit. Climate model uncertainties and resolution limits, combined with our imperfect understanding of historical and current lynx numbers and habitat distributions, preclude quantifying future habitat quality/ distribution or lynx population dynamics in this unit. Nonetheless, it appears likely that continued climate warming will further reduce habitat quality and quantity and, therefore, the likelihood that this geographic unit will support resident lynx in the future.

Vegetation Management - Future vegetation management and, therefore, its implications for future lynx habitats and populations in this unit, are closely linked to the current and future regulatory mechanisms described above. As noted, we expect future vegetation management on all Federal lands in this unit to continue to focus on maintaining and restoring lynx habitats by implementing standards, guidelines, and BMPs based on the best available scientific information. We expect these measures to continue to benefit lynx by limiting detrimental effects of timber harvest, thinning, fuels management, etc., and encouraging the use of these activities to restore, improve, or create high quality hare and lynx foraging habitats where feasible.

Wildland Fire Management - As noted in sections 3.4 and 4.2.5, above, past wildfire management, including fire suppression, does not appear to have altered the historical fire regime in lynx habitats in the western contiguous U.S., including this geographic unit. Also as noted there and in sections 3.1.1 and the Regulatory Mechanisms section of this chapter, current Federal management restricts, with few exceptions, fire management (fuels reductions, prescribed fires, etc.) impacts to lynx habitats, and it promotes the use of such activities and wildfire response to conserve and restore lynx and hare habitats. We expect such conservation-focused fire management to continue and, therefore, to benefit lynx rather than to affect them detrimentally in the future.

However, as also noted in section 4.2.5, increased wildfire frequency, size, and intensity have been documented in this geographic unit, and that pattern is anticipated to continue in the future with continued climate warming. Although the extent to which increased wildfire activity has impacted this unit's current ability to support resident lynx is uncertain, such impacts may become more likely in the future depending on the timing and extent of future fires. As described in section 3.4, increases in fire frequency and size could rapidly convert large areas to the temporarily unsuitable stand- initiation successional stage, thus reducing the amount and altering the distribution of higher-quality habitats and potentially compromising this unit's ability to support resident lynx until burned habitats recover. Because lynx habitats are naturally patchily-distributed and landscape-level hare densities already marginal in many parts of this unit, it is possible that very large wildfires or many over a short time period could tip some parts of this unit from just barely capable of supporting resident lynx to incapable of doing so in the future. Although fire suppression was considered a potential risk factor for lynx in the DPS range, given the trends discussed above and the likely continued increase in future fire activity resulting from continued climate warming and drying, it may be necessary to reconsider whether fire suppression in some lynx habitats could benefit lynx by reducing the potential for extirpation of resident populations, especially in places already apparently only marginally capable of supporting them.

<u>Habitat Loss/Fragmentation</u> - As described above in section 4.2.5, lynx habitats in this unit are naturally fragmented but otherwise appear to be largely intact relative to historical conditions in most of this geographic unit. Although some localized impacts of past timber harvest and related activities have likely occurred, anthropogenic habitat loss or fragmentation does not appear to have broadly diminished this unit's ability to support resident lynx. Current and probable future management for conservation of lynx habitats suggests that broad-scale habitat loss or fragmentation from timber harvest and other development activities are unlikely. The most likely sources of future habitat loss and fragmentation in this unit are the climate-mediated influences discussed above: increased wildfire activity and the projected contraction in vegetation and snow conditions favorable for lynx. Increased frequency, size, and severity of forest insect outbreaks, also driven by climate warming, has been documented in other geographic units and could occur in this unit in the future, too, resulting in temporary habitat loss and increased (though also temporary) fragmentation.

Additional highway construction and other transportation developments are likely in this unit, but the future locations, size, and potential impacts of such projects are difficult to predict. We are not currently aware of plans for specific major highway/road projects in this unit that would potentially impact lynx habitats and increase future habitat loss or fragmentation. Other potential sources of future habitat loss and fragmentation include recreation, minerals/energy development, and forest/ backcountry roads and trails; these are all considered second tier anthropogenic influences (ILBT 2013, pp. 78-85) that are unlikely to exert population-level influences, despite potential impacts to individual lynx.

<u>Other Factors</u>: *Connectivity/immigration* – This geographic unit is not directly connected to lynx populations in Canada or elsewhere in the DPS range, although lynx released into Colorado

have dispersed northward into and through this unit. There is little evidence of intermittent immigration into this unit during past irruptions of lynx from Canada, as has been documented in other parts of the contiguous U.S. Nonetheless, as elsewhere in the DPS, immigration may influence the persistence of resident lynx in this unit. If continued climate warming or other factors further reduce the chances that dispersing lynx will reach this unit and contribute to its demographic and genetic health, either through habitat loss and fragmentation in potential dispersal corridors or declines in the amplitude of northern hare and lynx population cycles, the likelihood that the unit will support resident lynx in the future may also decline. However, as in Unit 3 above, because we lack information of historic, recent, and likely future rates of immigration and its contribution to the persistence of lynx populations in this geographic unit, impacts of potentially reduced future immigration are difficult to project and are largely speculative at this time.

Conclusion

After reviewing the scientific literature and evaluating the factors that may influence lynx persistence in this unit, we concur with the experts' conclusion that this geographic unit is the least secure in the DPS. We find that conditions for lynx in this unit are naturally marginal, its historical or current ability to support a persistent resident lynx population are questionable, and that continued climate warming and associated impacts are likely to further diminish its already limited ability to support resident lynx. We conclude that it may continue to occasionally/ intermittently support a small number of resident lynx and some reproduction over the short term (through 2025), but that it is very unlikely to support a persistent resident population over that time frame, even less likely that it will do so at mid-century, and highly improbable that this geographic unit will support resident lynx by the end-of-century.

5.2.6 Unit 6 - Western Colorado

Expert Projections of Lynx Persistence

The experts we consulted suggested an initially high probability of persistence in Colorado, declining gradually with increasing uncertainty through the end of the century. Experts predicted near-term (year 2025) persistence probabilities of 60 percent to 100 percent (median = 90 percent), and mid-century persistence at 50 percent to 85 percent (median = 80 percent). Experts predicted end-of-century persistence probabilities of 20 percent to 70 percent for this unit, with a median of 50 percent, by 2100 (Figure 13).

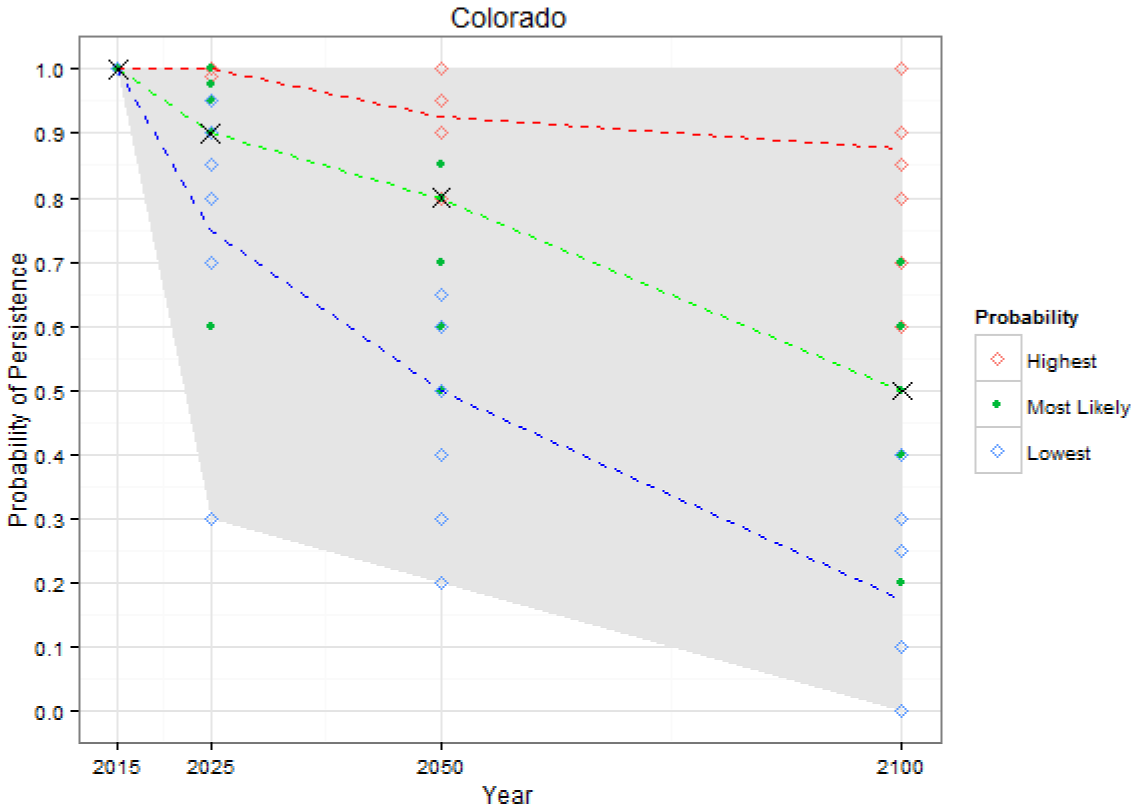


Figure 13. Expected probability of persistence for the Western Colorado Geographic Unit at present, 2015, and in 2025, 2050 and 2100.

Some experts indicated that beetle kill and fire could potentially create poor habitat conditions in large areas of this unit by mid-century, but that regeneration after these impacts could result in good lynx/hare habitats. Others expressed uncertainty about whether fire and insect impacts would be temporary or permanent, especially considering climate change and the potential for conversion from boreal/subalpine forests to other forest types. Although 8 of 10 experts graphed 50 percent to 70 percent probability of persistence by 2100, during subsequent discussions, several expressed greater uncertainty about whether resident lynx will persist in the unit at the end of the century. Higher-quality lynx habitat occurs primarily in two areas and is patchily-distributed. Lynx in this unit may occur as several smaller, relatively isolated subpopulations, which are likely more vulnerable to stochastic events. This unit's relative isolation may limit exchange with other lynx populations, increasing the likelihood of genetic drift and reducing the chance of demographic rescue or recolonization if lynx in the unit become extirpated. There was discussion about whether ski areas may affect daily movements of lynx, and hares may be declining in ski areas. Ski areas tend to expand and may, therefore, have larger impacts on lynx in the future. There is some evidence of lynx using ski areas in summer months but avoiding them during the ski season. It is uncertain whether ski areas may affect genetic connectivity within the Western Colorado geographic unit. Two-thirds to three-quarters of the lynx in this unit are in the southern portion of the range in the San Juan Mountains. There is a large area

(Weminuche Wilderness) in Colorado that has not been well surveyed for lynx, so it is possible that lynx also could be using that area.

Service Evaluation of Factors Potentially Influencing Future Conditions

Regulatory Mechanisms - Regulatory mechanisms for the conservation of lynx in the Southern Rockies consist of seven amended USFS management plans in south-central Wyoming and Colorado. We concluded that the Southern Rockies Lynx Amendment substantively reduced the inadequate regulatory mechanisms by addressing the major adverse impacts of Forest Service land management on lynx (USFWS 2008b, p. 70-71). Lynx habitat on all other ownerships makes up the remaining 15 percent of lynx habitat in Colorado, of which, only five percent is in Federal ownership. Other ownerships include state, county, municipal, etc., and private lands. Some BLM resource management plans have not been amended to include conservation specifically for lynx. Lynx habitat on BLM ownership mostly consists of narrow forest extensions connected to larger blocks of habitat on adjacent USFS lands. Generally these extensions are insufficient on their own to support a lynx home range. However, the Gunnison Field Office is the only BLM unit that contains sufficient habitat to map and identify LAUs.

The State of Colorado manages lynx as a State endangered species C.R.S. 33-2-105, prohibiting take of the species with exceptions for protection of human life (C.R.S. 33-6-205 and incidentally during depredation management (not caused by lynx) [C.R.S. 33-6-207].

Climate Change - ILBT (2013, p. 61) – "Climate change generally is expected to result in warmer winters, earlier spring snowmelt, and a reduction in the extent of snow cover in the Southern Rockies. McKelvey *et al.* (2011, entire) used a variety of climate models to predict snow depth and the persistence of spring snow across the western United States. The models predicted an overall decline in persistent snow of 40 percent, but large areas of persistent snow would continue to be retained late in the 21st century, including the high elevations of Colorado."

"All of the climate models under all representative concentration pathways (RCPs) project that Colorado's climate will warm substantially by 2050. Under RCP 4.5 (medium-low emissions scenario), Colorado's annual temperatures are projected to warm by +2.5°F to +5°F by mid-century relative to 1971–2000 observed baseline. Under RCP 8.5 (high emissions scenario), Colorado's annual temperatures are projected to warm by +3.5°F to +6.5°F by mid-century. Summers are projected to warm slightly more than winters under both RCPs. Looking beyond the 2050-centered analysis period, the warming trend is projected to continue into the late-21st century under all RCPs except RCP 2.6. By the period centered on 2070 (2055–2084), the projected warming in Colorado annual temperatures under RCP 4.5 is +2.5°F to +6.5°F relative to the 1971–2000 baseline. Under RCP 8.5, the projected warming is +5.5°F to +9.5°F relative to the 1971–2000 baseline." [Lukas *et al.* 2014, p. 61]

An analysis of projected 21st century temperature trends as a function of elevation in the Northern Hemisphere mid-latitudes from CMIP5 models shows more warming at higher elevations during winter, particularly in the daily minimum temperature (Rangwala *et al.* 2013 [cited in Lukas *et al.* 2014, p. 63]). “However, as discussed in Section 3, the global climate models do not represent the topography of Colorado very well, so it is difficult to discern whether the warming projected for the higher elevation regions (>10,000’) in the state is substantially different from that projected for lower elevations” (Lukas *et al.* 2014, p. 63).

On average, the climate models indicate a seasonal shift in precipitation for Colorado, with increasing winter precipitation, and in some areas a decrease in late spring precipitation (Lukas *et al.* 2014, p. 65).

Vegetation Management - In the past decade, vegetation management within lynx habitat has been predominantly salvage of dead and dying timber caused by a mountain pine beetle infestation in the northern part of the state (generally north of Interstate 70), and a spruce bark beetle infestation south of the interstate. Salvage operations may temporarily impact understory regeneration, if present, reducing the capacity of the stand to support higher snowshoe hare densities. Assuming the existing US Forest Service plans retain their current conservation framework, USFS lands should continue to provide sufficient habitat for lynx through the end of the century.

Vegetation management on non-Federal ownerships within lynx habitat is unlikely to cause significant concern for lynx conservation in Colorado through the remainder of the century.

Wildland Fire Management - “It is generally acknowledged that in the Southern Rocky Mountains fire suppression has altered historical vegetative patterns. This effect has been most pronounced within vegetation communities where fire regimes are of low intensity or mixed severity. It is generally agreed that spruce-fir habitats have been little affected by fire suppression because the fire regimes within this type tend to be stand-replacing events occurring at long intervals (100+ years). Depending on the moisture regime, large stand-replacing fires within lynx habitat may produce young age class snowshoe hare habitat after approximately 10-30 years. Although this vegetative condition may provide some high quality snowshoe hare habitat, mature forests are also very important as winter foraging habitat.” (USFS 2008, p. 36)

Habitat Fragmentation - Sources of current habitat fragmentation include high-speed high-volume highways, high mountain valley developments, vegetation management, ski/recreation area development, and wildland fire. Currently, only vegetation management on USFS lands is managed to limit lynx habitat fragmentation. Highways are likely to be expanded to accommodate increasing traffic volume as mountain valley communities continue to develop and expand. While these linear features already exist on the landscape, widening of the cleared right-of-way, as well as lynx behavioral avoidance of highway rights-of-way because of increasing traffic volume reduces available habitat function for lynx. Many ski areas in Colorado are located within lynx habitat and will likely be expanded in the future through permanent removal of vegetation to create conventional ski runs, reducing tree density and clearing understory vegetation to create glade conditions, reduces lynx habitat. The magnitude of fragmentation caused by these sources has not been quantified, but is unlikely to remove enough lynx habitat to eliminate the possibility of lynx persistence in Colorado.

Conclusion

Based on the best scientific information available, the Core Team retains some uncertainty about the fate of lynx in western Colorado. Our uncertainty stems primarily from the historic record of lynx in Colorado, where the presence of lynx is questionable or non-existent for several decades. In addition, one of the metrics for our assessment is productivity (pregnancy rate), which was low for this population relative to the other units (except the GYA, for which we had no data). Despite these uncertainties, we anticipate lynx populations to persist through the end of the century. Our conclusion about their persistence relies on consistent reproductive success.

We have considered the future of lynx in Colorado in the absence of the protections offered by the ESA. We believe that as long as the current regulatory mechanisms provided by the State of Colorado to prevent take of lynx, and the USFS SRLA conservation framework remains in place, lynx are likely protected from take, and their habitat requirements likely met in a significant majority of the available habitat within the state. Projected future climate warming is likely to result in reduction of available habitat and increased fragmentation resulting in larger areas of non-habitat between habitat blocks. Vegetative changes caused by climate change will likely result in less habitat in private and BLM ownership, due to the anticipated upslope shift in vegetation that supports snowshoe hares and lynx.

The movement capability of lynx is well documented, and lynx in Colorado will likely continue to explore the landscape and exploit the available habitat despite gaps between functional habitat blocks. Discussions during our expert elicitation reflect concern that ski area and base area developments could affect daily movements of lynx. The discussions revealed that ski area related development, including residential development of base areas, may limit lynx's ability to fully exploit habitats year round. Colorado is isolated from source populations in the northern part of the range relative to the other units, which injects uncertainty about the possibility of genetic drift from mid-century onward. Our expert elicitation documented some uncertainty whether ski areas may affect genetic connectivity within the unit. However, the Core Team is less concerned about this particular issue because we cannot foresee the development of barriers that would prevent lynx from accessing all available lynx habitat in the future.

Chapter 6: Synthesis

This section synthesizes the needs, current condition, and likely future condition of the Canada lynx in the contiguous U.S. DPS with respect to the conservation biology principles of representation, redundancy, and resiliency. Its purpose is to provide an understanding of the range-wide status of this DPS that is as clear as possible given the unavoidable uncertainties involving demography and long-term threats.

Needs

Throughout the species' range, the lynx is a habitat and prey specialist requiring boreal forests with dense horizontal cover, long winters, and deep, fluffy snow, which gives it a competitive advantage for exploiting its primary prey, the snowshoe hare. Lynx in the contiguous U.S. have ecological requirements similar to those of lynx in Canada and Alaska, and throughout the species' range hare abundance is the primary driver of lynx population dynamics. However, the DPS is at the southernmost margin of the species' range, where boreal forests transition to temperate conifer and hardwood forests, and where snow conditions and hare abundance generally become less favorable with decreasing latitude. Because of this, habitat is less extensive and generally more fragmented within the DPS range than in the core of the species' range in Canada and Alaska. As a result, lynx in the contiguous U.S. are naturally less abundant and more patchily distributed than in the core of the range. Maintaining connectivity between lynx populations in Canada and the DPS is thought to be important; however, whether and if so to what extent the demographic and/or genetic health of DPS populations relies on periodic immigration from Canadian populations remains uncertain.

Current Conditions and Threats

Resiliency, the ability to withstand stochastic disturbance events, and redundancy, the ability to withstand catastrophic events, are currently exhibited in the lynx DPS by the persistence of individual lynx populations and their broad distribution across the geographic scope of the DPS. Available information indicates that five out of six geographic units in the DPS (all but the GYA) contain resident breeding lynx populations. Although we have no reliable population-size estimates for any of the geographic units, Northern Maine (Unit 1) is believed to currently have habitat to support the largest resident population in the DPS, perhaps 500-1,000 individual lynx. In Northeastern Minnesota (Unit 2), a resident population of perhaps 50-200 lynx occupies the Arrowhead Region of the State. Northwestern Montana and northeastern Idaho (Unit 3) continue to support resident lynx, thought to number 200-300, although a small subpopulation in the Garnet Mountains on the southern periphery of this unit may have been extirpated recently. In North-central Washington (Unit 4), recent extensive wildfires have temporarily reduced the amount of high-quality lynx habitat and may have caused a decline in lynx numbers there from perhaps 100 before the large fires to half of that currently. The Greater Yellowstone Area (GYA, Unit 5) is thought to have historically supported a small resident population; however, resident lynx have not been documented recently in this unit. Since the release of Canadian and Alaskan lynx in 1999-2006, resident lynx currently occupy western Colorado (Unit 6). The apparent long-term (historical and current) persistence of resident lynx populations in at least four of the six geographic units (Units 1-4) and the absence of reliable information indicating that the current distribution and relative abundance of resident lynx are substantially reduced from historical conditions suggest the historical and recent resiliency of lynx populations in the DPS. The large sizes and broad geographic distributions of the areas occupied by resident lynx populations likewise indicate adequate historical and current redundancy in the DPS to preclude its extirpation because of catastrophic events.

Representation, the ability of a species to adapt to changing environmental conditions over time, is characterized by the breadth of genetic and ecological diversity within and among populations (Lynx SSA Team 2016, p. 25). Information provided by lynx experts and geneticists indicates high rates of dispersal and gene flow and, therefore, generally low levels of genetic differentiation across most of the species' range, including the DPS (Lynx SSA Team 2016, pp. 12-14, 55-56). Hybridization with bobcats has been documented but is not considered a substantial current threat to the DPS (Lynx SSA Team 2016, p. 13). Despite differences in forest community types and topographic/elevation settings, lynx across the range of the DPS occupy a similarly narrow and specialized ecological niche defined by specific vegetation structure, snow conditions, and the abundance of a single prey species. Thus, lynx naturally have little ability to adapt to changing environmental conditions (i.e., shift to other forest habitats, snow conditions, or prey species). However, although some small populations may have become extirpated recently, resident lynx in the DPS remain broadly distributed across the range of ecological settings that seems to have supported them historically in the contiguous U.S. There are no indications of current threats to the genetic health or adaptive capacity of lynx populations in the DPS, and the current level of representation does not appear to represent a decrease from historical conditions.

The primary threat identified at the time of listing, lack of regulations protecting lynx habitat on Federal lands, has been largely addressed by formal and binding amendments or revisions to most Federal land management plans within the DPS range. Although uncertainty remains about the efficacy of this improved regulatory framework, Federal lands are now being managed specifically to protect and restore lynx habitats, with the goal of supporting continued lynx presence on these lands. Most Federal lands, which constitute 64 percent of lynx habitat evaluated in this SSA, are found in the western U.S.

Other stressors affect lynx in one or more geographic units. For example, in northern Maine, where most high-quality lynx habitat occurs on private commercial timber lands and is the result of past timber harvest, changes in State forestry regulations (the Maine Forest Practices Act of 1989) that govern private forest management may currently be causing decreases in habitat quantity, quality, and distribution, and in lynx numbers (also see *Future Conditions and Threats*, below). The lack of binding lynx conservation commitments on private lands may exacerbate this risk to current lynx habitats in Maine. However, the current amount and distribution of high-quality lynx and hare habitats created in Maine by past timber harvest is thought to be several times higher than the likely natural historical condition. In North-central Washington, recent large-scale wildfires have resulted in the temporary loss of nearly 50 percent of lynx habitat, likely reducing this unit's current lynx population and potentially compromising its current ability to support a resident population until habitats recover. Increased wildfire activity also has impacted lynx habitats in the other western geographic units (Northwestern Montana/Northeastern Idaho, the GYA, and Western Colorado), but the extent to which it may have influenced the current condition of lynx populations in those units is uncertain.

Climate change is occurring at a global and, thus, a DPS-wide scale. Climate warming has reduced snow amount, duration, and quality (in terms of conditions favorable for lynx), it has been linked to increased frequency, size, and severity of wildfires and forest insect outbreaks, and it likely has already resulted in some changes in forest vegetative communities. Climate warming has also been linked to changes in the amplitude, periodicity, and synchronicity of northern hare population cycles, which could alter the timing and magnitude of irruptions of lynx from Canada into the contiguous U.S. If lynx populations in the DPS depend on immigration from Canada which is no longer occurring or has been substantially reduced relative to historical conditions, population declines and an increased likelihood of extirpation among resident populations would be expected. However, whether, and if so to what extent, these climate-mediated factors have influenced current lynx numbers, other demographic parameters, and/or habitat quality and distribution is uncertain and has not been quantified across the range of the DPS or in individual geographic units. Despite uncertainty regarding its influence over current conditions for lynx, climate modeling and expert opinion concur that continued climate warming will adversely impact lynx in the DPS in the future (see below).

Future Conditions and Threats

Overall, our evaluations of the scientific literature and expert input suggest that resident lynx populations in each of the geographic units are likely to be smaller and their distributions reduced in the future. These anticipated declines are most likely to be influenced by projected loss and increasing fragmentation and isolation of boreal forests and favorable snow conditions resulting from continued climate warming and related impacts (e.g., increased wildfire and forest insect activity, diminished hare populations; Lynx SSA Team 2016, p. 58). Forest management on private lands that lack lynx conservation commitments may also contribute to future declines, particularly in northern Maine. In each geographic unit, the probability that resident lynx populations will persist is expected to decline through the end of the century, with uncertainty about the rate of decline increasing with time from the present. The loss of resident lynx from one or more geographic unit would represent reduced future resiliency, redundancy, and representation within the lynx DPS.

The resiliency of lynx populations in individual geographic units is the primary determinant of the future viability of the lynx DPS. Our analyses and expert predictions suggest a declining probability of persistence (loss of resiliency) for each of the geographic units within the DPS throughout the rest of this century (the analysis did not extend beyond 2100). Projected climate warming is expected to exert the greatest influence on the resiliency of individual populations, and thus continued presence of resident lynx in each geographic unit. Climate models project that boreal forests and snow conditions favorable for lynx at the southern periphery of the range will retreat northward and upslope with continued warming, further fragmenting and diminishing the quality of lynx and hare habitat within the DPS. Although uncertainty remains regarding the timing, extent, and biological consequences of such impacts, as habitat conditions decline, hare populations will decline and lynx mortality rates are likely to increase and reproductive rates decrease. As snow conditions become less favorable, competitors (e.g., bobcats) are likely to outcompete and displace lynx. This in turn will reduce lynx abundance and density within populations, making populations more susceptible to stochastic events.

The loss of any geographic units would also reduce the level of redundancy and could diminish representation within the DPS. With regard to redundancy, however, we find that none of the five geographic units that currently support resident lynx is vulnerable to extirpation from a single catastrophic event. Given that, we conclude that the DPS as a whole is not vulnerable to extirpation from a catastrophic event (i.e., we find that there is a zero probability that a single catastrophic event could result in extirpation of resident lynx from any of the five geographic units that currently support them and, therefore, a zero probability of catastrophic extirpation of the entire DPS). We recognize that a sequence of discrete but spatially-clustered catastrophic events in lynx habitats over a short time could increase the potential for functional extirpation in one or more of the individual geographic units (especially the possibility of additional large wildfires in north-central Washington), thereby reducing redundancy within the DPS. However, as long as resident lynx remain geographically well-distributed in one or more units within the DPS, extirpation of the DPS from a single catastrophic event is very unlikely.

With regard to representation, although some lynx populations in the DPS units are demographically isolated from each other and the level of interaction between others is uncertain, there seems to be little risk of significant genetic drift. This is because of the currently-observed and likely future high level of gene flow across most of the lynx's continental range, the species' well-documented dispersal capability, the current and likely future absence of significant barriers to dispersal between Canada and the DPS, and continued connectivity between most parts of the DPS and lynx populations in Canada. Furthermore, based on expert input, we conclude that there is no indication that the relatively low level of genetic diversity currently observed among lynx populations is likely to reduce DPS viability in the future (USFWS 2016, p. 51). This information suggests the current and likely future relative genetic health of the DPS.

How the potential loss of resident lynx from one or more geographic unit may affect representation within the DPS in terms of ecological diversity is uncertain. Despite similarities in the fundamental components (vegetation, snow conditions, and hares) that define the ecological niche of lynx DPS-wide, differences in habitats and how lynx use them are apparent. For example, snow depth that seems to demarcate a boundary between lynx and bobcat occupancy in Maine (270 cm/yr) is almost twice that observed in Minnesota (140 cm/yr]), and lynx in some parts of the West select mature forest stands, particularly in winter, while in other parts of the DPS, young regenerating stands are most important. The loss of resident lynx from any of the geographic units could result in the loss of behavioral and potential future genetic adaptations to the climate-mediated changes now occurring and likely to continue into the future at the southern edge of the lynx range. Such potential adaptability to diminished snow conditions, increasingly patchy and isolated boreal forests, and reduced hare abundance may be important to the taxon as a whole faced with a rapidly changing climate.

Given the high percentage of Federal land ownership in the West, regulatory commitments that these lands will continue to be managed in accordance with lynx conservation principles, and the existence of potential high-elevation climate refugia to which lynx habitats and some lynx might move, the western geographic units (Units 3-6) may be more likely to support resident lynx longer under projected continued climate warming. Nonetheless, it is unlikely that any management actions can abate the long-term northward and upslope retreat of boreal forests and diminished snow conditions projected by climate models. Further, the size, frequency, and intensity of wildfires and forest insect outbreaks are expected to increase with continued climate warming, particularly in the western portion of the DPS, although we do not anticipate such events in-and-of-themselves are likely to cause the permanent loss of breeding lynx populations in any geographic unit.

Although projections of climate-mediated losses of boreal forests and favorable snow conditions suggest impacts to lynx and hare populations throughout the DPS, persistence of resident lynx in Maine and Minnesota may be relatively lower than the western geographic units given the smaller percent of Federal lands and the absence of associated regulatory commitments to lynx conservation, and the lack of potential elevational refugia. Additionally, as noted above, changes to regulations governing timber harvest on private forest lands in Maine are unlikely to maintain the current historically-high amount and distribution of good lynx habitat or the current large population of resident lynx. These changes, which may affect over 90 percent of lynx habitats in northern Maine, are projected to result in substantial declines in habitat quality and distribution, and lynx numbers, over the next 10-30 years, primarily through restrictions on clearcutting and the proliferation of partial harvesting, which are detrimental to snowshoe hare and lynx needs. On private forest lands, energy development (wind energy, mining), rapid turnover in ownership and parcelization of forest land, and uncertain forest markets may also reduce the future quality and quantity of lynx habitat.

<u>DPS Viability</u>

Although all five geographic units that currently support populations (all units except the GYA) are expected by lynx experts to continue to do so through mid-century, only one (Northwestern Montana/ Northeastern Idaho) has an estimated probability of persistence greater than 50 percent (i.e., persistence more likely than not) by the end of the century (Lynx SSA Team 2016, pp. 36-49, 58). The experts we consulted projected that all the other geographic units have a 50 percent or greater probability of functional extirpation (i.e., no longer capable of supporting resident lynx populations) by the end of the century, with a moderate to high likelihood that resident lynx will be lost from two to four units by then. Potential elevational refugia may increase the likelihood of persistence in western units, although uncertainty remains about the timing of warming-driven upslope movements of habitats and snow conditions and the extent to which hare and lynx populations may follow them. Regardless, future lynx habitats throughout the DPS range are likely to be smaller and more fragmented, and geographic units that are already relatively isolated from other lynx populations are likely to become even more isolated in the future. Despite the lack of elevational refugia, lynx may also persist at the end of the century in Maine and Minnesota, depending on the timing and severity of climate change effects and, in Maine, on trends in development and private forest management. Uncertainty increases at mid- to late-century concerning the timing and extent of various stressors that will affect lynx and hare habitat and snow regimes, especially those related to climate change. However, review of the best available science in concert with input from lynx experts suggests that the probability of the persistence of resident breeding populations will decline in all geographic units, with the negative DPS-wide trajectory continuing to the end of the century, and (with no evidence to the contrary) beyond that time frame.

Our evaluation generally concurs with the expert input we received. We believe that lynx populations and habitats in the DPS will decline over time largely as a result of continued climate warming and associated impacts, which are likely to exacerbate the potential adverse effects of other factors (e.g., forest management, competition from other hare predators). Because resident lynx populations in all geographic units that currently support them are expected to be smaller and more fragmented and isolated in the future, each geographic unit and the DPS as a whole will be less resilient in the future. Our analyses and expert input suggest that resiliency will likely be adequate to foster persistence of resident lynx through mid-century in most of the five geographic units that currently support them. However, we believe it is very unlikely that resident lynx populations will persist through the end of this century in all of the geographic units that currently support them. That is, we believe that resiliency will be substantially diminished because of reduced population sizes and distributions throughout the DPS, with resulting extirpation of resident populations from two to three (of five) units more likely than not by the end of the century.

We conclude that the functional extirpation of resident lynx populations from one or more geographic unit would demonstrate a loss of resiliency, reduced redundancy, and, possibly, reduced representation within the DPS. The probability of losses in resiliency, redundancy, and representation puts the Canada lynx DPS at increasing risk of extirpation through the end of this century.

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