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

Scientific Name:

Pinus albicaulis

Common Name:

Whitebark pine

Lead region:

Region 6 (Mountain-Prairie Region)

Information current as of:

04/12/2012

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 to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status
>
> ___ Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species
>
> ___ Range is no longer a U.S. territory
>
> ___ Insufficient information exists on biological vulnerability and threats to support listing
>
> ___ 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

___ More abundant than believed, diminished threats, or threats eliminated.

Petition Information

___ Non-Petitioned

_X_ Petitioned - Date petition received: 12/09/2008

90-Day Positive:07/20/2010

12 Month Positive:07/19/2011

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**:State(s) information not available
- **US Counties**:County information not available
- **Countries**:Country information not available

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories**: Idaho, Montana, Oregon, Wyoming
- **US Counties**: Adams, ID, Benewah, ID, Blaine, ID, Boise, ID, Bonner, ID, Bonneville, ID, Boundary, ID, Butte, ID, Camas, ID, Cassia, ID, Clark, ID, Clearwater, ID, Custer, ID, Elmore, ID, Fremont, ID, Gem, ID, Idaho, ID, Lemhi, ID, Shoshone, ID, Valley, ID, Washington, ID, Beaverhead, MT, Broadwater, MT, Carbon, MT, Cascade, MT, Chouteau, MT, Deer Lodge, MT, Flathead, MT, Gallatin, MT, Glacier, 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, Deschutes, OR, Douglas, OR, Grant, OR, Hood River, OR, Jackson, OR, Jefferson, OR, Josephine, OR, Klamath, OR, Lake, OR, Lane, OR, Linn, OR, Marion, OR, Union, OR, Wallowa, OR, Wasco, OR, Fremont, WY, Hot Springs, WY, Lincoln, WY, Park, WY, Sublette, WY, Teton, WY
- **Countries**:Country information not available

Land Ownership:

Roughly 44 percent of the species' range occurs in the United States, with the remaining 56 percent of its range occurring in British Columbia and Alberta, Canada (COSEWIC 2010, p. iv). In Canada, the majority of the species' distribution occurs on private lands (Achuff 2010, pers. comm.). In the United States, approximately 96 percent of land where the species occurs is federally owned or managed. The majority is located on U.S. Forest Service (USFS) lands (approximately 81 percent, or 4,698,388 hectares (ha) (11,609,969 acres (ac)). The bulk of the remaining acreage is located on National Park Service (NPS) lands (approximately 13 percent, or 740,391 ha (1,829,547 ac)). Small amounts of *Pinus albicaulis* also can be found on Bureau of Land Management (BLM) lands (approximately 2 percent, or 119,598 ha (295,534 ac)). The remaining 4 percent is under non-Federal ownership.

Lead Region Contact:

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Biological Information

Species Description:

Pinus albicaulis is a tree that is typically 5 to 20 meters (m) (16 to 66 feet (ft)) tall with a rounded or irregularly spreading crown shape. On higher density conifer sites, *P. albicaulis* tends to grow as tall, single-stemmed trees, whereas on open, more exposed sites, it tends to have multiple stems (McCaughey and Tomback 2001, pp. 113–114). Above tree line, it grows in a krummholz form, with stunted, shrub-like growth caused by high winds and cold temperatures (Arno and Hoff 1989, p. 6). This pine species is monoecious (with both male pollen and female seed cones on the same tree). Its characteristic dark brown to purple seed cones are 5 to 8 centimeters (cm) (2 to 3 inches (in.)) long and grow at the outer ends of upper branches (Hosie 1969, p. 42).

Taxonomy:

Pinus albicaulis is a 5-needled conifer species placed in the subgenus *Strobus*, which also includes other 5-needled white pines. This subgenus is further divided into two sections (*Strobus* and *Parrya*), and under section *Strobus*, into two subsections (*Cembrae* and *Strobi*). The traditional taxonomic classifications placed *P. albicaulis* in the subsection *Cembrae* with four other Eurasian stone pines (Critchfield and Little 1966, p. 5; Lanner 1990, p. 19). However, recent phylogenetic studies (Liston et al. 1999, 2007; Syring et al. 2005, 2007; as cited in Committee on the Status of Endangered Wildlife in Canada (COSEWIC) 2010, p. 4) showed no difference in monophyly (ancestry) between subsection *Cembrae* and subsection *Strobi* and merged them to form subsection *Strobus.* No taxonomic subspecies or varieties of *P. albicaulis* are recognized (COSEWIC 2010, p. 6). Based on this taxonomic classification information, we recognize *P. albicaulis* as a valid species and a listable entity.

Habitat/Life History:

Pinus albicaulis is a hardy conifer that tolerates poor soils, steep slopes, and windy exposures and is found at alpine tree line and subalpine elevations throughout its range (Tomback *et al*. 2001, pp. 6, 27). It grows under a wide range of precipitation amounts, from about 51 to over 254 cm (20 to 100 in.) per year (Farnes 1990, p. 303). *Pinus albicaulis* may occur as a climax species, early successional species, or seral (midsuccessional

stage) co-dominant associated with other tree species. Although it occurs in pure or nearly pure stands at high elevations, it typically occurs in stands of mixed species in a variety of forest community types.

Pinus albicaulis is a slow-growing, long-lived tree with a life span of up to 500 years and sometimes more than 1,000 years (Arno and Hoff 1989, pp. 5–6). It is considered a keystone, or foundation species in western North America where it increases biodiversity and contributes to critical ecosystem functions (Tomback *et al*. 2001, pp. 7– 8). As a pioneer or early successional species, it may be the first conifer to become established after disturbance, subsequently stabilizing soils and regulating runoff (Tomback *et al*. 2001, pp. 10–11). At higher elevations, snow drifts around *P. albicaulis* trees, thereby increasing soil moisture, modifying soil temperatures, and holding soil moisture later into the season (Farnes 1990, p. 303). These higher elevation trees also shade, protect, and slow the progression of snowmelt, essentially reducing spring flooding at lower elevations.

Pinus albicaulis also provides important, highly nutritious seeds for a number of birds and mammals (Tomback *et al*. 2001, pp. 8, 10). *P. albicaulis* trees are capable of producing seed cones at 20–30 years of age, although large cone crops usually are not produced until 60–80 years (Krugman and Jenkinson 1974, as cited in McCaughey and Tomback 2001, p. 109). Therefore, the generation time of *P. albicaulis* is approximately 60 years (COSEWIC 2010, p. v). *P. albicaulis* seed predators are numerous and include more than 20 species of vertebrates including Clark's nutcracker (*Nucifraga columbiana*), pine squirrels (*Tamiasciurus* spp.), grizzly bears (*Ursus arctos*), black bears (*Ursus americanus*), Steller's Jay (*Cyanocitta stelleri*), and pine grosbeak (*Pinicola enucleator*) (Lorenz *et al*. 2008, p. 3). Seed predation plays a major role in *P. albicaulis* population dynamics, as seed predators largely determine the fate of seeds. However, *P. albicaulis* has co-evolved with seed predators and has several adaptations, like masting, that has allowed the species to persist despite heavy seed predation (Lorenz *et al*. 2008, p. 3–4). Masting is the process by which populations synchronize their seed production and provide varying amounts from year to year. During years with high seed production, typically once every 3–5 years in *P. albicaulis* (McCaughey and Tomback 2001, p. 110), seed consumers are satiated, resulting in excess seeds that escape predation (Lorenz *et al*. 2008, pp. 3–4).

Historical Range/Distribution:

The historical distribution of *Pinus albicaulis* is unknown.

Current Range Distribution:

Pinus albicaulis occurs in scattered areas of the warm and dry Great Basin but it typically occurs on cold and windy high-elevation or high-latitude sites in western North America. As a result, many stands are geographically isolated (Arno and Hoff 1989, p. 1; Keane *et al*. 2010, p. 13). Its range extends longitudinally between 107 and 128 degrees west and latitudinally between 27 and 55 degrees north (McCaughey and Schmidt 2001, p. 33). The distribution of *P. albicaulis* includes coastal and Rocky Mountain ranges that are connected by scattered populations in northeastern Washington and southeastern British Columbia (Arno and Hoff 1990, p. 268; Keane *et al*. 2010, p. 13). The coastal distribution of *P. albicaulis* extends from the Bulkley Mountains in British Columbia to the northeastern Olympic Mountains and Cascade Range of Washington and Oregon, to the Kern River of the Sierra Nevada Range of east-central California (Arno and Hoff 1990, p. 268). Isolated stands of *P. albicaulis* are known from the Blue and Wallowa Mountains in northeastern Oregon and the subalpine and montane zones of mountains in northeastern California, south-central Oregon, and northern Nevada (Arno and Hoff 1990, p. 268; Keane *et al*. 2010, p. 13). The Rocky Mountain distribution of *P. albicaulis* ranges from northern British Columbia and Alberta to Idaho, Montana, Wyoming, and Nevada (Arno and Hoff 1990, p. 268; Keane et al. 2010, p. 13), with extensive stands occurring in the Yellowstone ecosystem (McCaughey and Schmidt 2001, p. 33). The Wind River Range in Wyoming is the eastern most distribution of the species (Arno and Hoff 1990, p. 268; McCaughey and Schmidt 2001, p. 33) (Figure 1).

Figure 1.—Estimated Pinus albicaulis range distribution (Little, 1971).

Population Estimates/Status:

Mortality data collected in multiple studies throughout the range of *Pinus albicaulis* strongly suggests that the species is in range-wide decline. Although the majority of available data was collected in the last several decades, the decline in *P. albicaulis* populations likely began sometime following the 1910 introduction of the exotic disease white pine blister rust. Although we do not have a study that quantifies the rate of decline across the entire range, we conclude that the preponderance of data from the studies listed below and elsewhere in this status review provides evidence of a substantial and pervasive decline throughout almost the entire range of the species.

In Canada, based on current mortality rates, it is anticipated that *Pinus albicaulis* will decline by 57 percent by 2100 (COSEWIC 2010, p. 19). The value for this anticipated decline is likely an underestimate, as it assumes current mortality rates remain constant into the foreseeable future. Past trends have shown that mortality rates have been increasing over the last several decades (this is discussed in more detail under Factor C, Disease or Predation). The range of mortality rates for *P. albicaulis* in the United States are similar to those in Canada, which suggests that the anticipated rates of decline will be similar.

Distinct Population Segment(DPS):

N/A (*Pinus albicaulis* is a plant, therefore designation of Distinct Population Segments does not apply to this taxonomic group).

Threats

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

Fire and Fire Suppression

Fire is one of the most important landscape-level disturbance processes within high-elevation *Pinus albicaulis* forests (Agee 1993, p. 259; Morgan and Murray 2001, p. 238; Spurr and Barnes 1980, p. 422), and has been important to perpetuating early seral (successional stage) *P. albicaulis* communities (Arno 2001, p. 82; Shoal *et al.* 2008, p. 20). Without regular disturbance, primarily from fire, these forest communities follow successional pathways that eventually lead to dominance by shade-tolerant conifers such as *Abies lasiocarpa*, *Picea engelmannii*, and *Tsuga mertensiana*, to the exclusion of *P. albicaulis* (Keane and Parsons 2010, p. 57). When fire is present on the landscape, *P. albicaulis* has an advantage over its competitors for several reasons (Keane and Parsons 2010, p. 57). The Clark's nutcracker serves as the main dispersal agent for *P. albicaulis* by caching seeds in disturbed sites, such as burns. Fire creates sites that are suitable for this seed caching behavior and that most importantly contain optimal growing conditions for *P. albicaulis* (Tomback *et al.* 2001, p. 13). In addition, Clark's nutcrackers can disperse seeds farther than the wind-dispersed seeds of other conifers, thereby facilitating *P. albicaulis* succession in burned sites over a broad geographic area (McCaughey *et al.* 1985, Tomback *et al*. 1990, 1993 in Keane and Parsons 2010, p. 58). Additionally, *P. albicaulis* has thicker bark, a thinner crown, and a deeper root system, which allow it to withstand low-intensity fires better than many of its competitors (Arno and Hoff 1990 in Keane and Parsons 2010, p. 58). Historically, fire has been an important factor in maintaining healthy stands of *P. albicaulis* on the landscape.

Fires in the high-elevation ecosystem of *Pinus albicaulis* can be of low intensity, high intensity, or mixed intensity. These varying intensity levels result in very different impacts to *P. albicaulis* communities. Low-intensity, surface-level ground fires occur frequently under low-fuel conditions. These fires remove small-diameter, thin-barked seedlings and allow large, mature trees to thrive (Arno 2001, p. 82). Low-intensity fires also reduce fuel loads and competition from fire-susceptible conifers, shrubs, and grasses, thereby opening up spaces necessary for the shade-intolerant *P. albicaulis* to regenerate and thus maintain prominence in seral communities (Arno 1986 in Keane *et al.* 1994, p. 215). High-intensity fires occur where high fuel loads, ladder fuels (vegetation below the crown level of forest trees, which allows fire to move from the forest floor to tree crowns), and other compounding conditions result in increased flammability (Agee 1993, p. 258). High-intensity fires, often referred to as stand replacement fires, or crown fires (Agee 1993, p. 16), produce intensive heat, resulting in the removal of all or most of the vegetation from the ground. High-intensity fires begin the process of vegetative succession by opening seed beds that become available for the establishment and development of shade-intolerant species like *P. albicaulis*. High-intensity fires are generally less frequent because it takes longer time intervals to build the large fuel accumulations necessary to promote these types of fires (Agee 1993, p. 258). Mixed intensity fires are most common and result in a

mosaic of dead trees, live trees, and open sites for regeneration (Arno 1980, p. 460; Keane 2001a, p. 17). In general, historical fire return intervals in *P. albicaulis* communities have been estimated at between 50 and 300 years (Arno 1980, p. 461).

Beginning in the 1930s, a policy of fire suppression was effectively implemented by the USFS (Arno 1980, p. 460; USFS 2000, p. 1). During the 1970s, in recognition of the importance of wildfire to maintenance of healthy forests, the USFS began a policy shift away from total fire suppression (Cohen 2008, p. 21; USFS 2000, p. 1). However, despite this shift, fire suppression is still carried out, most frequently in areas where a threat to human health and safety are anticipated, and we expect this trend of fire suppression to continue into the future (Arno 1980, p. 460; Cohen 2008, p. 21; Keane 2011a, pers. comm.).

Fire suppression has had unintended negative impacts on *Pinus albicaulis* populations (Keane 2001a, entire), due to this shift from a natural fire regime to a managed fire regime. Stands once dominated by *P. albicaulis* have undergone succession to more shade-tolerant conifers (Arno *et al.* 1993 in Keane *et al.* 1994, p. 225; Flanagan *et al.* 1998, p. 307). Once shade-tolerant conifer species become firmly established, the habitat is effectively lost to *P. albicaulis* until a disturbance like fire once again opens the area for *P. albicaulis* regeneration. Determining the total amount of *P. albicaulis* habitat lost to succession rangewide is difficult, as there is seldom a historic baseline for comparison, and the degree of succession is very specific to local conditions (Keane 2011a, pers. comm.). Shade-tolerant conifer species grow more densely than shade intolerant conifer species like *P. albicaulis* (Minore 1979, p. 3). Denser stands eliminate the open sites that are often used by Clark's nutcracker for seed caching and which are also the sites required to facilitate the regeneration of the shade-intolerant *P. albicaulis*. Additionally, the growth of more homogeneously structured stands with continuous crowns and increased surface fuels has resulted in fires that are larger and more intense (Keane 2001b, p. 175).

Pinus albicaulis cannot withstand high-intensity fires; during such fires, all age and size classes can be killed. However, newly burned areas provide a seedbed for *P. albicaulis*, and if stands of unburned cone-producing *P. albicaulis* are nearby (i.e., within the range of Clark's nutcracker caching behavior), Clark's nutcrackers will cache those seeds on the burned site, and regeneration is very likely. However, the introduction of the disease white pine blister rust and the current epidemic of the predatory mountain pine beetle (*Dendroctonus ponderosae*) have reduced or effectively eliminated *P. albicaulis* seed sources on a landscape scale (see Factor C, Disease or Predation). Although there is variation in the degree to which specific stands have been impacted, over the range of *P. albicaulis* the widespread incidence of poor stand health from disease and predation, coupled with changes in fire regimes, means that regeneration of *P. albicaulis* following fire is unlikely in many cases (Tomback *et al*. 2008, p. 20).

<u>Fire and Fire Suppression and the Interaction of Other Factors</u>

Environmental changes resulting from climate change are expected to exacerbate the already observed negative effects of fire suppression (i.e., forest succession, increased fire intensity) (see the Climate Change section below). These environmental changes are predicted to increase the number, intensity, and extent of wildfires (Aubry *et al.* 2008, p. 6; Keane 2001b, p. 175). Already, large increases in wildfire have been documented and are particularly pronounced in Northern Rockies forests, which account for 60 percent of documented increases in large fires (Westerling *et al.* 2006, p. 941, 943). Some of the increase has been independent of past management activities and, thus, appears to be a direct result of warming trends in the last several decades (Westerling *et al.* 2006, p. 943).

Fire suppression is also expected to negatively interact with white pine blister rust and mountain pine beetle predation. As forests become more dense, individual *Pinus albicaulis* are more vulnerable to white pine blister rust and infestation by mountain pine beetle (see Factor C, Disease and Predation). As mortality from white pine blister rust and mountain pine beetle increase, forest succession to more dense stands of shade tolerant conifers is accelerated (Keane 2011a, pers. comm.).

Climate Change

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

Direct habitat loss from climate change is anticipated to occur with current habitats becoming unsuitable for *P. albicaulis* as temperatures increase and soil moisture availability decreases (Hamman and Wang 2006, p. 2783; Schrag *et al.* 2007, p. 8; Aitken *et al.* 2008, p. 103). Habitat loss is expected because (1) temperatures become so warm that they exceed the thermal tolerance of *P. albicaulis* and the species is unable to survive or (2) warmer temperatures favor other species of conifer that currently cannot compete with *P. albicaulis* in cold high-elevation habitats. *Pinus albicaulis* is widely distributed and thus likely has a wide range of tolerance to varying temperatures (Keane 2011c, pers.comm.). Therefore, increasing competition from other species that cannot normally persist in current *P. albicaulis* habitats is possibly the more probable climate-driven mechanism for habitat loss.

Given the anticipated loss of suitable habitat, *P. albicaulis* persistence will likely be dependent on the species’ ability to either migrate to new suitable habitats, or adapt to changing conditions (Aitken *et al.* 2008, p. 95). Historical (paleoecological) evidence indicates that plant species have generally responded to past climate change through migration, and that adaptation to changing climate conditions is less likely to occur (Bradshaw and McNeilly 1991, p. 12; Huntley 1991, p. 19). Adaptation to a change in habitat conditions as a result of a changing climate is even more unlikely for *P. albicaulis*, given its very long generation time of approximately 60 years (Bradshaw and McNeilly 1991, p. 10). The rate of latitudinal plant migration during past warming and cooling events is estimated to have been on the order of 100 m (328 ft) per year (Aitken *et al*. 2008, p. 96). Given the current and anticipated rates of global climate change, migration rates will potentially need to be substantially higher than those measured in historic pollen records to sustain the species over time. A migration rate of at least a magnitude higher (1,000 m (3,280 ft)) per year is estimated to be necessary in order for tree species to be capable of tracking suitable habitats under projected warming trends (Malcolm *et al.* 2002, entire). Latitudinal migration rates on this scale may significantly exceed the migration abilities of many plant species, including *P. albicaulis* (Malcolm *et al*. 2002, p. 844–845; McKenney *et al.* 2007, p. 941).

Pinus albicaulis may have an advantage in its ability to migrate given that its seeds are dispersed by Clark’s nutcracker. As mentioned above, Clark’s nutcrackers can disperse seeds farther than the wind-dispersed seeds of other conifers (McCaughey *et al.* 1985, Tomback *et al.* 1990, 1993 in Keane and Parsons 2010, p. 58). However, migration of *P. albicaulis* to the north may be impeded by the disease white pine blister rust, which is currently present at the northern range limits of *P. albicaulis* (Smith *et al.* 2008, Figure 1, p. 984; Resler and Tomback 2008, p. 165).

Pinus albicaulis already is typically the first species to establish on cold, exposed high-elevation sites, thus the species could potentially migrate higher in elevation to more suitable habitats. Shifts in the optimum elevation for many high-elevation plant species have already been documented under current warming trends

(Lenoir *et al*. 2008, p. 1770). However, elevational migration as a refuge from temperature increase has limits, because eventually, suitable habitat may not be present even on mountaintops due to continuing temperature increases.

Climate change is expected to significantly decrease the probability of rangewide persistence of *Pinus albicaulis*. Projections from an empirically based bioclimatic model for *P. albicaulis* showed a rangewide distribution decline of 70 percent and an average elevation loss of 333 m (1,093 ft) for the decade beginning in 2030 (Warwell *et al.* 2007, p. 2). At the end of the century, less than 3 percent of currently suitable habitat is expected to remain (Warwell *et al*. 2007, p. 2). Similarly, climate envelope modeling on *P. albicaulis* distribution in British Columbia estimated a potential decrease of 70 percent of currently suitable habitat by the year 2055 (Hamman and Wang 2006, p. 2783). The area occupied by *P. albicaulis* in the Greater Yellowstone Ecosystem also is predicted to be significantly reduced with increasing temperature under various climate change scenarios (Schrag *et al*. 2007, p. 6). *P. albicaulis* is predicted to be nearly extirpated under a scenario of warming only and warming with a concomitant increase in precipitation (Schrag *et al*. 2007, p. 7). Climate envelope modeling by the USDA Forest Service using the A2 scenario projects that by 2090, a temperature increase of 9.1 °F (5.1 °C) would cause *P. albicaulis* suitable climate to contract to the highest elevation areas in the northern Shoshone National Forest and Greater Yellowstone Ecosystem or be extirpated (Rice 2012, p. 31). Loehman and others' (2010) modeling study indicated that climate changes may significantly impact whitebark pines in Glacier National Park through the indirect mechanisms of altered distributions of competing tree species and increased fire frequency and fire size. The above studies all suggest that the area currently occupied by *P. albicaulis* will be severely reduced in the foreseeable future.

We recognize, however, that there are many limitations to such modeling techniques, specifically for *Pinus albicaulis.* For example, climate envelope models use current environmental conditions in the distribution of the species' range to determine whether similar environmental conditions will be available in the future given predicted climate change. *P. albicaulis*, however, is a very long-lived species, and current environmental conditions may not closely resemble environmental conditions present when the trees currently on the landscape were established (Keane 2001c, pers. comm.). Additionally, these models also describe current environmental variables in averages taken over large areas. *P. albicaulis* may experience very different environmental conditions even over a small range as individuals can be separated by thousands of meters (Keane 2011c, pers. comm.).

Climate Change and the Interaction of Other Factors

In addition to direct habitat loss, *Pinus albicaulis* is expected to experience decrease in population size from synergistic interactions between habitat changes as a result of climate change and other threat factors including altered fire regimes, disease, and predation. *P. albicaulis* has evolved with fire, and under many conditions, fire is beneficial to the species (see Fire and Fire Suppression above). However, environmental changes resulting from climate change are expected to alter fire regimes resulting in increased fire intervals, increased fire severity, and habitat loss (Westerling et al. 2006, p. 943).

Pinus albicaulis also evolved with the predatory native mountain pine beetle (*Dendroctonus ponderosae*). However, the life cycle of the mountain pine beetle is temperature dependent, and warming trends have resulted in unprecedented mountain pine beetle epidemics throughout the range of *P. albicaulis* (the interaction of mountain pine beetle and *P. albicaulis* is discussed further below under Factor C, Predation) (Logan *et al.* 2003, p. 130; Logan *et al.* 2010, p. 896). At epidemic levels, mountain pine beetle outbreaks become stand-replacing events killing 80 to 95 percent of suitable host trees, and in many parts of the *P. albicaulis* range, those levels of mortality have already been reached (Gibson *et al.* 2008, p. 10). Even populations of *P. albicaulis* once considered mostly immune to mountain pine beetle epidemics are now being severely impacted; mountain pine beetles have now moved into areas previously climatically inhospitable for epidemic-level mountain pine beetle population growth (Carroll *et al*. 2003 in Gibson *et al.*

2008, p. 4; Raffa *et al*. 2008, p. 503; Logan *et al.* 2010, p. 895). Given ongoing and predicted environmental changes resulting from global climate change, we expect the expansion of habitat favorable to mountain pine beetle (and mountain pine epidemics) to continue into the foreseeable future.

In summary, we analyzed the effects of fire and fire suppression and climate change as related to the present or threatened destruction, modification, or curtailment of the habitat or range of *Pinus albicaulis*. As identified in our analysis above, fire historically played an integral role in maintaining healthy stands of *P. albicaulis* on the landscape. As a result of past and present fire suppression, forest stands where *P. albicaulis* were once prominent have become dense stands of shade-tolerant conifers. This change in forest composition and structure combined with impacts from climate change has resulted in an increase in the severity, intensity, and frequency of wildfires. We expect that changing fire regimes and fire suppression efforts that create these impacts will continue to affect the species into the foreseeable future. *P. albicaulis* can regenerate, even following stand-replacing burns, if a seed source is available. However, widespread predation and disease currently impacting *P. albicaulis* are limiting available seed sources, reducing the probability of regeneration following increasing wildfire episodes, and increasing the rate forest succession.

The pace of predicted climate change will outpace many plant species' ability to respond to the concomitant habitat changes. *Pinus albicaulis* is potentially particularly vulnerable to warming temperatures because it is adapted to cool, high-elevation habitats. Therefore, current and anticipated warming is expected to make its current habitat unsuitable for *P. albicaulis*. The rate of migration needed to respond to predicted climate change will be significant (Malcolm *et al*. 2002, p. 844–845; McKenney *et al.* 2007, p. 941). It is not known whether *P. albicaulis* is capable of migrating at a pace sufficient to move to areas that are more favorable to survival as a result of climate change. It is also not known the degree to which Clark's nutcracker could facilitate this migration. In addition, the presence of significant white pine blister rust infection in the northern range of *P. albicaulis* could serve as a barrier to effective northward migration. *P. albicaulis* survives at high altitudes already so there is little remaining habitat for the species to migrate to higher elevations in response to warmer temperatures. Adaptation in response to a rapidly warming climate also is unlikely as *P. albicaulis* is a long-lived species. Climate models suggest that climate change is expected to act directly to significantly decrease the probability of rangewide persistence in *P. albicaulis* within the next 100 years. This time interval is less than two generations for this long-lived species. In addition, projected climate change is a significant threat to *P. albicaulis*, because the impacts of climate change interact with other stressors such as mountain pine beetle epidemics and wildfire, resulting in habitat loss and population decline.

Therefore, we conclude that the best scientific and commercial information available indicates that the present or threatened destruction, modification, or curtailment of its habitat or range is a threat to *Pinus albicaulis* now and in the foreseeable future. Based on the current and ongoing issues identified here, their synergistic effects, and their likely continuation in the future, we conclude that this threat affects the species to such an extent that the species warrants listing under the Act as a threatened or endangered species.

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

<u>Commercial Harvest</u>

Pinus albicaulis is not targeted for commercial timber production in any part of its range (Arno and Hoff 1989, p. 5; COSEWIC 2010, p. 12; Keane *et al*. 2010, p. 30). At lower elevations where *P. albicaulis* occurs with species of commercial interest, some incidental harvest of *P. albicaulis* does take place. The average yearly estimated harvest of *P. albicaulis* in the United States is less than 405 ha (1,000 ac) (Losensky 1990 in Keane *et al.* 2010, p. 30). We have no information to indicate that harvest is a significant threat to the species or is contributing to the rangewide decline, or decline in any portion of the range of *P. albicaulis*.

<u>Recreational Use</u>

Pinus albicaulis stands are subject to a variety of nonconsumptive recreational activities including hiking and camping. These activities have the potential to cause negative impacts in localized areas through degradation of habitat in areas experiencing overuse. However, we have no information to indicate that recreational use is a threat to *P. albicaulis*.

Scientific and Educational Use

Pinus albicaulis is the subject of many scientific research studies. Currently, there is significant interest in collecting seed cones from individuals identified as being resistant to white pine blister rust. Given the relatively low number of seeds being collected, it is highly unlikely that seed removal is contributing to *P. albicaulis* declines. We have no information to indicate that *P. albicaulis* is being used consumptively for educational purposes. Therefore, the best available scientific information does not indicate that scientific and educational uses are a significant threat to *P. albicaulis.*

In summary, at this time, the best available information indicates that overutilization for commercial, recreational, scientific, or educational purposes is not a threat to *Pinus albicaulis*.

C. Disease or predation:

Disease

White Pine Blister Rust

White pine blister rust is a disease of 5-needled pines caused by a nonnative fungus, *Cronartium ribicola* (Geils *et al*. 2010, p. 153). It was introduced into western North America in 1910 near Vancouver, British Columbia (McDonald and Hoff 2001, p. 198). White pine blister rust initially spread rapidly through maritime and montane environments, which have environmental conditions more conducive to spread of infection, but over several decades, it spread through continental and alpine environments throughout western North America (Geils *et al.* 2010, p. 163). White pine blister rust's rate and intensity of spread is influenced by microclimate and other factors (described below). Therefore, the incidence of white pine blister rust at stand, landscape, and regional scales varies due to time since introduction and environmental suitability for its development. It continues to spread into areas originally considered less suitable for persistence, and it has become a serious threat, causing severe population losses to several species of western pines, including *Pinus albicaulis*, *P. monticola* (western white pine), and *P. lambertiana* Dougl. (sugar pine) (Schwandt *et al*. 2010, pp. 226–230). Its current known geographic distribution in western North America includes all U.S. States (except Utah, as well as the Great Basin Desert) and British Columbia and Alberta, Canada (Tomback and Achuff 2010, pp. 187, 206).

The white pine blister rust fungus has a complex life cycle: It does not spread directly from one tree to another, but alternates between living primary hosts (i.e., 5- needle pines) and alternate hosts. Alternate hosts in western North America are typically woody shrubs in the genus *Ribes* (gooseberries and currants) but also may include herbaceous species of the genus *Pedicularis* (lousewort) and the genus *Castilleja* (paintbrush) (McDonald and Hoff 2001, p. 193; McDonald *et al.* 2006, p. 73). *Ribes* is widespread in North America and, while most species are susceptible to white pine blister rust infection, they vary in their susceptibility and capability to support inoculum (spores) that are infective to white pines, depending on factors such as habitat, topographic location, timing, and environment (Zambino 2010, pp. 265–268). A widescale Federal program to eradicate *Ribes* from the landscape was conducted from the 1920s to the 1960s. However, due to the abundance of *Ribes* shrubs, longevity of *Ribes* seed in the soil, and other factors, white pine blister rust continued to spread, and pathologists realized that eradication was ineffective in controlling white pine blister rust. White pine blister rust is now pervasive in high-altitude 5-needled pines within most of the western United States (McDonald and Hoff 2001, p. 201).

White pine blister rust progresses through five spore stages to complete each generation: two spore stages

occur on white pine (*Pinus* spp.), and three stages occur on an alternate host. The five fungal spore stages require specific temperature and moisture conditions for production, germination, and dissemination. The spreading of spores depends on the distribution of hosts, the microclimate, and the different genotypes of white pine blister rust and hosts (McDonald and Hoff 2001, pp. 193, 202). Local meteorological conditions also may be important factors in infection success, infection periodicity, and disease intensity (Jacobi *et al.* 2010, p. 41).

On white pines, spores enter through openings in the needle surface, or stomates, and move into the twigs, branches, and tree trunk, causing swelling and cankers to form. White pine blister rust attacks seedlings and mature trees, initially damaging upper canopy and cone-bearing branches and restricting nutrient flows; it eventually girdles branches and trunks, leading to the death of branches or the entire tree (Tomback *et al.* 2001, p. 15, McDonald and Hoff 2001, p. 195). White pine blister rust can kill small trees within 3 years, and even one canker can be lethal. While some infected mature trees can continue to live for decades, their cone-bearing branches typically die, thereby eliminating the seed source required for reproduction (Geils *et al* . 2010, p. 156). In addition, the inner sapwood moisture decreases, making trees prone to desiccation and secondary attacks by insects (Six and Adams 2007, p. 351). Death to upper branches results in lower or no cone production and a reduced likelihood that seed will be dispersed by Clark's nutcrackers (McKinney and Tomback 2007, p. 1049). Similar to a total loss of cone production, even when cone production is low there could be a loss of regeneration for two reasons: (1) Clark's nutcrackers abandon sites with low seed production and (2) the proportion of seeds taken by predators becomes so high that no seeds remain for regeneration (COSEWIC 2010, p. 25).

Each year that an infected tree lives, the white pine blister rust infecting it continues to produce spores, thereby perpetuating and intensifying the disease. A wave, or massive spreading, of new blister rust infections into new areas or intensification from a cumulative buildup in already-infected stands occurs where *Ribes* shrubs are abundant and when summer weather is favorable to spore production and dispersal. Spores can be produced on pines for many years, and appropriate conditions need to occur only occasionally for white pine blister rust to spread and intensify (Zambino 2010, p. 265). The frequency of wave years depends on various factors, including elevation, geographical region, topography, wind patterns, temperature, and genetic variation in the rust (Kendall and Keane 2001, pp. 222–223).

Because its abundance is influenced by weather and host populations, white pine blister rust also is affected by climate change. If conditions become moister, white pine blister rust will likely increase; conversely, where conditions become both warmer and drier, it may decrease. Because infection is usually through stomates, whatever affects the stomates affects infection rates (Kliejunas *et al.* 2009, pp. 19–20). Stomates close in drought conditions and open more readily in moist conditions. In general, weather conditions favorable to the intensification of white pine blister rust occur more often in climates with coastal influences than in dry continental climates (Kendall and Keane 2001, p. 223). Due to current climate conditions in western North America, white pine blister rust now infects *Pinus albicaulis* populations throughout all of its range except for the interior Great Basin (Nevada and adjacent areas) (Tomback and Achuff 2010, Figure 1a, p. 187). However, the small uninfected area in the Great Basin accounts for only 0.4 percent of *P. albicaulis* distribution in the United States. The incidence of white pine blister rust is highest in the Rocky Mountains of northwestern Montana and northern Idaho, the Olympic and western Cascade Ranges of the United States, the southern Canadian Rocky Mountains, and British Columbia's Coastal Mountains (Schwandt *et al.* 2010, p. 228; Tomback *et al.* 2001, p. 15).

<u>White Pine Blister Rust Infection Rates</u>

Researchers have used various sampling methods to assess the effects of white pine blister rust on *Pinus albicaulis* and the amounts of infection present; therefore, exact comparisons between studies are not possible. While white pine blister rust occurs throughout almost all of *P. albicaulis'* range, not all trees are infected and infection rates vary widely. Furthermore, it can be difficult to detect white pine blister rust, especially if cankers occur on gnarled canopy branches where infections may remain undetected (Rochefort

2008, p. 294). However, despite slight differences in sampling methods general trends can be identified from the published literature (Schwandt *et al*. 2010, p. 228). Trends strongly indicate that white pine blister rust infections have increased in intensity over time and are now prevalent even in trees living in cold, dry areas originally considered less susceptible (Tomback and Resler 2007, p. 399), such as the Greater Yellowstone Ecosystem (Table 1).

Table 1.—Percentage of live trees with blister rust infection on plots/transects from recent surveys (adapted from Schwandt 2006, Table 1, p. 5).

GEOGRAPHIC REGION - NUMBER OF REPORTS [REFERENCE]	RANGE OF INFECTION (%)	MEAN (%)
British Columbia (rangewide) [Campbell and Antos 2000]	0 - 100	50.0
British Columbia (rangewide) [Zeglen 2002]	11 - 52.5	38.0
Northern Rocky Mountains (United States and Canada) [Smith *et al.* 2006]	0 - 100	43.6
Selkirk Mountains, northern Idaho - 5 stands [Kegley *et al.* 2004]	57 - 81	70.0
Colville National Forest, northeast Washington - 2 reports [Ward *et al.* 2006]	23 - 44	41.4
Greater Yellowstone Ecosystem [2005]	0 - 100	25.0
Intermountain West (Idaho, Nevada, Wyoming, California) [Smith and Hoffman 2000]	0 - 100	35.0
Blue Mountains, northeast Oregon [Ward *et al.* 2006]	0 - 100	64.0
Coast Range, Olympic Mountains, Washington - 2 reports [Ward *et al.* 2006)	4 - 49	19.0
Western Cascades, Washington and Oregon - 6 reports (Ward *et al.* 2006]	0 - 100	32.3
Eastern Cascades, Washington and Oregon - 13 reports [Ward *et al.* 2006]	0 - 90	32.3
Coastal Mountains, southwest Oregon [Goheen *et al.* 2002]	0 - 100	52.0
California, Statewide [Maloney and Dunlap 2006]	0 - 71	11.7

While numerous studies have reported the incidence of white pine blister rust on *Pinus albicaulis* and subsequent mortality, few have reported on rates of change. The Greater Yellowstone Whitebark Pine Monitoring Working Group's monitoring results from resurveys conducted in 2008–2009 indicated an average of 32.4 percent of live trees had blister rust, a 12.4 percent increase from their overall 2007 baseline estimate of 20 percent (Greater Yellowstone Whitebark Pine Monitoring Working Group 2011, p. 8). Results from resurveys conducted in 2010-2011 indicate an average of 18 percent of live trees had blister rust (Greater Yellowstone Whitebark Pine Monitoring Working Group 2012, p. 8). It should be recognized that these estimates do not denote a cumulative proportion of live trees infected from 2008 to 2011. As stated in the monitoring report, the working group anticipates completing a step-trend analysis on white pine blister rust change, severity of infection, and survival of *P. albicaulis* in 2012 (Greater Yellowstone Whitebark Pine Monitoring Working Group 2012, p. 7). That analysis is not available to include in this document. In Region 1 (USFS), aerial detection surveys are annually performed to determine the approximate location and amount of tree mortality, defoliation, and other non-fire damage (Steve Shelly 2012, pers. comm.). Aerial survey results from 2000-2011 show an increasing *P. albicaulis* mortality in acres, spiking to its highest level in 2009 (Steve Shelly 2012, pers. comm.). Acres of mortality decreased from 2010 to 2011 with approximately 75,000 acres in 2011 (Steve Shelly 2012, pers. comm.).

Additional information on trends has been reported for Canada. In the Canadian Rockies, stands surveyed in 2003 and 2004 had an overall infection level of 42 percent and 18 percent mortality. These were remeasured in 2009 and found to have increased to 52 percent infection and 28 percent mortality (Smith et al. 2010, p. 67). Infection and mortality from white pine blister rust were present in all stands, with the highest levels

occurring in the southern portions of the study area. The high mortality and infection levels, high crown kill, and reduced regeneration potential in the southern portion of their study area suggests that long-term persistence of *P. albicaulis* is unlikely (Smith *et al*. 2008, p. 982).

Pinus albicaulis infected with white pine blister rust has increased in all regions of the Canadian Rockies, where it ranged from 7 to 70 percent in 2003–2004 to 13 to 83 percent in 2009. Further, based on current mortality rates, the estimated *P. albicaulis* population decline within 100 years is 78 percent in the Canadian Rockies, 97 percent in Waterton Lakes National Park, and 57 percent for all of Canada (COSEWIC 2010, p. viii and Table 4, p. 19). *P. albicaulis* was designated in April 2010 as endangered in Canada due to the high risk of extirpation. Based on these studies showing rates of change in the United States and Canada as well as the plethora of infection percentage data, we conclude that the trend of white pine blister rust infection is increasing rangewide.

Genetic Investigations of White Pine Blister Rust Resistance and Virulence

Genetic research and development on white pine blister rust resistance may offer the best long-term prospect for control (Kinloch, Jr. 2003, p. 1045); however, understanding the dynamics of resistance to white pine blister rust, as well as its virulence and evolution, is incomplete (Schwandt *et al*. 2010, p. 241; Richardson *et al.*2010, p. 321). In *Pinus albicaulis*, some rust resistance has been documented on the landscape and in seeds, suggesting some level of heritable resistance (Hoff *et al.* 2001, p. 350; Mahalovich *et al.* 2006, p. 95). A limited number of *P. albicaulis* rust-resistance trials, in which seedlings are grown from rust-resistant seeds under varying conditions, have produced progeny seedlings with a range of resistance levels from 0 percent resistance in some areas to more than 40 percent resistance in other areas (Sniezko 2011, pers. comm.). In the northwestern United States, where white pine blister rust has infected trees for as long as 60 years or more, *P. albicaulis* rust-resistance trial results have indicated a trend of increasing resistance levels from southern Oregon north to Mount Rainier in Washington (Sniezko 2011, pers. comm.). Despite some encouraging results in limited trials, efforts are in early stages. Further, effective rust-resistance breeding programs to develop *P. albicaulis* trees for planting will likely take decades (Hoff *et al.* 2001, p. 359), and their outcomes are uncertain.

Even if genetic resistance is identified in *Pinus albicaulis*, hybridization between different white pine blister rust populations or mutations within populations could result in genetic variation in virulence, creating a new assortment of genes and behaviors (McDonald and Hoff 2001, p. 210). The potential for development of new white pine blister rust strains between eastern and western North America with greater virulence, fitness, and aggressiveness is currently unknown (Schwandt *et al*. 2010, p. 241). While North American populations of white pine blister rust have low genetic diversity and differentiation overall (Richardson *et al*. 2010, p. 316), rust genotypes with specific virulence to major resistance genes currently exist in some local populations at high frequencies (Kinloch, Jr. 2003, p. 1044). The reintroduction of white pine blister rust from goods imported from abroad also poses a serious danger to genetic selection and breeding programs. In Asia, white pine blister rust exists with different alternate host affinities and also may contain additional genes with wider virulence (Kinloch, Jr. 2003, pp. 1044, 1046).

Management and Restoration Efforts

Most current management and research focuses on producing white pines with inherited resistance to white pine blister rust, but also includes natural regeneration and silvicultural treatments, such as appropriate site selection and preparation, pruning, and thinning (Zeglen *et al.* 2010, p. 347). While genetic management of white pine blister rust is actively conducted for several 5-needled white pine species breeding programs, including the USFS' resistance screening programs for *P. albicaulis*, these investigations are only preliminary (King *et al*. 2010, p. 293).

High-elevation pines such as *Pinus albicaulis* also present management challenges to restoration due to remoteness, difficulty of access, and conflicting wilderness values (wilderness values are discussed in more

detail under Factor D) (Schwandt *et al.* 2010, p. 242). Furthermore, the vast scale at which planting rust-resistant trees would need to occur will make it challenging to restore *P. albicaulis* throughout its range. For example, approximately 5 percent of the historical distribution of the commercial species *Pinus monticola* (western white pine) was planted with resistance-improved stock between 1976 and 1996; however, the rates of planting have declined since then, and given current rates of planting, 60 years would now be required to plant an additional 5 percent (Schwandt *et al*. 2010, pp. 241–242). Therefore, current planting efforts appear to be insufficient to restore *P. albicaulis* throughout its range.

Model Predictions

Several models have been developed to predict residence times of white pine blister rust infection and long-term persistence of *Pinus albicaulis*. Ettl and Cottone (2004, pp. 36–47) developed a spatial stage-based model to examine *P. albicaulis* persistence in the presence of heavy white pine blister rust infections in Mt. Rainier National Park. They predicted median time to quasi extinction (population of less than 100 individuals) is 148 years, which represents approximately two to three generations of *P. albicaulis*. The most recent modeling effort by Hatala *et al.* (2011) is the first known study of the rate of blister rust progression and residence time in *P. albicaulis*. Their analysis compares four possible white pine blister rust dynamic infection models in *P. albicaulis* at the ecosystem scale (Greater Yellowstone Ecosystem) and predicts that on average, *P. albicaulis* trees live with white pine blister rust infection for approximately 20 years before succumbing to the disease. Their model also predicts that, within all their study sites, an average of 90 percent of the trees will be infected with white pine blister rust by the year 2013, while two other models calculated a 90 percent infection level within sites by the years 2026 and 2033. These results predict white pine blister rust will continue to spread within *P. albicaulis* in 10–20 years to a level where almost all trees will be impacted. Based on these modeling results, we conclude that, in addition to white pine blister rust occurring across almost the entire range of *P. albicaulis*, individual sites with white pine blister rust infection will continue to increase and intensify, ultimately resulting in stands that are no longer viable and potentially facing extirpation.

Predation (Herbivory)

Insect Predation

Pinus albicaulis trees are fed upon by a variety of insects; however, none has had a more widespread impact than the native mountain pine beetle (*Dendroctonus ponderosae* Hopkins). The mountain pine beetle is recognized as one of the principal sources of *P. albicaulis* mortality (Raffa and Berryman 1987, p. 234; Arno and Hoff 1989, p. 7). Mountain pine beetles are true predators on *P. albicaulis* and other western conifers because, to successfully reproduce, the beetles must kill host trees (Logan and Powell 2001, p. 162; Logan *et al.* 2010, p. 895). Upon locating a suitable host (i.e., large diameter tree with greater resources for brood production success), adult female mountain pine beetles emit pheromones that attract adult males and other adult females to the host tree. This attractant pheromone initiates a synchronized mass attack for the purpose of overcoming the host tree's defenses to mountain pine beetle predation. Once a tree has been fully colonized, the beetles produce an anti-aggregation pheromone that signals to incoming beetles to pass on to nearby unoccupied trees. Almost all host trees, even stressed individuals, will mount a chemical defense against these mass attacks. However, given a sufficient number of beetles, even a healthy tree's defensive mechanisms can be exhausted (Raffa and Berryman 1987, p. 239). Following the pheromone-mediated mass attack, male and female mountain pine beetles mate in the phloem (living vascular tissue) under the bark of the host tree. Females subsequently excavate vertical galleries where they lay eggs. Larvae hatched from these eggs feed on the phloem, pupate, and emerge as adults to initiate new mass attacks of nearby suitable trees (Gibson *et al.* 2008, p. 3). Mountain pine beetle development is directly controlled by temperature. The entire mountain pine beetle life cycle (from egg to adult) can take between 1 and 2 years depending on ambient temperatures. Warmer temperatures promote a more rapid development that facilitates a 1-year life cycle (Amman *et al.* 1997, p. 4; Gibson *et al*. 2008, p. 3).

Beetle activity in the phloem mechanically girdles the host tree, disrupting nutrient and water transport and ultimately killing the host tree. Additionally, mountain pine beetles carry on their mouthparts symbiotic blue-stain fungi, which are introduced into the host tree. These fungi also inhibit water transport and further assist in killing the host tree (Raffa and Berryman 1987, p. 239; Keane *et al.* 2010, p. 34).

Mountain pine beetles are considered an important component of natural forest disturbance (Raffa *et al*. 2008, p. 502; Bentz *et al.* 2010, p. 602). At endemic or 'natural' levels, mountain pine beetle remove relatively small areas of trees, changing stand structure and species composition in localized areas. However, when conditions are favorable, mountain pine beetle populations can erupt to epidemic levels and create stand-replacing events that kill 80 to 95 percent of suitable host trees (Keane *et al.* 2010, p. 34). Such outbreaks are episodic, can have a magnitude of impact on the structure of western forests greater than wildfire (the other major component of natural forest disturbance), and are often the primary renewal source for mature stands of western pines (Hicke *et al*. 2006, p. 1). Mountain pine beetle outbreaks typically subside only when suitable host trees are exhausted or temperatures are sufficiently low to kill larvae and adults (Gibson *et al.* 2008, p. 2).

The range of mountain pine beetle completely overlaps with the range of *Pinus albicaulis*, and mountain pine beetle epidemics affecting *P. albicaulis* have occurred throughout recorded history (Keane *et al.* 2010, p. 34). Recent outbreaks occurred in the 1930s, 1940s, and 1970s, and numerous 'ghost forests' of dead *P. albicaulis* still dot the landscape as a result (Arno and Hoff 1989, p. 7; Ward *et al*. 2006, p. 8).

Despite recorded historical impacts to the species, *Pinus albicaulis* has not been considered an important host of mountain pine beetle in the past. Unlike the lower elevation sites occupied by mountain pine beetle's primary hosts, *P. contorta* Douglas (lodgepole pine) and *P. ponderosae* (ponderosa pine), the high-elevation sites occupied by *P. albicaulis* typically have been climatically inhospitable to mountain pine beetle (Logan and Powell 2001, p. 161). At the low temperatures typical of high-elevation sites, mountain pine beetle mostly experience a 2-year life cycle, which is not favorable to epidemic outbreaks (i.e., eruptive population growth). Warmer temperatures promote a 1-year life cycle, which facilitates the synchronized mass attacks important in overcoming host tree defenses (Logan and Powell 2001, p. 167).

However, unlike previous epidemics, the current mountain pine beetle outbreak is having an increasingly significant impact on *Pinus albicaulis* (Logan *et al.* 2003, p. 130; Logan *et al*. 2010, p. 896). The reported mortality rates of mostly mature trees (i.e. large-diameter trees) can be as high as 96 percent (Gibson *et al*. 2008, p. 9). In 2007 alone, *P. albicaulis* trees on almost 202,342 ha (500,000 ac) were killed. At the time this was the highest recorded mountain pine beetle mortality ever reported for *P. albicaulis* (Gibson *et al.* 2008, p. 2). The number of acres with mountain pine beetle-killed *P. albicaulis* trees continues to increase significantly rangewide, and in 2009 *P. albicaulis* trees on an estimated 809,371 ha (2,000,000 ac) were killed (Service 2010).

Trends of environmental effects from climate change have provided the favorable conditions necessary for the current, unprecedented mountain pine beetle epidemic in high-elevation communities across the western United States and Canada (Logan and Powell 2001, p. 167; Logan *et al*. 2003, p. 130; Raffa *et al*. 2008, p. 511). Warming trends have resulted in not only intensified mountain pine beetle activity in high-elevation *Pinus albicaulis* forests, but have resulted in mountain pine beetle range expansion into more northern latitudes and higher elevations (Logan and Powell 2003, p. 131; Carroll *et al.* 2003 in Gibson *et al*. 2008, p. 4; Raffa *et al.* 2008, p. 503; Logan *et al*. 2010, p. 895). Winter temperatures are now warm enough for winter survival for all mountain pine beetle life stages and for maintenance of the 1-year life cycle that promotes epidemic mountain pine beetle population levels (Bentz and Schen-Langenheim 2007, p. 47; Logan *et al*. 2010, p. 896). Along with warmer winter conditions, summers have been drier, with droughts occurring through much of the range of *P. albicaulis* (Bentz *et al.* 2010, p. 605). Mountain pine beetles frequently target drought-stressed trees, which are more vulnerable to attack as they are less able to mount an effective

defense against even less dense mass attacks by mountain pine beetles (Bentz *et al*. 2010, p. 605). Given ongoing and predicted environmental effects from climate change, we expect the expansion of habitat favorable to mountain pine beetle (and mountain pine epidemics) to continue into the foreseeable future.

Current management and research continue to explore methods to control mountain pine beetle mainly with the use of the pesticide Carbaryl and the antiaggregation pheromone called Verbenone. Both methods can be effective for limited time periods (Progar 2007, p. 108). However, use of either control method may be prohibitively expensive and challenging given the scale of mountain pine beetle outbreaks (i.e., millions of acres) and the inaccessibility of much of *Pinus albicaulis* habitat. Currently these methods are mostly being suggested for use in targeted protection of high-value trees (e.g. individuals resistant to white pine blister rust, stands in recreational areas) rather than as a large-scale restoration tool (Keane *et al.* 2010, p. 94). Therefore, these control methods are not currently sufficient to protect the species as a whole from mountain pine beetle predation.

Synergistic Interactions between Disease and Predation

White pine blister rust and mountain pine beetle act both individually and synergistically to threaten *Pinus albicaulis* rangewide. Mountain pine beetle will preferentially attack *P. albicaulis* infected with, and weakened by, white pine blister rust (Six and Adams 2007, p. 351). This preference results in increased susceptibility of *P. albicaulis* to mountain pine beetle-caused mortality. Mountain pine beetles and white pine blister rust also interact in other ways that threaten *P. albicaulis* regeneration and persistence. Mountain pine beetles preferentially target large mature trees. As a result, large trees are removed from populations, leaving smaller trees for regeneration in a less competitive environment. Unfortunately, white pine blister rust is not selective and infects all age and size classes of *P. albicaulis*. Thus, in the current environment that contains epidemic levels of mountain pine beetle and a nearly ubiquitous presence of white pine blister rust, *P. albicaulis* that have escaped mountain pine beetle mortality are still susceptible to white pine blister rust, and the possibility of regeneration following mountain pine beetle epidemics is jeopardized. Conversely, the small percentage of *P. albicaulis* individuals that are genetically resistant to white pine blister rust, and thus critical to species persistence, are still vulnerable to mountain pine beetle attack.

White pine blister rust and mountain pine beetle further impact the probability of *Pinus albicaulis* regeneration because both act to severely decrease seed cone production. White pine blister rust does this by killing cone-bearing branches, such that even if the tree itself remains alive for some time, seed production is compromised. Mountain pine beetles decrease seed production by targeting and killing larger trees, which are the main trees that bear cones. A severe reduction in seed production has the potential to limit the effectiveness of the masting strategy employed by *P. albicaulis* (see Taxonomy and Life History), such that the proportion of seeds taken by seed predators will eventually become too high to allow regeneration. Additionally, severe seed reduction disrupts the relationship between *P. albicaulis* and Clark's nutcracker. Clark's nutcrackers eventually abandon *P. albicaulis* stands when seed production is too low (McKinney *et al*. 2009, p. 599).

Limited research has focused on detecting amounts of *Pinus albicaulis* regeneration. Most remaining high-elevation *P. albicaulis* stands in the U.S. Intermountain West that are climax communities have little regeneration (Kendall and Keane 2001b, p. 228). In contrast, new and advanced *P. albicaulis* regeneration was documented on the majority of plots in southwestern Montana and eastern Oregon, indicating that the Wallowa and Pioneer Mountains sites seem to be more vigorous and to be regenerating better than sites farther north in the Rockies (Larson 2007, pp. 16–18). However, there is much *P. albicaulis* site variability and the regeneration on some of these sites was preceded by a particularly large cone crop in 2006. In addition, as seedlings grow, their increased foliage surface area becomes a larger target for infection by white pine blister rust spores (Tomback *et al*. 1995, p. 662). Therefore, despite observed regeneration, the level of effective regeneration (i.e., seedlings that actually reach a reproductive age) is questionable given the high incidence of white pine blister rust currently on the landscape. We conclude that *P. albicaulis* regeneration will generally be less successful in the future than it has been in the past.

In summary, disease in the form of white pine blister rust and predation from mountain pine beetle are contributing, individually and in combination, to the decline of *Pinus albicaulis* rangewide. White pine blister rust is now ubiquitous on the landscape; millions of acres (hectares) of *P. albicaulis* have been infected, and that number is increasing yearly. Due to the warmer temperatures and drier conditions brought on by climate change within the range of *P. albicaulis*, mountain pine beetle epidemics now occur at unprecedented levels, causing mortality in millions of acres (hectares) of *P. albicaulis*, much of which was previously thought to be mostly climatically immune from large-scale mountain pine beetle attacks. Additionally, the interaction between white pine blister rust and the mountain pine beetle further intensifies the impact of both threats. White pine blister rust and mountain pine beetle are impacting *P. albicaulis* equally in both Canada and the U.S. portion of the range. In other words, there is currently no refuge from these threats (COSEWIC 2010, p. viii).

There is no known way to control or reduce or eliminate either threat at this time, particularly at the landscape scale needed to effectively conserve this species. Thus, we expect both disease and predation to continue to heavily impact *Pinus albicaulis*. On the basis of a review of the best scientific and commercial information available concerning present threats to *P. albicaulis* from white pine blister rust and mountain pine beetle, their synergistic effects, and their likely continuation in the future, we conclude that disease and predation is a threat to *P. albicaulis*.

D. The inadequacy of existing regulatory mechanisms:

Federal Laws and Regulations

More than 96 percent of the distribution of *Pinus albicaulis* in the contiguous United States is federally owned or managed (Service 2011, p. 1), 34 percent of which is designated as wilderness.

The Wilderness Act of 1964

The USFS and other Federal agencies manage lands designated as wilderness areas under the Wilderness Act of 1964 (16 U.S.C. 1131–1136). Considerable amounts of *Pinus albicaulis* occur within wilderness areas managed by the USFS and NPS (31 percent and 2.5 percent of the total United States distribution, respectively) (Service 2011, p. 1) and, therefore, are afforded protection from direct loss or degradation by some human activities (e.g. commercial timber harvest, road construction, some fire management actions).

Conversely, the regulations covering wilderness areas on Federal lands also may impede or restrict potential activities necessary for restoring *Pinus albicaulis* (Aubry 2011, pers. comm.; Reinhart 2010, pers. comm.). Currently, there are inconsistent policy interpretations across wilderness areas (Schwandt 2011, pers. comm.). Consequently, Federal agencies are engaged in ongoing discussions regarding whether restoration of *P. albicaulis* in wilderness areas is appropriate, and if so, what types of actions would be allowed. Taking action on *P. albicaulis* restoration in wilderness areas could compromise the “untrammeled” value of wilderness, but not taking action may compromise the “naturalness” value of wilderness by allowing the extirpation of a keystone species. If restoration actions are not restricted under the Wilderness Act, they would likely be limited (Reinhart 2011, pers. comm.). To date, limited surveys and monitoring of *P. albicaulis* trees and cone collecting for seeds have occurred in wilderness areas (Schwandt 2011, pers. comm.). While the Wilderness Act may allow for some restoration actions, it does not directly address or alleviate the threats of environmental effects resulting from climate change, white pine blister rust, mountain pine beetle, or fire suppression. The Wilderness Act does influence some fire management actions, which are described under Federal Wildland Fire Management Policies, Plans, and Guides below.

National Environmental Policy Act of 1970

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 that cannot be avoided, and any irreversible or irretrievable commitments of resources involved (40 CFR 1502). Additionally, activities on non-Federal lands are subject to NEPA if there is a Federal nexus. Since NEPA is a disclosure law, it does not require subsequent minimization or mitigation measures by the Federal agency involved. Although Federal agencies may include conservation measures for *Pinus albicaulis* as a result of the NEPA process, any such measures are typically voluntary in nature and are not required by the statute. As NEPA does not provide any regulatory mechanisms, it does not directly address or alleviate the threats of the environmental effects resulting from climate change, white pine blister rust, mountain pine beetle, or fire suppression.

National Forest Management Act of 1976

Under the National Forest Management Act (NFMA) of 1976, as amended, (16 U.S.C. 1600–1614), the USFS manages National Forest lands based on multiple-use, sustained-yield principles, and implement resource management plans to provide for a diversity of plant and animal communities. As such, individual forests may identify species of concern that are significant to each forest's biodiversity. The USFS recognizes the decline of *Pinus albicaulis* and is developing various strategies that focus on restoration, including the Pacific Northwest Region's Restoration Strategy, individual forest action strategies (Aubry *et al.* 2008, entire), and the Rocky Mountain Research Station's draft General Technical Report, "A Range-wide Restoration Strategy for Whitebark Pine (*Pinus albicaulis*)" (Keane *et al*. 2010, entire). The latter report may provide the most effective rangewide restoration strategy available because it integrates the genetics, pathology, and ecology of *P. albicaulis*.

The Forest Service also implements *Pinus albicaulis* restoration and management activities (stand thinning, pruning, fire management) on non-wilderness lands, although *P. albicaulis* forests are generally not accessed for commercial forestry commodity extraction and, therefore, tend to be excluded from most stand improvement actions. The USFS has, along with university researchers and others, made important strides in understanding the white pine blister rust pathosystem and mountain pine beetle life history, researching and propagating rust-resistant *P. albicaulis* seeds and seedlings, and developing strategic plans. Their efforts are encouraging and may provide some benefit to the species at local scales, but these efforts under the NFMA do not directly address or alleviate the threats from the environmental effects resulting from climate change, white pine blister rust, mountain pine beetle, or fire suppression at the rangewide level of the species.

Forest Service Policy

As of July 27, 2011, the USFS Region 2 and Region 4 policy, as established in the Forest Service Manual 2670 Supplement, states species identified as candidates are automatically placed on the sensitive species list (FSM 2672.11(1)) (Kent Houston 2012, pers. comm.; Lee Jacobson 2012, pers. comm.). By the end of 2011, Region 1 has also included *Pinus albicaulis* on their sensitive species list (Steve Shelly 2012, pers. comm.). Forest Service policy requires review of programs and activities through a Biological Evaluation (BE) to determine potential effects of projects to sensitive species. Decisions must not result in loss of species viability or create a significant trend towards federal listing (FSM 2670.32). BEs must include an evaluation of effects of proposed management actions on *P. albicaulis* or its habitat occurring within an analysis area.

National Park Service Organic Act of 1916

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 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 *Pinus albicaulis* occurs in National Parks, the NPS Organic Act directs the NPS to address *P. albicaulis* and its health. As such, the NPS has made considerable efforts to survey and monitor *P.*

albicaulis stands and identify white pine blister rust infection levels. While the NPS makes certain that natural processes will occur, such as natural *P. albicaulis* regeneration, they may actively intervene when natural ecological processes are not adequately functioning. In the case of *P. albicaulis*, intervention could include restoration actions, and these actions would likely mimic criteria provided under the Wilderness Act (D. Reinhart 2011, pers. comm.). While the NPS Organic Act directs the NPS to address *P. albicaulis* health, it does not provide mechanisms that directly address or alleviate the threats from the environmental effects associated with climate change, white pine blister rust, mountain pine beetle, or fire suppression.

Clean Air Act of 1970

As explained under Factor A, warming temperatures are expected to result in direct habitat loss and are also currently causing an increase in populations of the predatory mountain pine beetle resulting in significant mortality rangewide. 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. 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. EPA's 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 EPA's finding or how effective they would be in addressing climate change. Therefore, the Clean Air Act and its existing implementing regulations do not currently provide regulatory mechanisms relevant to threats from the environmental effects associated with climate change, and the synergistic interactions with white pine blister rust, mountain pine beetle, or fire suppression.

Federal Wildland Fire Management Policies, Plans, and Guides

A variety of Federal fire management policies, plans, and implementation guides have been developed to both standardize interagency procedures and provide for a full spectrum of fire management options, including suppression and allowing some fires to function in their natural ecological role. Federal Land and Resource Management Plans also incorporate fire management, including use of prescribed fire, and typically provide more detailed guidance for individual agency units, such as a National Forest. These planning and implementation documents have the potential to benefit the species. However, these documents are typically broad in scope allowing a wide degree of latitude in potential fire management actions. We do not have information to indicate that fire management policies are currently being used in a way that alleviates the threat of fire suppression rangewide or contain fire use prescriptions that could protect *Pinus albicaulis*. Therefore, at this time we conclude that current fire management policies are inadequate to reduce or eliminate the threat of fire suppression across the entire range of *P. albicaulis*.

State Laws and Regulations

Pinus albicaulis generally has not been tracked by State wildlife or natural heritage programs in States where the species occurs. NatureServe's last status review revision of *P. albicaulis* (October 2008) ranked it as a G3 species, which means the species is vulnerable across its entire range (NatureServe 2010, p. 1; NatureServe 2011, p. 2). State rankings include Idaho (S4, apparently secure), Montana (S4, apparently secure), Oregon

(S4, apparently secure), and Wyoming (S3, vulnerable), and Washington, which recently elevated *P. albicaulis* to S3 (vulnerable) (Arnett 2011, pers. comm.). California and Nevada have not ranked the species. However, these rankings do not grant *P. albicaulis* any special status under any State legislation (NatureServe 2010, p. 1; NatureServe 2011, p. 2). The individual State rankings of S4 (apparently secure) are contrary to what the most current data suggest, that is, that *P. albicaulis* is declining rangewide. A very minimal amount of the whitebark pine range is known to occur on State lands. We do not know of any existing State laws or regulations that address or alleviate impacts from white pine blister rust, mountain pine beetle, or fire suppression. Additionally, we are not aware of any State laws or regulations that address the environmental effects resulting from climate change.

Canadian Federal and Provincial Laws and Regulations

The Committee on the Status of endangered Wildlife in Canada recently designated *Pinus albicaulis* as Endangered due to the high risk of extirpation and recommended the species be protected under Canada's Species at Risk Act (SARA) (COSEWIC 2010, p. iii). While listing a species under SARA may provide some benefits, such as providing official recognition, it provides no legal protection. In addition, it applies only to Federal lands, and most of *P. albicaulis'* distribution in Canada occurs on non-Federal lands (most public lands, or Crown lands, are under provincial jurisdiction). At the provincial level, in Alberta, *P. albicaulis* is currently ranked as S2 (imperiled) and assessed as Endangered under the Alberta Wildlife Act, and in British Columbia, it's ranked as S3 (special concern/vulnerable) and blue-listed (species of special concern) (Wilson 2007, p. 1; Environment Canada 2010, p. 71; COSEWIC 2010, p. 30). However, these rankings and assessments do not provide legal protections and only suggest voluntary conservation measures. Parks Canada has initiated conservation efforts including monitoring, prescribed fire, white pine blister rust-resistant tree identification, seed collection, and use of pheromones to protect apparent blister rust-resistant trees from mountain pine beetle attack (Wilson 2007, pp. 12–13). The provincial designations likely benefit the species and raise public awareness; however, they provide no legal protections, as conservation measures are largely voluntary.

In summary, we examined a number of existing regulatory mechanisms that have the potential to address current and projected threats to *Pinus albicaulis* populations. The majority of *P. albicaulis* habitat in the United States occurs on Federal lands, where Federal agencies have broad regulatory authority to plan and manage land use activities, including timber harvest, recreation, and a variety of other actions. Some management activities have the potential to benefit *P. albicaulis* and its habitat. However, in our review of existing regulatory mechanisms, only the policies related to Federal Wildland Fire Management Policies, Plans, and Guides directly address any of the four main threats to the species identified in this document. Specifically, these policies have the potential to reduce or eliminate threats to *P. albicaulis* from fire suppression. However, at this time we find that these policies are inadequate to address this threat.

The existing regulatory mechanisms currently in place throughout the range of *Pinus albicaulis* are inadequate to reduce or eliminate any of the four main threats to the species identified above—the loss of habitat from fire suppression and the exacerbating environmental effects of climate change under Factor A, and mortality from white pine blister rust and mountain pine beetle under Factor C. Therefore, based on our review of the best scientific and commercial information available, we conclude that existing regulatory mechanisms are inadequate to protect *P. albicaulis* or its habitat.

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

We did not identify any other natural or manmade factors that are likely to significantly threaten the existence of the species. Therefore, we conclude that the best scientific and commercial information available indicates that *Pinus albicaulis* is not threatened by other natural or manmade factors affecting its continued existence.

Conservation Measures Planned or Implemented :

Most current management and research focuses on producing *Pinus albicaulis* with inherited resistance to white pine blister rust. Additional research investigates natural regeneration and silvicultural treatments, such as appropriate site selection and preparation, pruning, and thinning in order to protect genetic resources, increase reproduction, reduce blister rust damage, and increase stand volume (Zeglen *et al.* 2010, p. 361). While genetic management of white pine blister rust is actively conducted for several 5-needled white pine species breeding programs, including the Forest Service resistance screening programs for *P. albicaulis*, these investigations are preliminary and ongoing (King *et al.* 2010, p. 293, Keane *et al.* 2011, Mahalovich 2012).

The BLM continues to institute various programs for the conservation of *Pinus albicaulis*. In Wyoming on Commissary Ridge, the BLM is currently removing mountain pine beetle infested trees and thinning subalpine fir and lodgepole pine from around surviving, healthy *P. albicaulis* (Bob Means 2012, pers. comm.). This project is proposed to be completed in 2012. Further conservation projects conducted by BLM in 2011 included a *P. albicaulis* inventory throughout Idaho, Montana and Wyoming. Wyoming inventory results thus far identified 8 plus trees (trees resistant to blister rust) (Bob Means 2012, pers. comm.). This inventory is continuing in 2012 (Bob Means 2012, pers. comm.). However, BLM plans to implement another mapping and health inventory of *P. albicaulis* in western Wyoming in 2012. Lastly, a seed collection project was started in 2009 by the BLM for the purpose of studying rust resistance from inoculated seedlings (Bob Means 2012, pers. comm.). Further data collection is planned in June 2012 on the seedlings with rust resistance data available in 2015 (Bob Means 2012, pers. comm.).

Currently, the USFS in Region 1 is developing a range-wide restoration strategy for *Pinus albicaulis* pine forests (Keane *et.al*. 2012). The objectives are to promote *P. albicaulis* survival and regeneration for ecological diversity, wildlife, hydrologic and other benefits through the use of planned and unplanned ignitions (Keane *et.al.* 2012). It contains guiding principles, central tenets for a strategy and assessment criteria for future planning (Keane *et.al.* 2012).

Summary of Threats :

The primary threat to the species is from disease (Factor C) in the form of the nonnative white pine blister rust and its interaction with other threats. We found that white pine blister rust is now nearly ubiquitous throughout the range of *Pinus albicaulis*. White pine blister rust results in the mortality of an overwhelming majority of infected individuals, and all age classes of trees are susceptible. Seedlings are killed rapidly, and while some mature individuals may persist on the landscape for decades following infection, white pine blister rust typically kills seedcone-bearing branches. White pine blister rust has impacted millions of acres (hectares) of *P. albicaulis*. Currently, colder, drier areas of the range that were originally thought to be less susceptible to the disease are now showing considerable rates of infection. Based on current mortality rates, the estimated population decline for the northern 56 percent of the range (i.e., Canada), is expected to be 57 percent within 100 years, which is less than two generations for this species (COSEWIC 2010, pp. viii, 19). However, that is likely an underestimate, as it assumes current mortality rates remain constant.

After examining information collected on the incidence of white pine blister rust, we conclude that white pine blister rust will continue to intensify and kill *Pinus albicaulis* throughout its entire range. The remainder of the range (i.e., United States) is experiencing similar rates of mortality, and thus we anticipate a decline similar to that estimated for the northern portion of the range (Canada). A small percentage of genetic resistance to white pine blister rust is present in *P. albicaulis* on the landscape, and research is currently being conducted to identify and propagate resistant individuals. However, these programs are still in the early stages and an effective breeding program will take decades, if it can be achieved at all.

Pinus albicaulis also is currently experiencing significant mortality from predation (Factor C) by the native mountain pine beetle. Millions of acres (hectares) of *P. albicaulis* have been lost in this decade (i.e., late 1990’s to 2011), and we expect that number to continue to increase. For the last decade in particular, warming temperatures have facilitated large mountain pine beetle outbreaks even in areas of *P. albicaulis*

habitat that were previously thought to inhibit epidemic levels of mountain pine beetle. Given projected warming trends, we conclude that conditions will remain favorable for epidemic levels of mountain pine beetle to continue into the foreseeable future.

We also anticipate that continuing environmental effects resulting from climate change will result in direct habitat loss (Factor A) for *Pinus albicaulis*, a high-elevation species occurring only in cool mountaintop habitats. Bioclimatic models predict that suitable habitat for *P. albicaulis* will decline precipitously within the next 100 years. Research indicates that northern migration of *P. albicaulis* is a possible, but unlikely, response to the projected rate of warming climatic conditions. Additionally, the presence of white pine blister rust on the northern portions of the range could potentially impede effective migration. Adaptation to a rapidly warming climate also seems unlikely for a species that has an estimated generation time of 60 years.

Past and ongoing fire suppression is also negatively impacting populations of *Pinus albicaulis* through direct habitat loss (Factor A). Many stands of trees once dominated by *P. albicaulis* are now dense stands of shade-tolerant conifers. This change in forest structure and composition facilitates an increased frequency and intensity of wildfire and an increased susceptibility to predation and disease. Additionally, environmental changes resulting from changing climatic conditions are acting alone and in combination with the effects of fire suppression to increase the frequency and severity of wildfires. *P. albicaulis* could potentially regenerate following even stand-replacing wildfires, if an available seed source is available. However, widespread predation and disease currently impacting *P. albicaulis* are limiting available seed sources, making the probability of regeneration following wildfire less likely.

In our analysis of Factor D, we examined several Federal mechanisms that could potentially address the threats to *Pinus albicaulis*. These mechanisms may be useful in minimizing the adverse effects to *P. albicaulis* from potential stressors such as commercial harvest or habitat destruction and degradation from road construction; however, none of these potential stressors rises to the level of a threat to *P. albicaulis*. None of the existing regulatory mechanisms we examined provide adequate protection to *P. albicaulis* from stressors that rise to the level of a threat, including white pine blister rust, mountain pine beetles, the exacerbating effects of environmental change resulting from changing climatic conditions, and fire suppression. Thus, we concluded the existing regulatory mechanisms are inadequate to address the threats presented above.

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 support continuing monitoring efforts across several states by BLM for the conservation of *Pinus albicaulis*. The USFS in Region 1 has conducted aerial monitoring for almost 50 years. The valuable information gathered from these surveys includes determining the approximate location and amount of tree mortality, defoliation, and other non-fire damage for *P. albicaulis*. We recommend continuing the aerial surveys. Various efforts are ongoing in research of blister rust and its impacts on *P. albicaulis*. Most current management and research focuses on producing *P. albicaulis* with inherited resistance to white pine blister rust and genetic management. This research may provide important information in conserving *P. albicaulis* populations in the future.

Priority Table

Magnitude	Immediacy	Taxonomy	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:

N/A

Magnitude:

The threats that face *Pinus albicaulis* are high in magnitude because the major threats (disease, predation, environmental changes and exacerbating effects of climate change, fire and fire suppression) occur throughout all of the species' range and are having a demonstrable effect on the species. The primary threat, white pine blister rust, currently occurs throughout all of the range of *P. albicaulis* except for the interior Great Basin, which accounts for only 0.4 percent of *P. albicaulis* distribution in the United States. The incidence of white pine blister rust is highest in the Rocky Mountains of northwestern Montana and northern Idaho, the Olympic and western Cascade Ranges of the United States, the southern Canadian Rocky Mountains, and British Columbia's Coastal Mountains. Trends strongly indicate that white pine blister rust infections have increased in intensity over time and are now prevalent in even drier and colder areas originally considered less susceptible to infection. The other major threats, predation, fire and fire suppression, and environmental effects of climate change, which exacerbate some of the threats, also occur throughout the entire range and have resulted in significant loss of *P. albicaulis*. We anticipate these threats to continue to impact *P. albicaulis* into the foreseeable future.

Imminence :

The threats are imminent because rangewide disease, predation, fire and fire suppression, and environmental effects of climate change are affecting *Pinus albicaulis* currently and are expected to continue and likely intensify in the foreseeable future. These actual, identifiable threats are covered in detail under the discussion of Factors A and C, and currently include mortality from white pine blister rust, predation by mountain pine beetle, fire and fire suppression, and environmental effects of climate change. Trends indicate that these threats are currently having a significant negative impact on *P. albicaulis*. Attempts to control white pine blister rust and mountain pine beetle have been ineffective, and we believe both threats will have increasingly negative impacts on *P. albicaulis* into the foreseeable future.

__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?

After re-analyzing the threats to *Pinus albicaulis*, we have determined that emergency listing the species is not warranted. All known threats were reevaluated and found to be of the same magnitude and imminence as was determined in the July, 2011 12-month finding. For this reason, we find that the previously assessed listing priority number (LPN 2) is still appropriate and an emergency listing is not warranted.

Description of Monitoring:

In Region 1 (USFS), aerial detection surveys are annually performed to determine the approximate location and amount of tree mortality, defoliation, and other non-fire damage. These surveys have been conducted for nearly 50 years, although procedures have varied during that time. Aerial survey results from 2000-2011 show increasing Pinus albicaulis mortality, spiking to its highest level in 2009. Acres of mortality decreased from 2010 to 2011 with approximately 75, 000 acres in 2011.

Since 2004, an interagency working group (USFS, US Geological Survey, National Park Service, Montana State University, Greater Yellowstone Coordinating Committee) effort has resulted in a monitoring protocol and a complete sampling frame of data. The objectives of the *Pinus albicaulis* monitoring program are to detect and monitor changes in the health and status of *P. albicaulis* populations across the greater yellowstone ecosystem due to infection by white pine blister rust, attack by mountain pine beetle, and damage by other environmental and anthropogenic agents. The current report presents a summary of the data collected between 2008 and 2011 (Greater Yellowstone Whitebark Pine Monitoring Working Group, 2012).

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

Idaho,Montana,Oregon,Wyoming

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

none

State Coordination:

Montana, Wyoming, Oregon, Idaho, California, Utah, and British Columbia, Canada also provided information. No information was provided from Nevada.

Literature Cited:

Agee, J.K. 1993. Fire ecology of Pacific Northwest forests. Island Press. Washington, D.C. 493 pp.

Aitken, S.N., S. Yeaman, J.A. Holliday, T. Wang, and S. Curtis-McLane. 2008. Adaptation, migration or extirpation: climate change outcomes for tree populations. Evolutionary Applications 1:95–111.

Amman, G.D., M.D. McGregor, and R.E. Dolph, Jr. 1997. Mountain pine beetle. USDA Forest Service. Forest Insect & Disease Leaflet 2. Available online at: http://www.fs.fed.us/r6/nr/fid/fidls/fidl-2.pdf. 12 pp.

Arno, S.F. 1980. Forest fire history in the northern Rockies. Journal of Forestry 78:460–465.

Arno, S.F. 2001. Community types and natural disturbance processes. Pages 74–88, Chapter 4 In Tomback,

D.F., S.F. Arno, and R.E. Keane (eds.). Whitebark Pine Communities: Ecology and Restoration. Island Press. Washington, D.C. 440 pp.

Arno, S.F. and R.J. Hoff. 1989. Silvics of whitebark pine (Pinus albicaulis). U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT. General Technical Report INT–253. January 1989. 11 pp.

Arno, S.F. and R.J. Hoff. 1990. Pinus albicaulis Engelm. Whitebark pine. Pages 268–279 In Burns, R.M. and B.H. Honkala (tech. coords.). Silvics of North America. USDA Forest Service, Agriculture Handbook 654. Washington, D.C. 675 pp.

Aubry, C., D. Goheen, R. Shoal, T. Ohlson, T. Lorenz, A. Bower, C. Mehmel, and R. Sniezko (compilers). 2008. Whitebark pine restoration strategy for the Pacific Northwest Region 2009–2013. USDA Forest Service, Pacific Northwest Region. Olympia, Washington. 90 pp.

Bentz, B.J. and G. Schen-Langenheim. 2007. The mountain pine beetle and whitebark pine waltz: has the music changed? Pages 43–50 In Proceedings of the Conference Whitebark Pine: A Pacific Coast Perspective. USDA Forest Service, Rocky Mountain Research Station. Logan, Utah.

Bentz, B.J., J. Régnière, C.J. Fettig, E.M. Hansen, J.L. Hayes, J.A. Hicke, R.G. Kelsey, J.F. Negrón, and S.J. Seybold. 2010. Climate change and bark beetles of the western United States and Canada: direct and indirect effects. BioScience 60:602–613.

Bradshaw, A.D. and T. McNielly. 1991. Evolutionary response to global climatic change. Annals of Botany 67:5–14

Carroll, A.L., S.W. Taylor, J. Regniere, and L. Safranyik. 2003. Effects of climate change on range expansion by the mountain pine beetle in British Columbia. Pages 223–232 In Shore, T.L., J.E. Brooks, and J.E. Stone (eds.). Proceedings of the Symposium on Mountain Pine Beetle Symposium: Challenges and Solutions. Oct. 30–31, 2003, Kelowna, British Columbia. Information Report BC–X–399. National Resources Canada, Canadian Forest Service, and the Pacific Forestry Centre. Victoria, British Columbia.

Cohen, J. 2008. The wildland-urban interaface fire problem: A consequence of the fire exclusion paradigm. Forest History Today. Fall: 20-26.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2010. COSEWIC assessment and status report on the whitebark pine Pinus albicaulis in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Canada. Available online at: http://www.sararegistry.gc.ca/status/status_e.cfm. x + 44 pp.

Critchfield, W.B. and E.L. Little, Jr. 1966. Geographic Distribution of the Pines of the World. U.S.D.A. For. Serv. Misc. Public. 991, Washington, D.C.

Environment Canada. 2010. Consultation on amending the list of species under the species at risk act: terrestrial species. Environment Canada, Canadian Wildlife Service. Ottawa, Ontario. 76 pp.

Ettl, G.J. and N. Cottone. 2004. Whitebark pine (Pinus albicaulis) in Mt. Rainier National Park, Washington, USA. Pages 36–47 In Akçakaya, M. Burgman, O. Kindvall, C.C. Wood, P. Sjögren-Gulve, J.S. Hatfield, and M.A. McCarthy (eds.). Species Conservation and Management Case Studies. Oxford University Press. Oxford, United Kingdom.

Farnes, P.E. 1990. SNOTEL and snow course data: describing the hydrology of whitebark pine ecosystems. Pages 302–304 In Schmidt, W.C. and K.J. McDonald (compilers). Proceedings-Symposium on Whitebark

Pine Ecosystems: Ecology and Management of a High-Mountain Resource. 1989 March 29–31. Boseman, Montana. General Technical Report INT–270. Ogden, Utah. USDA Forest Service, Intermountain Research Station. 386 pp.

Flanagan, P.T., P. Morgan, and R.L. Everett. 1998. Snag Recruitment in subalpine forests. Northwest Science 72:303–309.

Geils, B.W., K.E. Hummer, and R.S. Hunt. 2010. White pines, Ribes, and blister rust: a review and synthesis. Forest Pathology 40:147–185.

Gibson, K., K. Skov, S. Kegley, C. Jorgensen, S. Smith, and J. Witcosky. 2008. Mountain pine beetle impacts in high-elevation five-needled pines: current trends and challenges.

USDA Forest Service. Forest Health Protection. R1–08–020. September 2008. Missoula, Montana. 32 pp.

Global Climate Change Impacts in the United States. 2009. A state of the knowledge report from the U.S. Global Change Research Program. Karl, T.R., J.M. Melillo, and T.C. Peterson (eds.). Cambridge University Press. New York, New York. 188 pp.

Greater Yellowstone Whitebark Pine Monitoring Working Group. 2012 in press. Monitoring whitebark pine in the Greater Yellowstone Ecosystem: 2011 annual report. Greater Yellowstone Whitebark Pine Monitoring Working Group. 2012. Natural Resource Report NPS/XXXX/NRR—20XX/XXX. National Park Service, Fort Collins, Colorado.

Hamann, A. and T. Wang. 2006. Potential effects of climate change on ecosystem and tree species distribution in British Columbia. Ecology 87:2773–2786.

Hatala, J.A., M.C. Dietze, R.L. Crabtree, K. Kendall, D. Six, and P.R. Moorcroft. In press. An ecosystem-scale model for the spread of a host-specific forest pathogen in the Greater Yellowstone Ecosystem. Ecological Applications.

Hicke, J.A., J.A. Logan, J. Powell, and D.S. Ojima. 2006. Changing temperatures influence suitability for modeled mountain pine beetle (Dendroctonus ponderosae) outbreaks in the western United States. Journal of Geophysical Research 111:G02019:1–12.

Hoff, R.J., D.E. Ferguson, G.I. McDonald, and R.E. Keane. 2001. Strategies for managing whitebark pine in the presence of white pine blister rust. Pages 346–366, Chapter 17 In Tomback, D.F., S.F. Arno, and R.E. Keane (eds.). Whitebark Pine Communities: Ecology and Restoration. Island Press. Washington, D.C. 440 pp.

Hosie, R.C. 1969. Native Trees of Canada. Can. Forest Service. Queen’s Printer for Canada. Ottawa. 380 pp.

Huntley, B. 1991. How plants respond to climate change: migration rates, individualism and the consequences for plant communities. Annals of Botany 67:15–22.

Hutchins, H.E. and R.M. Lanner. 1982. The central role of Clark’s nutcracker in the dispersal and establishment of whitebark pine. Oecologia 55:192–201.

IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K., and A. Reisinger (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

Jacobi, W., B. Goodrich, H.S.J. Kearns, K. Burns, and B. Geils. 2010. Can micro-scale meteorological

conditions predict the impact of white pine blister rust in Colorado and Wyoming? Presentation and abstract In High-Five Symposium: the Future of High-Elevation Five-Needle White Pines in Western North America. Missoula, Montana. June 28–30, 2010.

Keane, R.E. 2001a. Can the fire-dependent whitebark pine be saved? Fire Management Today 61: 17–20.

Keane, R.E. 2001b. Successional dynamics: modeling an anthropogenic threat. Pages 159–192, Chapter 9 In Tomback, D.F., S.F. Arno, and R.E. Keane (eds.). Whitebark Pine Communities: Ecology and Restoration. Island Press. Washington, D.C. 440 pp.

Keane, R.E. and R.A. Parsons. 2010. Restoring whitebark pine forests of the Northern Rocky Mountains, USA. Ecological Restoration 28:56–70.

Keane, R.E., D. Tomback, C. Aubry, A. Bower, E. Campbell, M. Jenkins, M. Manning, S. McKinney, M. Murray, D. Perkins, D. Reinhart, C. Ryan, A.W. Schoettle, and C.M. Smith. 2010. A range-wide restoration strategy for whitebark pine (Pinus albicaulis). General Technical Report RMRS–GTR–XXX. Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 126 pp. + Tables, Figures, and Appendix.

Keane, Robert E., Tomback, D., Aubry, C., Bower, A., Campbell, E., Jenkins, M., Manning, M., McKinney, S., Murray, M., Perkins, D., Reinhart, D., Ryan, C., Schoettle, A., Smith, C. 2012, in press. A range-wide restoration strategy for whitebark pine (Pinus albicaulis). General Technical Report RMRS-GTR-XXX. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, XXX pp.

Keane, R.E.; Tomback, D.F.; Murray, M.P.; and Smith, C.M., eds. 2011. The future of high-elevation, five-needle white pines in Western North America: Proceedings of the High Five Symposium. 28-30 June 2010; Missoula, MT. Proceedings RMRS-P-63. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 376 p.

Kendall, K.C. and R.E. Keane. 2001. Whitebark pine decline: infection, mortality, and population trends. Pages 221–242, Chapter 11 In Tomback, D.F., S.F. Arno, and R.E. Keane (eds.). Whitebark Pine Communities: Ecology and Restoration. Island Press. Washington, D.C. 440 pp.

King, J.N., A. David, D. Noshad, and J. Smith. 2010. A review of genetic approaches to the management of blister rust in white pines. Forest Pathology 40:292–313.

Kinloch, Jr., B.B. 2003. White pine blister rust in North America: past and prognosis. Phytopathology 93:1044–1047.

Kliejunas, J.T., B.W. Geils, J.M. Glaeser, E.M. Goheen, P. Hennon, M.-S. Kim, H. Kope, J. Stone, R. Sturrock, and S.J. Frankel. 2009. Review of literature on climate change and forest diseases of western North America. USDA Forest Service, Pacific Southwest Research Station. General Technical Report PSW–GTW–225. 54 pp.

Lanner, R.M. 1990. Biology, taxonomy, evolution, and geography of stone pines of the world. Pages 14–24 in W.C. Schmidt and K.J. McDonald (compilers). Symposium on whitebark pine ecosystems: ecology and management of a high-mountain resource. USDA Forest Service. Gen. Tech. Rpt. INT-270. June 1990. 386 pp.

Lanner, R.M. 1996. Made for Each Other: A Symbiosis of Birds and Pines. Oxford University Press. New York, NY. 155 pp.

Larson, E.R. 2007. Whitebark pine regeneration in southwest Montana and eastern Oregon. Nutcracker Notes

13:16–18.

Larson, E.R. 2009. Status and dynamics of whitebark pine (Pinus albicaulis Engelm.) forests in southwest Montana, central Idaho, and Oregon, U.S.A. Ph.D. dissertation. University of Minnesota. Twin Cities, Minnesota. 176 pp.

Lenoir, J., J.C. Gégout, P.A. Marquet, P. de Ruffray, and H. Brisse. 2008. A significant upward shift in plant species optimum elevation during the 20th century. Science 320:1768–1771.

Logan, J.A. and J.A. Powell. 2001. Ghost forests, global warming, and the mountain pine beetle (Coleoptera: Scolytidae). American Entomologist 47:160–172.

Logan, J.S., J. Regniere, and J.A. Powell. 2003. Assessing the impacts of global warming on forest pest dynamics. Frontiers in Ecology and the Environment 1:130–137.

Logan, J.A., W.W. MacFarlane, and L. Willcox. 2010. Whitebark pine vulnerability to climate- driven mountain pine beetle disturbance in the Greater Yellowstone Ecosystem. Ecological Applications 20:895–902.

Lorenz, T.J., C. Aubry, and R. Shoal. 2008. A review of the literature on seed fate in whitebark pine and the life history traits of Clark's nutcracker and pine squirrels. USDA Forest Service, Pacific Northwest Research Station. Portland, Oregon. General Technical Report PNW–GTR–742. April 2008. 62 pp.

Mahalovich, M.F., K.E. Burr, and D.L. Foushee. 2006. Whitebark pine germination, rust resistance, and cold hardiness among seed sources in the Inland Northwest: planting strategies for restoration. USDA Forest Service Proceedings RMRS–P–43.

Malcolm, J.R., A. Markham, R.P. Neilson, and M. Garaci. 2002. Estimated migration rates under scenarios of global climate change. Journal of Biogeography 29:835–849.

McCaughey, W.W. and W.C. Schmidt. 2001. Taxonomy, distribution, and history. Pages 29– 40, Chapter 2 In Tomback, D.F., S.F. Arno, and R.E. Keane (eds.). Whitebark Pine Communities: Ecology and Restoration. Island Press. Washington, D.C. 440 pp.

McCaughey, W.W. and D.F. Tomback. 2001. The natural regeneration process. Pages 105– 120, Chapter 6 In Tomback, D.F., S.F. Arno, and R.E. Keane (eds.). Whitebark Pine Communities: Ecology and Restoration. Island Press. Washington, D.C. 440 pp.

McDonald, G.I. and R.J. Hoff. 2001. Blister rust: an introduced plague. Pages 193–220, Chapter 10 In Tomback, D.F., S.F. Arno, and R.E. Keane (eds.). Whitebark Pine Communities: Ecology and Restoration. Island Press. Washington, D.C. 440 pp.

McDonald, G.I., B.A. Richardson, P.J. Zambino, N.B. Klopfenstein, and M.-S. Kim. 2006. Pedicularis and Castilleja are natural hosts of Cronartium ribicola in North America: a first report. Forest Pathology 36:73–82.

McKenney, D.W., J.H. Pedlar, K. Lawrence, K. Campbell, and M.F. Hutchinson. 2007. Potential impacts of climate change on the distribution of North American trees. Bioscience 57:939–948.

McKinney, S.T. and D. Tomback. 2007. The influence of white pine blister rust on seed dispersal in whitebark pine. Canadian Journal of Forest Research 27:1044–1057.

McKinney, W.T., C.E. Fiedler, and D.F. Tomback. 2009. Invasive pathogen threatens bird-pine mutualism:

implications for sustaining a high-elevation ecosystem. Ecological Applications 19:597–607.

Morgan, P. and M.P. Murray. 2001. Landscape ecology and isolation: implications for conservation of whitebark pine. 2001. Pages 289–309, Chapter 14 In Tomback, D.F., S.F. Arno, and R.E. Keane (eds.). Whitebark Pine Communities: Ecology and Restoration. Island Press. Washington, D.C. 440 pp.

NatureServe. 2010. NatureServe conservation status. Available online at: http://www.natureserve.org/explorer/ranking.htm. Accessed February 5, 2011. 7 pp.

NatureServe. 2011. Pinus albicaulis – Engelm. Available online at: http://www.natureserve.org/explorer/servlet/NatureServe?sourceTemplate=tabular_report.wmt&loadTemplate=n&selectedIndexes=128475. Accessed January 11, 2011. 9 pp.

Progar, R.A. 2007. Verbenone suppression of mountain pine beetle in lodgepole pine at the Sawtooth National Recreation Area in Central Idaho. USDA Forest Service R6-NR- FHP-2007-01. 1 pp.

Raffa, K.F. and A.A. Berryman. 1987. Interacting selective pressures in conifer-bark beetle systems: a basis for reciprocal adaptations? The American Naturalist 129:234–262.

Raffa, K.F., B.H. Aukema, B.J. Bentz, A.L. Carroll, J.A. Hicke, M.G. Turner, and W.H. Romme. 2008. Disturbances prone to anthropogenic amplification: the dynamics of bark beetle eruptions. BioScience 58:501–517.

Resler, L.M. and D.F. Tomback. 2008. Blister rust prevalence in krummholz whitebark pine: implications for treeline dynamics, Northern Rocky Mountains, Montana, U.S.A. Arctic, Antarctic, and Alpine Research 40:161–170.

Rice, Janine; Tredennick, Andrew; Joyce, Linda A. 2012. Climate change on the Shoshone National Forest, Wyoming: a synthesis of past climate, climate projections, and ecosystem implications. Gen. Tech. Rep. RMRS-GTR-264. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 60 p.

Richardson, B.A., A.K.M. Ekramoddoulah, J.-J. Liu, M.-S. Kim, and N.B. Klopfenstein. 2010. Current and future molecular approaches to investigate the white pine blister rust pathosystem. Forest Pathology 40:314–331.

Rochefort, R.M. 2008. The influence of white pine blister rust (Cronartium ribicola) on whitebark pine (Pinus albicaulis) in Mount Rainer National Park and North Cascades National Park Service Complex, Washington. Natural Areas Journal 28:290–298.

Schwandt, J.W. 2006. Whitebark pine in peril: a case for restoration. United States Department of Agriculture. Forest Service Report R1–06–28. August 2006. Available online at: http://www.fs.fed.us/r1-r4/spf/fhp/publications. 20 pp.

Schwandt, J.W., I.B. Lockman, J.T. Kliejunas, and J.A. Muir. 2010. Current health issues and management strategies for white pines in the western United States and Canada. Forest Pathology 40:226–250.

Schrag, A.M., A.G. Bunn, and L.J. Graumlich. 2007. Influence of bioclimatic variables on treeline conifer distribution in the Greater Yellowstone Ecosystem: implications for species of conservation concern. Journal of Biogeography doi:10.1111/j.1365- 2699.2007.01815.x.

Service (U.S. Fish and Wildlife Service). 2010. USDA Forest Service aerial detection mountain pine beetle survey results overlayed on whitebark pine distribution.

Service (U.S. Fish and Wildlife Service). 2011. Whitebark pine on Federal lands. Excel table. January 14, 2011. 1 p.

Shoal, R., T. Ohlson, and C. Aubry. 2008. Land managers guide to whitebark pine restoration in the Pacific Northwest Region 2009-2013. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 37 pp.

Six, D. and J. Adams. 2007. White pine blister rust severity and selection of individual whitebark pine by the mountain pine beetle (Coleoptera: Curculionidae, Scolytinae). Entomology Science 42:345–353.

Smith, C.M. B. Wilson, S. Rasheed, R.C. Walker, T. Carolin, and B. Shepherd. 2008. Whitebark pine and white pine blister rust in the Rocky Mountains of Canada and northern Montana. Canadian Journal of Forest Research 38:982–995.

Smith, C.M., B. Shepherd, C. Gillies, and J. Stuart-Smith. 2010. Re-measurement of whitebark pine infection and mortality in the Canadian Rockies. High-Five Symposium: The Future of High Elevation Five-Needle White Pines in Western North America, Presentation and Abstract (p. 67). University of Montana, Missoula, Montana. June 2010.

Spurr, S.H. and B.V. Barnes. 1980. Forest ecology (third edition). John Wiley and Sons, Inc. New York, NY. 687 pp.

Tomback , D. 1982. Dispersal of whitebark pine seeds by Clark's nutcracker: A mutualism hypothesis. Journal of Animal Ecology 51:451–467.

Tomback, D.F. and P. Achuff. 2010. Blister rust and western forest biodiversity: ecology, values and outlook for white pines. Forest Pathology 40:186–225.

Tomback, D.F. and L.M. Resler. 2007. Invasive pathogens at alpine treeline: consequences for treeline dynamics. Physical Geography 28:397–418.

Tomback, D.F., L.A. Hoffmann and S.K. Sund. 1990. Coevolution of whitebark pine and nutcrackers: implications for forest regeneration. Pages 118–129 in W.C. Schmidt and K.J. McDonald (compilers). Symposium on whitebark pine ecosystems: ecology and management of a high-mountain resource. USDA Forest Service. Gen. Tech. Rpt. INT- 270. June 1990. 386 pp.

Tomback, D.F., J.K. Clary, J. Koehler, R.J. Hoff, and S.F. Arno. 1995. The effects of blister rust on post-fire regeneration of whitebark pine: the Sundance Burn of northern Idaho. Conservation Biology 9:654–664.

Tomback, D.F., Arno, S.F., and R.E. Keane. 2001. The compelling case for management intervention. Pages 4–25 In Tomback, D.F., S.F. Arno, and R.E. Keane (eds.). Whitebark Pine Communities: Ecology and Restoration. Island Press. Washington, D.C. 440 pp.

Tomback , D.F., S. Wirt, W.W. McCaughey, and R.E. Keane. 2008. Preliminary pattern of investigation of the magnitude and time-frame of post-fire whitebark pine regeneration within selected areas in the Bob Marshall Wilderness Area and adjacent lands. Final Report 2008. JVA 03-JV-11222022-251. Unpublished data.

USDA Forest Service 2000. An agency strategy for fire management. A report from the National Mangement Review Team. 27 pp.

Ward, K., R. Shoal, and C. Aubry. 2006. Whitebark pine in Washington and Oregon: a synthesis of current studies and historical data. USDA Forest Service, Pacific Northwest Region. February 2006.

Warwell, M.V., Rehfeldt, G.E., and Crookston, N.L. 2007. Modeling contemporary climate profiles of whitebark pine (Pinus albicaulis) and predicting responses to global warming. Pages 139–142 In Proceedings of the Conference Whitebark Pine: A Pacific Coast Perspective. USDA Forest Service R6–NR–FHP-2007–01.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase in western U.S. forest wildfire activity. Science 313:940-943.

Wilson, B. 2007. Status of the whitebark pine (Pinus albicaulis) in Alberta. Alberta Sustainable Resource Development. Edmonton, Alberta, Canada. Publication No. T/151. 26 pp.

Zambino, P.J. 2010. Biology and pathology of Ribes and their implications for management of white pine blister rust. Forest Pathology 40:264–291.

Zeglen, S., J. Pronos, and H. Merler. 2010. Silvicultural management of white pines in western North America. Forest Pathology 40:347–368.

Personal communication:

Achuff, P. L., Scientist Emeritus, Parks Canada, in Waterton Lakes National Park, Waterton Park, Alberta. Telephone interview. (November 15, 2010).

Arnett, J., Rare Plant Botanist, Washington Natural Heritage Program, in Olympia, Washington. Telephone interview. (January 19, 2011).

Aubry, C., Area Genetist, USDA U.S. Forest Service, in Olympia, Washington. Telephone interview. (January 5, 2011).

Houston, K., Botanist, Shoshone National Forest, Region 2, in Cody, Wyoming. Email exchange (March 1, 2012).

Jacobson, L., Threatened and Endangered Species Program Manager, USDS Forest Service, Region 2, in Ogden, Utah. Email exchange (March, 2012)

Keane, R., Research Ecologist, USDA Forest Service, Rocky Mountain Research Station, in Missoula, Montana. (April 7, 2011)a.

Keane, R., Research Ecologist, USDA Forest Service, Rocky Mountain Research Station, in Missoula, Montana. (April 27, 2011)c.

Keane, R., Research Ecologist, USDA Forest Service, Rocky Mountain Research Station, in Missoula, Montana. (April 27, 2011).

Keane, R., Research Ecologist, USDA Forest Service, Rocky Mountain Research Station, in Missoula, Montana. Email exchange (February 3, 2012).

Means, B., Forestry Program Lead, USDI Bureau of Land Management, in Cheyenne, Wyoming. Telephone interview. (March and April, 2012).

Reinhart, D., Resource Specialist, U.S. National Park Service, in Yellowstone National Park, Montana. Telephone interview. (July 1, 2010).

Reinhart, D., Resource Specialist, U.S. National Park Service, in Yellowstone National Park, Montana. Email exchange. (February 15, 2011).

Sniezko, R., Center Geneticists, USDA Forest Service, Dorena Genetic Resource Center, in Cottage Grove, Oregon. Telephone interview. (February 8, 2011).

Sniezko, R., Center Geneticists, USDA Forest Service, Dorena Genetic Resource Center, in Cottage Grove, Oregon. Email exchange. (March, 2012).

Schwandt, J., Plant Pathologist and Whitebark Coordinator, USDA Forest Service, Forest Health Protection, in Coeur d'Alene, Idaho. Telephone interview. (April 7, 2011).

Shelly, S., Botany/Research Natural Areas/Invasive Species, USDA Forest Service, Region 1. Email exchange. (March 3, 2012)

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: 05/31/2012
Date

Concur: 11/06/2012
Date

Did not concur: _____ _____
Date

Director's Remarks: