# U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

## Scientific Name:

Gulo gulo luscus

## Common Name:

North American wolverine

## Lead region:

Region 6 (Mountain-Prairie Region)

## Information current as of:

04/01/2011

## Status/Action

___ Funding provided for a proposed rule. Assessment not updated.

___ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

___ New Candidate

_X_ Continuing Candidate

___ Candidate Removal

___ Taxon is more abundant or widespread than previously believed or not subject

___ Taxon not subject to the degree of threats sufficient to warrant issuance of

___ Range is no longer a U.S. territory

___ Insufficient information exists on biological vulnerability and threats to su

___ Taxon mistakenly included in past notice of review

___ Taxon does not meet the definition of "species"

___ Taxon believed to be extinct

___ Conservation efforts have removed or reduced threats

## Petition Information

___ Non-Petitioned

_X_ Petitioned - Date petition received: 07/13/2000

90-Day Positive:

12 Month Positive:12/14/2010

Did the Petition request a reclassification? **No**

**For Petitioned Candidate species:**

Is the listing warranted(if yes, see summary threats below) **Yes**

To Date, has publication of the proposal to list been precluded by other higher priority listing? **Yes**

Explanation of why precluded:

Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for this species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. The Progress on Revising the Lists section of the current CNOR (http://endangered.fws.gov/) provides information on listing actions taken during the last 12 months.

## Historical States/Territories/Countries of Occurrence:

- **States/US Territories**: Colorado, Idaho, Minnesota, Montana, Nevada, North Dakota, Utah, Wyoming
- **US Counties**:County information not available
- **Countries**:Country information not available

## Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories**: California, Colorado, Idaho, Montana, Oregon, Utah, Washington, Wyoming
- **US Counties**: Alamosa, CO, Archuleta, CO, Boulder, CO, Chaffee, CO, Clear Creek, CO, Conejos, CO, Costilla, CO, Custer, CO, Delta, CO, Dolores, CO, Eagle, CO, El Paso, CO, Fremont, CO, Garfield, CO, Gilpin, CO, Grand, CO, Gunnison, CO, Hinsdale, CO, Huerfano, CO, Jackson, CO, Jefferson, CO, La Plata, CO, Lake, CO, Larimer, CO, Las Animas, CO, Mesa, CO, Mineral, CO, Moffat, CO, Montezuma, CO, Montrose, CO, Ouray, CO, Park, CO, Pitkin, CO, Pueblo, CO, Rio Blanco, CO, Rio Grande, CO, Routt, CO, Saguache, CO, San Juan, CO, San Miguel, CO, Summit, CO, Teller, CO, Ada, ID, Adams, ID, Benewah, ID, Blaine, ID, Boise, ID, Bonner, ID, Boundary, ID, Butte, ID, Camas, ID, Clark, ID, Clearwater, ID, Custer, ID, Elmore, ID, Fremont, ID, Gem, ID, Idaho, ID, Kootenai, ID, Latah, ID, Lemhi, ID, Lewis, ID, Nez Perce, ID, Shoshone, ID, Teton, ID, Valley, ID, Beaverhead, MT, Broadwater, MT, Carbon, MT, Cascade, MT, Deer Lodge, MT, Flathead, MT, Gallatin, MT, Glacier, MT, Golden Valley, MT, Granite, MT, Jefferson, MT, Judith Basin, MT, Lake, MT, Lewis and Clark, MT, Lincoln, MT, Madison, MT, Meagher, MT, Mineral, MT, Missoula, MT, Park, MT, Pondera, MT, Powell, MT, Ravalli, MT, Sanders, MT, Silver Bow, MT, Stillwater, MT, Sweet Grass, MT, Teton, MT, Wheatland, MT, Baker, OR, Clackamas, OR, Crook, OR, Deschutes, OR, Douglas, OR, Grant, OR, Harney, OR, Hood River, OR, Jackson, OR, Jefferson, OR, Josephine, OR, Klamath, OR, Lake, OR, Lane, OR, Linn, OR, Malheur, OR, Multnomah, OR, Umatilla, OR, Union, OR, Wallowa, OR, Wasco, OR, Wheeler, OR, Chelan, WA, Ferry, WA, King, WA, Kittitas, WA, Klickitat, WA, Lewis, WA, Okanogan, WA, Pend Oreille, WA, Pierce, WA, Skagit, WA,

Skamania, WA, Stevens, WA, Thurston, WA, Whatcom, WA, Yakima, WA, Fremont, WY, Hot Springs, WY, Lincoln, WY, Park, WY, Sublette, WY, Teton, WY
- **Countries**:Country information not available

### Land Ownership:

Private, city, county, state, Federal

Within the three States that currently harbor wolverines in the northern Rocky Mountains (Montana, Idaho, and Wyoming), an estimated 104,363 km2 (40,295 mi2) of wolverine habitat exists (Copeland 2010, pers. comm.). Based on the habitat model developed by Brock et al. (2007), 95 percent (120,000 km2; 46,332 mi2) is in Federal ownership with the largest portion of that (108,969 km2; 42,073 mi2) managed by the U.S. Forest Service (Forest Service) (Inman 2007b, pers. comm.).

### Lead Region Contact:

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### Lead Field Office Contact:

Montana ESFO, Shawn Sartorius, 4062477369, shawn_sartorius@fws.gov

## Biological Information

### Species Description:

The wolverine is the largest terrestrial member of the family Mustelidae. Adult males weigh 12 to 18 kilograms (kg) (26 to 40 pounds (lb), and adult females weigh 8 to 12 kg (17 to 26 lb) (Banci 1994, p. 99). The wolverine resembles a small bear with a bushy tail. It has a broad, rounded head; short, rounded ears, and small eyes. Each foot has five toes with curved, semi-retractile claws used for digging and climbing (Banci 1994, p. 99).

### Taxonomy:

The wolverine has a holarctic distribution including northern portions of Europe, Asia, and North America. The currently accepted taxonomy classifies wolverines worldwide as a single species, *Gulo gulo*. Old and New World wolverines are divided into separate subspecies. Wolverines in the contiguous United States are a part of the New World subspecies, *G. g. luscus*: the North American wolverine (Kurten and Rausch 1959 p. 19; Pasitschniak-Arts and Lariviere 1995, p. 1). The species is known by several common names including mountain devil, glutton, caracajou, quickhatch, gulon, skunk bear, as well as wolverine.

### Habitat/Life History:

In North America, wolverines occur within a wide variety of alpine, boreal, and arctic habitats, including boreal forests, tundra, and western mountains throughout Alaska and Canada. The southern portion of the species' range extends into the contiguous United States, including high-elevation alpine portions of Washington, Idaho, Montana, Wyoming, California, and Colorado (Wilson 1982, p. 644; Hash 1987, p. 576; Banci 1994, p. 102, Pasitschniak-Arts and Lariviere 1995, p. 499; Aubry *et al*. 2007, p. 2152; Moriarty *et al*. 2009, entire; Inman et al. 2009, pp. 22-25). Wolverines do not appear to specialize on specific vegetation or geological habitat aspects, but instead select areas that are cold and receive enough winter precipitation to reliably maintain deep persistent snow late into the warm season (Copeland *et al*. 2010, entire). The requirement of cold, snowy conditions means that, in the southern portion of the species' range where ambient temperatures are warmest, wolverine distribution is restricted to high elevations, while at more northerly latitudes, wolverines are present at lower elevations and even at sea level in the far north (Copeland *et al*. 2010, Figure 1).

In the contiguous United States, wolverines likely exist as a metapopulation (Aubry et al. 2007, p. 2147, Figures 1, 3). A metapopulation is a network of semi-isolated populations, each occupying a suitable patch of habitat in a landscape of otherwise unsuitable habitat (Pulliam and Dunning 1997, pp. 212-214). Metapopulations require some level of regular or intermittent migration and gene flow among subpopulations, in which individual populations support one-another by providing genetic and demographic enrichment through mutual exchange of individuals (Meffe and Carroll 1997, p. 678). Individual subpopulations may go extinct or lose genetic viability, but are then "rescued" by immigration from other subpopulations, thus ensuring the persistence of the metapopulation as a whole. Metapopulation dynamics (the process of extinction and recolonization by subpopulations) rely on the ability of subpopulations to support one another through exchange of individuals for genetic and demographic enrichment. If metapopulation dynamics break down, either due to changes within subpopulations or loss of connectivity, then the entire metapopulation may be jeopardized due to subpopulations becoming unable to persist in the face of inbreeding or demographic and environmental stochasticity (Pulliam and Dunning 1997b, pp. 221-222). We believe this outcome is likely for wolverine, due to their naturally low reproductive rates and low densities.

Wolverines are opportunistic feeders and consume a variety of foods depending on availability. They primarily scavenge carrion, but also prey on small animals and birds, and eat fruits, berries, and insects (Hornocker and Hash 1981, p. 1290; Hash 1987, p. 579; Banci 1994, pp. 111-113). Wolverines have an excellent sense of smell that enables them to find food beneath deep snow (Hornocker and Hash 1981, p. 1297).

Wolverines require a lot of space; the availability and distribution of food is likely the primary factor in determining wolverine movements and home range size (Hornocker and Hash 1981, p. 1298; Banci 1994, pp. 117-118). Female wolverines forage close to den sites in early summer, progressively ranging further from dens as kits become more independent (May et al. 2010, p. 941). Wolverines travel long distances over rough terrain and deep snow, and adult males generally cover greater distances than females (Hornocker and Hash 1981, p. 1298; Banci 1994, pp. 117-118; Moriarty et al. 2009, entire; Inman et al. 2009, pp. 22-28; Brian 2010, p. 3; Copeland and Yates 2006, Figure 9). Home ranges of wolverines are large, and vary greatly in size depending on availability of food, gender and age of the animal, and differences in habitat quality. Home ranges of adult wolverines also vary in size depending on geographic location. Home ranges in Alaska were approximately 100 square kilometers ($km^2$) to over 900 $km^2$ (38.5 square miles ($mi^2$) to 348 $mi^2$) (Banci 1994, p. 117). Average home ranges of resident adult females in central Idaho were 384 $km^2$ (148 $mi^2$), and average home ranges of resident adult males were 1,522 km2 (588 $mi^2$) (Copeland 1996, p. 50). Wolverines in Glacier National Park had average adult male home ranges of 496 $km^2$ (193 $mi^2$) and adult female home ranges of 141 $km^2$ (55 $mi^2$) (Copeland and Yates 2006, p. 25). Wolverines in the Greater Yellowstone Ecosystem had average adult male home ranges of 797 $km^2$ (311 $mi^2$), and average adult female home ranges of 329 $km^2$ (128 $mi^2$) (Inman et al. 2007a, p. 4). These home range sizes are large relative to the body size of wolverines, and may indicate that wolverines occupy a relatively unproductive niche in which they must forage over large areas to consume the amount of calories needed to meet their life-history requirements (Inman et al. 2007a, p. 11).

A large number of female wolverines (40 percent) are capable of giving birth at 2 years old, become pregnant most years, and produce litter sizes of approximately 3.4 kits on average. Pregnant females commonly resorb or spontaneously abort litters prior to giving birth (Magoun 1985, pp. 30-31; Copeland 1996, p. 43; Persson et al. 2006, p. 77; Inman et al. 2007c, p. 70). It is likely that, despite the high rate of initiation of pregnancy, due to the spontaneous abortion of litters resulting from resource limitation, actual rates of successful reproduction in wolverines are among the lowest known for mammals (Persson 2005, p. 1456). In one study of known-aged females, none reproduced at age 2, 3 of 10 first reproduced at age 3, and 2 did not reproduce until age 4; the average age at first reproduction was 3.4 years (Persson et al. 2006, pp. 76-77). The average age at first reproduction is likely more than 3 years (Inman et al. 2007c, p. 70).

It is common for females to forgo reproducing every year, possibly saving resources to increase reproductive success in subsequent years (Persson 2005, p. 1456). Supplemental feeding of females increases reproductive potential (Persson 2005, p. 1456). Food-supplemented females were also more successful at raising kits to the time of weaning, suggesting that wolverine reproduction and ultimately population growth rates and viability are food-limited. By age 3, nearly all female wolverines become pregnant every year, but energetic constraints due to low food availability result in loss of pregnancy in about half of them each year. It is likely that, in many places in the range of wolverines, it takes 2 years of foraging for a female to store enough energy to successfully reproduce (Persson 2005, p. 1456).

Breeding generally occurs from late spring to early fall (Magoun and Valkenburg 1983, p. 175; Mead et al. 1991, pp. 808-811). Females undergo delayed implantation until the following winter to spring, when active gestation lasts from 30 to 40 days (Rausch and Pearson 1972, pp. 254-257). Litters are born from mid-February through March, containing one to five kits, with an average in North America of between 1 and 2 kits (Magoun 1985, pp. 28-31; Copeland 1996, p. 36; Krebs and Lewis 1999, p. 698; Copeland and Yates 2006, pp. 32-36; Inman et al. 2007c, p. 68).

Female wolverines use natal (birthing) dens that are excavated in snow. Persistent, stable snow greater than 1.5 meters (m) (5 feet (ft)) deep appears to be a requirement for natal denning, because it provides security for offspring and buffers cold winter temperatures (Pulliainen 1968, p. 342; Copeland 1996, pp. 92-97; Magoun and Copeland 1998, pp. 1317-1318; Banci 1994, pp. 109-110; Inman et al. 2007c, pp. 71-72; Copeland et al. 2010, pp. 240-242). Female wolverines go to great lengths to find secure den sites, suggesting that predation is a concern (Banci 1994, p. 107). Natal dens consist of tunnels that contain well-used runways and bed sites and may naturally incorporate shrubs, rocks, and downed logs as part of their structure (Magoun and Copeland 1998, pp. 1315-1316; Inman et al. 2007c, pp. 71-72). In Idaho, natal den sites occur above 2,500 m (8,200 ft) on rocky sites, such as north-facing boulder talus or subalpine cirques in forest openings (Magoun and Copeland 1994, pp. 1315-1316). In Montana, natal dens occur above 2,400 m (7,874 ft) and are located on north aspects in avalanche debris, typically in alpine habitats near timberline (Inman et al. 2007c, pp. 71-72). Offspring are born from mid-February through March, and the dens are typically used through late April or early May (Myrberget 1968, p. 115; Magoun and Copeland 1998, pp. 1314-1317; Inman et al. 2007b, pp. 55-59). Occupation of natal dens is variable, ranging from approximately 9 to 65 days (Magoun and Copeland 1998, pp. 1316-1317).

Females may move kits to multiple secondary (maternal) dens as they grow during the month of May (Pulliainen 1968, p. 343; Myrberget 1968, p. 115), although use of maternal dens may be minimal (Inman et al. 2007c, p. 69). Timing of den abandonment is related to accumulation of water in dens (due to snow melt), the maturation of offspring, disturbance, and geographic location (Myrberget 1968, p. 115; Magoun 1985, p. 73). After using natal and maternal dens, wolverines may also use rendezvous sites through early July. These sites are characterized by natural (unexcavated) cavities formed by large boulders, downed logs (avalanche debris), and snow (Inman et al. 2007c, p. 55-56).

## Historical Range/Distribution:

Delineating wolverine historical and present range is difficult for several reasons. Wolverines tend to live in remote and inhospitable places away from human populations where they are seldom encountered, documented, or studied. Wolverines naturally occur at low population densities and are rarely and unpredictably encountered where they occur. Wolverines often move long distances in short periods of time, when dispersing from natal ranges, into habitats that are unsuitable for long-term survival (Aubry et al. 2007, p. 2147; Moriarty et al. 2009, entire; Inman et al. 2009, pp. 22-28; Brian 2010, p. 3). Such movements make it difficult to distinguish with certainty between occurrence records that represent established populations and those that represent short-term occupancy or exploratory movements without the potential for establishment of home ranges, reproduction, and eventually populations. These natural attributes of wolverines make it difficult to precisely determine their present range, or trends in range expansion or contraction that may have occurred in the past. Therefore, we must be cautious and use multiple lines of evidence when trying to determine where wolverine populations occurred in the past.

Throughout this assessment, we focus on the use of verifiable and documented wolverine occurrence records to define historic and present range because we have determined that these records constitute the best scientific information available on the past and present distribution of wolverines (See Aubry et al. 2007, p. 2148). Verifiable records are records supported by physical evidence such as museum specimens, harvested pelts, DNA samples, and diagnostic photographs. Documented records are those based on accounts of wolverines being killed or captured. Use of only verifiable and documented records avoids mistakes of misidentification often made in eyewitness accounts of visual encounters. Visual-encounter records often represent the majority of occurrence records for elusive forest carnivores, and their inherently high rate of misidentification of the species involved can result in wildly inaccurate conclusions about species occurrence (McKelvey et al. 2008, entire). The paper by Aubry et al. (2007, entire) used only verifiable and documented records to investigate wolverine distribution through time. This paper is the only available comprehensive treatment of these distribution patterns that attempts to distinguish between records that represent resident animals versus animals that have dispersed outside of suitable habitat. For these reasons we believe that Aubry et al. (2007, entire) represents the best available summary of wolverine occurrence records in the contiguous United States at this time. Since the publication of Aubry et al. (2007, entire), verified records of wolverine have also been documented in Colorado and California, which we will describe in greater detail below.

Aubry et al. (2007, entire) used verifiable and documented records from museum collections, literature sources, and State and Federal institutions to trace changes in geographic distribution of wolverines in the historic record. They then used an overlay of suitable wolverine habitats to further refine which records represent wolverines in habitats that may support residency, and by extension, populations, and which records likely represent wolverines outside the range of suitable habitats, so called “extralimital” records. Aubry et al.’s (2007, entire) focus on verifiable and documented records corrected past overly broad approaches to wolverine range mapping (Nowak 1973, p. 22; Hall 1981, p. 1009; Wilson 1982, p. 644; Hash 1987, p. 576) that used a more inclusive but potentially misleading approach when dealing with occurrence records. Many of the extralimital records used in these publications represent individuals dispersing from natal ranges that ended up in habitats that cannot support wolverines, and the use of this data to determine the historic geographic range of wolverines results in gross overestimation of the area that can actually be used successfully by wolverines for the establishment of populations. Subsequent to publication of Aubry et al. (2007, entire), Copeland et al. (2010, entire) further refined our understanding of wolverine habitat needs and corroborated the approach of Aubry et al. (2007, entire).

We agree with Aubry et al. (2007, p. 2149) that the most appropriate method to determine the current and historic range of wolverines is to use a combination of occurrence records and habitat suitability, along with other information, such as documented successful reproduction events, that indicate where reproductive and potentially self-sustaining populations may occur. We also generally agree with their conclusions about the historic and current range of the species. We believe that the species’ range is the area that may support viable populations, and does not include extralimital occurrences outside of habitat that is likely to support wolverine life-history needs. Areas that can support wolverine populations may be referred to as potential “source” populations because they provide surplus individuals through reproduction beyond what is needed for replacement. Areas that do not have the habitat to support viable populations may be referred to as population “sinks” because wolverines may disperse to these areas and remain for some time, but will either die there without reproducing, leave the area in search of better habitat conditions, or may actually reproduce, but at a rate lower than that needed for replacement of individuals lost to mortality or emigration, leading to eventual population extinction. For a widely dispersing species like wolverines, we expect many locality records to represent dispersers into sink habitats. The value to the population (and thus the DPS) of these dispersers in sink habitat is unclear; however, it is likely that most dispersers into sink habitats will be lost to the population unless they are able to move back into source habitats. Therefore, it is our belief that population sink areas, here defined as places where wolverines may be found but where habitat is not suitable for long-term occupancy and reproduction, do not represent part of the species historic range and have little conservation value for the DPS, other than possibly serving as way-stations for attempted dispersers as they search for suitable habitats. This approach to defining historic range results in reducing the bias of extralimital dispersers and concentrates conservation attention on areas capable of maintaining populations, and is more in keeping with the intentions of the Act than broader depictions of geographic range.

Aubry et al. (2007, pp. 2147-2148) divided records into "historical" (recorded prior to 1961), "recent" (recorded between 1961 and 1994), and "current" (recorded after 1994). Historical records occurred before systematic surveys. Historical records encompass the time during which wolverine numbers and distribution were hypothesized to be at their highest (prior to European settlement) and also at their lowest (early 20th Century) (Wright and Thompson 1935; Grinnell et al. 1937; Allen 1942; Newby and Wright 1955, all as cited in Aubry et al. 2007, p. 2148). The recent time interval covers a hypothesized population expansion and rebound from the early 20th Century low. Current records offer the most recent evidence available for wolverine occurrences and potential populations. We believe all occurrence records must be individually analyzed in light of their context in terms of habitat conditions conducive to wolverine population establishment and whether or not they occur clustered with other records, which might indicate that populations have historically occurred in the area. The authors of Aubry et al. (2007) did such an analysis as they compiled their records.

## Wolverine Distribution

Of 729 mappable records (those records with precise location information) compiled by Aubry et al. (2007, p. 2150), 188 were from the historical time interval (see Figure 1). We assessed the historical, recent, and current distribution data for each of the regions below to determine the likelihood of the presence of historical populations (rather than extralimital dispersers). The discussion below draws heavily from both Aubry et al. (2007, entire) and Copeland et al. (2010, entire).

Table 1. Wolverine records from three time periods from Aubry *et al*. 2007. Numbers represent total documented and verifiable records with the subset of those records that were verifiable in parentheses.

| | Historical (<1961) | Recent (1961-1994) | Current (>1994) |
|---|---|---|---|
| Northeast | 13 (1) | 0 | 0 |
| Upper Midwest | 4 (2) | 0 | 0 |
| Great Lakes | 36 (4) | 1 | 0 |
| Central Great Plains | 71* (2) | 1 | 0 |
| Rocky Mountains | 147 (45) | 332 (283) | 215 (210) |
| Pacific Coast | 89 (14) | 23 (15) | 7 |
| TOTALS | 362 (68) | 357 (298) | 222 (210) |

* 35 records from a single source (the journals of Alexander Henry).

Northeast and Upper Midwest—The low number of records and scattered nature of their distribution combined with a lack of suitable habitat indicate that wolverines were likely only occasional transients to the area and not present as a reproducing population after 1800.

Great Lakes—The lack of large numbers of verifiable records in this area of relatively high human population density and the lack of suitable habitat suggests that wolverines did not exist in this area as a viable population after 1900. Widely scattered records generally before 1900, with an occasional record after that year, suggest that if a reproducing population existed in the Great Lakes, it predated 1900, and that post-1900 records represent dispersal from a receding Canadian population. Wolverine distribution in Ontario, Canada, appears to have receded north from the Great Lakes region since the 1800s, and currently wolverines occupy only the northern portion of the province, a distance of over 400 miles from the U.S. border (COSEWIC 2003, p. 9). The pattern of record distribution illustrated in Aubry et al. (2007, p. 2152) is consistent with what would be expected if those records were of dispersing individuals from a Canadian population that receded progressively further north into Canada after 1900, possibly due to natural climate changes.

Central Great Plains—The lack of precise locality records and suitable habitat from the Great Plains States leads us to conclude that reproducing populations of wolverines did not historically inhabit this area. Thirty-five of thirty-six records from North Dakota are from the journals of a single fur trader (see Table 1), and it is not clear that the records represent actual collection localities or are localities where trades or shipments occurred (Aubry 2007, pers. comm.). Given the habitat relationships of wolverines (e.g., Copeland et al. 2010, Figure 1), it is unlikely that these records represent established wolverines or that this area was in any way wolverine habitat.

Rocky Mountains—Five Rocky Mountains States (Idaho, Montana, Wyoming, Colorado, and Utah) contained numerous wolverine records. Records with precise locality information appear to coalesce around several areas that may have been population centers, such as central Colorado, the greater Yellowstone region, and northern Idaho-northwestern Montana. The large number of verifiable and documented records for this region, along with the suggestion of population centers or strongholds, suggests that wolverines existed in reproducing populations throughout much of the Rocky Mountains during the historical time interval. The lack of records for Colorado and Utah after 1921 suggests that the southern Rocky Mountain population of wolverines was extirpated in the early 1900s, concurrent with widespread systematic predator control by government agencies and livestock interests. The northern Rocky Mountain population (north of Wyoming) was reduced to historic lows or possibly even extirpated during the early 1900s, and then increased dramatically in the second half of the 1900s (see Table 1) as predator control efforts subsided and trapping regulations become more restrictive (Aubry et al. 2007, p. 2151). This increase likely indicates a population rebound from historic lows in this period.

Wolverine records from 1995 to 2005 indicate that wolverine populations currently exist in the northern Rocky Mountains (see Table 1). Legal trapping in Montana in the recent past removed an average of 10.5 individuals from this population each year (Montana Department of Fish, Wildlife, and Parks 2007, p. 2), and harvest mortality has been reduced due to regulatory changes in 2008 (Montana Department of Fish, Wildlife and Parks 2008, p. 8). Populations in British Columbia and Alberta, Canada, are extant (COSEWIC 2003, pp. 18-19), and may have been a source of surplus wolverines to the contiguous U.S. population during population lows. Recently, a male wolverine moved on its own from the southern Greater Yellowstone Area of Wyoming into the southern Rocky Mountains of Colorado where it still persisted as of August 2010 (Inman et al. 2009, pp. 22-26; Inman 2010, pers. comm.). This attempted dispersal event is the first verified wolverine occurrence in Colorado since 1919 and may represent a continuation of the wolverine expansion in the Rocky Mountains detailed above. It is possible that other wolverines have travelled to the southern Rocky Mountains and have remained undetected. There is no evidence that Colorado currently hosts a wolverine population or that female wolverines have made, or are likely to make, similar movements.

Pacific Coast—Historically, wolverines occurred in two population centers in the North Cascades Range and the Sierra Nevada. These areas are separated by an area with no historic records (southern Oregon and northern California), indicating that the historical distribution of wolverines in this area is best represented by two disjunct populations rather than a continuous peninsular extension from Canada. This conclusion is supported by genetic data indicating that the Sierra Nevada and Cascades wolverines were separated for at least 2,000 years prior to extirpation of the Sierra Nevada population (Schwartz et al. 2007, p. 2174).

Only one Sierra Nevada record exists after 1930, indicating that this population was likely extirpated in the first half of the 1900s concurrent with widespread systematic predator control programs. In 2008, a male wolverine was discovered in the Sierra Nevada Range of California, the first verified record from California since 1922 (Moriarty et al. 2009, entire). Genetic testing revealed that this wolverine was not a descendant of the endemic Sierra Nevada wolverine population, but was likely derived from wolverines in the Rocky Mountains (Moriarty et al. 2009, p. 159). This attempted dispersal event may represent a continuation of the wolverine expansion in the contiguous United States as detailed above. Other wolverines may have travelled to the Sierra Nevada and remain undetected. There is no evidence that California currently hosts a wolverine population or that female wolverines have made or are likely to make similar dispersal movements.

Wolverines were likely extirpated from the North Cascades in the early 20th century and then recently recolonized from Canada. Currently, a small population persists in this area (Aubrey et al. 2009, entire). The Northern Cascades population may be connected with, and is possibly dependent on, the larger Canadian population for future expansion and long-term persistence.

## Current Range Distribution:

Currently, wolverines appear to be distributed as functioning populations in two regions in the contiguous United States: the North Cascades in Washington, and the northern Rocky Mountains in Idaho, Montana, and Wyoming. Wolverines were likely extirpated, or nearly so, from the entire contiguous United States in the first half of the 20th Century (Aubry et al. 2007, Table 1). The available evidence suggests that, in the second half of the 20th Century and continuing into the present time, wolverine populations have expanded in the North Cascades and the northern Rocky Mountains, but that populations have not been reestablished in the Sierra Nevada Range or the southern Rocky Mountains. We conclude that the current range of the species in the contiguous United States includes the North Cascades Mountains, the northern Rocky Mountains, the southern Rocky Mountains, and the Sierra Nevada Mountains, but that reestablishment of populations in the southern Rocky Mountains and Sierra Nevada has not yet occurred.

We also conclude that wolverines either did not exist as established populations, or were extirpated prior to settlement and the compilation of historical records, in the Great Lakes region, possibly due to climate changes that occurred through the 1800s and 1900s. The Great Lakes region lacks suitable wolverine habitat, and suitable habitat does not appear to exist in adjacent Canada (Copeland et al. 2010, Figure 1). The widely scattered records from this region are consistent with dispersing individuals from a Canadian population that receded north early in the 1800s. We cannot rule out the possibility that wolverines existed as established populations prior to the onset of trapping in this area, but we have no reliable evidence that they did.

No reliable evidence in the historical records indicates that wolverines were ever present as established populations in the Great Plains, Midwest, or Northeast.

Deep, persistent, and reliable spring snow cover (April 15 to May 14) is the best overall predictor of wolverine occurrence in the contiguous United States (Aubry et al. 2007, pp. 2152-2156; Copeland et al. 2010, entire). Deep persistent snow correlates well with wolverine year-round habitat use across wolverine distribution in North America and Eurasia at both regional and local scales (Copeland et al. 2010, entire). It is uncertain why spring snow cover so accurately predicts wolverine habitat use; however, it is likely related to wolverines' need for deep snow during the denning period, and also wolverines' physiological requirement for year-round cold temperatures (Copeland et al. 2010, pp. 242-243). Snow cover during the denning period is essential for successful wolverine reproduction range-wide (Hatler 1989, p. iv; Magoun and Copeland

1998, p. 1317; Inman et al. 2007c, pp. 71-72; Persson 2007; Copeland et al. 2010, p. 244). Wolverine dens tend to be in areas of high structural diversity such as logs and boulders with deep snow (Magoun and Copeland 1998, p. 1317; Inman et al. 2007c, pp. 71-72; Persson 2007, entire). Reproductive females dig deep snow tunnels to reach the protective structure provided by logs and boulders. This behavior presumably protects the vulnerable kits from predation by large carnivores, including other wolverines (Pulliainen 1968, p. 342; Zyryanov 1989, pp. 3-12), but may also have physiological benefits for kits by buffering them from extreme cold, wind, and desiccation (Pullianen 1968, p. 342, Bjärvall et al. 1978, p. 23). Wolverines live in low-temperature conditions and appear to select habitats in part to avoid high summer temperatures (Copeland et al. 2010, p. 242). Wolverine distribution is likely affected by climatic conditions at two different scales. Wolverines require deep persistent snow for denning, and this likely determines where wolverine populations can be found at the grossest range-wide scale (Copeland et al. 2010, p. 244). At smaller scales, wolverines likely select habitats to avoid high summer temperatures. These cool habitats also tend to retain snow late into spring, leading to wolverines' year-round association with areas of persistent spring snow (Copeland et al. 2010, p. 244).

All of the areas in the contiguous United States for which good evidence of persistent wolverine populations (either present or historic) exists (i.e., North Cascades, Sierra Nevada, northern and southern Rocky Mountains) contain large and well-distributed areas of deep snow cover that persists through the wolverine denning period (Brock et al. 2007, pp. 36-53; Aubry et al. 2007, p. 2154; Copeland et al. 2010, Figure 1). The Great Plains, Great Lakes, Midwest, and Northeast lack the spring snow conditions and low summer temperatures thought to be required by wolverines for successful reproduction and year-round occupancy (Aubry et al. 2007, p. 2154; Copeland et al. 2010, Figure 1). The lack of persistent spring snow conditions in the Great Plains, Great Lakes, Midwest, and Northeast supports the exclusion of these areas from the current range of wolverines. Whether wolverines once existed as established populations in any of these regions is uncertain, but the current climate appears to preclude their presence as reproducing populations now, and the sparse historical record of wolverine presence in this area makes historic occupation of these areas by wolverine populations doubtful. It is our conclusion that the ecosystem that supports wolverines does not exist in these areas currently, and may never have existed in the past.

Large areas of habitat with characteristics suitable for wolverines still occur in the southern Rocky Mountains and Sierra Nevada, despite the extirpation of wolverines from those areas (Aubry et al. 2007, p. 2154, Brock et al. 2007, p. 26; Copeland et al. 2010, Figure 1). Wolverine extirpations in these areas were coincident with systematic predator eradication efforts in the early 1900s, which have been discontinued for many years. Each of these areas has received at least one and possibly more migrants from adjacent populations in the northern Rocky Mountains; however, there is no evidence that females have migrated to these areas or that populations of wolverines exist in them (Aubry et al. 2007, Table 1; Moriarty et al. 2009, entire; Inman et al. 2009, entire).

We conclude that areas of wolverine historical occurrence can be placed in one of three categories: (1) areas where wolverines are extant as reproducing and potentially self-sustaining populations (North Cascades, northern Rocky Mountains); (2) areas where wolverines historically existed as reproducing and potentially self-sustaining populations prior to human-induced extirpation, and where reestablishment of those populations is possible given current habitat condition and management (the Sierra Nevada Mountains in California and southern Rocky Mountains in Colorado, New Mexico, Wyoming, and Utah); and (3) areas where historical presence of wolverines in reproducing and potentially self-sustaining populations is doubtful, and where the current habitat conditions preclude the establishment of populations (Great Plains, Midwest, Great Lakes, and Northeast). We, therefore, consider the current range of wolverines to include suitable habitat in the North Cascades of Washington and possibly Oregon, the northern Rocky Mountains of Idaho, Wyoming, and Montana, the southern Rocky Mountains of Colorado, Utah, and Wyoming, and the Sierra Nevada of California. We here include the Sierra Nevada and southern Rocky Mountains in the current range of wolverines despite the probability that functional populations do not exist in these areas. They are included due to the known existence of one individual in each area and the possibility that more, as yet undetected, individuals inhabit these areas.

## Population Estimates/Status:

Wolverines naturally occur in low densities of about 1 wolverine per 150 km2 (58 mi2) with a reported range from 1 per 65 to 337 km2 (25 to 130 mi2) (Hornocker and Hash 1981, pp. 1292-1295; Hash 1987, p. 578; Copeland 1996, pp. 31-32; Copeland and Yates 2006, p. 27; Inman et al. 2007a, p. 10; Squires et al. 2007, p. 2218). No systematic population census exists over the entire current range of wolverines in the contiguous United States, so the current population level and trends remain unknown. However, based on our current knowledge of occupied wolverine habitat and wolverine densities in this habitat, it is reasonable to estimate that the wolverine population in the contiguous United States numbers approximately 250 to 300 individuals (Inman 2010b, pers. comm.). The bulk of the current population occurs in the northern Rocky Mountains with a few individuals in the North Cascades and one known individual each in the Sierra Nevada and southern Rocky Mountains. Within the area known to currently have wolverine populations relatively few wolverines can coexist due to their naturally low population densities, even if all areas were occupied at or near carrying capacity. Given the natural limitations on wolverine population density, it is likely that historic wolverine population numbers were also low (Inman et al. 2007a, Table 6). Because of these natural limitations, we believe that densities and population levels in the northern Rocky Mountains and North Cascades where populations currently exist are likely not substantially lower than population densities were in these areas prior to European settlement. However, historically, the contiguous U.S. population would have been larger than it is today due to the larger area occupied by populations when the southern Rocky Mountains and Sierra Nevada were occupied at full capacity.

## Distinct Population Segment(DPS):

Under our DPS policy, three elements are considered in a decision regarding the status of a possible DPS as endangered or threatened under the Act. These are applied similarly for additions to the list of endangered and threatened species, reclassification, and removal from the list. They are: (1) Discreteness of the population segment in relation to the remainder of the taxon; (2) the biological or ecological significance of the population segment to the taxon to which it belongs; and (3) the population segment's conservation status in relation to the Act's standards for listing (i.e., whether the population segment is, when treated as if it were a species or subspecies, endangered or threatened). Discreteness refers to the degree of isolation of a population from other members of the species, and we evaluate this based on specific criteria. If a population segment is considered discrete, we must consider whether the discrete segment is "significant" to the taxon to which it belongs by using the best available scientific and commercial information. If we determine that a population segment is both discrete and significant, we then evaluate it for endangered or threatened status based on the Act's standards. The DPS evaluation in this assessment concerns the segment of the wolverine species occurring within the 48 States, including the northern and southern Rocky Mountain physiographic provinces, Sierra Nevada Range, and North Cascades Range.

Distinct Population Segment Analysis for Wolverine in the Contiguous United States

Analysis of Discreteness

Under our DPS Policy, a population segment of a vertebrate species may be considered discrete if it satisfies either one of the following conditions: (1) It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors (quantitative measures of genetic or morphological discontinuity may provide evidence of this separation); or (2) it is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act (inadequacy of existing regulatory mechanisms). The wolverine within the contiguous United

States meets the second DPS discreteness condition because of differences in conservation status as delimited by the Canadian-U.S. international governmental boundary.

Discreteness Based on the International Border—Differences in Conservation Status

We find that differences in conservation status of the wolverine between the United States and Canada are substantial and significant in light of section 4(a)(1)(D) of the Act. In the remaining current range in Canada-Alaska, wolverines exist in well-distributed, interconnected, large populations. Conversely, wolverine populations in the remaining U.S. range appear to be at numbers so low that their continued existence could be at risk, especially as considered in light of the five threat factors discussed below. These risks come from three main factors: (1) small total population size; (2) effective population size below that needed to maintain genetic diversity and demographic stability; and (3) the fragmented nature of wolverine habitat in the contiguous United States that results in smaller, isolated “sky island” patches separated by unsuitable habitats. It is apparent that maintaining wolverines within their native range in the contiguous United States into the future is likely to require regulatory mechanisms that are not currently in place. These three factors are explained in more detail below.

The total population sizes for Canada-Alaska and the contiguous United States differ by more than an order of magnitude. The contiguous U.S. population likely numbers approximately 250 to 300 individuals (Inman 2010b, pers. comm.). This contrasts with western Canada, where wolverine populations are estimated at 15,089 to 18,967 individuals (COSEWIC 2003, p. 22). Wolverine population size in Alaska is unknown; however, the average annual harvest exceeds 500 individuals and the population does not appear to be in decline (Alaska Department of Fish and Game 2004, entire), indicating that the population is likely to number over ten thousand individuals (calculated using demographic data in Lofroth and Ott 2007, pp. 2196-2198; assumes sustainable harvest). The difference in total population size coincides with the international boundary between the contiguous United States and Canada. Wolverine populations number 2,089-3,567 in British Columbia and 1,500–2,000 in Alberta (COSEWIC 2003, p. 22), the two provinces immediately adjacent to the contiguous U.S. wolverine population. The difference in total population sizes is significant because critically small populations such as those in the contiguous United States face higher extinction risk than large ones such as the Canada-Alaska population. Therefore, the contiguous U.S. population is more vulnerable to extinction, and thus of poor conservation status, relative to the more secure Canada-Alaska population.

Wolverines in Canada’s eastern provinces are listed under the Species at Risk Act of Canada. Wolverines in the eastern provinces appear to have been extirpated by the early 20th century (COSEWIC 2003, p. 20). There is a general lack of reliable historic information on wolverines in this area, and significant doubt exists about whether a population ever occurred there historically (COSEWIC 2003, p. 20). For the purposes of this assessment, we considered the Canadian wolverine population to include only wolverines from Ontario west to the Pacific coast and Alaska, and assumed that wolverines in eastern Canada were either extirpated or are at such low numbers as not to be part of a functioning population. It is our determination that the conservation status of the eastern population, if it does indeed exist, is not relevant to the discreteness analysis for this DPS for the following reasons: (1) if wolverines currently reside in the eastern Canadian Provinces, they are likely disjunct from wolverines in western Canada (COSEWIC 2003, Figure 3); and (2) there is significant doubt that wolverine populations existed in this part of Canada historically, so the current lack of evidence of a population may not represent a degradation of species status in this area (COSEWIC 2003, pp. 20-21).

The second substantial difference in wolverine status between the contiguous United States and Canada is reflected in the size of the effective populations. Population ecologists use the concept of a population’s “effective” size as a measure of the proportion of the actual population that contributes to future generations (for a review of effective population size, see Schwartz et al. 1998, entire). In a population where all of the individuals contribute offspring equally, effective population size would equal true population size. For populations where contribution to the next generations is often unequal, effective population size will be smaller than the true or "census" population size. The smaller the effective population size, the more reproduction is dominated by a few individuals. Effective population size is important because it determines rates of loss of genetic variation, fixation of deleterious alleles and the rate of inbreeding. Populations with small effective population sizes show reductions in population growth rates and increases in extinction probabilities (Leberg 1990, p. 194; Jimenez et al. 1994, pp. 272-273; Newman and Pilson 1997, p. 360; Saccheri et al. 1998, p. 492; Reed and Bryant 2000, p. 11; Schwartz and Mills 2005, p. 419; Hogg et al. 2006, p. 1495, 1498; Allendorf and Luikart 2007, pp. 338-342). Franklin (1980, as cited in Allendorf and Luikart 2007, p. 359) proposed an empirically based general rule suggesting that for short-term (a few generations) maintenance of genetic diversity, effective population size should not be less than 50. For long-term (hundreds of generations) maintenance of genetic diversity, effective population size should not be less than 500 (for appropriate use of this rule and its limitations see Allendorf and Luikart 2007, pp. 359-360). Others suggest that even higher numbers are required to ensure that populations remain viable, suggesting that long-term connectivity to the reservoir of genetic resources in the Canadian population of wolverines will be required (Traill et al. 2010, p. 32).

Wolverine effective population size in the largest extant population in the contiguous United States is exceptionally low (Schwartz personal communication 2007, entire) and is below what is thought necessary for short-term maintenance of genetic diversity. Effective population size for wolverines in the Rocky Mountains averaged 39 (Schwartz personal communication 2007, entire) (this study excluded the small population from the Crazy and Belt Mountains (hereafter "CrazyBelts") as they may be an isolated population, which could bias the estimate using the methods of Tallmon et al. (2007, entire)). Measures of the effective population sizes of the other populations in the contiguous United States have not been completed, but given their small census sizes, their effective sizes are expected to be smaller than for the northern Rocky Mountain population. Thus, wolverine effective population sizes are very low. For comparison, estimates of wolverine effective population size are bracketed by estimates of effective population sizes for critically endangered species like the black-footed ferret (4.10) (Wisely et al. 2007, p. 3) and ocelots (2.9 to 13.9) (Janecka et al. 2007, p. 1), but substantially smaller than estimates for the Yellowstone Grizzly bear (greater than 100), which has reached the level of recovery under the Act (Miller and Waits 2003, p. 4338). Therefore, we conclude that effective population size estimates for wolverines do not suggest that populations are currently critically endangered, but they do suggest that populations are low enough that they could be vulnerable to loss of genetic diversity, and may require intervention in the future to remain viable.

The concern with the low effective population size is highlighted in recent research that determined that, absent immigration, at least 400 breeding pairs would be necessary to sustain long-term genetic viability of the contiguous U.S. wolverine population (Cegelski et al. 2006, p. 197). However, the entire population is likely 250–300 (Inman 2010b, pers. comm.), with a substantial number of these being nonbreeding subadults. Furthermore, the U.S. population appears to be split into at least five smaller subpopulations (Northern Cascades, CrazyBelts, Idaho, Greater Yellowstone Ecosystem, and Northern Montana) that are semi-isolated from each other, meaning that genetic exchange does not occur frequently enough to prevent genetic drift (changes in genetic composition due to random sampling in small populations) and loss of genetic diversity (Cegelski et al. 2006, p. 206) further reducing the effective population size. Based on available scientific and commercial information, it does not appear that any of the wolverine populations that historically existed in the contiguous United States would have had effective population sizes approaching 400 animals. Therefore, it is likely that connectivity to Canadian populations to the north would have been necessary to maintain genetic diversity in these populations prior to European settlement.

The concern that low effective population size may result in negative effects is already being realized for the contiguous U.S. population of wolverine. Genetic drift has occurred in the remaining populations in the contiguous United States: wolverines here contain 3 of 13 haplotypes (sets of closely linked genetic markers that are inherited together) found in Canadian populations (Kyle and Strobeck 2001, p. 343; Cegelski et al. 2003, pp. 2914-2915; Cegelski et al. 2006, p. 208; Schwartz et al. 2007, p. 2176; Schwartz et al. 2009, p. 3229). The haplotypes found in these populations are a subset of those in the larger Canadian population, indicating that genetic drift had caused a loss of genetic diversity. A single haplotype dominates the northern Rocky Mountain wolverine population, with 71 of 73 wolverine sampled expressing that haplotype (Schwartz et al. 2007, p. 2176). The reduced number of haplotypes indicates not only that genetic drift is occurring, but also that there is some level of genetic separation; if these populations were freely interbreeding, they would share more haplotypes. The reduction of haplotypes is likely a result of small population size and the fragmented nature of wolverine habitat in the United States and is consistent with an emerging pattern of reduced genetic variation at the southern edge of the range documented in a suite of boreal forest carnivores (Schwartz et al. 2007, p. 2177). Whether or not the wolverine population in the contiguous United States has suffered any deleterious effects due to this reduction in genetic diversity is unknown. However, based on principles of conservation genetics, we do expect that reduced genetic diversity would make this population more vulnerable to other threats due to reduced genetic resiliency and reduced ability to adapt to change (Allendorf and Luikart 2007, pp. 338-342).

No effective population size estimate exists for populations in Canada or Alaska; however, because of the large and contiguous nature of the population and the relatively high genetic diversity in Canada and Alaska, there is a reasonable scientific basis to conclude that the effective population size is large enough that it is not a cause for conservation concern. None of the Canadian or Alaskan populations tested show signs of genetic drift or inbreeding. This information indicates that the population does not have a low effective population size.

Reduced genetic diversity and low effective population sizes result in high extinction risk in animal populations (Frankham 1995, p. 795). The fragile nature of wolverine populations in the contiguous United States contrasts with Canada and Alaska where wolverines are relatively abundant and exist in habitats with a high level of connectivity (COSEWIC 2003, p.8; Slough 2007, p. 78).

The third substantial difference in wolverine status between the contiguous United States and Canada is reflected by the amount and distribution of available habitat for the species. Habitat in the contiguous United States consists of small isolated “islands” of high-elevation alpine habitats separated from each other by low valleys of unsuitable habitats. Habitat islands are represented by areas containing spring snow (Copeland et al. 2010, Figure 2). Wolverine range in the contiguous United States is characterized by isolated mountain habitats dissected by lower-elevation valleys, while habitat in adjoining Canada comprises mostly large blocks of contiguous habitat (Copeland et al. 2010, Figure 2; Copeland 2010, pers. comm.). Wolverines occupy habitat at high elevations, generally above 2,100 m (6,888 ft), in the mountains of the contiguous United States. The intervening valleys in this area range from 975 m to 1,500 m (3,198 ft to 4,920 ft), and are dominated by ecosystems that are unsuitable for long-term wolverine presence, but do serve as routes for wolverine movement between suitable habitat patches. Intermountain valleys are increasingly becoming the sites of human residential and commercial developments and transportation corridors. The large distances between suitable wolverine habitats results in wolverines existing on an archipelago of suitable habitats in a sea of unsuitable habitat. The low population density and genetic diversity of wolverines in this area requires that exchange of individual wolverines between islands of habitat occurs to avoid inbreeding or local extinction due to demographic stochasticity.

Wolverine populations in the Canadian Rocky Mountains also exist on habitat islands, but the islands are much larger, so that exchange of individuals is less critical for demographic and genetic stability. Further north in Canada, where cold snowy conditions occur at lower elevations, wolverines inhabit lower elevations and valley bottom habitats (COSEWIC 2003, pp. 7-8). In the far north of Canada, wolverine habitat extends into low-elevation valleys and the vast expanses of low-elevation boreal forest and tundra. For these reasons, exchange of wolverines between habitat islands in the Canadian Rocky Mountains is both more likely to occur and less critical for the long-term maintenance of those populations.

In the contiguous United States, wolverines must cross unsuitable habitats to achieve connectivity among subpopulations, which is required to avert further genetic drift and loss of genetic diversity (Kyle and Strobeck 2002, p. 1148; Cegelski et al. 2006, pp. 208-209; Schwartz et al. 2009, p. 3230). The highly fragmented nature of the habitat in the contiguous United States contributes to the low effective population size for wolverines in this area, making the continued persistence of the population precarious relative to the Canadian-Alaskan population. Habitats in Canada and Alaska exist in larger contiguous blocks that have few or no impediments to demographic or genetic connectivity with peripheral smaller blocks (Copeland et al. 2010, Figure 2). The fragmented nature and distribution of wolverine habitat in the contiguous United States results in a population that is highly vulnerable to extirpation because of lack of connectivity between subpopulations, it also makes them more vulnerable to external threats such as those analyzed under the five threat factors below.

Conservation status of wolverines in the contiguous United States differs significantly with that of the Canada-Alaska population. The Canada-Alaska population is large, well-connected, and exists in large blocks of contiguous habitat. In contrast, the population in the contiguous United States is small in total size and is fragmented on small patches of suitable habitat that are separated by large areas of unsuitable habitat. These differences result in a Canada-Alaska population that is robust and better able to respond to habitat changes, while the contiguous United States population is vulnerable to changes in habitat or management. We believe that the differences in conservation status between the contiguous United States and Canada are significant in light of section 4(a)(1)(D) of the Act (inadequacy of existing regulatory mechanisms) because they reveal that the existing mechanisms in Canada are sufficient to maintain wolverine, while in the United States, the existing regulatory mechanisms are not sufficient to address the biological conservation concerns.

Legal Status Conveyed by National, State, and Provincial Governments

The United States currently confers no Federal status on the wolverine. Each State regulates the species relative to its existing populations. In Washington, the wolverine is listed as State Endangered (Washington Department of Fish and Wildlife 2010, entire). Idaho and Wyoming designate it as a protected nongame species (Idaho Fish and Game 2010, p. 4; Wyoming Game and Fish 2005, p. 4), and Montana regulates it as a furbearer (Montana Department of Fish, Wildlife, and Parks 2010, entire). Oregon, while currently not considered to have any individuals other than possible unsuccessful dispersers, has a closed season on trapping of wolverines. California and Colorado currently each have only one confirmed wolverine, and the States do not allow harvest.

The Canadian Government has listed its Eastern population of wolverine as Endangered under the Species at Risk Act (SARA) in Quebec and Labrador, where it may be extirpated due to trapping and hunting and declining caribou herds (Government of Canada 2010, entire). Because wolverines appear to have been extirpated from this area since the early part of the century and their historical status as a viable population is uncertain, we do not consider it to be in the current range, and thus consider the species' status there not relevant to the question of whether significant differences in status exist between the two countries. The Western population of wolverines occurs in eight Provinces, two of which (British Columbia and Alberta) are contiguous to the wolverine range in the United States. This population in Canada has no status under SARA, but has a designation of Special Concern (Vulnerable) under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Government of Canada 2010, entire), a status that does not provide legal protections. British Columbia and Alberta have Provincial species conservation lists, which are priority-setting tools for establishing baseline ranks and conservation activities (Province of British Columbia 2002, p. 1). Both Provinces include the wolverine on their provincial "blue list," indicating that it may be at risk (Peterson 1997, p. 1), except on Vancouver Island where the wolverine is possibly extirpated and is "red listed" (threatened, endangered, or candidate; not harvested) (Lofroth and Ott 2007, p. 2193; Province of British Columbia 2002, p. 2).

In our 2008 12-month finding, we determined that differences in management status conveyed by the States and Provinces that regulate wolverine management were not significantly different from each other, as States and Provinces both allowed regulated harvest and there were a variety of regulatory mechanisms in each.

Regulatory status in the Canadian Provinces and U.S. States regulatory status remains unchanged, and we continue to find no significant difference between the legal status of wolverines between Canada and the United States.

While similarities exist in the legal conservation statuses bestowed on the wolverine in the four U.S. States where it currently persists, and the two adjacent Canadian Provinces, the differences in biological conservation status are significant and affect the future of the species. In western Canada, the wolverine has no protection under SARA; in the United States the wolverine currently has no status under the Act. This allows piecemeal management by States and Provinces with little regard for regional management directed at the continued existence of the species in the contiguous United States.

Because British Columbia and Alberta are contiguous to a larger, and more robust, portion of the wolverine’s range in northwestern Canada, documented declines in wolverine populations (likely due to harvest levels) in the southern portions of both Provinces have not raised the status of the species to a level of concern that would result in its consideration for status under SARA (Lofroth and Krebs 2007, pp. 2164-2165; Lofroth and Ott 2007, p. 2193; Peterson 1997, pp. 4-5).

Differences in Control of Exploitation

Significant differences exist in control of exploitation between the United States and Canadian wolverine populations. U.S. populations are largely not harvested, with the exception of a carefully controlled and very limited harvest in Montana; while in Canada, harvest is widespread throughout the provinces within the current range. British Columbia has a 3- to 4-month trapping season with no provincial quota, while adjacent Washington considers the species State Endangered and allows no trapping. Alberta allows a 3-month trapping season with quotas in 6 of its 8 fur management zones for an annual average harvest of 37 (zones 7 and 8 in Alberta are closed to trapping but are outside the species’ normal range and so the closure is of little conservation consequence (Province of Alberta 2007, entire)), while adjacent Montana allows up to a 2.5-month hunting and trapping season with a total quota of 5 wolverines (maximum of 3 females).

Although we do not have comprehensive numbers of the annual wolverine harvest in Canada, we have estimated a total annual harvest of 719 animals (see Table 2) based upon the best information available to us. Based on available information, we presume this to be an underestimate, because it is based upon reported harvests, which, for Canadian territories, likely accounts for only one-fifth to one-third of the total harvest because of heavy unreported harvest and use by local communities (Melchoir et al. 1987 as cited in Banci 1994, p. 101).

Table 2. Estimated annual wolverine harvest in Canada.

| Province or Territory | Estimated Annual Harvest | Source |
|---|---|---|
| British Columbia | 175 | Lofroth and Ott, 2007, pp. 2196-2197 |
| Alberta | 37 | Province of Alberta 2006, p. 14 |
| Saskatchewan | 10 | COSEWIC 2007, Table 1 |
| Manitoba | 48 | COSEWIC 2007, Table 1 |
| Ontario | 8 | COSEWIC 2007, Table 1 |
| Yukon | 150 | COSEWIC 2007, Table 1 |
| Northwest Territories | 209 | COSEWIC 2007, Table 1* |
| Nunavut | 82 | COSEWIC 2007, Table 1^ |
| Total | 719 | |

* corrected to adjust for majority being unreported in pelt production statistics
^ corrected using Dumond and Krizan 2002 as cited in COSEWIC 2007 p. 17

Based upon these numbers, we conservatively estimate that harvest in Canada is a minimum of 4.7 percent of the population annually. This estimate is nearly three times the amount of harvest in the United States, which is approximately 5 animals of 300, or 1.6 percent. We find that this nearly 300 percent difference is significant, because the wolverine is sensitive to even small increases in mortality rates (Squires et al. 2007, p. 2218). Human-caused mortality of wolverines is likely additive to natural mortality due to the low reproductive rate and relatively long life expectancy of wolverines (Krebs et al. 2004, p. 499; Lofroth and Ott 2007, pp. 2197-2198; Squires et al. 2007, pp. 2218-2219).

These differences may be significant in light of section 4(a)(1)(D) of the Act, because they show that regulatory mechanisms are necessary in the United States and Canada to ensure that the contiguous U.S. population continues to receive migrants from the genetically richer Canadian population. However, the differences in control of exploitation favor the U.S. population, which is the population that is potentially at risk. In Canada, no such mechanisms are currently needed to protect the species. About 15,000 to 19,000 wolverines occur in western Canada where suitable habitat is plentiful (COSEWIC 2003, pp. 14-21). Because of this abundance of habitat, conservative management and careful geographic control of harvest are not necessary to conserve wolverines in western Canada. This situation contrasts with the situation in the United States, where habitat is fragmented and wolverine populations are limited to high elevations over portions of four States (Washington, Idaho, Montana, and Wyoming). Because differences in control of exploitation exist, but control favors the at-risk population, we do not rely on control of exploitation to establish discreteness.

Summary for Discreteness

The international boundary between Canada and the United States currently leads to division of the control of exploitation and conservation status of the wolverine. This division is significant because it allows for potential extirpation of the species within the contiguous United States through loss of small populations and lack of demographic and genetic connectivity of the two populations. This difference in conservation status is likely to become more significant in light of threats discussed in the five factors analyzed below. Therefore, we find that the difference in the conservation statuses in Canada and the United States result in vulnerability to the significant threats (discussed below) in the U.S. wolverine population but not for the Canadian population. Existing regulatory mechanisms are inadequate to ensure the continued existence of wolverines in the contiguous United States in the face of these threats. Therefore, it is our determination that the difference in conservation status between the two populations is significant in light of section 4(a)(1)(D) of the Act, because existing regulatory mechanisms appear sufficient to maintain the robust conservation status of the Canada-Alaska population, while existing regulatory mechanisms in the contiguous United States are insufficient to protect the wolverine from threats due to its depleted conservation status. As a result, the contiguous United States population of the wolverine meets the discreteness criterion in our DPS Policy (61 FR 4725). Consequently, we use the international border between the United States and Canada to define the northern boundary of the North American wolverine DPS.

Analysis for Significance

If we determine a population segment is discrete, its biological and ecological significance will then be considered in light of Congressional guidance that the authority to list DPS's be used sparingly while encouraging the conservation of genetic diversity. In carrying out this examination, we consider available scientific evidence of the population's importance to the taxon to which it belongs (i.e., the North American wolverine (Gulo gulo luscus). Our DPS policy states that this consideration may include, but is not limited to: (1) persistence of the discrete population segment in an ecological setting unusual or unique for the taxon; (2) evidence that loss of the discrete population segment would result in a significant gap in the range of the taxon; (3) evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range; or (4) evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics. Below we address Factors 1, 2, and 4. Factor 3 does not apply to the continental U.S. wolverine population because North American wolverines are distributed widely across Alaska and Canada.

## Significant Gap in the Range of the Taxon

Loss of wolverines in the contiguous United States would represent a significant gap in the range of the taxon. Wolverines once lived throughout the North American Rocky Mountains from Alaska and Canada, south through Colorado and into New Mexico, and in the North Cascades of Washington and the Sierra Nevada Range of California—an extent covering approximately 38º of latitude. Wolverines were extirpated from most of the southern portions of their historic range, including all of the Sierra Nevada in California and all of Colorado, and possibly even the North Cascades and northern Rocky Mountains in the early 20th century (Aubry et al. 2007, Table 1), a loss of approximately 15º of latitude. The wolverines that have moved to California and Colorado in the past 2 years (Moriarty et al. 2009, Figure 1; Inman et al 2009, pp. 22-25) may represent the initial attempts to recolonize the southernmost extent of the species' historic range and a continuation of a recolonization of the contiguous United States that began in the 1930s (Aubry et al. 2007, Table 1). Based on the current scientific information, we conclude that there is at least one wolverine each in the Sierra Nevada and southern Rocky Mountains. Both of these animals are males that dispersed from known populations rather than being from undiscovered remnant populations native to the regions in question, and there is no reason to believe that functional populations exist in these areas. Today, the contiguous United States represents the southernmost reach of the wolverine's range. The loss of this population would be significant because it would substantially curtail the range of the wolverine by moving the southern range terminus approximately 15º of latitude to the north (or approximately 40 percent of the latitudinal extent of wolverine range) and eliminate wolverines from the fauna of the contiguous United States. Therefore, the loss of this population would result in a significant gap in the range of the taxon. The estimated area that would be lost from wolverine range in North America if the contiguous U.S. population was extirpated is 205,942 $km^2$ (79,515 mi2) based on the habitat model developed by Copeland et al. (2010, entire; Copeland 2010, pers. comm.).

Given the wolverine's historic occupancy of the contiguous United States and the portion of the historic range they represent, maintenance and recovery of wolverines in their current range would provide some security for the rest of the taxon if conditions in Canada and Alaska deteriorated to the point that wolverines become endangered there. Populations on the periphery of species' ranges tend to be given lower conservation priority because they are thought to exist in low-quality habitats, and are also thought to be the populations that are least likely to survive a reduction in range (Wolf et al. 1996, p. 1147). However, this tendency presumes that the ultimate cause of the species' extinction will be one that operates by eroding away the species' range beginning at the periphery and progressing to the center. This presumption is based on biogeographical information that habitat and population densities of species are highest near the center of the species' range, and decline near the edge (Brown and Lomolino 1998, Figure 4.16). Data from real range collapses of species from around the world illustrate that species' ranges tend to collapse to peripheral areas rather than to the center of their historic ranges (Lomolino and Channell 1995, p. 342; Channell and Lomolino 2000, pp. 84-86). Of 96 species whose last remnant populations were found either in the core or periphery of their historic range (rather than some in both core and periphery), 91 (95 percent) of the species were found to exist only in the periphery, and 5 (5 percent) existed solely in the center (Channell and Lomolino 2000, p. 85). Available scientific data support the importance of peripheral populations for conservation (Fraser 1999, entire; Lesica and Allendorf 1995, entire).

Based upon the 15 degree latitude gap that would result in the range of the wolverine if the U.S. population was lost, we determine that the loss of the contiguous U.S. wolverine population would result in a significant gap in the range of the taxon. Thus, the population meets the definition of significant in our DPS policy.

## Unusual or Unique Ecological Setting

Wolverines in the contiguous United States exist in an ecosystem that requires extensive movements between habitats to maintain demographic viability and genetic diversity. Within the range of North American wolverines, the northern Rocky Mountains and North Cascades have the highest diversity of large predators and native ungulate prey species, which results in complex ecological interaction among ungulate prey, predators, scavenger groups, and vegetation (Smith et al. 2003, pp. 330-339). In the proposed DPS area, wolverines share habitats with gray wolves (Canis lupus), black bears (Ursus americanus), grizzly bears (Ursus arctos horribilis), puma (Felis concolor), lynx (Lynx canadensis), coyotes (Canis latrans), badgers (Taxidea taxus), bobcats (Felis rufus), fishers (Martes pennanti), and martens (Martes americana). The unique and diverse assemblage of native prey, and sources of carrion, for these carnivores include elk (Cervus elaphus), mule deer (Odocoileus hemionus), white-tailed deer (Odocoileus virginianus), moose (Alces alces), woodland caribou (Rangifer caribou), bighorn sheep (Ovis canadensis), mountain goats (Oreamnos americanus), pronghorn (Antilocapra americana), bison (Bison bison) (only in the Greater Yellowstone Area), and beaver (Castor canadensis).

Despite the fragmented nature of the habitat and the high diversity of prey, wolverines in the contiguous United States appear to use habitat attributes that are similar to wolverine populations range-wide (Copeland et al. 2010, entire), and do not appear to exist in an unusual or unique ecological setting. Thus, we did not rely on this factor when determining that the wolverine in the United States is significant to the taxon as a whole.

Marked Genetic Differences

Several genetics studies have confirmed genetic differentiation between wolverines in the contiguous United States and those in Canada and Alaska (Cegelski et al. 2006, pp. 203-205; Kyle and Strobeck 2002, p. 342; Schwartz et al. 2007, p. 2175). The U.S. Rocky Mountain populations group together in mitochondrial DNA (mtDNA) analyses (Schwartz et al. 2007, p. 2176). The primary genetic difference is a reduction of diversity in the United States as compared with Canada so that the contiguous U.S. populations contain a subset of the genetics of the Canada-Alaska population (Cegelski et al. 2006, p. 200; Schwartz et al. 2007, p. 2172). The contiguous U.S. populations contain 3 mtDNA haplotypes and Canada-Alaska samples also contain those three haplotypes plus ten more. Idaho has substantially lower heterozygosity (a measure of the genetic variation in a population) (42 percent) than the nearest Canadian population (61 percent) sampled only 700 km (435 mi) away (Kyle and Strobeck, 2001, p. 341, 345). Genetic structure in the contiguous United States indicates that population fragmentation caused by either natural or anthropogenic factors, has reduced gene flow between populations, and that genetic drift has occurred and may still be occurring (Kyle and Strobeck 2001, p. 343; Cegelski et al. 2003, pp. 2914-2915; Cegelski et al. 2006, p. 208). This reduced genetic diversity and gene flow coincides with the international border and indicates that individuals are not passing freely between Canadian and U.S. populations (Schwartz et al. 2009, pp. 3229-3230). Four wolverine subpopulations have been identified within Montana based on genetic data (Cegelski et al. 2003, p. 2913; Guillot et al. 2005, p. 1274). Subsequent work suggests that Montana may contain a single population that is genetically structured by both distance and ecological factors meaning that wolverines across their range in Montana occasionally exchange individuals but do not freely interbreed because of the great distances and frequent unsuitable habitat that separates populations (Schwartz et al. 2009, p. 3227).

The levels of gene flow in the contiguous United States are low compared to wolverines in Alaska and Northern Canada (Kyle and Strobeck 2001; 2002, pp. 343-345), indicating that habitat in the contiguous United States is much more fragmented than habitats further north in Canada and Alaska (Schwartz et al. 2009, p. 3227). A distinct break was identified between the U.S. population and the Canadian populations (Cegelski et al. 2006, p. 203; Schwartz et al. 2009, pp. 3229-3230). Similarly, Schwartz et al. (2007, p. 2176) found that wolverines in Idaho, Montana, and Wyoming have few haplotypes (2 in the main Rocky Mountain group, plus 1 identified by Cegelski et al. 2006 in north-central Montana) compared to 13 distinct haplotypes in Canada, despite greater numbers of samples collected in the contiguous United States. Of these two haplotypes found by Schwartz, one is predominant, with 71 of 73 samples containing this haplotype (Schwartz et al. 2007, p. 2176).

The genetic differences between the U.S. and Canadian wolverine populations identified above are the result of loss of genetic diversity, either through genetic drift or founder effects. The differences consist of lower genetic diversity in the United States, a difference that is of conservation concern because it reflects loss of genetic diversity through inbreeding. This is not the kind of genetic difference that would lead us to conclude that a population is significant under our DPS policy. That policy is designed to ensure the protection of rare or unique biological diversity rather than mere differences in gene frequencies. Therefore, we do not rely on marked genetic differences in our determination of significance for this DPS.

Summary for Significance

We conclude that the wolverine population in the contiguous United States is significant because its loss would result in a significant gap in the range of the taxon.

Summary of the Distinct Population Segment Analysis

We conclude that the wolverine population in the contiguous United States is both discrete and significant under our DPS policy. Conservation status of wolverines in the contiguous United States is less secure than wolverines in adjacent Canada due to fragmented habitat, small population size, reduced genetic diversity, and their vulnerability to threats analyzed in this assessment. Loss of the contiguous U.S. wolverines would result in a significant gap in the range of the taxon. Therefore, we determine that the wolverine in the 48 States, as currently described, meets both the discreteness and significance criteria of our DPS policy, and is a listable entity under the Act. We now consider the conservation status of this DPS.

# Threats

## A. The present or threatened destruction, modification, or curtailment of its habitat or range:

Under Factor A we will discuss a variety of impacts to wolverine habitat including: (1) Climate change, (2) human use and disturbance, (3) dispersed recreational activities, (4) infrastructure development, (5) transportation corridors, and (6) land management. Many of these impact categories overlap or act in concert with each other to affect wolverine habitat. Climate change is discussed under Factor A because although climate change may affect wolverines directly by creating physiological stress, the primary impact of climate change on wolverines is expected to be through changes to the availability and distribution of wolverine habitat.

Two efforts to map wolverine habitat in the contiguous United States have been completed, although only one has been peer-reviewed (Brock et al. 2007, entire; Copeland et al. 2010, entire). As the single peer reviewed source, we rely on Copeland et al. (2010, entire) and supplemental information about that publication supplied in Copeland (pers. comm. 2010, p. 1) unless specified otherwise. We also report some statistics from the Brock et al. (2007) analysis because the authors report habitat broken down by land ownership whereas Copeland et al. (2010) do not. Both the Copeland et al. (2010) and Brock et al. (2007) analyses largely agree on the location of wolverine habitat within their geographic area of overlap; however, Brock et al. (2007) tends to be more inclusive and hence habitat area estimates for their model tend to be somewhat larger than for Copeland et al. (2010). Within the three States that currently harbor wolverines in the northern Rocky Mountains (Montana, Idaho, and Wyoming), an estimated 104,363 km2 (40,295 mi2) of wolverine habitat exists (Copeland 2010, pers. comm.). Based on the habitat model developed by Brock et al. (2007), 95 percent (120,000 km2; 46,332 mi2) is in Federal ownership with the largest portion of that (108,969 km2; 42,073 mi2) managed by the U.S. Forest Service (Forest Service) (Inman 2007b, pers. comm.).

Reduction in Habitat due to Climate Change

Department of the Interior Secretarial Order Number 3289, issued September 14, 2009 (Department of the

Interior (DOI) 2009), provides guidance that DOI bureaus and offices shall ‘‘...[c]onsider and analyze potential climate change impacts when undertaking long-range planning exercises, setting priorities for scientific research and investigations, developing multi-year management plans, and making major decisions regarding potential use of resources under the Department’s purview.’’

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization and the United Nations Environment Program in response to growing concerns about climate change and, in particular, the effects of global warming. Although the extent of warming likely to occur is not known with certainty at this time, the IPCC has concluded that warming of the climate is unequivocal, and that continued greenhouse gas emissions at or above current rates will cause further warming (IPCC 2007, p. 30). Climate-change scenarios estimate that the mean air temperature could increase by more than 3 degrees Celsius (5.4 degrees Fahrenheit) by 2100 (IPCC 2007, p. 46). The IPCC also projects that there will very likely be regional increases in the frequency of hot extremes, heat waves, and heavy precipitation (IPCC 2007, p. 46), as well as increases in atmospheric carbon dioxide (IPCC 2007, p. 36).

We recognize that there are scientific uncertainties on many aspects of climate change, including the role of natural variability in climate. In our analysis, we rely both on synthesis documents (e.g., IPCC 2007; Karl et al. 2009) that present the consensus view of a very large number of experts on climate change from around the world, and on four analyses that relate the effects of climate changes directly to wolverines (Gonzalez et al. 2008, entire; Brodie and Post 2009, entire; McKelvey et al. 2010b, entire; Peacock 2011, entire). McKelvey et al. (2010b) is the most sophisticated analysis so far available of climate change effects to wolverines. This report is based on data from global climate models including both temperature and precipitation downscaled to reflect the regional climate patterns and topography found within the range of wolverines in the contiguous United States. The scale of representation of climate change impacts and projections is very important for wolverines because their habitat is dependent on small scale landscape features in mountain ranges such as changes in elevation and slope aspect. For this reason we believe the McKelvey et al. (2010) report represents the best scientific information available regarding the impacts of climate change to wolverine habitat for this assessment.

Peacock (2011) used global climate models to project changes in spring snow cover and summer air temperature across the range of the DPS. This analysis shows projected changes in these values only at very gross scales, this fact makes interpretation of the intensity and timing of actual reductions in wolverine habitat difficult to infer. Brodie and Post (2009) use correlation to infer historical impacts of climate changes on Canadian wolverine populations based on harvest returns, but do not provide predictions of the future effects of climate changes on wolverines or wolverine habitat. Their report is suggestive of likely negative impacts to wolverine populations from continued warming; however, they do not provide estimates of the scale or spatial extent of future impacts. The Brodie and Post (2009) paper has also received several published criticisms of its methods (McKelvey et al. 2010a, entire; Devink et al. 2010, entire). The authors responded to these criticisms, but the controversy remains (Brodie and Post 2010b, entire). The report by Gonzalez et al. (2008) was the first available wolverine climate change analysis; however, the methods used in the report took into account only changes in temperature and not precipitation. It is our determination that the reports by Brodie and Post (2009), Gonzalez et al. (2008), and Peacock (2011) are all broadly congruent with the conclusions of McKelvey et al. (2010b), however they are of less utility in this analysis because of the scale of their analysis, or lack of consideration of key variables.

Snowpack changes (and concomitant changes to wolverine habitat suitability) result from both changes in temperature (negative relationship) and changes in snowfall (positive relationship). Because many climate models predict higher precipitation levels associated with climate warming, the interaction between these two variables can be quite complex. Consequently, predictions about snow coverage that rely only on temperature projections are less reliable than those that rely on both temperature and precipitation. McKelvey et al. (2010b, entire) report projections for wolverine habitat and dispersal routes through the time interval from 2070 to 2099. Therefore, we use 2099 as the outer limit of the foreseeable future for climate change in this assessment.

Climate Effects to Wolverines

Across their worldwide distribution, wolverines are dependent on persistent spring snow cover for successful reproduction (Pulliainen 1968, pp. 338-341; Myrberget 1968, p. 115; Copeland 1996, pp. 93-94; Magoun and Copeland 1998, pp. 1315-1319; Aubry et al. 2007, p. 2153; Inman et al. 2007c, pp. 71-72; Copeland et al. 2010, entire). No records exist of wolverines denning anywhere but in snow, despite the wide availability of snow-free denning opportunities within the species' geographic range. The snow tunnel and complex structure associated with dens is likely required to protect young from interspecific and intraspecific predation (Persson et al. 2003, pp. 25-26; Magoun and Copeland 1998, p. 1318). A layer of deep snow may also add crucial insulation from cold temperatures and wind prevalent in denning habitat (Pulliainen 1968, p. 342; Bjärvall et al. 1978, p. 24-25; Copeland 1996, p. 100; Magoun and Copeland 1998, p. 1318).

Female wolverines have been observed to abandon reproductive dens when temperatures warm and snow conditions become wet (Magoun and Copeland 1998, p. 1316), indicating that the condition of the snow is also important to successful reproduction, and that the onset of spring snowmelt forces female wolverines to move kits into alternate denning sites with better snow conditions, if they are available. Female wolverines establish reproductive dens at elevations higher than those used by non-reproductive wolverines (Copeland 1996, p. 94; Magoun and Copeland 1998, pp. 1315-1316; Inman et al. 2007c, p. 71), suggesting that females find the conditions necessary for successful denning in the upper portion of their home range where snow is most persistent and occurs in the heaviest accumulations.

In the contiguous United States, wolverine year-round habitat is found at high elevations in conifer forests near treeline and in rocky alpine habitats such as cirque basins and avalanche chutes that have food sources such as marmots, voles, and carrion (Hornocker and Hash 1981, p. 1296; Copeland 1996, p. 124; Magoun and Copeland 1998, p. 1318; Copeland et al. 2007, p. 2211; Inman et al. 2007a, p. 11). In fact, the areas defined by persistent spring snow cover that wolverines use for denning also correspond closely to wolverine habitat use in the nonreproductive season; essentially, wolverines use the coldest available landscapes within their geographic range in the contiguous United States (Copeland et al. 2010, Figure 6), likely due to a physiological need for cooler temperatures during the warm season.

Mean seasonal elevations used by wolverines in the northern Rocky Mountains and North Cascades vary between 1,400 and 2,600 m (4,592 and 8,528 ft) depending on location, but are always relatively high on mountain slopes (Hornocker and Hash 1981, p. 1291; Copeland et al. 2007, p. 2207, Aubry et al. 2007, p. 2153). Elevation ranges used by historical wolverine populations in the Sierra Nevada and southern Rocky Mountains are unknown, but presumably wolverines used higher elevations, on average, than more northerly populations to compensate for the higher temperatures found at lower latitudes. In the contiguous United States, valley bottom habitat appears to be used only for dispersal movements and not for foraging or reproduction (Inman et al. 2009, pp. 22-28). Wolverine reproductive dens have been located in alpine, subalpine, taiga, or tundra habitat (Myrberget 1968, p. 115; Pulliainen 1968, pp. 338-341; Bjärvall 1982, p. 318; Lee and Niptanatiak 1996, p. 349; Landa et al. 1998, pp. 451-452; Magoun and Copeland 1998, pp. 1317-1318). Wolverines rarely, or never, den in lower elevation forested habitats, although they may occupy these habitats seasonally (Magoun and Copeland 1998, p. 1317).

Due to dependence of wolverines on deep snow that persists into late spring both for successful reproduction and for year-round habitat, and their restricted distribution in areas that maintain significant snow late into the spring season, we conclude that deep snow maintained through the denning period is an essential feature of wolverine habitat. Reduction of this habitat feature would reduce wolverine habitat proportionally.

Based on the information described above, we analyzed the effects of climate change on wolverines through three primary mechanisms: (1) Reduced snowpack and earlier spring runoff, which would reduce suitable habitat for wolverine denning; (2) increase in summer temperatures beyond the physiological tolerance of wolverines; and (3) ecosystem changes due to increased temperatures, which would move lower elevation ecosystems to higher elevations, eliminating high-elevation ecosystems on which wolverines depend and increasing competitive interactions with species that currently inhabit lower elevations. These mechanisms would tend to push the narrow elevational band that wolverines use up in elevation and, due to the conical structure of mountains, upward shifts would result in reduced overall suitable habitat for wolverines.

Reduced Snow Pack

Warmer winter temperatures are reducing snow pack in western North American mountains through 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; Mote 2003, p. 3-1; Christensen et al. 2004, p. 347; Knowles et al. 2006, pp. 4548-4549). This trend is expected to continue with future warming (Hamlet and Lettenmaier 1999, p. 1611; Christensen et al. 2004, p. 347; Mote et al. 2005, p. 48). Shifts in the initiation of spring runoff toward earlier dates 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). Earlier spring runoff leads to lack of snow or degraded snow conditions during April and May, the critical time period for wolverine reproductive denning. In addition, a feedback effect hastens the loss of snow cover due to the reflective nature of snow and the relative heat-absorbing properties of non-snow-covered ground. This effect leads to the highest magnitude of warming occurring 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). Due to the importance of deep snow cover in spring for wolverine reproduction, currently suitable habitat that lost this feature would be rendered unsuitable for wolverines.

Ecosystem Changes Associated with Climate Change

Changes in temperature and rainfall patterns are expected to shift the distribution of ecosystems northward (IPCC 2007c, p. 230) and up mountain slopes (McDonald and Brown 1992, pp. 411-412; Danby and Hik 2007, pp. 358-359, IPCC 2007c, p. 232). As climate changes over a landscape, the ecosystems that support wolverines are likely to move, tracking the change of temperature, but with a time lag depending on the ability of individual plant species to migrate (McDonald and Brown 1992, pp. 413-414; Hall and Fagre 2003, p. 138; Peterson 2003, p. 652). Wolverines in the contiguous United States, due to their reliance on mountainous habitat, will most likely adjust to climate changes by using higher elevations on mountain slopes, not by shifting their latitudinal distribution. Along a latitudinal gradient through the historic distribution of wolverines, records tended to be found at higher elevations in southern latitudes (Aubry et al. 2007, p. 2153), which suggests that wolverines were compensating for increased temperature at low latitudes by selecting higher elevations. Therefore, the regional availability of suitable habitat is not likely to change significantly (i.e., at least some wolverine habitat will continue to be available in all regions where wolverines currently occur), but within regional landscapes, smaller areas will be suitable for wolverines. Mountain ranges with maximum elevations within the elevation band that wolverines currently use, such as much of the wolverine habitat in central Idaho, may become entirely unsuitable for wolverines with the projected level of warming reported in McKelvey et al. (2010b, Figure 3).

Timing of Climate Effects

Unlike snow conditions, which respond directly to temperature change without a time lag, ecosystem responses to temperature change lag depending on constituent species' individual migratory abilities. Wolverines are described as a "treeline" species because they are most often found in an elevation band that is approximately centered on the alpine treeline at any given locality within their range. Alpine treelines are maintained by a complex set of climactic and biotic factors, of which temperature is significantly important (Cogbill and White 1991, p. 169; Hättenschwiler and Körner 1995, p. 367; Jobbágy and Jackson 2000, p. 259; Pellat et al. 2000, pp. 80-81). However, the conditions that favor tree establishment and lead to elevational advance in the treeline may exist only sporadically, increasing time lags associated with treeline response to warming (Hessl and Baker 1997, p. 181; Klasner and Fagre 2002, p. 54). Within wolverine habitats, treelines have advanced up mountain slopes since 1850, due to climate warming, and this trend is expected to continue into the future (Hessl and Baker 1997, p. 176; Hall and Fagre 2003, p. 138). We expect that species reliant on resources associated with this biome will need to shift accordingly. Given the irregular nature of treeline response to warming, treeline migration is likely to lag significantly behind the climate warming that causes it.

Magnitude of Climate Effects on Wolverine

Several studies relating the effects of climate changes on wolverines in the past, present, and future are now available (Brock and Inman 2007, entire; Gonzales et al. 2008, pp. 1-5; Brodie and Post 2010, entire; McKelvey et al. 2010b, entire; Peacock 2011, entire). The Gonzalez et al. report and the report by Brock and Inman (2007) were both preliminary attempts to analyze climate change impacts to wolverines, but are not currently considered the best available science because they did not consider the effects of both changes in temperature and precipitation that may affect the distribution of persistent spring snow cover (McKelvey 2010, entire). Both Brock and Inman (2007) and Gonzalez et al. (2008) have been superseded by a more sophisticated analysis provided by McKelvey et al. (2010b). This analysis includes climate projections at a local scale for wolverine habitats and analyzes the effects of both temperature changes and changes to precipitation patterns. Lack of accounting for changes in precipitation was a weakness of their studies identified by the authors of both Brock and Inman (2007) and Gonzalez et al. (2008).

Brodie and Post (2010, entire) correlate the decline in wolverine populations in Canada over the past century with declining snowpack due to climate change over the same period. However, correlation does not imply causation; other factors could have caused the decline. The analysis used harvest data to infer population trends in addition to using correlation to imply causation (McKelvey et al. 2010a, entire); in this case, historic climate changes are inferred to have caused the declines in harvest returns, which are thought by the authors to reflect actual population declines. Due to the above-stated concerns, we view the analysis of Brodie and Post (2010, entire) with caution, although we do agree that the posited mechanism (loss of snowpack affecting wolverine populations and distribution) likely has merit.

McKelvey et al. (2010, entire) used downscaled global climate models to project the impacts of changes in temperature and precipitation to wolverine habitat as modeled by Copeland et al. (2010, entire). The authors also present an alternative method for evaluating climate impacts on wolverine habitat, by merely projecting onset of spring snowmelt to occur 2 weeks earlier than it currently does and essentially asking what would happen if spring snowmelt occurred 2 weeks earlier than it occurs now. Based on this information, wolverine habitat in the contiguous United States, which supports approximately 250 to 300 wolverines, would be shrinking and is likely to continue to shrink with increased climate warming (McKelvey et al. 2010b, Figures 1, 3). Habitat losses are likely to occur throughout the range of the DPS and are projected to be most severe in central Idaho (McKelvey et al. 2010b, Figures 1, 3). However, large areas of snow cover are likely to remain in British Columbia, North Cascades, Greater Yellowstone Area (GYA), and the Glacier Park-Bob Marshall Wilderness of Montana (McKelvey et al. 2010b, p. 14, Figure 2). The southern Rocky Mountains of Colorado retained significant high-elevation snow in some models but not others, and so may be another area that could support wolverine populations in the face of climate changes (McKelvey et al. 2010b, p. 19). The mountainous areas of Idaho that currently support wolverines are likely to lose proportionally more snow-covered area than other areas within the contiguous United States, making this area of wolverine habitat relatively more sensitive to climate warming (McKelvey et al. 2010b, p. 14).

Overall, wolverine habitat in the contiguous United States is expected to get smaller and more highly fragmented as individual habitat islands become smaller and the intervening areas between wolverine habitat become larger (McKelvey et al. 2010b, Figures 1, 3). Composite projections for the time interval centered on 2045 predict that 23 percent of current wolverine habitat in the contiguous United States will be lost due to climate warming (McKelvey et al. 2010b, p. 14). That loss expands to 63 percent of wolverine habitat by the time interval between 2070 and 2099. Given the spatial needs of animals with the home range size of wolverines and the limited availability of suitable wolverine habitat in the contiguous United States, this projected gross loss of habitat area should result in a loss of wolverine numbers that is greater than the overall loss of habitat area. As habitat patches become smaller and more isolated, they are likely to lose the ability to support wolverines as some home ranges become so reduced that they cannot support individual animals, and others become so fragmented or isolated that they no longer continue to function.

In addition to the effects of gross habitat loss, we expect wolverine populations to be negatively affected by changes in the spatial distribution of habitat patches as remaining habitat islands become progressively more isolated from each other as a result of climate changes (McKelvey et al. 2010b, Figure 8). Currently, wolverine habitat in the contiguous United States can be described as a series of habitat islands. Some of these islands are large and clumped closely together, such as in the North Cascades, Glacier Park-Bob Marshall Wilderness complex in Montana, and the GYA. Other islands are smaller and more isolated such as the island mountain ranges of central and southwestern Montana. Inbreeding and consequent loss of genetic diversity has occurred in the past within these smaller islands of habitat (Cegelski et al. 2006, p. 208), and genetic exchange between subpopulations is most difficult to achieve (Schwartz et al. 2009, Figure 4). Climate change projections indicate that, as warming continues, large contiguous blocks will become reduced in size and isolated to the extent that their ability to support robust populations is reduced and their connectivity to other source populations resembles the current situation for our most isolated wolverine populations (McKelvey et al. 2010b, Figure 8). This habitat alteration would result in a high likelihood of loss of genetic diversity due to inbreeding within a few generations (Cegelski et al. 2006, p. 209). Further isolation of wolverines on small habitat islands with reduced connectivity to other populations would also increase the likelihood of subpopulation loss due to demographic stochasticity, impairing the functionality of the wolverine metapopulation in the contiguous United States.

We believe that McKelvey et al. (2010b, entire) represents the best available science for predicting the future impacts of climate change on wolverine habitat for four primary reasons. First, their habitat projections are based on Global Climate Models which are thought to be the most reliable predictors of future climate available (IPCC 2007a, p. 12). Second, they conducted downscaling analyses to infer geographic climate variation at a scale relevant to wolverine habitat. Third, they used a hydrologic model to predict snow coverage during the spring denning period (the strongest correlate with wolverine reproductive success). Fourth, they used the habitat model developed by Copeland et al. (2010, entire), to relate projected climate changes to wolverine habitat. This report has not been peer-reviewed or published at the time of this assessment; however, based on our analysis of the methods and analysis used by the authors, we conclude it constitutes the best available information on the likely impact of climate change on wolverine distribution in the contiguous United States. Based on the analysis presented, we conclude that climate changes are likely to result in permanent loss of a significant portion of essential wolverine habitat within the foreseeable future. Additional impacts of climate change will be increased habitat fragmentation as habitat islands become smaller and intervening habitat disappears. Eventually, these processes are likely to lead to a breakdown of metapopulation dynamics as subpopulations are no longer able to rescue each other after local extinctions due to a lack of connectivity. It is also likely that loss of genetic diversity leading to lower fitness will occur as population isolation increases.

Summary of Impacts of Climate Changes

Wolverine habitat is projected to decrease in area and become more fragmented within the foreseeable future as a result of climate changes. These impacts are expected to have direct and indirect effects to wolverine populations in the contiguous United States including reducing the number of wolverines that can be supported by available habitat and reducing the ability of wolverines to travel between patches of suitable habitat. This reduction in connectivity is likely to affect metapopulation dynamics making it more difficult for subpopulations to recolonize areas where wolverines have been extirpated and to bolster the genetics or demographics of adjacent subpopulations. Due to the extent and magnitude of climate change impacts to wolverines and their habitat, we conclude that climate change constitutes a threat to the contiguous U.S. DPS of wolverines in the foreseeable future.

Habitat Impacts Due to Human Use and Disturbance

Because wolverine habitat is generally inhospitable to human use and occupation and most of it is also Federally managed, wolverines are somewhat insulated from impacts of human disturbances from industry, agriculture, infrastructure development, or recreation. Human disturbance in the contiguous United States has likely resulted in the loss of some wolverine habitat, although this loss has not yet been quantified. Potential sources of human disturbance to wolverines include winter and summer recreation, housing and industrial development, road corridors, and extractive industry such as logging or mining. In the contiguous United States, these human activities and developments often occur within or immediately adjacent to wolverine home ranges, such as in alpine or boreal forest environments at high elevations on mountain slopes. They can also occur in a broader range of habitats that are occasionally used by wolverines during dispersal or exploratory movements—habitats that are not suitable for the establishment of home ranges and reproduction.

Little is known about the behavioral responses of individual wolverines to human presence, or about the species' ability to tolerate and adapt to repeated disturbance. It is possible that disturbance may reduce the wolverine's ability to complete essential life-history activities, such as foraging, breeding, maternal care, routine travel, and dispersal. It may decrease habitat value, cause animals to avoid disturbed areas, or act as a barrier to movement (Packila et al. 2007, pp. 105-110). How effects of disturbance extend from individuals to characteristics of populations, such as vital rates (e.g., reproduction, survival, emigration, and immigration) and gene flow, and ultimately to wolverine population or meta-population persistence, is unknown.

Wolverine habitat is generally characterized by the absence of human presence and development (Hornocker and Hash 1981 p. 1299; Banci 1994, p. 114; Landa et al. 1998, p. 448; Rowland et al. 2003 p. 101; Copeland 1996, pp. 124-127; Krebs et al. 2007, pp. 2187-2190). This negative association is sometimes interpreted as active avoidance of human activity, but it may simply reflect the active avoidance by humans of the cold, snowy, and high-elevation habitats preferred by wolverines. In the contiguous United States, wolverine habitat is typically associated with high-elevation (e.g., 2,100 m to 2,600 m (6,888 ft to 8,528 ft) subalpine forests that comprise the Hudsonian Life Zone (weather similar to that found in northern Canada), environments not typically used by people for housing, industry, agriculture, or transportation. However, occupied wolverine habitat supports a variety of activities associated with extractive industry, such as logging and mining, as well as recreational activities in both summer and winter.

At broad spatial scales, it is difficult to separate human disturbance from negative, although interdependent, effects of habitat loss and fragmentation, and historic overexploitation; factors that could contribute to current differences in distributions of wolverines and humans.

Maternal females and their young often vacate dens if they feel threatened by people (Myrberget 1968, p. 115), which is a common predator avoidance strategy among carnivores. The security of the den and the surrounding foraging areas (i.e., protection from disturbance by humans and predation by other carnivores) is an important aspect of den site selection. Abandonment of natal and maternal dens may also be a preemptive strategy that females use in the absence of disturbance by humans or predators. Preemptive den abandonment might confer an advantage to females if prolonged use of the same den makes that den more evident to predators.

The reasons for den abandonment are uncertain. Managing human activity in wolverine habitat to limit premature den abandonment and associated stress and energy expenditure of maternal females may be important for successful reproduction. Premature den abandonment may also increase incidental mortality of offspring. Ultimately, low reproductive success and high mortality may reduce population viability in areas with high incidence of disturbance (Banci 1994, pp. 110-111). The potentially negative effects of disturbance may be more important at the southern margin of the species' North American range where wolverine productivity is particularly low (Inman et al. 2007c, p. 70). Wolverines typically occupy severe, unproductive environments that support low numbers of adult females with characteristically low birth rates (Persson et al. 2006, p. 77; Inman et al. 2007a, p. 68). The life-history strategy of wolverines makes it unlikely that they could compensate for increased mortality due to disturbance (Krebs et al. 2007, p. 2190; Persson et al. 2006, pp. 77-78), and they may be more vulnerable to extirpation than species with high reproductive rates (Ruggiero et al. 2007, p. 2146).

For the purposes of this assessment, we divide human disturbance into four categories: (1) dispersed recreational activities with primary impacts to wolverines through direct disturbance (e.g., snowmobiling and heli-skiing); (2) disturbance associated with permanent infrastructure such as residential and commercial developments, mines, and campgrounds; (3) disturbance and mortality associated with transportation corridors; and (4) disturbance associated with land management activities such as forestry, or fire/fuels reduction activities. Overlap between these categories is extensive, and it is often difficult to distinguish effects of infrastructure from the dispersed activities associated with that infrastructure. However, we believe that these categories account for most of the potential effects related to disturbance of wolverines.

Dispersed Recreational Activities

Dispersed recreational activities occurring in wolverine habitat include snowmobiling, heli-skiing, hiking, biking, off- and on-road motorized use, hunting, fishing, amongst other uses. Among the most often cited as potential threats to wolverines are snowmobiling and heli-skiing; however, other dispersed recreation activities may have similar effects.

One study documented (in two reports) the extent that winter recreational activity spatially and temporally overlapped wolverine denning habitat in the contiguous United States (Heinemeyer and Copeland 1999, pp. 1-17; Heinemeyer et al. 2001, pp. 1-35). This study took place in the GYA in an area of high dispersed recreational use. The overlap of modeled wolverine denning habitat and dispersed recreational activities was extensive. Strong temporal overlap existed between snowmobile activity (February–April) and the wolverine denning period (February–May). During 2000, six of nine survey units, ranging from 3,500 to 13,600 hectares (ha) (8,645 to 33,592 acres (ac)) in size, showed evidence of recent snowmobile use. Among the six survey units with activity, the highest use covered 20 percent of the predicted denning habitat, and use ranged from 3 to 7 percent over the other survey units. Snowmobile activity was typically intensive where detected.

Three of nine survey units in this study showed evidence of skier activity (Heinemeyer and Copeland 1999, p. 10; Heinemeyer et al. 2001, p. 16). Among the three units with activity, skier use covered 3 to 19 percent of the survey unit. Skiers also intensively used the sites they visited. Combined skier and snowmobile use covered as much as 27 percent of potential denning habitat in one unit, where no evidence of wolverine presence was detected. Although we do not have any information on the overlap of wolverine and winter recreation in the remaining part of the U.S. range, these areas likely do not get the high levels of recreational use seen in the portion of the GYA examined in this study.

Although we can demonstrate that recreational use of wolverine habitat is heavy in some areas, we do not have any information on the effects of these activities on the species. No rigorous assessments of anthropogenic disturbance on wolverine den fidelity, food provisioning, or offspring survival have been conducted. Disturbance from foot and snowmobile traffic associated with historic wolverine control activities (Pulliainen 1968, p. 343), and field research activities, may cause maternal females to abandon natal dens and relocate kits to maternal dens (Myrberget 1968, p. 115; Magoun and Copeland 1998, p. 1316; Inman et al. 2007c, p. 71).

At both a site-specific and landscape scale, wolverine natal dens were located particularly distant from public (greater than 7.5 km (4.6 mi)) and private (greater than 3 km (1.9 mi)) roads (May 2007, p. 14-31). Placement of dens away from public roads (and away from associated human-caused mortality) was also a positive influence on successful reproduction. It is not known if the detected effect is due to the influence of the roads themselves or if there are other habitat variables that cause the effect that are also correlated with a lack of roads.

Disturbance at maternal dens may be more likely to cause displacement than disturbance at natal dens

(Magoun and Copeland 1998, p. 1316), and maternal dens may be less secure from predators than natal dens (Myrberget 1968, p. 115), presumably because maternal dens are shallower and smaller. After pursuit by Scandinavian hunters, females near parturition used birthing sites that were less secure than natal dens (Pulliainen 1968, p. 343). Maternal females apparently carry or pull their offspring to new den sites, and may be constrained by the distance and difficulty of simultaneously moving several reluctant offspring (Myrberget 1968, p. 115).

Stress from human activities has not been shown to affect reproductive rates, or to render home range or larger areas of habitat unsuitable. However, the absence of human disturbance that is afforded by refugia may be important for wolverine reproduction (Banci 1994, p. 122; Copeland 1996, p. 126). The extent that dispersed winter recreational activities affect selection of natal den sites by female wolverines is little studied. Rugged terrain and dense forests may naturally separate natal dens and wolverine foraging areas from centers of snowmobile or backcounty skier activity. Maternal females may specifically choose to locate dens far from winter recreation (Inman et al. 2007c, p. 72; Heinemeyer and Copeland 1999, p. 2-9). Six of seven natal dens documented in the Yellowstone Ecosystem occurred where snowmobiles were not permitted, such as in designated wilderness or national parks (Inman et al. 2007c); recreational snowmobile use outside of these areas was common. Wolverine den, foraging, and traveling areas have anecdotally been found to be spatially separated from snowmobile activity (Heinemeyer et al. 2001, p. 17).

Dispersed recreation is likely to affect wolverines, at least in local areas where this activity occurs at high intensity in wolverine habitat. The magnitude of this effect in relation to the wolverine DPS is difficult to determine due to a lack of information on the effects of disturbance on wolverine vital rates, behavior, and habitat use, as well as a general lack of reliable information about the geographic distribution and intensity of dispersed recreational use of wolverine habitats. For these reasons, we conclude that dispersed recreation, by itself, is not a threat to wolverines in the contiguous United States, but that this potential threat may act in concert with other threats to contribute to wolverine declines. As climate changes continue to reduce wolverine habitats, dispersed recreational uses such as snowmobiling and skiing are likely to become more concentrated in any remaining snow-covered areas. This is an area of concern that deserves more scientific investigation as wolverine conservation efforts proceed into the future.

Infrastructure

Infrastructure includes all residential, industrial, and governmental developments such as buildings, houses, oil and gas wells, and ski areas. Infrastructure development on private lands in the Rocky Mountain West has been rapidly increasing in recent years and is expected to continue as people move to this area for its natural amenities (Hansen et al. 2002, p. 151). Infrastructure development may affect wolverines directly by eliminating habitats, or indirectly, by displacing wolverines from suitable habitats near developments. The latter effect tends to be most detrimental to sensitive wildlife, because the area of displacement may be much larger than the area of direct habitat loss.

Wolverine home ranges generally do not occur near human settlements, and this separation is likely due both to differential habitat selection by wolverines and humans and to some extent, disturbance-related effects (May et al. 2006, pp. 289-292; Copeland et al. 2007, p. 2211). In one study, wolverines did not strongly avoid developed habitat within their home ranges (May et al 2006, p. 289). Wolverines may respond positively to human activity and developments that are a source of food. They scavenge food at dumps in and adjacent to urban areas, at trapper cabins, and at mines (LeResche and Hinman 1973 as cited in Banci 1994 p. 115; Banci 1994, p. 99).

Wolverine dispersal may also be affected by development. Linkage zones are places where animals can find food, shelter, and security while moving across the landscape between suitable habitats. Wolverines prefer to travel in habitat that is most similar to habitat they use for home-range establishment, i.e., alpine habitats that maintain snow cover well into the spring (Schwartz et al. 2009, p. 3227). Wolverines may move large distances in an attempt to establish new home ranges, but the probability of making such movements decreases with increased distance between suitable habitat patches, and the degree to which the characteristics of the habitat to be traversed diverge from preferred habitat (Copeland et al. 2010, entire; Schwartz et al. 2009, p. 3230) Wolverine populations in the northern Rocky Mountains appear to be connected to each other at the present time through dispersal routes that correspond to habitat suitability (Schwartz et al. 2009, Figures 4, 5).

The level of development in these linkage areas that wolverines can tolerate is unknown, but it appears that the current landscape does allow some wolverine dispersal (Schwartz et al. 2009, Figures 4, 5; Moriarty et al. 2009, entire; Inman et al. 2009, pp. 22-28). However, gene flow between contiguous U.S. populations may not be high enough to prevent genetic drift (Cegelski et al. 2006, p. 208). Each subpopulation within the contiguous United States would need an estimated 400 breeding pairs, or 1 to 2 effective migrants per generation, to ensure long-term genetic viability (Cegelski et al. 2006, p. 209). Our current understanding of wolverine ecology suggests that no subpopulation historically or presently at carrying capacity would approach 400 breeding pairs within the contiguous United States (Brock et al. 2007, p. 26); nor is the habitat capable of supporting anywhere near this number. It is highly unlikely that 400 breeding pairs exist in the entire contiguous United States. For this reason, long-term viability of wolverines in the contiguous United States requires exchange of individuals between blocks of habitat.

Wolverines are capable of long-distance movements through variable and anthropogenically altered terrain, crossing numerous transportation corridors (Moriarty et al. 2009, entire; Inman et al. 2009, pp. 22-28). Wolverines are able to successfully disperse between habitats, despite the level of development that is currently taking place in the northern Rocky Mountains (Copeland 1996, p. 80; Copeland and Yates 2006, pp. 17-36; Inman et al. 2007a, pp. 9-10; Pakila et al. 2007, pp. 105-109; Schwartz et al. 2009, Figures 4, 5). Dispersal between populations is needed to avoid further reduction in genetic diversity; however, it is not clear that development or human activities are preventing wolverine movements between suitable habitat patches rather than simply small population sizes making movements infrequent. Future human developments may increase landscape resistance to wolverine dispersal; however, we have no information to suggest that this situation is likely to reach a level of impeding wolverine movements within the foreseeable future. Infrastructure developments that occur within wolverine habitat will affect wolverines in local areas and those impacts should be accounted for during planning activities. Infrastructure development, by itself, does not threaten the wolverine DPS; however, it may act in concert with the primary threat of climate change to further depress wolverine populations as habitats become more restricted.

Transportation Corridors

Transportation corridors may affect wolverines if located in wolverine habitat or between habitat patches. If located in wolverine habitat, transportation corridors result in direct loss of habitat and possibly displacement of wolverines for some distance. Direct mortality due to collisions with vehicles is also possible. Transportation corridors provide access to areas otherwise not affected by humans, which exacerbates the effects of human disturbance from a variety of activities. Outside of wolverine habitat, transportation corridors may affect wolverines if they present barriers to movement between habitat patches or result in direct mortality to dispersing wolverines. Because wolverines are capable of making long-distance movements between patches of suitable habitat, transportation corridors located many miles away from wolverine home ranges may affect their ability to disperse or recolonize vacant habitats after local extirpation events.

The Trans Canada Highway at Kicking Horse Pass in southern British Columbia, an important travel corridor over the Continental Divide, has a negative effect on wolverine movement (Austin 1998, p. 30). Wolverines partially avoided areas within 100 m (328 ft) of the highway, and preferred distant sites (greater than 1,100 m (3,608 ft)). Wolverines that approached the highway to cross repeatedly retreated and successful crossing occurred in only half of the attempts. Where wolverines did successfully cross, they used the narrowest portions of the highway right-of-way. Although not assessed, disturbance-related effects of the highway may have been greater in summer when traffic volumes were higher. A railway with minimal human activity, adjacent to the highway, had little effect on wolverine movements. Wolverines did not avoid, and even preferred, compacted, lightly-used ski trails in the area.

In the tri-State area of Idaho, Montana, and Wyoming, most crossings of Federal or State highways are done by subadult wolverines making exploratory or dispersal movements (ranges of resident adults typically did not contain major roads) (Packila et al. 2007, p. 105). Roads in the study area, typically 2-lane highways or roads with less improvement, were not absolute barriers to wolverine movement. The wolverine that moved to Colorado from Wyoming in 2008 successfully crossed Interstate 80 in southern Wyoming (Inman et al. 2008, Figure 6). Wolverines in Norway successfully cross deep valleys that contain light human developments such as railway lines, settlements, and roads (Landa et al. 1998, p. 454). Wolverines in central Idaho avoided portions of a study area that contained roads, although this was possibly an artifact of unequal distribution of roads that occurred at low elevations and peripheral to the study site (Copeland et al. 2007, p. 2211). Wolverines frequently used un-maintained roads for traveling during the winter, and did not avoid trails used infrequently by people or active campgrounds during the summer.

At both a site-specific and landscape scale, wolverine natal dens were located particularly distant from public (greater than 7.5 km (4.6 mi)) and private (greater than 3 km (1.9 mi)) roads (May 2007, p. 14-31). Placement of dens away from public roads (and away from associated human-caused mortality) was a positive influence on successful reproduction (May 2007, p. 14-31). Predictive, broad-scale habitat models, developed using historic records of wolverine occurrence, indicated that roads were negatively associated with wolverine occurrence (Rowland et al. 2003, p. 101). Although wolverines appear to avoid transportation corridors in their daily movements, the low density of these types of structures in wolverine habitat leads us to conclude that the effects are most likely local in scale. Development of transportation corridors in linkage areas may inhibit wolverine movements between habitat patches, potentially reducing connectivity among habitat islands. This isolating effect has not been measured for wolverines and remains theoretical at this point in time. Transportation corridors, by themselves, do not threaten the wolverine DPS, however, these corridors may work in concert with the primary threat of climate change to further depress populations or reduce habitat connectivity as habitat becomes more restricted. Therefore, we consider transportation corridors to be a potential threat to the wolverine DPS, in concert with the primary threat of climate change.

Land Management

Effects to wolverines from land management actions such as grazing, timber harvest, and prescribed fire are largely unknown. Wolverines in British Columbia used recently logged areas in the summer and moose winter ranges for foraging (Krebs et al. 2007, pp. 2189-2190). Although males did not appear to be influenced strongly by the presence of roadless areas, the researchers did not measure traffic volume, so may have been unable to detect responses of males to heavily used roads. In Idaho, wolverines used recently burned areas despite the loss of canopy cover (Copeland 1996, p. 124).

Intensive management activities such as timber harvest and prescribed fire do occur in wolverine habitat; however, for the most part, wolverine habitat tends to be located at high elevations and in rugged topography that is unsuitable for intensive timber management. Much of wolverine habitat is managed by the U.S. Forest Service or other Federal agencies and is protected from some practices or activities such as residential development. In addition, much of wolverine habitat within the contiguous United States is already in a management status such as wilderness or national park (see Factor D for more discussion) that provides some protection from management, industrial, and recreational activities. Wolverines are not thought to be dependent on specific vegetation or habitat features that might be manipulated by land management activities. We conclude that land management activities as discussed above do not constitute a threat to the wolverine DPS.

## B. Overutilization for commercial, recreational, scientific, or educational purposes:

Over much of recent history, trapping has been a primary cause of wolverine mortality (Banci 1994, p. 108; Krebs et al. 2004, p. 497; Lofroth and Ott 2007, pp. 2196-2197; Squires et al. 2007, p. 2217). Unregulated trapping is believed to have played a role in the historic decline of wolverines in North America in the late 1800s and early 1900s (Hash 1987, p. 580). Wolverines are especially vulnerable to targeted trapping and predator reduction campaigns due to their habit of ranging widely in search of carrion, which would bring them into frequent contact with poison baits and traps (Copeland 1996, p. 78; Inman et al. 2007a, pp. 4-10; Packila et al. 2007, p. 105; Squires et al. 2007, p. 2219).

Human-caused mortality of wolverines is likely additive to natural mortality due to the low reproductive rate and relatively long life expectancy of wolverines (Krebs et al. 2004, p. 499; Lofroth and Ott 2007, pp. 2197-2198; Squires et al. 2007, pp. 2218-2219). This means that trapped populations likely live at densities that are lower than carrying capacity, and may need to be reinforced by recruits from untrapped populations to maintain population viability and persistence.

A study in British Columbia determined that, under a regulated trapping regime, trapping mortality in 15 of 71 wolverine population units was unsustainable, and that populations in those unsustainable population units are dependent on immigration from neighboring populations or untrapped refugia (Lofroth and Ott 2007, pp. 2197-2198). Similarly, in southwestern Montana, intensive legal trapping in isolated mountain ranges reduced local populations and was the dominant form of mortality for the duration of the study (Squires et al. 2007, pp. 2218-2219). The harvest levels observed, which included two pregnant females in a small mountain range, could have significant negative effects on a small population (Squires et al. 2007, p. 2219). Harvest refugia, such as national parks and large wilderness, are important to wolverine persistence on the landscape because they can serve as sources of surplus individuals to bolster trapped populations (Squires et al. 2007, p. 2219; Krebs and Ott 2004, p. 500). Glacier National Park, though an important refuge for a relatively robust population of wolverines, was still vulnerable to trapping because most resident wolverine home ranges extended into large areas outside the Park (Squires et al. 2007, p. 2219).

Despite the impacts of trapping on wolverines in the past, trapping is no longer a threat within most of the wolverine range in the contiguous United States. Montana is the only State where wolverine trapping is still legal. Before 2004, average wolverine harvest was 10.5 wolverines per year. Due to preliminary results of the study reported in Squires et al. (2007, pp. 2213-2220), the Montana Department of Fish, Wildlife, and Parks adopted new regulations for the 2004-2005 trapping season that divided the State into three units, with the goal of spreading the harvest more equitably throughout the State.

For the 2008–2009 trapping season, Montana Department of Fish, Wildlife, and Parks adjusted its wolverine trapping regulations again to further increase the geographic control on harvest to prevent concentrated trapping in any one area, and to completely stop trapping in isolated mountain ranges where small populations are most vulnerable (Montana Department of Fish Wildlife and Parks 2010, pp. 8-11). Their new regulations spread harvest across three geographic units (the Northern Continental Divide area, the Greater Yellowstone area, and the Bitterroot Mountains), and establish a statewide limit of 5 wolverines. The 2008–2009 and 2009–2010 trapping seasons have resulted in four and three wolverines harvested, respectively (Montana Department of Fish Wildlife and Parks 2010, pp. 8-11). Under the current regulations, no more than three female wolverines can be legally harvested each year, and harvest in the more vulnerable isolated mountain ranges is prohibited.

Montana Department of Fish, Wildlife, and Parks conducts yearly monitoring using track surveys. Their protocol does not utilize verification methods such as DNA collection or camera stations to confirm identifications. Consequently, misidentifications are likely to occur. Given the relative rarity of wolverines and the relative abundance of other species with which they may be confused, such as bobcats, lynx, and bears, lack of certainty of identifications of tracks makes it highly likely that the rare species is over-represented in unverified tracking records (McKelvey et al. 2008, entire). The Montana Department of

Fish, Wildlife, and Parks wolverine track survey information does not meet our standard for verifiable or documented occurrence records described in the geographic distribution section, and we have not relied on this information in this assessment.

Montana wolverine populations have rebounded from historic lows in the early 1900s while at the same time being subject to regulated trapping (Aubry et al. 2007, p. 2151; Montana Department of Fish, Wildlife, and Parks 2007, p. 1). In fact, much of the wolverine expansion that we have described above took place under less-restrictive harvest regulations than are in place today. Through their refinement of harvest regulations over the past 10 years, Montana Department of Fish, Wildlife, and Parks has demonstrated its commitment to adjust harvest management when evidence indicates it is necessary for conserving wolverine populations. Therefore, we conclude that, in the absence of other threats, harvest would not be likely to threaten State-wide wolverine populations in Montana, or to threaten the continued existence of the wolverine population in the contiguous United States. However, the additive mortality caused by trapping could become a concern in the future as the size of the wolverine population shrinks in response to the loss of habitat due to climate change described above.

Current levels of incidental trapping (i.e., capture in traps set for species other than wolverine) and poisoning have been suggested to be a threat to wolverines, but no supporting information for this assertion is available.

## C. Disease or predation:

Limited information is currently available on the potential effects of disease on wolverine populations. Wolverines are sometimes killed by wolves, black bears, and puma (Burkholder 1962, p. 264; Hornocker and Hash 1981, p. 1296; Copeland 1996, p. 44-46; Inman et al. 2007d, p. 89). In addition, wolverine reproductive dens are likely subject to predation, although so few dens have been discovered in North America that determining the intensity of this predation is not possible. We have no information to suggest that losses of wolverines due to disease or predation are above historic levels or that these represent a threat to local populations or the DPS.

## D. The inadequacy of existing regulatory mechanisms:

The majority (95 percent) of wolverine habitat currently occupied by wolverine populations in the lower contiguous United States is Federally owned and managed, mostly (90 percent) by the Forest Service. An estimated 126,302 km2 (49,258 mi2) of wolverine habitat occurs in Montana, Idaho, and Wyoming. Of that, 120,000 km2 (46,332 mi2) is in Federal ownership and 109,000 km2 (42,085 mi2) of that is managed by the Forest Service. Additionally, 33,263 km (12,973 mi2) (26.3 percent) occurs in designated wilderness; 4,180 km2 (1,630 mi2) (3.3 percent) are in wilderness study areas. An additional 8,432 km2 (3,288 mi2) (6.7 percent) are within national parks (Brock et al. 2007, pp. 33-35; Inman 2007b, pers. comm.). Thus, a total of 36.3 percent of the estimated wolverine habitat in the three-State area occurs in locations with high levels of protection.

Several mechanisms exist that protect wolverine from other forms of disturbance and from overutilization from harvesting; these are described in more detail below.

Federal Laws and Regulations

The Wilderness Act

The Forest Service and National Park Service both manage lands designated as wilderness areas under the Wilderness Act of 1964 (16 U.S.C. 1131-1136). Within these areas, the Wilderness Act states the following: (1) New or temporary roads cannot be built; (2) there can be no use of motor vehicles, motorized equipment, or motorboats; (3) there can be no landing of aircraft; (4) there can be no other form of mechanical transport;

and (5) no structure or installation may be built. A large amount of suitable wolverine habitat occurs within Federal wilderness areas in the United States (Inman 2007b, pers. comm.). As such, a large proportion of existing wolverine habitat is protected from direct loss or degradation by the prohibitions of the Wilderness Act.

National Environmental Policy Act

All Federal agencies are required to adhere to the National Environmental Policy Act (NEPA) of 1970 (42 U.S.C. 4321 et seq.) for projects they fund, authorize, or carry out. The Council on Environmental Quality's regulations for implementing NEPA (40 CFR 1500-1518) state that agencies shall include a discussion on the environmental impacts of the various project alternatives (including the proposed action), any adverse environmental effects which cannot be avoided, and any irreversible or irretrievable commitments of resources involved (40 CFR 1502). The NEPA itself is a disclosure law, and does not require subsequent minimization or mitigation measures by the Federal agency involved. Although Federal agencies may include conservation measures for wolverines as a result of the NEPA process, any such measures are typically voluntary in nature and are not required by the statute. Additionally, activities on non-Federal lands are subject to NEPA if there is a Federal nexus.

For example, wolverines are designated as a sensitive species by the Forest Service, which requires that effects to wolverines be considered in documentation completed under NEPA. NEPA does not itself regulate activities that might affect wolverines, but it does require full evaluation and disclosure of information regarding the effects of contemplated Federal actions on sensitive species and their habitats.

National Forest Management Act

Under the National Forest Management Act of 1976, as amended (16 U.S.C. 1600-1614), the Forest Service shall strive to provide for a diversity of plant and animal communities when managing national forest lands. Individual national forests may identify species of concern that are significant to each forest's biodiversity. It is unknown what level of protection, if any, each of the individual national forests offer for wolverines. In many of the States in which wolverines are found, wolverines occur in wilderness areas and are thus protected under the Wilderness Act. Outside of wilderness but still on Forest Service-managed lands, wolverines occur mainly in alpine areas, which are sensitive to negative habitat alterations. Their habitat is generally offered more protections from harvest or road building than would otherwise be the case in lowland areas.

National Park Service Organic Act

The NPS Organic Act of 1916 (16 U.S.C. 1 et seq.), as amended, states that the NPS ‘‘shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations to conserve the scenery and the national and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.’’ Where wolverines occur in National Parks, they and their habitats are protected from large-scale loss or degradation due to the Park Service's mandate to ‘‘...conserve scenery... and wildlife...[by leaving] them unimpaired.’’

Clean Air Act of 1970

As stated earlier under Factor A, our status review indicated that increased temperatures and loss of persistent spring snow are a significant threat to wolverines across the DPS range in the foreseeable future. The Clean Air Act does not adequately address the effects of global climate change, such that the threat to wolverines from the reduction of spring snow pack would be ameliorated in the foreseeable future. The Clean Air Act of 1970 (42 U.S.C. 7401 et seq.), as amended, requires the Environmental Protection Agency (EPA) to develop and enforce regulations to protect the general public from exposure to airborne contaminants that are known to be hazardous to human health. In 2007, the Supreme Court ruled that gases that cause global warming are pollutants under the Clean Air Act, and that the EPA has the authority to regulate carbon dioxide and other heat-trapping gases (Massachusetts et al. v. EPA 2007 [Case No. 05-1120]). The EPA published a regulation to require reporting of greenhouse gas emissions from fossil fuel suppliers and industrial gas suppliers, direct greenhouse gas emitters, and manufacturers of heavy-duty and off-road vehicles and engines (74 FR 56260; October 30, 2009). The rule, effective December 29, 2009, does not require control of greenhouse gases; rather it requires only that sources above certain threshold levels monitor and report emissions (74 FR 56260; October 30, 2009). On December 7, 2009, the EPA found under section 202(a) of the Clean Air Act that the current and projected concentrations of six greenhouse gases in the atmosphere threaten public health and welfare. The finding itself does not impose requirements on any industry or other entities but is a prerequisite for any future regulations developed by the EPA. At this time, it is not known what regulatory mechanisms will be developed in the future as an outgrowth of the finding or how effective they would be in addressing climate change. However, at this time, we determine that the Clean Air Act and its implementing regulatory structure is not adequate to protect the wolverine from becoming endangered or threatened in the foreseeable future.

State Laws and Regulations

State Comprehensive Wildlife Conservation Strategies and State Environmental Policy and Protection Acts

The wolverine is listed as State Endangered in Washington, California, and Colorado. In Idaho and Wyoming it is designated as a protected nongame species (Idaho Department of Fish and Game 2010, p. 4; Wyoming Game and Fish 2005, p. 2). Oregon, while currently not considered to have any individuals other than possible unsuccessful dispersers, has a closed season on trapping of wolverines. These designations largely protect the wolverine from mortality due to hunting and trapping. In Montana, the wolverine is classified as a regulated furbearer (Montana Fish, Wildlife, and Parks 2010, p. 8). Montana is the only State in the contiguous United States where wolverine trapping is still legal.

Wolverines receive some protection under State laws in Washington, California, Idaho, Montana, Wyoming, and Colorado. Each State’s fish and wildlife agency has some version of a State Comprehensive Wildlife Conservation Strategy (CWCS) in place. These strategies, while not State or national legislation can help prioritize conservation actions within each State. Named species and habitats within each CWCS may receive focused attention during State Environmental Protection Act (SEPA) reviews as a result of being included in a State’s CWCS. However, only Washington, California, and Montana appear to have SEPA-type regulations in place. In addition, each State’s fish and wildlife agency often specifically names or implies protection of wolverines in their hunting and trapping regulations. Only the State of Montana currently allows wolverine harvest.

Before 2004, the Montana Department of Fish, Wildlife, and Parks regulated wolverine harvest through the licensing of trappers, a bag limit of one wolverine per year per trapper, and no statewide limit. Under this management, average wolverine harvest was 10.5 wolverines per year. Due to preliminary results of the study reported in Squires et al. (2007, pp. 2213-2220), Montana Department of Fish, Wildlife, and Parks adopted new regulations for the 2004-2005 trapping season that divided the State into three units with the goal of spreading the harvest more equitably throughout the State. In 2008, Montana Department of Fish, Wildlife, and Parks further refined their regulations to prohibit trapping in isolated mountain ranges, and reduced the overall statewide harvest to 5 wolverines with a statewide female harvest limit of 3. We concluded under Factor B that trapping in Montana, by itself, is not a threat to the wolverine DPS, but that by working in concert with the primary threat of climate change, the trapping program may contribute to population declines caused by other threats. Wolverine harvest regulations in Montana are inadequate to protect wolverines from this threat as long as harvest is allowed.

Several Federal and State regulatory mechanisms at least partially address various aspects of wolverine conservation, such as protection of habitat from the direct effects of development and protection from overharvest. However, these existing Federal and State regulatory mechanisms do not adequately address the threat of modification of wolverine habitat (i.e., loss of spring snowpack) due to climate change.

## E. Other natural or manmade factors affecting its continued existence:

Small Population Size

Wolverines in the contiguous United States are thought to be derived from a recent re-colonization event after they were extirpated from the area in the early 20th century (Aubry et al. 2007, Table 1, Schwartz 2007, pers. comm.). Consequently, wolverine populations in the contiguous United States have reduced genetic diversity relative to larger Canadian populations as a result of founder effects or inbreeding (Schwartz et al. 2009, pp. 3228-3230). As described in the DPS analysis above, wolverine effective population size in the contiguous United States is exceptionally low (Schwartz 2007, pers. comm.) and is below what is thought to be adequate for short-term maintenance of genetic diversity. Loss of genetic diversity can lead to inbreeding depression and is associated with increased risk of extinction (Allendorf and Luikart 2007, pp. 338-343). Effective population size is important because it determines rates of loss of genetic variation, fixation of deleterious alleles, and the rate of inbreeding. Small effective population sizes are caused by small actual population size (census size), or by other factors that limit the genetic contribution of portions of the population, such as polygamous mating systems. Populations may increase their effective size by increasing census size or by the regular exchange of genetic material with other populations through inter-population mating. Populations with small effective population sizes show reductions in population growth rates and increases in extinction probabilities (Leberg 1990, p. 194; Jimenez et al. 1994, pp. 272-273; Newman and Pilson 1997, p. 360; Saccheri et al. 1998, p. 492; Reed and Bryant 2000, p. 11; Schwartz and Mills 2005, p. 419; Hogg et al. 2006, p. 1495, 1498; Allendorf and Luikart 2007, pp. 338-342).

The concern with the low effective population size was highlighted in a recent analysis which determined that without immigration from other populations at least 400 breeding pairs would be necessary to sustain the long-term genetic viability of the contiguous U.S. wolverine population (Cegelski et al. 2006, p. 197). However, the entire population is likely only 250 to 300 (Inman 2010b, pers. comm.), with a substantial number of these being unsuccessful breeders or nonbreeding subadults.

Genetic studies demonstrate the essential role that genetic exchange plays in maintaining genetic diversity in small wolverine populations. The concern that low effective population size would result in negative effects is already being realized for the contiguous U.S. population of wolverine. Genetic drift has already occurred in subpopulations of the contiguous United States: wolverines here contained 3 of 13 haplotypes found in Canadian populations (Kyle and Strobeck 2001, p. 343; Cegelski et al. 2003, pp. 2914-2915; Cegelski et al. 2006, p. 208; Schwartz et al. 2007, p. 2176; Schwartz et al. 2009, p. 3229). The haplotypes found in these populations were a subset of those in the larger Canadian population, indicating that genetic drift had caused a loss of genetic diversity. One study found that a single haplotype dominated the northern Rocky Mountain wolverine population, with 71 of 73 wolverines sampled expressing that haplotype (Schwartz et al. 2007, p. 2176). The reduced number of haplotypes indicates not only that genetic drift is occurring but some level of genetic separation; if these populations were freely interbreeding, they would share more haplotypes (Schwartz et al. 2009, p. 3229). The reduction of haplotypes is likely a result of the fragmented nature of wolverine habitat in the United States and is consistent with an emerging pattern of reduced genetic variation at the southern edge of the range documented in a suite of boreal forest carnivores (Schwartz et al. 2007, p. 2177).

Immigration of wolverines from Canada is not likely to bolster the genetic diversity of wolverines in the contiguous United States. There is an apparent lack of connectivity between wolverine populations in Canada and the United States based on genetic data (Schwartz et al. 2009, pp. 3228-3230). The apparent loss of connectivity between wolverines in the northern Rocky Mountains and Canada prevents the influx of genetic material needed to maintain or increase the genetic diversity in the contiguous United States. The continued loss of genetic diversity may lead to inbreeding depression, potentially reducing the species' ability to persist through reduced reproductive output or reduced survival. Currently, the cause for this lack of connectivity is uncertain, and existing regulatory mechanisms may be inadequate to address population connectivity. Wolverine habitat appears to be well-connected across the border region (Copeland et al. 2010, Figure 2) and there are few man-made obstructions such as transportation corridors or alpine developments. However, this lack of genetically detectable connectivity may be related to harvest management in southern Canada. The current inadequacy of existing regulatory mechanisms to address connectivity across the international boundary may pose a risk to wolverines in the contiguous United States in the future through reduced effective population size resulting in potential loss of genetic diversity through inbreeding.

## Conservation Measures Planned or Implemented :

There are no currently planned or implemented conservation measures. The state of Colorado is exploring the possibility of reintroducing wolverines to the southern Rocky Mountains, but they have not yet concluded whether the action would be appropriate for them to undertake.

## Summary of Threats :

This status review identified threats to the contiguous U.S. population of the North American wolverine attributable to Factors A, B, D, and E. The primary threat to the DPS is from habitat and range loss due to climate warming (Factor A). Wolverines inhabit habitats with near-arctic conditions wherever they occur. In the contiguous United States, wolverine habitat is restricted to high-elevation areas in the West. Wolverines are dependent on deep persistent snow cover for successful denning, and they concentrate their year-round activities in areas that maintain deep snow into spring and cool temperatures throughout summer. Wolverines in the contiguous United States exist as small and semi-isolated subpopulations in a larger metapopulation that requires regular dispersal of wolverines between habitat patches to maintain itself. These dispersers achieve both genetic enrichment and demographic support of recipient populations. Climate changes are predicted to reduce wolverine habitat and range by 23 percent over the next 30 years and 63 percent over the next 75 years, rendering remaining wolverine habitat significantly smaller and more fragmented. We anticipate that, by 2045, maintenance of the contiguous U.S. wolverine population in the currently occupied area will require human intervention to facilitate genetic exchange and possibly also facilitate metapopulation dynamics by moving individuals between habitat patches that are no longer accessed regularly by dispersers. Other threats are minor in comparison to the driving primary threat of climate change; however, they could become significant when working in concert with climate change if they further suppress an already stressed population. These secondary threats include harvest (Factor B), disturbance, infrastructure, and transportation corridors (Factor A), and demographic stochasticity and loss of genetic diversity due to small effective population sizes (Factor E). All of these factors affect wolverines across their current range in the contiguous United States

On the basis of the best scientific and commercial data available, we find that listing the North American wolverine population in the contiguous United States as threatened or endangered continues to be warranted. We arrive at this determination due to the current status of wolverines in the contiguous United States, which exist as a small (250-300 individuals) and genetically depauperate (3 of 13 haplotypes) metapopulation with limited dispersal between subpopulations. This information, when combined with information about the primary and secondary threats indicates that wolverines are likely to lose 63 percent of their current habitat area over the next century.

**For species that are being removed from candidate status:**

_____ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions(PECE)?

### Recommended Conservation Measures :

We recommend the continued exploration of the possibility of using reintroduction as a conservation action for wolverines to re-occupy portions of their historic range.

We recommend that a comprehensive DPS-wide monitoring program be established for wolverines.

## Priority Table

| Magnitude | Immediacy | Taxonmomy | Priority |
|---|---|---|---|
| **High** | Imminent | Monotypic genus | 1 |
| | | Species | 2 |
| | | Subspecies/Population | 3 |
| | **Non-imminent** | Monotypic genus | 4 |
| | | Species | 5 |
| | | **Subspecies/Population** | **6** |
| Moderate to Low | Imminent | Monotype genus | 7 |
| | | Species | 8 |
| | | Subspecies/Population | 9 |
| | Non-Imminent | Monotype genus | 10 |
| | | Species | 11 |
| | | Subspecies/Population | 12 |

### Rationale for Change in Listing Priority Number:

### Magnitude:

The primary threat of habitat and range loss due to climate change would affect wolverine habitat across the entire DPS, therefore the magnitude of threats to the DPS is high.

### Imminence :

The primary threat facing the DPS is not imminent. The threat from habitat and range loss due to climate change is reasonably certain to occur, and its effects may be particularly acute for small, isolated populations, but we have no evidence that these effects are imminent (ongoing). The other identified threats were determined only to be potential threats when acting in concert with the driving threat of climate change. Therefore, based on our LPN Policy, the threats are not imminent (ongoing).

__Yes__ Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

## Emergency Listing Review

__No__ Is Emergency Listing Warranted?

We reviewed the available information to determine if the existing and foreseeable threats render the species at risk of extinction now such that issuing an emergency regulation temporarily listing the species under section 4(b)(7) of the Act is warranted. We determined that issuing an emergency regulation temporarily listing the species is not warranted for this species at this time, because the effects of climate warming on wolverines and their habitat are expected to unfold over many years and populations currently appear to be stable or expanding. However, if at any time we determine that issuing an emergency regulation temporarily listing the North American wolverine in the contiguous United States is warranted, we will initiate this action at that time.

## Description of Monitoring:

There is currently no coordinated monitoring of wolverines across the range of the DPS. Montana includes wolverines in its standard monitoring for furbearing species.

**Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:**

California,Colorado,Idaho,Montana,Oregon,Utah,Washington,Wyoming

**Indicate which State(s) did not provide any information or comment:**

none

## State Coordination:

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## Approval/Concurrence:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: ______________________________ 05/31/2011
Date

Concur: 10/07/2011
Date

Did not concur: ______________________________ ______________
Date

Director's Remarks: