PROPOSED

Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Whitebark Pine (*Pinus albicaulis*) in Canada

Whitebark Pine

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For copies of the recovery strategy, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk (SAR) Public Registry[1].

Cover illustration: Randy Moody

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[1] http://sararegistry.gc.ca/default.asp?lang=En&n=24F7211B-1

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years after the publication of the final document on the SAR Public Registry.

The Minister of Environment and Climate Change and Minister responsible for the Parks Canada Agency is the competent minister under SARA for the Whitebark Pine and has prepared this recovery strategy, as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with Natural Resources Canada (Canadian Forest Service), the Province of British Columbia, the Province of Alberta, and any others, as per section 39(1) of SARA.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment and Climate Change Canada and the Parks Canada Agency, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of Whitebark Pine and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment and Climate Change Canada and the Parks Canada Agency and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

The recovery strategy sets the strategic direction to arrest or reverse the decline of the species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When critical habitat is identified, either in a recovery strategy or an action plan, SARA requires that critical habitat then be protected.

In the case of critical habitat identified for terrestrial species including migratory birds SARA requires that critical habitat identified in a federally protected area[3] be described in the *Canada Gazette* within 90 days after the recovery strategy or action plan that

[2] http://registrelep-sararegistry.gc.ca/default.asp?lang=en&n=6B319869-1#2

[3] These federally protected areas are: a national park of Canada named and described in Schedule 1 to the *Canada National Parks Act*, The Rouge National Park established by the *Rouge National Urban Park Act*, a marine protected area under the *Oceans Act*, a migratory bird sanctuary under the *Migratory Birds Convention Act, 1994* or a national wildlife area under the *Canada Wildlife Act* see ss. 58(2) of SARA.

identified the critical habitat is included in the public registry. A prohibition against destruction of critical habitat under ss. 58(1) will apply 90 days after the description of the critical habitat is published in the *Canada Gazette*.

For critical habitat located on other federal lands, the competent minister must either make a statement on existing legal protection or make an order so that the prohibition against destruction of critical habitat applies.

If the critical habitat for a migratory bird is not within a federal protected area and is not on federal land, within the exclusive economic zone or on the continental shelf of Canada, the prohibition against destruction can only apply to those portions of the critical habitat that are habitat to which the *Migratory Birds Convention Act, 1994* applies as per SARA ss. 58(5.1) and ss. 58(5.2).

For any part of critical habitat located on non-federal lands, if the competent minister forms the opinion that any portion of critical habitat is not protected by provisions in or measures under SARA or other Acts of Parliament, or the laws of the province or territory, SARA requires that the Minister recommend that the Governor in Council make an order to prohibit destruction of critical habitat. The discretion to protect critical habitat on non-federal lands that is not otherwise protected rests with the Governor in Council.

Acknowledgments

Many people are to be acknowledged for their involvement in the federal recovery planning process for Whitebark Pine. Development of this recovery strategy was coordinated by Kella Sadler (Environment and Climate Change Canada, Canadian Wildlife Service - Pacific Region (ECCC-CWS-PAC)). Paul Johanson, Ken Corcoran, and Janet Beardall (ECCC-CWS – National Capital Region) provided helpful editorial advice and comment. Randy Moody and Allison Dickhout (Keefer Ecological Services Ltd.) prepared the first draft of this document. The Environment and Sustainable Resource Development (ESRD) shared the Recovery Plan for Whitebark Pine in Alberta[4] which provided a basis for several of the components outlined in this federal recovery strategy. Further input and advice was gathered from many Whitebark Pine and recovery experts throughout British Columbia and Alberta at two workshops (facilitated by Randy Moody and Allison Dickhout – Keefer Ecological Services), as well as independent meetings in Canada and the U.S.A. Contributors and participants include:

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[4] Alberta Whitebark and Limber Pine Recovery Team. 2014. Alberta Whitebark Pine Recovery Plan 2013-2018. Alberta Environment and Sustainable Resource Development, Alberta Species at Risk Recovery Plan No. 34. Edmonton, AB. 63 pp. Available at: http://www.esrd.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/plants/documents/SAR-WhitebarkPineRecoveryPlan-Jan-2014.pdf

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Executive Summary

The Whitebark Pine (*Pinus albicaulis*) is a five-needled pine that is essential to ecosystem functioning in many subalpine and treeline forests. In Canada, Whitebark Pine is found in high elevation habitat from the United States border northward to Mount Blanchet Park in British Columbia, and Willmore Wilderness Park in Alberta; and from the coastal mountain ranges in the west to the Rocky Mountains of southern Alberta in the east. Whitebark Pine was assessed as Endangered by COSEWIC in 2010 and listed as Endangered on Schedule 1 of SARA in 2012. Approximately 56% of the species' global range is in Canada.

There are four main range-wide threats to Whitebark Pine: White Pine Blister Rust, climate change, fire and fire suppression, and Mountain Pine Beetle. These factors also interact, often compounding or accelerating impacts. White Pine Blister Rust alone is projected to lead to a decline in Whitebark Pine of more than 50% over a 100-year time period. The impacts of Mountain Pine Beetle, altered fire management regimes, and climate change will increase the rate of decline. Additional human-activity related threats also affect Whitebark Pine populations at local scales. These threats should be considered in the context of cumulative effects when examining local population impacts.

Whitebark Pine recovery is naturally limited by its reliance on the Clark's Nutcracker for seed dispersal to reproduce, and also by its long generation time. Further, the development of higher-level planning and management tools to support recovery in Canada is limited by poor inventory data.

The population and distribution objective for Whitebark Pine is to establish a self-sustaining, rust-resistant population of Whitebark Pine throughout the species' range that demonstrates natural seed dispersal, connectivity, genetic diversity and adaptability to changing climate. Broad strategies are presented to address the threats to the survival and recovery of the species. Implementation of these broad strategies is required to meet the population and distribution objective.

Critical habitat has been identified to the extent possible with the best available information to address the population and distribution objective. Critical habitat was identified to address the species' needs for seed dispersal (i.e., in relation to stand densities), survival, regeneration, and long-term recovery, within the species known range in Canada. A schedule of studies has been included to address information gaps that prevent complete critical habitat identification at this time. It is acknowledged that White Pine Blister Rust currently poses the greatest threat to Whitebark Pine, and that impacts from this threat cannot be eliminated or completely avoided through habitat preservation.

Four performance indicators were developed to measure progress towards meeting the population and distribution objective. One or more action plans for Whitebark Pine will be posted on the Species at Risk Public Registry by 2022.

Recovery Feasibility Summary

Based on the following four criteria that Environment and Climate Change Canada uses to establish recovery feasibility, there are unknowns regarding the feasibility of recovery of Whitebark Pine. In keeping with the precautionary principle, this recovery strategy has been prepared as per section 41(1) of SARA, as would be done when recovery is determined to be technically and biologically feasible.

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.

   Yes. There are currently about 200 million mature individuals present on the Canadian landscape and seeds can be collected and stored from cones in order to be planted at a later date. However, individuals that are resistant to White Pine Blister Rust are required to sustain the population or improve its abundance in the foreseeable future. Rust resistant mechanisms may be relatively rare among current cone-producing individuals. Collected seeds must be screened and tested to identify resistant individuals.

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

   Yes. Currently there is sufficient suitable habitat available to support the species. However, climate change may alter the distribution of suitable habitats across the landscape, and human activities including landscape management can affect the quality and quantity of suitable habitat.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.

   Unknown. Active threat management and mitigation will be the focus, as some amount of impact from White Pine Blister Rust, climate change, fire and fire suppression, and Mountain Pine Beetle cannot be eliminated or avoided. Recovery efforts in the United States have demonstrated some success in mitigating the effects of White Pine Blister Rust (King et al. 2015, Mahalovich et al. 2006). Additionally, management techniques to reduce the impacts of Mountain Pine Beetle have had some success at the stand level (Perkins et al. In Press, Gillette et al. 2012). Threat avoidance and/or mitigation may be more feasible in some areas than others, depending on location and forest type (e.g. mixed vs. pure stands, seral vs. climax). While the exact implications of climate change are unknown, it is likely that assisted migration techniques and supplemental plantings may mitigate some of the impacts. Fire management techniques can minimize impacts to Whitebark Pine and create suitable habitat where needed.

4. Recovery techniques exist to achieve the population and distribution objectives, or, can be expected to be developed within a reasonable timeframe.

   Yes. Techniques exist and can be expected to be further developed and tested within a reasonable timeframe (i.e., 100 years, in consideration of the life cycle and life span of this species, which has a generation time of ~60 years)[5] in order to achieve the population and distribution objective. These techniques include, but are not limited to: identification of rust-resistant trees, deployment of rust-resistant individuals, prescribed burning, protecting Whitebark Pine from human impacts and wildfire, treatments to control Mountain Pine Beetle, stand treatments to reduce competition, and restoration plantings into both current and new habitats as identified by improved spatial inventory data.

[5] COSEWIC (2010) references "plants with seedbanks" IUCN guideline IUCN guidelines (2008): age of 1st reproduction + median time to germination is being used in this calculation = 60 yrs. Characterizing what is a "reasonable timeframe" likewise follows COSEWIC criteria for assessment, i.e., 10 years, or 3 generations (whichever is the longer), to a maximum of 100 years. A "reasonable timeframe" for recovery techiques to be developed and applied toward meeting Whitebark Pine objectives is thus considered to be 100 years.

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1. COSEWIC* Species Assessment Information

Date of Assessment: April 2010

Common Name (population): Whitebark Pine

Scientific Name: *Pinus albicaulis*

COSEWIC Status: Endangered

Reason for Designation:
This long–lived, five–needled pine is restricted in Canada to high elevations in the mountains of British Columbia and Alberta. White Pine Blister Rust alone is projected to cause a decline of more than 50% over a 100 year time period. The effects of Mountain Pine Beetle, climate change, and fire exclusion will increase the decline rate further. Likely, none of the causes of decline can be reversed. The lack of potential for rescue effect, life history traits such as delayed age at maturity, low dispersal rate, and reliance on dispersal agents all contribute to placing this species at high risk of extirpation in Canada.

Canadian Occurrence: British Columbia, Alberta

COSEWIC Status History: Designated Endangered in April 2010.

* COSEWIC (Committee on the Status of Endangered Wildlife in Canada)

2. Species Status Information

Legal Designation: SARA Schedule 1 (Endangered) (2012).

Whitebark Pine is listed as Endangered in Alberta under that province's *Wildlife Act* (Government of Alberta 2012a).

Whitebark Pine is Blue-listed in British Columbia (BC Conservation Data Centre 2014); this designation includes any indigenous species or subspecies considered to be of Special Concern (formerly Vulnerable).

It is estimated that 56% of the species' range occurs in Canada (COSEWIC 2010).

Table 1. Conservation Status of Whitebark Pine (from NatureServe 2014, BC Conservation Data Center 2014, and Alberta Conservation Information Management System 2014).

Global (G) Rank*	National (N) Rank*	Sub-national (S) Rank*	National Assessment Status	Provincial Conservation Status and/or Priority
G3G4	Canada: N2N3 United States: N3N4	Canada: Alberta (S2), British Columbia (S2S3) United States: California (SNR), Idaho (S4), Montana (S2), Nevada (SNR), Oregon (S4), Washington (SNR), Wyoming (S3)	COSEWIC: Endangered (2010) USESA**: Candidate (2011)	AB: Listed as Endangered under the Alberta *Wildlife Act* (2012a); BC: Blue List (considered to be of special concern, vulnerable to human activities or natural events). Highest priority: 3, under Goal 2 of the BC Conservation Framework***

*Rank 1– critically imperiled; 2– imperiled; 3- vulnerable to extirpation or extinction; 4- apparently secure; 5– secure; H– possibly extirpated; NR – status not ranked
**USESA = United States Endangered Species Act
***The three goals of the BC Conservation Framework are: 1. Contribute to global efforts for species and ecosystem conservation; 2. Prevent species and ecosystems from becoming at risk; 3. Maintain the diversity of native species and ecosystems

3. Species Information

3.1 Species Description

Whitebark Pine is a high elevation conifer characterized by needles that occur in bundles of five, and with closed cones that generally remain on the tree unless removed by animals. The tree may be single-stemmed, but it often occurs as a multi-stemmed tree, particularly in open-canopy or treeline sites. Upper branches are typically in an upright growth form, with cones held high on the outer branches. Whitebark Pine is a keystone species, essential to ecosystem function on many alpine and subalpine sites. Whitebark Pine performs a number of ecosystem services (particularly where it is the dominant tree species), including: moderating snowmelt and run-off, initiating tree islands and facilitating recruitment of more shade tolerant species, pioneering harsh sites, and providing food for wildlife (Tomback and Kendall 2001). The seeds borne by the tree in egg-shaped, purple cones are an important food source for Clark's Nutcrackers (*Nucifraga columbiana*), Red Squirrels (*Tamiasciurus hudsonicus*), Grizzly Bears (*Ursus arctos*) and other high elevation, mountain-dwelling wildlife (Felicetti et al. 2003). Whitebark Pine co-evolved with, and formed a mutualistic relationship with the Clark's Nutcracker. The nutcracker disperses pine seeds by burying them in small caches for retrieval during times of low food availability. Unretrieved caches may germinate new trees. The distribution of Whitebark Pine across the landscape is almost exclusively due to the caching behaviour of the Clark's Nutcracker (Hutchins and Lanner 1982). Whitebark Pine tends to produce mast cone crops at irregular intervals of 3-5 years (Morgan and Bunting 1992, Crone et al. 2011), thus large cone crops are often followed by several years of little to no cone production (Sala et al. 2012). Once established, it takes between 30-50 years for trees to begin producing cones, and 60-80 years to produce cones in a sizeable quantity (COSEWIC 2010).

3.2 Species Population and Distribution

In Canada, Whitebark Pine occurs in BC and Alberta. Its range continues south into the United States, into the Rocky Mountains and the Sierra Nevada (Figure 1). The southernmost latitude at which the species has been found is 37° N in California (Arno and Hoff 1990, Ogilvie 1990). Its distribution in Canada is split into two main sections, the coastal mountain ranges (Coast and Cascade Mountains in Canada) and the interior ranges east of the Okanagan Valley. These two populations are connected by scattered populations in southern and central BC and northeastern Washington (Little and Critchfield 1969, Ogilvie 1990). The Canadian range comprises approximately 56% of the species' global range (COSEWIC 2010).

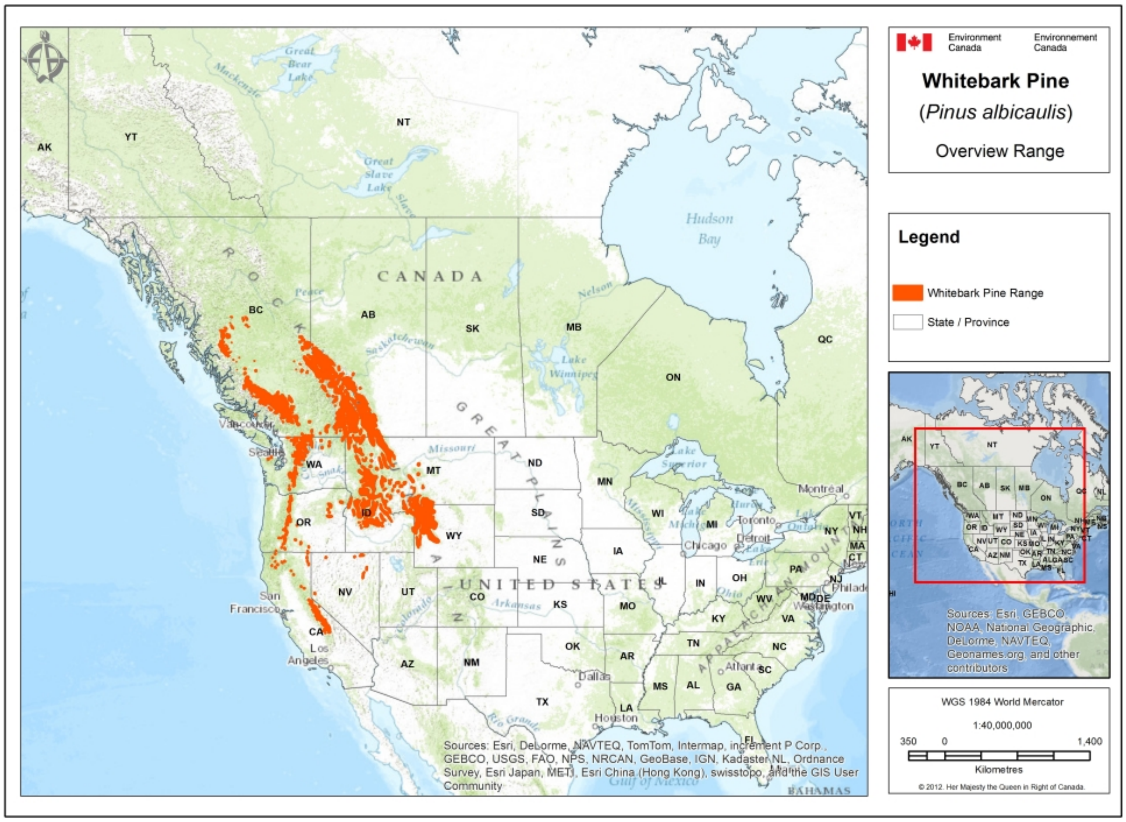

Figure 1. Global distribution of Whitebark Pine (2013).

Based on the best available information, it is currently estimated that approximately 76% of the Canadian range of Whitebark Pine is in BC, and approximately 24% of its Canadian range is in Alberta (Figure 2) (COSEWIC 2010). However, the area of occupancy in Canada may be underestimated due to poor mapping and remote occurrences that remain unsurveyed (J. Vinnedge pers. comm. 2013, B. Jones, pers. comm. 2013). In Canada, the western range of Whitebark Pine includes high elevation habitat from the US border northward to Mount Blanchet Provincial Park about 200 kilometres northwest of Fort St. James, BC. In the eastern portion of its range Whitebark Pine extends to Kakwa Wildlands Park, about 70 kilometres north of

McBride, BC (Clason pers. comm. 2013). The eastern-most extent of the species in Canada occurs in the Rocky Mountains of southern Alberta. The current latitudinal extent of Whitebark Pine is estimated at 55° N in the west of the range, though climatically suitable habitat may exist north of this latitude (McLane and Aitken 2012).

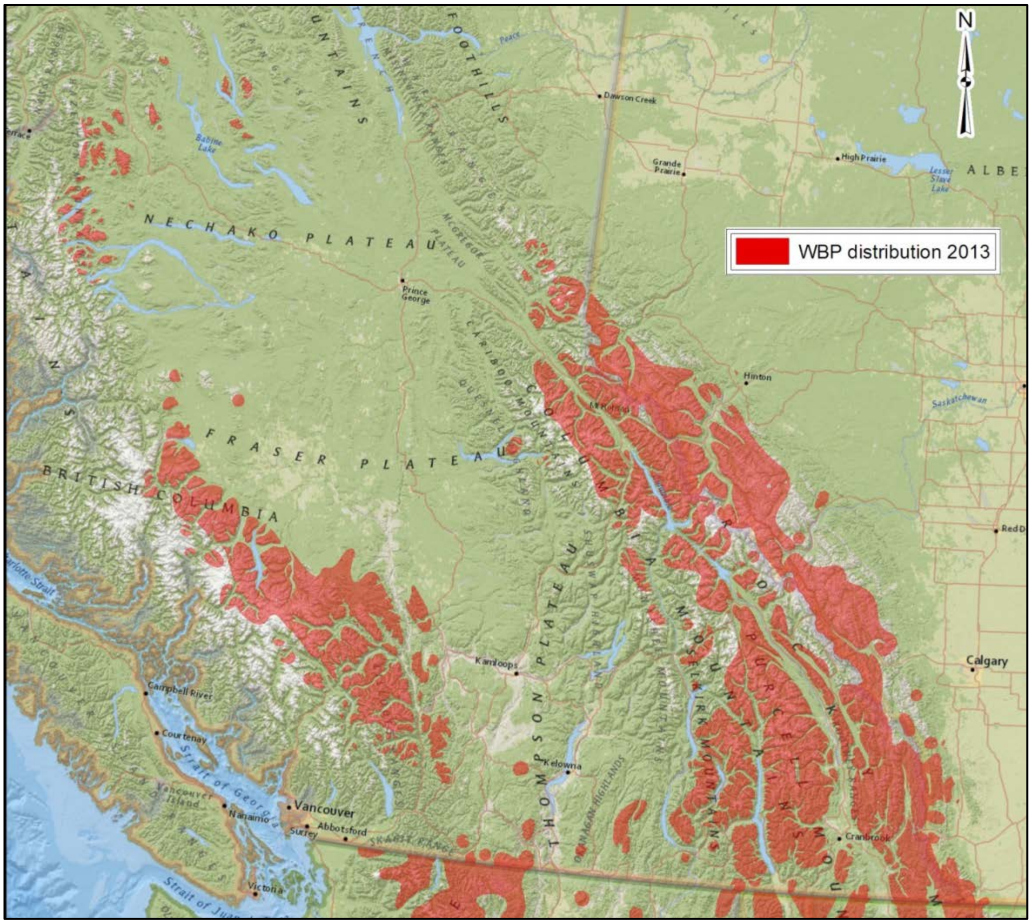

Figure 2. Canadian range of Whitebark Pine (WBP) in 2013 (Parks Canada 2013). This figure represents the current generalized understanding of the species' range in Canada.

Though there is general understanding of the species' known range in Canada, ongoing research is needed to determine and locate the full extent of Whitebark Pine stands, and estimate their spatial coverage (COSEWIC 2010). Based on existing data, the abundance of Whitebark Pine in Canada was estimated at 198 million mature stems with an index of area of occupancy of 47,972 km^2 (COSEWIC 2010).

Whitebark Pine occurs in a diversity of forested ecosystems, predominantly in the upper montane and subalpine. The low-elevation extent of the species ranges from 1700 metres at the Canada-US border to as low as 765 metres at Morice Lake to 1600 metres in north-central BC (Ogilvie 1990, S. Haeussler pers. comm. 2013, B. Jones pers. comm. 2013). This elevation range may be highly variable due to Clark's Nutcrackers opportunistic caching on competition-free sites such as burns and rocky ridges, at higher and lower elevational limits. In moist climates, Whitebark Pine is most prevalent on dry, warm aspects, and often on ridge crests or upper slopes. In drier climates, it may be common on moist cool sites (Arno and Hoff 1990). Physiological relationships and tolerance to climate extremes are detailed by COSEWIC (2010).

Whitebark Pine occurs on well- to rapidly-drained soils that are coarse, rocky and shallow over bedrock. The soils that support Whitebark Pine are typically Orthic Regosols, Orthic Eutric Brunisols, Orthic Dystric Brunisols and Ortho Humo-ferric Podzols (Burns and Honkala 1990). Whitebark Pine commonly occurs on serpentine (ultramafic) soils where they are found in BC (Krakowski pers. comm. 2013, Vinnedge pers. comm. 2013) and it may occur at relatively lower elevations on these soil types (Kruckeberg 1979, Campbell 1998).

In the northwestern part of its continental range, Whitebark Pine is associated with forest communities containing Spruce (*Picea* spp.), Subalpine Fir (*Abies lasiocarpa*), and Mountain Hemlock (*Tsuga mertensiana*). Across its range at lower elevations Lodgepole Pine (*Pinus contorta*) and Douglas-fir (*Pseudotsuga menziesii*) share Whitebark Pine habitat. In high-elevation areas in the eastern portion of its range, Whitebark Pine is also associated with Subalpine Larch (*Larix lyallii*) (Burns and Honkala 1990). At lower elevations in the eastern part of its range, Whitebark Pine may occur with Limber Pine (*Pinus flexilis*) (Ogilvie 1990, Campbell 1998, Wilson and Stuart-Smith 2002). Whitebark Pine is a moderately shade intolerant species. It typically regenerates in open-canopied sites, created either through disturbances such as fire, avalanches, and glacial retreat (Perkins and Swetnam 1996) and/or by other ecological processes that create or maintain open canopies in absence of stand-initiating disturbance (A. Clason pers. comm. 2013, J. Gould pers. comm. 2013).

Climatically suitable habitat for Whitebark Pine is projected to shift under climate change scenarios, with negligible predicted *net* change in climatically suitable habitat as habitat lost is replaced by new habitat at higher elevations and higher latitudes (Hamann and Wang 2006). However, the ability of Whitebark Pine to respond to climate change through species migration or *in-situ* genotypic adaptation will lag behind the rate at which the climate is anticipated to change, owing to its requirement for suitable microsites for establishment, and slow growth rate to maturity. Recovery needs of Whitebark Pine will require that potentially suitable habitat for growth is identified within predicted suitable climate envelopes, to facilitate assisted migration trials or operational migration plantings where appropriate. All restoration activities must address how natural or planted Whitebark Pine will survive under the constant threat of White Pine Blister Rust.

3.3 Needs of Whitebark Pine

The survival and recovery of Whitebark Pine in Canada depends on meeting the species' needs for: (a) survival of individuals, (b) adequate seed dispersal, (c) availability of regeneration habitat, and (d) recovery via research and restoration.

a) Survival Needs

Survival needs for Whitebark Pine are characterized as habitat required to allow individuals to persist and grow on the landscape throughout its range.

Within the areas it occurs, the microsites that are suitable for Whitebark Pine germination and growth are limited. Research indicates that seedlings require limited overstory and understory competition, avoidance of frost pockets, protection from shade and wind, protection from snow or soil movement, adequate growing space, and absence of crowding from other species, particularly Lodgepole Pine (McCaughey et al. 2009, Campbell and Antos 2000). High elevation environments are associated with short growing seasons, and Whitebark Pine has a slow growth rate. Once established, it takes 30-50 years for a tree to begin producing cones, and 60-80 years to produce cones in a sizeable quantity (COSEWIC 2010). Ensuring trees that are cone-producing and/or putatively[6] rust resistant are maintained on the landscape (in sufficient density to support continued distribution by Clark's Nutcracker, as described below) is paramount to species recovery.

The habitat required to support individual trees includes root area, ectomycorrhizal fungal associations, and specific soil attributes at established suitable microsites as described. Maintaining integrity of the substratum layer is important for the persistence and viability of cached seeds.

b) Seed Dispersal Needs

Seed dispersal needs for Whitebark Pine are characterized as habitat that is required for seed dispersal services, i.e. for maintaining the mutualistic relationship between Whitebark Pine and the Clark's Nutcracker (which is essential for recruitment, and maintaining genetic diversity within and between populations) across the range of Whitebark Pine.

As the seed of Whitebark Pine is wingless, the Whitebark Pine is dependent on the Clark's Nutcracker for seed dispersal (Lanner 1996). Seed dispersal distances can vary considerably. Dispersal distances of up to 32.6 km are reported, with a median transport distance of 2.1 km (Lorenz et al. 2011); i.e., most seed caches are located in relatively close proximity to the source stand. While the Clark's Nutcracker is the primary seed disperser of Whitebark Pine, it is also a seed predator. It generally forages on Whitebark Pine seeds in early summer and switches to seed caching behaviour in late summer as the seed coats harden (Tomback 1978). Whitebark Pine is an obligate mutualist of the Clark's Nutcracker, because it requires the Clark's Nutcracker to disperse its seeds. However, the Clark's Nutcracker is a facultative mutualist of the Whitebark Pine – the nutcracker benefits from the seed but does not require it for survival. Ponderosa Pine

[6] "Putative" resistance is defined as commonly accepted or supposed (but not confirmed) to have resistance to blister rust based on observable phenotypic traits.

and Douglas-fir[7] constitute important components of nutcracker home ranges and foraging behavior in the west of its range (Schaming 2015, Lorenz et al. 2011). The range overlap of Whitebark Pine with Limber Pine in the east may have a similar influence. Where there are lower levels of Whitebark Pine, maintaining a suitable threshold of alternate food sources on the landscape may be critical to maintaining nutcrackers in the area – particularly over years of low cone production (i.e., non-mast years for Whitebark Pine).

A study in the northern US Rocky Mountains and portions of Waterton Lakes National Park showed that the visitation of a stand and subsequent seed dispersal by Clark's Nutcracker falls to near zero if Whitebark Pine cone densities fall below 130 cones/ha, but rises to 83% when Whitebark Pine cone densities reach 1000 cones/ha (McKinney et al. 2009). To achieve 1000 cones per ha, it is estimated that stands require basal areas of Whitebark Pine ranging from at least 2 m^2/ha (Barringer et al. 2012) to 5 m^2/ha (McKinney et al. 2009). Stands with this basal area range of Whitebark Pine may be required to ensure natural seed dispersal by Clark's Nutcracker. Similarly, Maier (2012) found that stands with higher proportions of Whitebark Pine had higher rates of visitation and seed dispersal, although no quantifiable threshold was identified.

c) Regeneration Needs

Regeneration needs for Whitebark Pine are characterized as habitat that is required for regeneration, recognizing the importance of seral stage and successional dynamics, which may vary widely across the range of sites on which Whitebark Pine occurs and which may limit recruitment or facilitate self-replacing stands.

Relative to other conifer species, Whitebark Pine is slow to reach reproductive maturity. It takes up to a century to achieve a self-sustaining population, and to replace stands and/or individuals that are lost to disturbance. Thus, it is crucial to maintain a range of recruitment opportunities and regeneration habitat (including suitable microsites for germination). Regeneration habitat needed by Whitebark Pine includes recent burns, logged areas, open canopy stands, edges of avalanche paths, and/or areas where restoration work has been deliberately undertaken to create habitat for Whitebark Pine seedlings.

The interaction between recruitment and disturbance regimes is complex and often site-specific in terms of whether the effects aid or hinder Whitebark Pine recruitment and persistence. In some cases disturbance may be more of a detriment to regeneration because mature trees that provide a critical seed source are killed (B. Jones pers. comm. 2013, R. Moody, pers. comm. 2013). Other site-specific factors may limit local recruitment and persistence, such as existing forest composition, dominance of competing species, and presence of suitable microsites. For example, even in highly suitable habitat, the relative abundance of Lodgepole Pine regeneration

[7] Although Clark's Nutcrackers regularly forage on Douglas-fir, the seeds contain much less nutrition than Whitebark Pine seeds (0.06 versus 1.19 kcal per seed, respectively).

following fire strongly influences the successful recruitment of Whitebark Pine (Campbell and Antos 2003, Moody 2006). Whitebark Pine cannot compete with regenerating Lodgepole Pine, except where located at upper elevational limits. Competitive pressure is particularly high where Lodgepole Pine forms extensive dense stands.

d) Recovery Needs

Recovery needs for Whitebark Pine are characterized as areas and activities focused on the identification and propagation of White Pine Blister Rust-resistant individuals, as well as other areas and activities focused on mitigating further population decline (e.g., habitat restoration, and assisted migration to newly identified and available suitable habitat created by climate change).

Throughout much, if not all of its range, the perpetuation of Whitebark Pine will almost certainly require selection for rust-resistant traits to overcome the significant threat of White Pine Blister Rust. Though naturally occurring at low levels, genetic resistance to White Pine Blister Rust has been observed in nursery trials (Mahalovich et al. 2006, Sniezko et al. 2011). The number of mechanisms that impart rust-resistance is unknown, however, resistance screening trials in the US evaluate seedlings for a variety of traits (Sniezko et al. 2011). In Canada, screening for resistance to White Pine Blister Rust is also occurring, but currently at a much more limited scale. Based on phenotype, putatively-resistant trees have been identified across the range and selected for rust-resistance testing. Seed from BC and Alberta has also been sent to rust screening facilities in the US; however, no conclusions regarding resistance of the progeny have yet been made, since resistance may take several years to be expressed and evaluated. It is important to maximize the number and geographic distribution of rust-resistant individuals used for regeneration and recovery in order to preserve Whitebark Pines' genetic diversity.

Current knowledge of the genecology of Whitebark Pine is incomplete, so that the impacts of climate change or transferring seed sources across the species range are not clear. A study with seedling data (Bower and Aitken 2008) indicates that the species is relatively broadly adapted and that it should thrive even if transferred several degrees of latitude to the North. Trials have been established in the US (Mahalovich et al. 2006) and Canada to assess the expression of adaptive traits in response to a broad range of environments over time. This knowledge is required to fit suitable resistant genotypes to amenable environments, within current and/or projected suitable climate envelopes.

An improved inventory of Whitebark Pine distribution, populations, age classes, and community types is required to effectively manage the needs of Whitebark Pine across its range. The best available information to date is not sufficiently detailed to identify the extent of the potential range of the species or to readily identify conservation and management needs at a regional scale. More detailed information is essential to determine the actual area of occupancy, and to develop predictive models to determine potentially suitable habitat for current and future climate change including priority habitat for assisted migration, and/or identifying habitat that will likely become climatically unsuitable.

4. Threats

Threats are the proximate activities or processes that have caused, are causing or may cause in the future, the destruction, degradation, or impairment of the entity being assessed (population, species, community or ecosystem) in the area of interest (Salafsky et al. 2008). For purposes of threat assessment, only present and future threats are considered. This document uses the unified threat classification scheme developed by Salafsky et al. (2008) for the International Union for Conservation of Nature (IUCN) and the Conservation Measures Partnership (CMP). For a detailed description of the classification scheme, see the Conservation Measures Partnership website (IUCN 2006).

4.1 Threat Assessment

A summary of the threats assessment for BC and Alberta is provided in Table 2. The calculated overall threat impact for both of these provinces is Very High, primarily owing to the main range-wide threats of White Pine Blister Rust, climate change, fire and fire suppression, and Mountain Pine Beetle; logging and wood harvesting is also considered a threat in BC. The threats outlined below are generally consistent across the Alberta-BC range of the species, except for those relating to resource extraction. Mining and forestry are currently more prevalent in BC, while oil and gas drilling are currently more prevalent in Alberta.

Table 2. IUCN[a] threats summary for Whitebark Pine in Canada.

Threat #	Threat description	Impact[b]	Scope[c]	Severity[d]	Timing[e]	Comments
1	Residential & commercial development	Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
1.2	Commercial & industrial areas	Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Primary concern is loss of habitat and trees to due to construction of ridge-top communication towers.
1.3	Tourism & recreation areas	Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	All existing ski areas in range, plus new developments and expansions. Includes heli- or cat-ski operations, and backcountry ski cabins.
2	Agriculture & aquaculture	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
2.3	Livestock farming & ranching	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	This impact applies to trampling of regenerating (rather than mature) trees. Soil disturbance and compaction caused by livestock trampling may destroy microsites for cached seeds, interrupt drainage, limit tree rooting, and damage seedlings. Any trampling damage of young seedlings would be because of overuse caused by the time and duration of grazing and poor distribution. Additional concerns related to ranching include similar potential impacts of feral horses. Heavy grazing in Whitebark Pine habitats characterized by grassy fine fuels can substantially reduce natural fire occurrence (Murray et al. 1998).
3	Energy production & mining	Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
3.1 (AB)	Oil & gas drilling	Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Alberta: Potential to increase in the next 10 years. The Province has also developed industrial setback guidelines to be employed in such developments (Government of Alberta 2012b).
3.1 (BC)	Oil & gas drilling	Negligible	Negligible (<1%)	Extreme (71-100%)	Moderate (Possibly in the short term, <10 yrs/3 gen)	British Columbia: Limited potential, most likely drilling in Whitebark Pine range limited to coalbed methane in the Elk Valley and Sacred Headwaters.
3.2 (AB)	Mining & quarrying	Negligible	Negligible (<1%)	Extreme (71-100%)	Moderate (Possibly in the short term, <10 yrs/3 gen)	Alberta: Most Alberta mines are below Whitebark Pine range. Potential to expand into range of Whitebark Pine.
3.2 (BC)	Mining & quarrying	Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	British Columbia: At least 10 mines currently operate in Whitebark Pine habitat. Mining exploration and proposed mine development is ongoing.

Threat #	Threat description	Impact[b]	Scope[c]	Severity[d]	Timing[e]	Comments
3.3	Renewable energy	Negligible	Negligible (<1%)	Serious (31-70%)	Low (Possibly in the long term, >10 yrs/3 gen)	Wind farm potential to be developed within Whitebark Pine range in the future.
4	Transportation & service corridors	Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
4.1	Roads & railroads	Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Roads are relevant to commercial and industrial development, not just public transportation. Depending on the size of development the road size and impacts may vary.
4.2	Utility & service lines	Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	Construction and maintenance of power lines. Powerline right-of-ways may create beneficial scenarios for seedling planting where trees can be pruned to acceptable heights.
5	Biological resource use	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	
5.2	Gathering terrestrial plants	Unknown	Unknown	Unknown	Unknown	Limited First Nations traditional use known.
5.3 (AB)	Logging & wood harvesting	Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Alberta: In Alberta, timber companies in the C5 Forest Management Unit (a management unit occurring from north of Waterton Lakes National Park to just south of Kananaskis Country) may not destroy Whitebark Pine unless unavoidable and written consent from the Environment and Sustainable Resource Development (ESRD) is obtained (Government of Alberta 2019). The Province has also developed industrial setback guidelines to be more broadly applied (Government of Alberta 2012b).
5.3 (BC)	Logging & wood harvesting	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	British Columbia: Incidental harvest. There has been notable harvesting in mixed Whitebark Pine forests of Kootenays, Omineca, and possibly in the Coast Range; a net loss due to timber harvesting activities is occurring on the landscape. There are active attempts to voluntarily reduce harvest, but no regulatory mechanisms. Harvest of Whitebark Pine is not well tracked as records often group it with other species or ignore it. Stands that contain Whitebark Pine prior to harvest are not routinely replanted with Whitebark Pine thus silviculture approaches create a system that excludes regeneration opportunities and increases competition by planting faster-growing species. Some timber companies have incorporated Whitebark Pine into Sustainable Forest Management Plans (SFMP).

Threat #	Threat description	Impact[b]	Scope[c]	Severity[d]	Timing[e]	Comments
6	Human intrusions & disturbance	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	ATVs, snowmobiles, backcountry lodges, backcountry visitors on trails (ground compression, climbing on trees, trail clearing), increased access from logging road networks, burning for campfires, bike trail construction; impacts of horses used by recreationists and/or picketed at campsites.
7	Natural system modifications	Medium - Low	Restricted (11-30%)	Serious - Moderate (11-70%)	High (Continuing)	
7.1	Fire & fire suppression	Medium - Low	Restricted (11-30%)	Serious - Moderate (11-70%)	High (Continuing)	Trees can be destroyed by severe forest fires, and depending on site-specific factors, trees stressed by fire may be more susceptible to Mountain Pine Beetle. Fire suppression may facilitate successional replacement by other tree species and reduce abundance of suitable regeneration sites. Mixed severity fires may create regeneration sites and retain mature trees. Fire requirements for recruitment are variable across the range and need to be considered within local contexts.
7.3	Other ecosystem modifications	Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	Potential decrease of Clark's Nutcracker populations due to decline of Whitebark Pine and thereby reduced seed dispersal of remaining Whitebark Pine. Alternative food sources for Clark's Nutcracker may play a large role in population stabilization, but these species occur at varying abundance across the range of Whitebark Pine. Main alternative species in Canada documented so far are Limber Pine, Ponderosa Pine and Douglas-fir. Limber Pine is COSEWIC-assessed as endangered and faces similar recovery challenges as Whitebark Pine.
8	Invasive & other problematic species & genes	Very High	Pervasive (71-100%)	Extreme (71-100%)	High (Continuing)	
8.1	Invasive non-native/alien species	Very High	Pervasive (71-100%)	Extreme (71-100%)	High (Continuing)	White Pine Blister Rust found throughout the Canadian range. Smith et al. (2013) found increases of 35% infection and 39% mortality from 1996 to 2009. Study was along Rocky Mountains from McBride to Waterton Lakes National Park.

Threat #	Threat description	Impact[b]	Scope[c]	Severity[d]	Timing[e]	Comments
8.2	Problematic native species	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	There are several unknowns regarding the future impacts of Mountain Pine Beetle. The epidemic is over through much of Whitebark Pine's range, but endemic native beetle populations may still kill some stressed (particularly weakened, rust-infected trees. Based on a 3 generation time to maximum of 100 years and estimating beetle epidemics at 30 year intervals, severity was rated serious. Bark Beetles were identified as being a potentially significant cause of mortality in stressed trees and on sites with high solar radiation (Wong 2012). Pine Leaf Adelgid (*Pineus pinifoliae*) also kills and damages Whitebark Pine in areas where it co-occurs with White or Engelmann Spruce. There are also a variety of other native insects and pathogens that may reduce tree vigour (increasing susceptibility to other stressors) or kill trees outright (S. Haeussler pers. comm. 2013). Scope of current impact is small, but this could increase in the future if a subsequent epidemic outbreak occurs. Impacts of future outbreaks may be exacerbated owing to (a) ongoing loss of Whitebark Pine, and (b) an increase in the amount of monotypic stands of susceptible pine plantations on the landscape.
9	Pollution	Negligible	Negligible (<1%)	Unknown	Unknown	
9.2	Industrial & military effluents	Negligible	Negligible (<1%)	Unknown	Unknown	Industry specific: may include leaking pipe lines, gas flaring, spills, blow out, tailings sites and ponds, avalanche control artillery along mountain passes.
9.5	Air-borne pollutants	Negligible	Negligible (<1%)	Unknown	Unknown	Difficult to determine. Some areas may have high elevation impacts.
11	Climate change & severe weather	High	Pervasive - Large (31-100%)	Serious (31-70%)	High (Continuing)	
11.1	Habitat shifting & alteration	High - Medium	Pervasive - Large (31-100%)	Serious - Moderate (11-70%)	High (Continuing)	Shifts in climatically suitable habitat to more northerly latitudes and higher elevations are anticipated (Hamann and Wang 2006, Hamann and Aitken 2013). There are knowledge gaps regarding the degree to which Whitebark Pine morphological or physiological plasticity can permit adaptation to climate change *in situ*. The ability of Whitebark Pine to migrate/establish in newly suitable climates is projected to be slower than the predicted rate of change.

Threat #	Threat description	Impact[b]	Scope[c]	Severity[d]	Timing[e]	Comments
11.2	Droughts	High	Large (31-70%)	Serious (31-70%)	High (Continuing)	It is speculated that there will be increased drought potential in the eastern part of the range in Crowsnest Pass (D. Sauchyn pers. comm. 2013); however, the driest regions of B.C. range such as Chilcotin and portions of Cariboo also likely susceptible. Drought stress may also exacerbate other threats such as insect and fire impacts.
11.3	Temperature extremes	High - Low	Large - Restricted (11-70%)	Serious - Slight (1-70%)	High (Continuing)	Temperature extremes have potential effects on seed viability and may cause direct death due to changes in natural cold stratification. Temperature extremes may also exacerbate other stressors such as insects and fire. There is uncertainty about the response of subalpine and treeline forest ecosystems to increased temperatures; they may create higher stress on some sites making them better suited to Whitebark Pine recruitment; however they may create conditions on some sites that either limit all tree species recruitment or result in suitable conditions for more competitive species.
11.4	Storms & flooding	Unknown	Unknown	Unknown	High (Continuing)	Storms and flooding cause increased blowdown and mechanical damage.

[a] Classification of Threats adopted from IUCN-CMP, Salafsky et al. (2008).

[b] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low as threat is only considered to be in the past); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.

[c] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%; Negligible < 1%).

[d] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

[e] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

4.2 Description of Threats

Whitebark Pine is threatened range-wide by four main threats (Table 2 above): White Pine Blister Rust, climate change, fire and fire suppression, and Mountain Pine Beetle. These factors also interact, often compounding or accelerating the effects and impacts. For example, White Pine Blister Rust influences the threat posed by Mountain Pine Beetle (see IUCN-CMP Threat 8.2). Trees stressed from rust infection are more susceptible to beetle infestation, which is usually fatal and skewed towards mature, cone-bearing trees (Kendall and Keane 2001, Six and Adams 2007). Blister rust also compounds the problem of competitive dominance of other conifer species in mixed stands. For example, in some cases where there are effects of seral replacement attributed to fire suppression, Whitebark Pine trees that normally could have persisted in mixed stands are killed by the rust pathogen. Conversely, where fires have spread, trees damaged by the fire may experience stress leading to increased Mountain Pine Beetle attack. Climate change projections and data from the most recent beetle outbreak predict that warmer temperatures are to decrease winter beetle mortality, shorten insect generation time, and create more favourable conditions for dispersal flights of the Mountain Pine Beetle (Logan and Powell 2008). Climate change is also expected to cause more drought-stressed trees, which would lead to impaired defenses against Mountain Pine beetle (Kipfmueller et al. 2002).

Logging and wood harvesting is also characterized as a threat in BC. Additional human-caused threats also impact Whitebark Pine populations at regional and/or local scales; however, these were classed as negligible threats to the species, individually. All threats should be considered in the context of cumulative effects of site-specific factors when examining local population impacts. Some human-related impacts may have a low or negligible impact when viewed in isolation, but significant impacts on Whitebark Pine when combined. It is also important to note that even low or negligible threats may have serious impacts if rust-resistant trees (representing the future of the species) are harmed or destroyed. In this way, even if the effects are very localized and/or only a few trees are destroyed, the actual impacts to Whitebark Pine survival and recovery could be very severe.

The four main range-wide threats are discussed below, in order of threat impact.

IUCN-CMP Threat # 8.1 Invasive non-native/alien species: White Pine Blister Rust

White Pine Blister Rust is caused by an exotic fungus species introduced from Eurasia in the early 20th century (Peterson and Jewel 1968, Littlefield 1981, McDonald and Hoff 2001). Whitebark Pine, along with all other five-needle pine species in North America, has been infected by this rust nearly range-wide. Blister rust is currently found in almost all Whitebark Pine populations with general trends showing range-wide high levels. For example, Smith et al. (2013) reported a mean infection level of 52% in the eastern part of its range in Canada with an increase in infection and mortality rates of 3% per year.

The extent of White Pine Blister Rust infection depends not only on the distribution of Whitebark Pine or other five-needle pines, but also on the presence of the alternate hosts required by the rust to complete its life cycle, primarily native currant and gooseberry shrubs (*Ribes* spp.). These shrub species are widespread in western North America (Zillar 1974, Geils *et al*. 2010) and rust spores from these non-pine host species can spread several kilometres (Van Arsdel et al. 2006). Recent evidence indicates that native species of Paintbrush (e.g. *Castilleja miniata*) and Lousewort (e.g. *Pedicularis bracteosa, P. racemosa*) may also serve as alternate hosts (McDonald et al. 2006, Zambino et al. 2007).

White Pine Blister Rust can kill or damage Whitebark Pine directly or indirectly. White Pine Blister Rust kills trees directly by forming cankers that girdle the stem. Where the rust girdles and kills cone-producing branches, functional seed production can be prevented or limited for many years prior to the death of the tree (McKinney and Tomback 2007). The rust can also cause damage indirectly by attracting rodents that chew on the cankers and remove vascular tissue, girdling the cone-bearing branches (Hoff 1992).

Of the four main threats, White Pine Blister Rust is projected to cause the greatest population declines. Throughout its Canadian range, rust-related population declines are estimated at 56% over the next 100 years (COSEWIC 2010). Declines in Waterton Lakes National Park are estimated to reach 97%, and in the Rocky Mountain region outside of Waterton, it is estimated that there will be a 78% population decline due to rust over the next 100 years (COSEWIC 2010).

IUCN-CMP Threat #11 Climate change and severe weather

Whitebark Pine population growth is highly influenced by temperature (Arno and Hoff 1989, McKenzie et al. 2003, Schrag et al. 2007). Warming temperatures due to climate change will shift suitable climate envelopes for Whitebark Pine to higher latitudes, and higher elevations, than observed in the present day. One model predicted a 73% loss of current suitable habitat in BC by 2085 and a roughly equivalent-sized gain in new climatic range at higher elevations and northwest of the current range (Hamann and Wang 2006). Over the same time period, there is a predicted loss of over 97% of Whitebark Pine's climatic range in United States (Warwell et al. 2007). By the 2080s, a recent model predicts a shift in BC's Engelmann-Spruce-Subalpine Fir Biogeoclimatic zone, the general ecosystem classification type which Whitebark Pine primarily inhabits, by 278 km north and 123 m upward in elevation (Wang et al. 2012). Likewise, models for the Rocky Mountains estimate that, on average, the suitable habitat for Engelmann Spruce (a common site associate), may shift 719 km north and 317 m upward in elevation by 2050 (Gray and Hamann 2013).

Whitebark Pine is slow to establish and reach reproductive maturity. This life history characteristic means it may be impossible for Whitebark Pine populations to migrate or adapt rapidly enough to follow the shift in its climatic envelope (Malcolm et al. 2002, Aitken et al. 2008, COSEWIC 2010). Along with the stress of warming temperatures, climate change is likely to cause changes to disturbance regimes, increased direct competition from other tree species such as Subalpine Fir, Engelmann Spruce, Amabalis Fir, Mountain Hemlock, and Western Hemlock, and increased susceptibility to Mountain Pine Beetle and other biotic damaging agents. Further, key ecological associations such as with mychorrizal fungi and the Clark's Nutcracker may be affected to an unknown extent. For example, climate change may impact the range of alternate Clark's Nutcracker food sources (as described in Section 3.3(b)), which could be particularly detrimental in lower-density Whitebark Pine stands. Climate change may promote the introduction of new pathogens into the Canadian range of Whitebark Pine, or change the virulence of existing, non-lethal pathogens.

IUCN-CMP Threat #7.1 Fire and Fire Suppression

Whitebark Pine occurs across a broad climate spectrum and occupies a range of forest types and associated stand densities across these climates (e.g., closed forest, parkland tree islands, and krummholz[8]). The net benefit or detriment of fire, and fire disturbance regimes, is likewise variable across this climate spectrum and between forest types. The role of fire should be considered on a case by case basis. Depending on the circumstance, fire and fire suppression may each be viewed as either a threat, or beneficial to Whitebark Pine persistence and regeneration at any given site (Murray 2007, 2008).

In relatively dense lower elevation forests, recruitment and regeneration of Whitebark Pine may occur only following a stand-replacing disturbance such as fire. However, as those forest canopies close over time, Whitebark Pine is typically outcompeted by shade-tolerant species. In these stand types, fire suppression may pose a threat to the species' survival. Fire suppression promotes less fire-hardy competitors such as Engelmann Spruce and Supalpine Fir. Murray (2007) observed that these late-successional species have gained dominance at 12.5% of Whitebark Pine sites in the Cascade Mountains and nearly half of stands in the Bitterroot Mountains of Idaho-Montana (Murray et al. 2000). Keane and Arno (1993) documented Whitebark Pine volume declining more than 9% during a 20-year period, as a result of successional replacement. Thus, fire suppression leading to seral replacement has been viewed as a primary threat to Whitebark Pine (e.g., Arno 1986, Keane and Arno 2001).

On high elevation, rocky, and other sites with characteristics that limit competing tree growth, conditions may be too inhospitable for other species (including other competing conifers) to establish. In these sites, Whitebark Pine may form near-pure self-replacing stands. That is, where ecological processes naturally limit the recruitment of competing species, open canopies required for recruitment can be maintained in the absence of stand-initiating disturbance. Fires are less likely to occur at higher elevations, and/or at rocky sites, because fuels (accumulated undergrowth etc.) are typically too sparse to carry fires. However, allowing fire disturbance (e.g. permitting lower-elevation fires to

[8] Stunted windblown trees growing near the tree line on mountains.

run up into adjacent high-elevation/low-competition stands containing Whitebark Pine) or deliberately introducing fire in these high elevation/low-competition environments may be viewed as a threat.

These two examples illustrate opposite ends of the recruitment spectrum, and it should be recognized that a range of intermediate scenarios exist such as when Whitebark Pine forms a co-dominant component of closed mixed-canopy stands. For example, there are sites where Whitebark Pine occurs as a co-dominant component of the canopy, and shows few signs of being serally replaced (B. Jones, pers. comm. 2013).

In these intermediate circumstances the net impact of fire must be considered in the context of the specific stand ecology, weighing the positive effects of opening stands against the negative impacts of destroying important cone-bearing trees (particularly those not terminally infected by blister rust, which may possess some degree of genetic resistance). For example, the direct mortality of seed trees due to fire may have greater negative consequences than the lack of suitable recruitment sites within an area.

Fire severity, frequency, and size are also important factors to consider in assessing fire as a threat. Historically, many Whitebark Pine stands established following low to mixed severity fires. Mixed severity fires were more common than low-severity fires, and these mixed severity fires could be non-lethal surface fires with differential mortality, variable mortality stand-replacing fires and, most often, fires that contained elements of both (Keane et al. 2012). Mixed severity fires typically burned off trees that competed with Whitebark Pine, retaining some seed trees on site, while also creating openings important for seed caching by the Clark's Nutcracker (Hutchins and Lanner 1982; Tomback et al. 1990; Norment 1991; Hesburg et al. 1999; Keane and Arno 2001). Low severity surface fires burned more frequently on drier sites, often resulting in open parkland stands dominated by Whitebark Pine (Arno 1986). An increase in forest in-growth due to fire suppression may lead to increased fuels accumulation resulting in a greater risk of high intensity and severity fire. A changing fire regime as a result of fire suppression over the last century has impacted Whitebark Pine, as frequent mixed or low-intensity fires have been replaced with occasional, high-intensity fires (Murray et al. 1998, Taylor and Carroll 2004, Van Wagner et al. 2006). These fires kill more Whitebark Pine, including seed-producing and rust-resistant individuals, than low or mixed severity fires.

IUCN-CMP Threat #8.2 Problematic native species: Mountain Pine Beetle

Mountain Pine Beetle is a native bark beetle that causes mortality in western pines, including Whitebark Pine. Mountain Pine Beetle has been present at endemic levels, with episodic outbreaks in high elevation pine ecosystems, for more than 8500 years (Brunelle et al. 2008). Epidemic levels of this species can cause rapid, widespread mortality in western pines, including Whitebark Pine. Of the high elevation five-needle species in western North America, Whitebark Pine has suffered the highest mortality from Mountain Pine Beetle (Gibson et al. 2008). During an epidemic, typically around 90% of the mature Whitebark Pine trees in a stand will be killed (Campbell 2007, Gibson et al. 2008, Rankin 2008, Schwandt 2009, Wilson 2009, COSEWIC 2010). In British Columbia, the most recent epidemic affected over 10 million hectares in 2007 (the year of highest mortality) to a present level of 3 million hectares in 2013 (BC MFLNRO 2013). During the past century there have been four or five smaller epidemics of Mountain Pine Beetle in BC (Taylor and Carroll 2003). In Alberta the epidemic is also slowing from a peak in 2008-2009, with low beetle populations observed in Whitebark Pine habitat in 2013 (Government of Alberta 2013).

Factors such as climate change, fire suppression, and management increasing monotypic stands of susceptible age-class pines on the landscape have facilitated the geographic expansion of the beetle (Taylor and Carroll 2003, Carroll et al. 2003). Increasingly mild winter temperatures, warmer summer temperatures and longer growing seasons have likewise facilitated increases in Mountain Pine Beetle survival, growth and reproduction (Carroll et al. 2003, Taylor et al. 2006, Logan and Powell 2008). Owing to these climatic changes, Mountain Pine Beetle can now complete a univoltine life-cycle (i.e., one brood of offspring per year) in Canada and it is now typical to observe Whitebark Pine tree mortality within a single summer instead of 2-3 seasons as seen historically (Bentz et al. 2011, Esch 2012).

5. Population and Distribution Objectives

The population and distribution objective for Whitebark Pine in Canada is:

To establish a self-sustaining, rust-resistant population of Whitebark Pine throughout the species' range that demonstrates natural seed dispersal, connectivity, genetic diversity and adaptability to changing climate.

Rationale:

The Whitebark Pine population in Canada is declining due to a combination of threats, mainly: White Pine Blister Rust, Mountain Pine Beetle, fire and fire suppression, and climate change (COSEWIC 2010). Whitebark Pine life history traits such as slow growth rate to maturity, and reliance on the Clark’s Nutcracker for seed dispersal, further complicate threat mitigation and recovery. Establishing a self-sustaining, rust resistant population throughout the species’ range requires that populations and distributions are maintained and/or restored in such a way that recovery is feasible in light of these factors.

The primary and most widespread cause of Whitebark Pine mortality is White Pine Blister Rust, which alone is anticipated to cause a population decline of more than 50% over a 100-year time frame (COSEWIC 2010). As there are no feasible means to cease or slow the impacts of blister rust on pre-existing trees, maintaining and/or restoring the population and distribution of Whitebark Pine will be primarily through (a) mitigation or avoidance of other identified threats that cause mortality to rust-resistant and/or potentially rust-resistant individuals (including any human-related activities that may exacerbate impacts in this regard), and (b) mitigating effects of ongoing loss attributed to blister rust by increasing recruitment (through identification and deployment) of rust-resistant seedlings.

Whitebark Pine occurs in a range of stem densities. Higher-density stands facilitate the continuation of natural seed dispersal and regeneration. A study based in the US range, with some samples from Waterton Lakes National Park, found that visitation and subsequent caching of seeds by Clark's Nutcrackers was linked to cone densities (Barringer et al. 2012). The best available information suggests that stands with basal areas of Whitebark Pine ranging from 2 m^2/ha (Barringer et al. 2012) to 5 m^2/ha (McKinney et al. 2009) may be required to ensure Clark's Nutcracker visitation. A distribution of stands that contain seed-producing Whitebark Pine at this density (i.e. ≥ 2 m^2/ha) is desired across the landscape, at spatial intervals that prevent genetic isolation. Intermittent stands with lower densities (visited less frequently by Clark's Nutcracker) may be important to maintaining dispersal and genetic continuity between higher-density stands. Lower density stands may also contain rust-resistant individuals.

Maintaining natural genetic diversity is important as it provides a wide range of species differentiation that allows for species adaption to changing climates and minimizes the risk of inbreeding depression (Bower et al. 2011). Genetic resistance and tolerance of White Pine Blister Rust is the foundation of Whitebark Pine recovery. Maximizing the size of the population on which selection is occurring is crucial as some resistance mechanisms may be present in only 1 out of 10 000 individuals (Kinloch Jr. et al. 2003, Schoettle and Sniezko 2007). At present, Forest Genetics Councils in BC and AB are mandated to promote the conservation of genetic resources; however, these agencies rely on partnerships with other groups/agencies to implement operational conservation and restoration measures.

6. Broad Strategies and General Approaches to Meet Objectives

6.1 Actions Already Completed or Currently Underway

Actions contributing to Whitebark Pine recovery have been implemented by various government agencies, industry, and non-profit groups within BC and AB (Table 3). There has also been extensive work conducted in the US that may be used to further inform the Canadian recovery process.

Table 3. Summary of ongoing recovery-related Whitebark Pine work completed as of 2014.

Purpose	Jurisdiction	Recovery-related Action(s)
Gene conservation	BC, AB, Parks Canada	• Seed collections
Identify trees with White Pine Blister Rust resistance	BC, AB, Parks Canada	• Permanent transect establishment and periodic re-measurement of Whitebark Pine trees across range • Identifying and monitoring putatively-resistant candidate trees for seed collection • Seed collection from putatively-resistant parent trees for screening • Inoculation of potentially resistant seedlings with White Pine Blister Rust spores
Protect trees from Mountain Pine Beetle	BC, AB, Parks Canada	• Protection of putatively-resistant parent trees through deployment of verbenone and/or leaf volatiles[9]. • Prescribed fires and/or thinning to remove Mountain Pine Beetle habitat
Promote regeneration and restoration	BC, AB, Parks Canada	• Seedling planting, including: direct sowing trials, planting seedlings inoculated with ectomycorrhizal fungi • Prescribed burns to enhance sites for regeneration/planting • Improve and implement Whitebark Pine habitat predictive mapping tools • Development of guidelines and best management practices for operations occurring in Whitebark Pine habitat

6.2 Strategic Direction for Recovery

The strategic direction for Whitebark Pine recovery is summarized in Table 4; these provide general approaches to recovery planning and implementation in both BC and Alberta.

[9] Verbenone and leaf volatiles are chemicals that act as signaling compounds for insects including Mountain Pine Beetle. They can be used to protect Whitebark Pine from Mountain Pine Beetle by chemically communicating that the tree is not suitable for occupation.

Table 4. Recovery planning table for Whitebark Pine in Canada. Threats are according to the IUCN-CMP classification (refer to Table 2). Priority is characterized as essential (urgent and important, needs to start immediately), necessary (important but not urgent, action can start in 2–5 years); or beneficial (action would be beneficial at any time that it was feasible to start).

Threat or Limitation	Priority[a]	Broad Strategy to Recovery	General Description of Research and Management Approaches
8.1 White Pine Blister Rust	Essential	Increase the frequency of trees that have resistance to White Pine Blister Rust	• Monitor stands for White Pine Blister Rust levels, identify environmental and stand-level characteristics that may indicate rust hazard levels • Protect putatively-resistant trees (enable the development and application of legal tools on provincial land), collect seed for propagation and screening[b] • Support breeding and production programs to screen and propagate rust-resistant seedlings • Use putatively-resistant seedlings in restoration plantings
	Necessary	Maximize stand-level resilience to blister rust epidemics	• Plant resistant or putatively resistant seedlings on a range of sites representing a range of ecological conditions. • Maintain a range of Whitebark Pine age classes across the landscape and within appropriate stands
8.2 Mountain Pine Beetle	Necessary	Minimize losses of Whitebark Pine trees and genetic diversity to Mountain Pine Beetle	• Identify and protect at-risk Whitebark Pine stands and/or individual trees from Mountain Pine Beetle through the deployment of verbenone, green leaf volatiles, carbaryl or other means • Assess Whitebark Pine genotypes for beetle resistance
7.1 Fire and Fire Suppression	Necessary	Minimize negative impacts of wildfire and/or prescribed fire in areas deemed important to Whitebark Pine recovery; facilitate recruitment and productivity.	• Include Whitebark Pine in Fire Management Plans • Identify and protect Whitebark Pine critical habitat in the vicinity of planned prescribed fire • Identify and protect other high-value individuals[14] and habitats, particularly areas with local high densities of healthy, putatively resistant trees, and/or high elevation (treeline) stands with low competition from other species • Minimize damage in these areas by: completing pre-burn fuel reduction work (e.g. thinning); using water delivery systems to protect stands/individuals; developing prescriptions to take advantage of naturally occurring moisture differentials, pre-identifying stand configuration to inform ignition pattern • Plant Whitebark Pine seedlings post-burn
	Beneficial	Assess the role of fire in promoting recruitment of Whitebark Pine within different forest types	• Assess the response of Whitebark Pine to fire across forest types by monitoring seedling establishment and survival following fire • Assess the reliance of Whitebark Pine to fire by characterizing recruitment opportunities within forest types and successional stages

Threat or Limitation	Priority[a]	Broad Strategy to Recovery	General Description of Research and Management Approaches
11 Climate Change	Necessary or Beneficial	Ensure a sufficient amount of suitable habitat persists across current and potential range of Whitebark Pine	• Identify suitable, or potentially suitable habitat that is unoccupied (present, future projections as indicated by climate models). • Habitat restoration, Whitebark Pine planting in suitable or potentially suitable habitat across range: consider whether assisted migration (deliberately planting species in projected suitable habitat) is feasible or appropriate; identify suitable genotypes considering latitude, altitude. • Monitor and identify any new pest organisms that may become problematic.
Limited spatial data on extent of occurrence	Essential	Improve mapping and inventory data in order to meet objectives and address other threats	• Identify and map extent of White Pine Blister Rust infection and/or risk to infection across the species' range (and any other pathogens that are or may become problematic, e.g. Mountain Pine Beetle). • Identify and map the distribution and densities Whitebark Pine individuals that are either cone-producing and/or not terminally infected with White Pine Blister Rust; apply to wildfire planning mapping and protection. • Update modeling and mapping to identify quality and quantity of existing or potentially suitable habitat as new climate data and technology become available. • Analyze spatial mapping data to identify any populations at-risk due to genetic isolation. • Identify stand attributes desired for inventory that may address other objectives (e.g., basal area or mature tree density for cone production and seed dispersal).
Loss of genetic diversity	Essential	Conserve genetic diversity represented among and within populations that may be lost by rapid population decline and/or increasing isolation of stands	• Develop and achieve targets for implementing ex-situ genetic conservation activities including collections from across the range of the species. • Collect seed from Whitebark Pine in areas where it is at risk of extirpation and/or where stands are isolated.

Threat or Limitation	Priority[a]	Broad Strategy to Recovery	General Description of Research and Management Approaches
Local and/or cumulative impacts of other threats	Necessary	Minimize localized and/or cumulative effects causing or contributing mortality to Whitebark Pine individuals that are cone-bearing, and/or that are not terminally-infected with a pathogen	• Maintain Clark's Nutcracker populations at a sufficient level to conserve the essential means of seed dispersal and regeneration of Whitebark Pine by sustaining enough cone-producing Whitebark Pine trees in a population to support resident nutcracker populations across the range. • Identify and maintain alternate natural seed sources for Clark's Nutcracker at sufficient level and in proximity to Whitebark Pine, particularly where the tree naturally occurs at lower densities. • Develop/apply Best Management Practices and/or setback guidelines for Whitebark Pine to avoid, minimize, or mitigate losses owing to: industrial development, livestock use, energy and mining development and exploration, road and service corridor development, timber harvest and post-harvest activities, commercial and recreation activity. • Address lack of legal tools to protect Whitebark Pine on non-federal lands. • Engage in communications and outreach activities to increase public understanding of the species, their status and how they can contribute to their protection and recovery.

[a] *"Priority" reflects the degree to which the broad strategy contributes directly to the recovery of the species or is an essential precursor to an approach that contributes to the recovery of the species.*

[b] **Note:** Considering the rapid rate of population decline, and the uneven/unknown distribution of rust-resistant progeny on the landscape, any Whitebark Pine individuals that are either cone-producing and/or not terminally infected with White Pine Blister Rust may be important contributors to recovery.

6.3 Narrative to Support the Recovery Planning Table

The recovery planning table (Table 4) addresses the main threats from White Pine Blister Rust, Mountain Pine Beetle, climate change, and fire or fire suppression. It also addresses the knowledge gaps and/or limitations relating to poor spatial and inventory data and the loss of genetic diversity, as well as additional threats that may cause cumulative effects and/or localized impacts contributing to Whitebark Pine mortality.

The strategic direction for recovery is generally consistent across the range of Whitebark Pine for strategies addressing the threats and limitations. There may be variation in considered ecological factors and mechanisms, but these are best viewed as variations across the range rather than across provincial boundaries. For example, fire and fire suppression approaches can be more appropriately compared between ecologically similar areas of Alberta (e.g., the rainshadow of the Rocky Mountains) and BC (e.g., the rainshadow of the Coast Mountains in BC), as opposed to ecologically different areas of the same province (e.g., the rainshadow of the Coast Mountains in BC, and the leeward slopes of the Columbia Mountains in BC). However, strategic direction between provinces may differ in relation to additional/cumulative threats and impacts to Whitebark Pine, owing to the relatively higher prevalence of oil and gas exploration in Alberta, versus the relatively higher prevalence of forestry and mining in BC.

Broad strategies regarding White Pine Blister Rust will have the greatest influence on the success of all conservation and restoration measures; these are directed at identifying and augmenting naturally occurring genetic resistance to the fungus, maintaining genetic diversity in the wake of blister rust, and increasing ecosystem resilience to support natural blister rust tolerance and selection for rust-resistance. The broad strategy linked to addressing poor spatial and inventory data was classed as essential or beneficial because the lack of inventory for Whitebark Pine confounds most other recovery efforts (including development of realistic baselines). Utilizing existing inventories for rangewide planning is further confounded by the use of differing methods to inventory forests (e.g. within each province, and within National Parks), which inhibits comparisons across jurisdictions. An improved spatial inventory is required for conservation prioritization, monitoring population and health trends, improving fire management planning, and developing better models regarding suitability of future habitat under climate change. Further, an improved inventory will greatly facilitate addressing the cumulative effects and/or localized impacts of additional threats.

7. Critical Habitat

7.1 Identification of the Species' Critical Habitat

Section 41 (1)(c) of SARA requires that recovery strategies include an identification of the species' critical habitat, to the extent possible, as well as examples of activities that are likely to result in its destruction.

Critical habitat for Whitebark Pine in Canada is identified to the extent possible, to meet the species' needs described in Section 3.3. It is acknowledged that White Pine Blister Rust (in combination with Mountain Pine Beetle, and climate change) currently poses the greatest threat to Whitebark Pine, and impacts cannot be eliminated or completely avoided through habitat preservation. However, based on demographic and genetic studies, it has been determined that recovery may be feasible by strategic restoration to increase rust resistance levels in natural populations, and by mitigating or avoiding human-related impacts within habitats that the species requires for survival or recovery.

This federal recovery strategy identifies critical habitat to the extent possible, based on the best available information at this time regarding:

- Current distribution (known range) of Whitebark Pine in Canada;
- Stand densities required to support the Clark's Nutcracker (the species that Whitebark Pine entirely depends on for seed dispersal) and corresponding dispersal, survival, and establishment of seeds and seedlings (i.e., stands with basal area of Whitebark Pine greater than or equal to 2 m^2/ha, as described in Section 3.3); and,
- Additional habitat required to support the regeneration and recovery of Whitebark Pine (i.e., as described in Section 3.3).

As per SARA S.45 the competent minister may at any time amend the recovery strategy to reflect new knowledge. More precise boundaries may be mapped, and/or the criteria for identification may be refined if supported by additional research and/or new information.[10]

Critical habitat identified in this document was assessed in relation to the population and distribution objective (Section 5). Critical habitat can only be partially identified at this time owing to:

- Incomplete information about the current range and actual area of occupancy;
- Insufficient knowledge of projected climate change impacts (as relates to future potential range and occupancy of Whitebark Pine)[11]; and
- Insufficient knowledge of the composition, density, and structure of Whitebark Pine stands necessary for long term persistence and maintenance of genetic diversity across the species' range, particularly as pertains to the amount and

[10] For example it is acknowledged that there is ongoing research investigating relationships between Clark's Nutcracker population size and/or occupancy, and Whitebark Pine basal area and/or cone densities at different scales (i.e., landscape-level, vs. stand-level), e.g. T. Schaming & C. Sutherland, in prep. (Cornell University, U.S.A.), A. McLane et al. in prep (University of Calgary, Canada). Some important unknowns with respect to influence on these relationships on the landscape scale are yearly variation in nutcracker population size, and squirrel predation levels in relation to general seed availability from all conifers (D. Tomback, pers. comm. 2016).

[11] Climate change scenarios and predictions do exist for some areas and/or regions, however the level of detail and knowledge about projected impacts on future range and occupancy of Whitebark Pine is insufficient for the purpose of critical habitat identification.

quality of habitat needed to sustain suitable connective habitat for recovery and regeneration and/or habitats required to sustain lower-density stands.

A schedule of studies (Section 7.2, Table 2) has been developed to provide the information necessary to complete the identification of critical habitat required to support the population and distribution objective. The identification of critical habitat will be updated when this information becomes available, either in a revised recovery strategy or action plan(s).

Considering the nature and extent of information that is lacking, a conservative approach (with regards to the species needs, and habitats required to support survival or recovery) is deemed appropriate for this federally endangered species. The extent and distribution of rust-resistant individuals which represent the future of this species' survival in Canada is unknown. Without this knowledge there is no rationale to support creation of strategic benchmarks or targets, i.e., threshold numbers of individuals and/or proportions of habitat that could be lost without affecting the survival or recovery of the species. There is a projected decline of mature individuals of more than 50% over the next 100 years owing to White Pine Blister Rust alone (COSEWIC 2010). Considering this rapid rate of population decline, and the uneven/unknown distribution of rust-resistant progeny on the landscape, the best available information supports the current approach to identify critical habitat for all areas that have a high-density of Whitebark Pine trees that are cone-producing and/or not terminally infected[12], and for additional habitats that are necessary to support the species' survival or recovery. As responsible jurisdictions inventory stands and conduct research (see schedule of studies, section 7.2), the critical habitat methodology and identification may be modified to reflect new knowledge.

Critical habitat for Whitebark Pine has been identified at a landscape scale. This document provides information on the broad area within which critical habitat is found (i.e., the geospatial area representing the known range of Whitebark Pine in Alberta and British Columbia), and the criteria by which the biophysical attributes of critical habitat are defined within that geospatial area. Owing to the lack of detailed occurrence information for Whitebark Pine across this broad area, the precise location of critical habitat will need to be determined by landscape managers or planners on a case-by-case basis.

Known range of Whitebark Pine

The known range of Whitebark Pine in Canada was derived using the best available information, by identifying all landscape inventory polygons[13] where Whitebark Pine

[12] A terminal infection by White Pine Blister Rust is defined as any tree with a stem canker where the entire crown is dead or chlorotic (losing green colour) indicating imminent death. Trees with stem cankers and green vigorous crowns should not be considered terminally infected.

[13] Landscape inventory polygon data assessed included: Vegetation Resource Inventory (VRI), Terrestrial Ecosystem Mapping (TEM/TEI), and Predictive Ecosystem Mapping (PEM) in BC; and, Ecological Land Classification (ELC) in most National Parks. The AVI system in Alberta was considered; however this

trees are known or documented to occur (Figure 3). The known range was determined by (1) identifying all landscape inventory polygons which have Whitebark Pine indicated as a vegetation component (either in the label or in the polygon descriptor), and (2) identifying all landscape inventory polygons which have a record of occurrence by local-scale field data (e.g., individual observations, research plots, health monitoring, cone collections, restoration work, tree inventories, etc.)[14]. All identified landscape inventory polygons were overlapped and merged to form the boundaries of the known range.

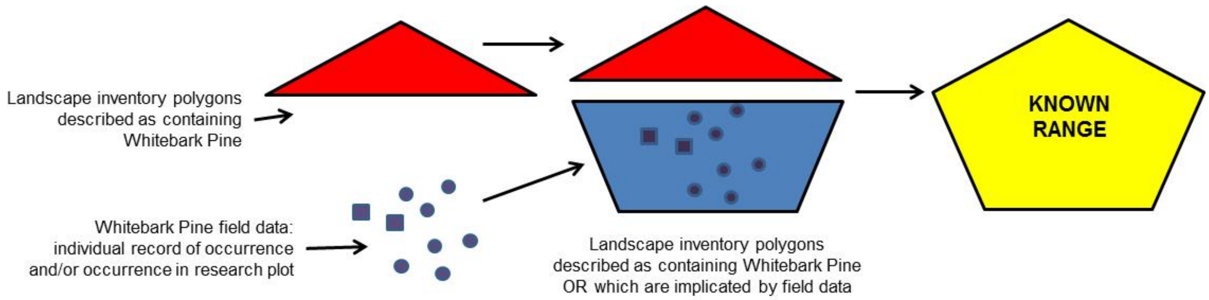

Figure 3. Overview of methods to determine known range for Whitebark Pine.

Note that within any of the implicated landscape inventory polygons, the Whitebark Pine could comprise a greater or lesser component of forest stands (and the sizes of the implicated polygons themselves will vary). Although the landscape inventory polygons are deemed sufficient to reflect the best available information about what constitutes the current known range of the species (i.e., presence or absence of Whitebark Pine), associated information about the relative dominance of Whitebark Pine within polygons is inadequate and/or unavailable. As noted above, actual Whitebark Pine tree distribution and densities within the known range will need to be determined at a local scale, by agencies and individuals who are responsible for landscape management.

Critical habitat is identified from a broad scale to a narrower scale, based on the primary consideration of stand density (see also illustrations in Figure 4a,b). Stand densities are determined on the basis that trees included in the quantification meet at least one of these two criteria: (a) trees are cone-producing, and/or (b) trees are not terminally infected by White Pine Blister Rust. Note that trees that are terminally infected and not cone-producing are excluded from the quantification of stand density, and are excluded from the identification of critical habitat.

system was not considered reliable or comparable to the others in accuracy or scale, in terms of identifying Whitebark Pine as a vegetation component. Incomplete information about the current range and actual area of occupancy is addressed in the schedule of studies section.

[14] Field data were used to identify additional landscape inventory polygons using the VRI system in BC, and the ELC system was used in Jasper, Waterton Lakes and Banff National Parks.

Location and description of seed dispersal and regeneration habitat:

Within the known range area (as identified above), where landscape inventory polygons have a high density of Whitebark Pine (i.e., threshold level of greater than or equal to 2 m^2/ha basal area as averaged across the landscape inventory polygon), the entire landscape inventory polygon is identified as seed dispersal and regeneration habitat. Whitebark Pine trees that are either cone-producing and/or not terminally infected by White Pine Blister Rust are required at high densities to support Clark's Nutcracker, which in turn allows for survival, dispersal, regeneration, and recovery of potentially rust-resistant individuals. The substratum layer provides the physiological niche (moisture, drainage, aspect) that Whitebark Pine requires for growth and persistence, including ectomycorrizal associations, and microsites for seed caching, and regeneration. The majority of habitat needs for Whitebark Pine (i.e., for survival, regeneration, and/or recovery as outlined in Section 3.3) are naturally encompassed by the identification of high-density polygons as critical habitat, as well as the areas immediately surrounding.

Within landscape inventory polygons that have a high density of Whitebark Pine, critical habitat is identified by the following biophysical attributes:

- Cone-bearing and/or non-terminally infected Whitebark Pine
- Any substrate areas that are:
  - within the subsurface root area of existing Whitebark Pine individuals; and/or,
  - open (not encroached by dense shrub, or competitive tree understory or overstory) at the surface layer; and,
  - well- to rapidly-drained, coarse or rocky soils (including Orthic Regosols, Orthic Eutric Brunisols, Orthic Dystric Brunisols and Ortho Humo-ferric Podzols), serpentine soils.

Within a 2 km distance (i.e., the median dispersal distance of Clark's Nutcracker) around all landscape inventory polygons that have a high density of Whitebark Pine, critical habitat is identified by the following biophysical attributes:

- natural open parkland and forest openings (not encroached by dense shrub, or competitive tree understory or overstory) that:
  - are ≥ 0.5 ha in area[15]
  - have suitable substrates for regeneration: well- to rapidly-drained, coarse or rocky soils (including Orthic Regosols, Orthic Eutric Brunisols, Orthic Dystric Brunisols and Ortho Humo-ferric Podzols), serpentine soils; and
  - occur within the known regional elevation limits for Whitebark Pine; and/or

[15] 0.5 ha area corresponds with the typical minimum ecosystem feature size used in landscape inventory mapping systems.

- occur within the projected climate change envelope model limits (where this information is available) for Whitebark Pine.

Location and description of recovery habitat

Within the known range area (including all landscape inventory polygons regardless of Whitebark Pine density), and within the 2 km area surrounding landscape inventory polygons that have a high density of Whitebark Pine, critical habitat is identified anywhere that:

- Whitebark Pine research and monitoring plots or transects have been established to directly inform and assist the recovery process. These sites include, but may not be limited to: permanent health monitoring plots or transects, parent trees selected for *ex-situ* conservation, parent trees being tested for resistance to White Pine Blister Rust, and climate change plots; and/or
- Recovery activities are deliberately applied to create regeneration habitat (e.g., prescribed burning, or mechanical removal of competing vegetation) for the purpose of Whitebark Pine seed sowing or Whitebark Pine seedling planting, and/or any areas where Whitebark Pine seed sowing or seedling planting has already taken place in these habitats.

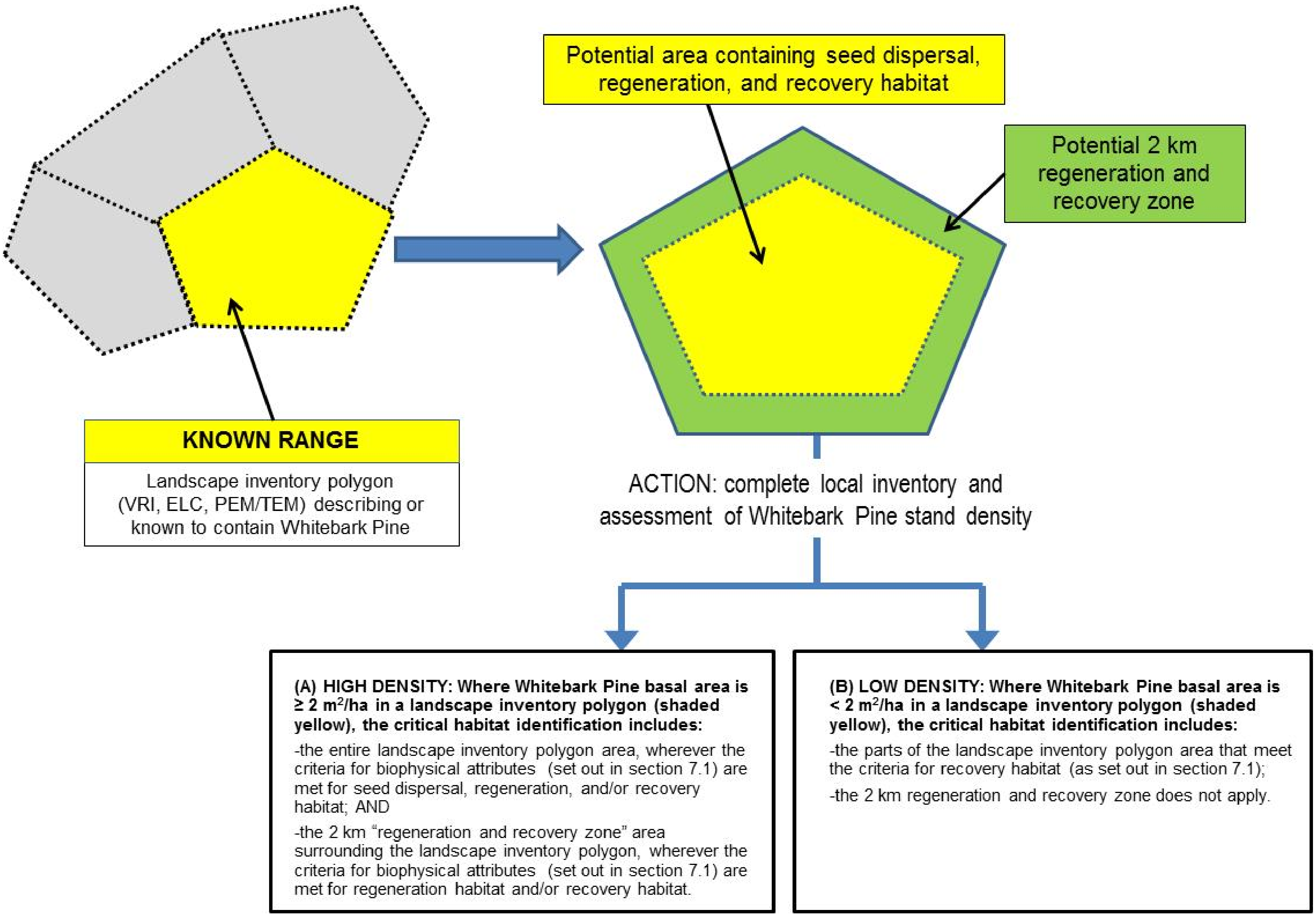

Figure 4a. Schematic diagram showing critical habitat identification for Whitebark Pine. Example outcome of applied methodology is shown in Figure 4b.

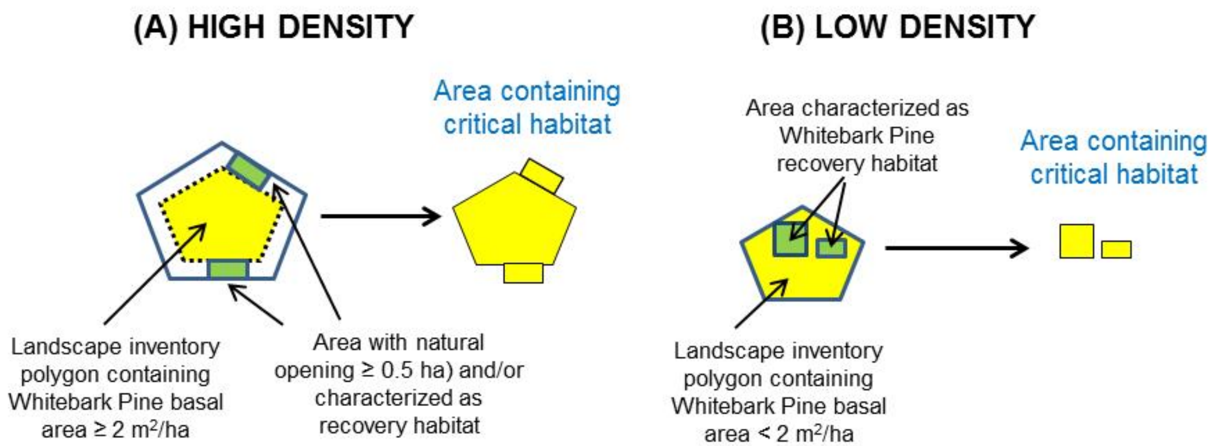

Figure 4b. Outcome of critical habitat identification methodology (Figure 4a) as applied to area containing critical habitat for Whitebark Pine (WBP): (A) high density stands (seed dispersal, regeneration, and recovery habitat), (B) low density stands (recovery habitat).

The area(s) containing critical habitat for Whitebark Pine are presented in Figures 5-8. Critical habitat for Whitebark Pine in Canada occurs within the known range of the species (shaded yellow polygons) and the 2 km regeneration and recovery zone (shaded green polygons) where the critical habitat criteria and methodology described in this section are met. Unsuitable habitats such as lakes and ponds (below lowest documented water line), anthropogenic features (including active trails, existing ski runs, utility corridors, roads, and existing infrastructure such as buildings) do not possess the attributes required by Whitebark Pine and they are not identified as critical habitat. More detailed information on the location of critical habitat to support protection of the species and its habitat may be requested, on a need-to-know basis, by contacting Environment and Climate Change Canada's Recovery Planning section at: ec.planificationduretablissement-recoveryplanning.ec@canada.ca.

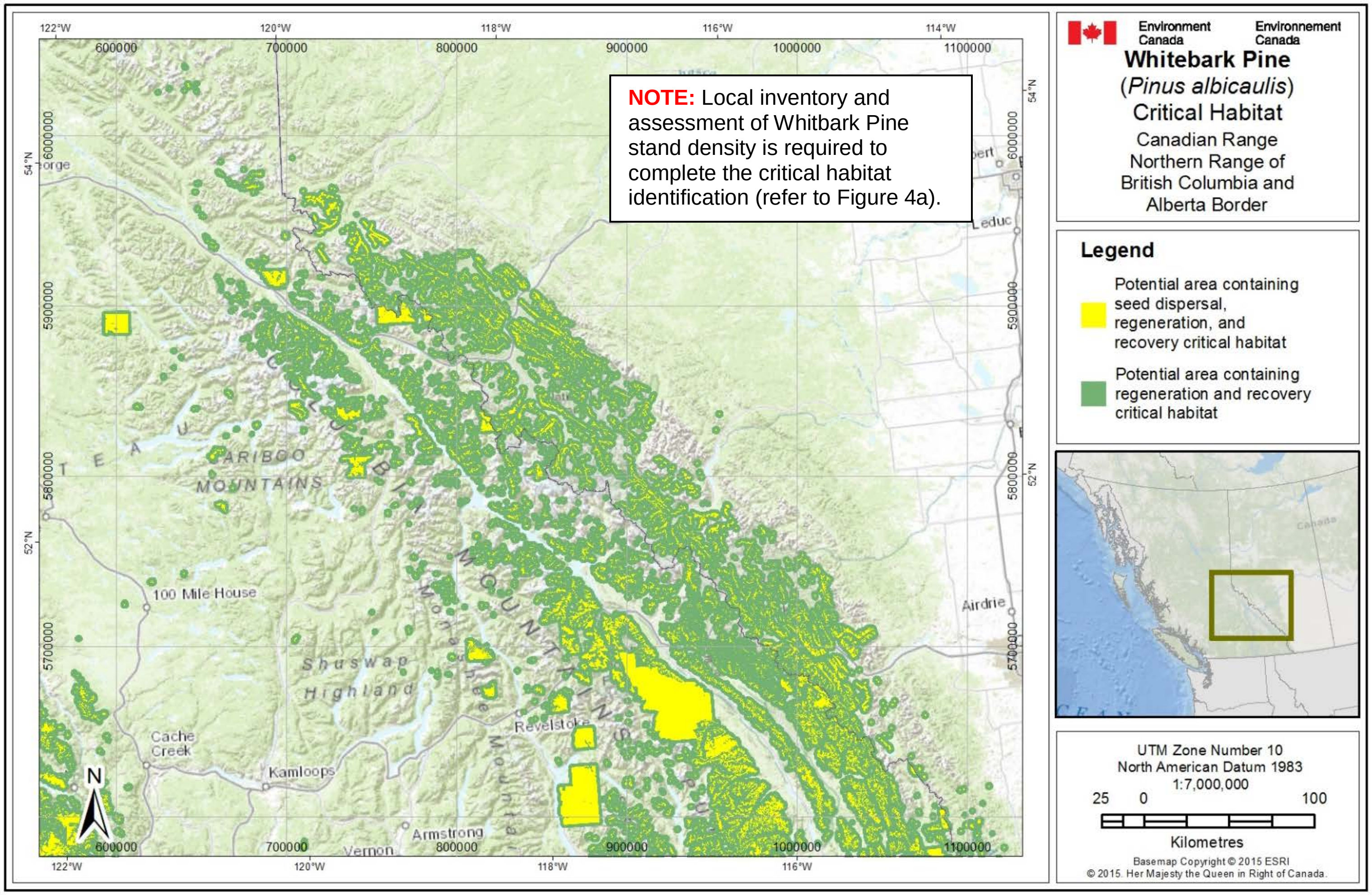

Figure 5. Potential area containing critical habitat for Whitebark Pine in the northern range of the British Columbia – Alberta border is represented by the yellow shaded polygons (units) comprising the known range, and the green shaded polygons (units) comprising the 2 km regeneration and recovery zone, where the criteria and methodology set out in Section 7.1 are met.

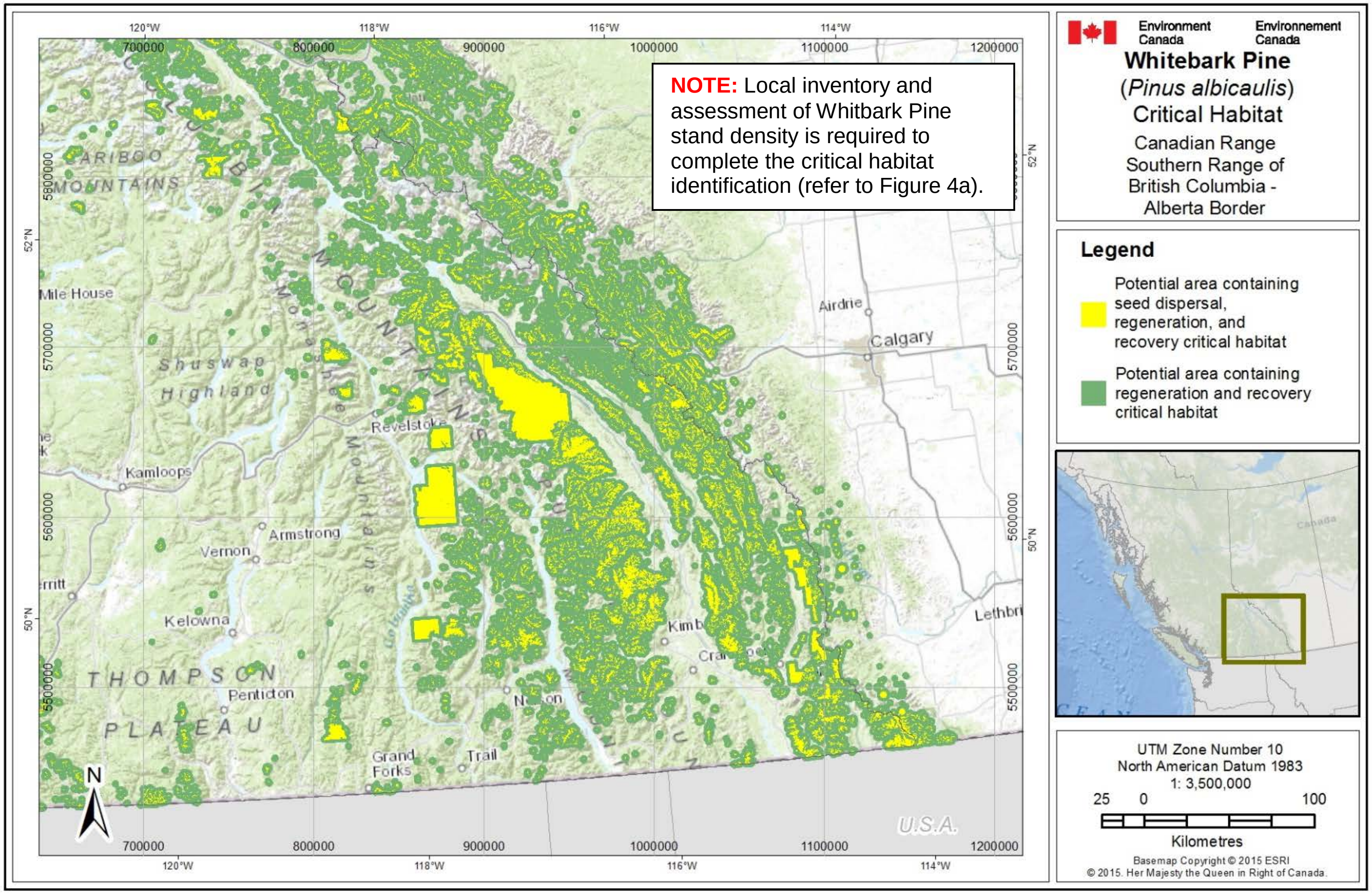

Figure 6. Potential area containing critical habitat for Whitebark Pine in the southern range of the British Columbia – Alberta border is represented by the yellow shaded polygons (units) comprising the known range, and the green shaded polygons (units) comprising the 2 km regeneration and recovery zone, where the criteria and methodology set out in Section 7.1 are met.

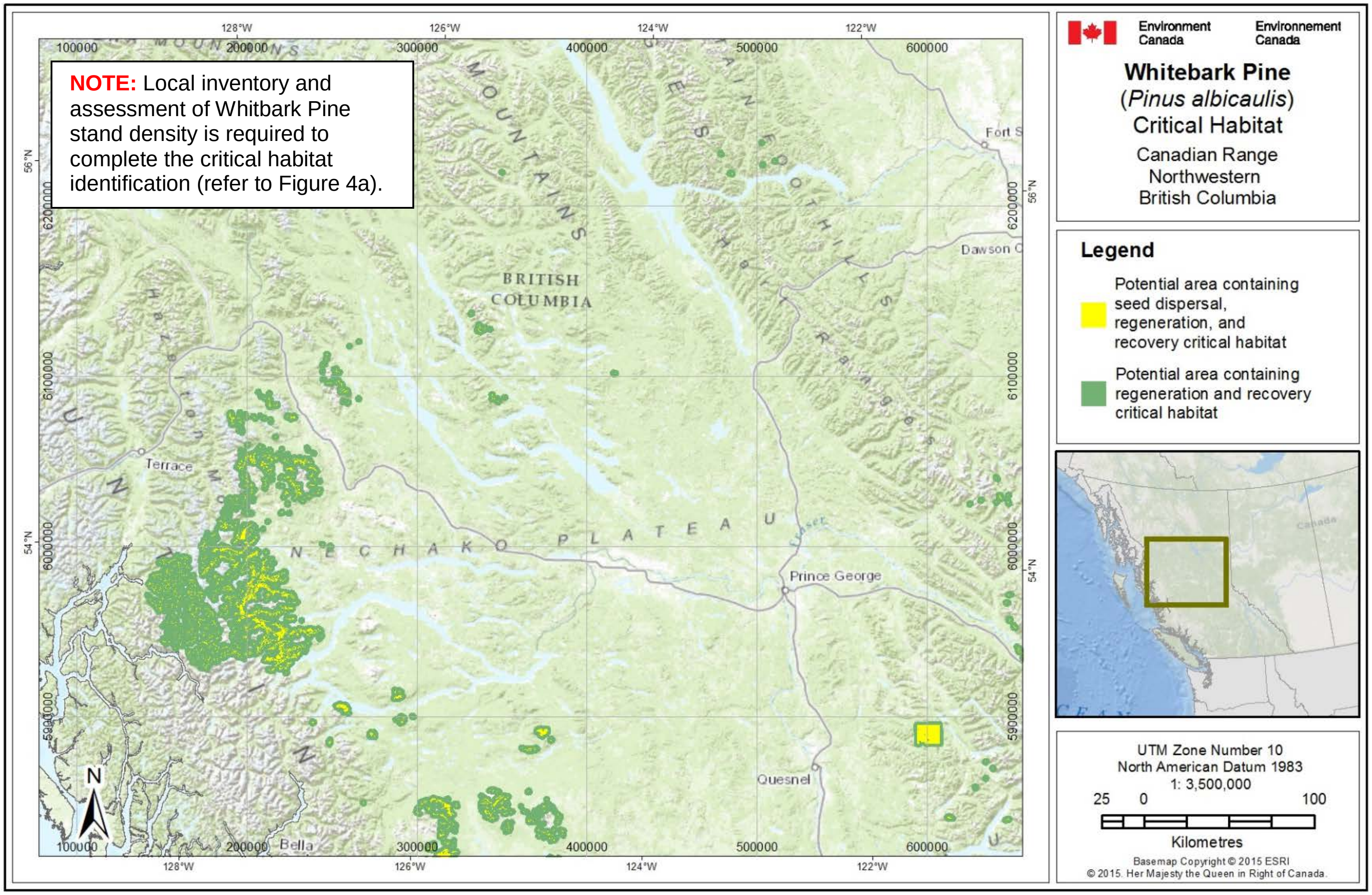

Figure 7. Potential area containing critical habitat for Whitebark Pine in northwestern British Columbia is represented by the yellow shaded polygons (units) comprising the known range, and the green shaded polygons (units) comprising the 2 km regeneration and recovery zone, where the criteria and methodology set out in Section 7.1 are met.

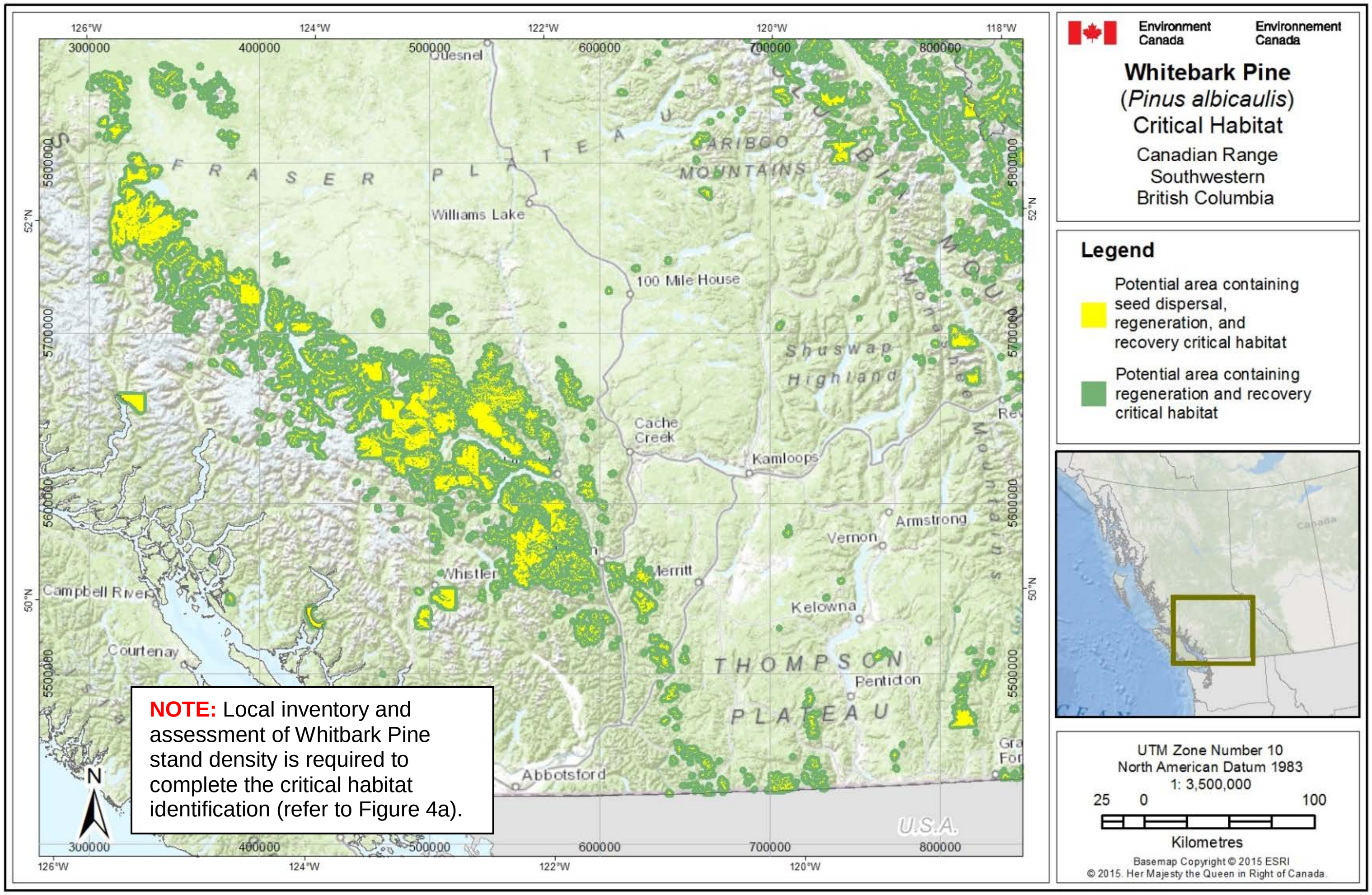

Figure 8. Potential area containing critical habitat for Whitebark Pine in southwestern British Columbia is represented by the yellow shaded polygons (units) comprising the known range, and the green shaded polygons (units) comprising the 2 km regeneration and recovery zone, where the criteria and methodology set out in Section 7.1 are met.

7.2 Schedule of Studies to Identify Critical Habitat

The information necessary to complete the identification of critical habitat for Whitebark Pine is summarized in Table 5.

Table 5. Schedule of studies required to identify critical habitat.

Description of Activity	Rationale	Timeline
Inventory to identify the full extent of current range and area of occupancy of Whitebark Pine.	The "known" range as identified in the critical habitat section likely underestimates the full range that Whitebark Pine occupies at present time due to insufficient spatial information. Further, the accuracy of landscape inventory polygon systems that identify Whitebark Pine as a vegetation component are not equivalent between provinces. This information is required to complete the identification of critical habitat, particularly in parts of Alberta where landscape inventory information is currently unavailable and/or inadequate.	2017-2022
Inventory and studies to identify the future potential range of Whitebark Pine.	The distribution and availability of habitat for Whitebark Pine will be affected by climate change. Current information is inadequate to identify habitats which may become suitable under projected climate change scenarios, which suitable areas are unoccupied, and whether there are any barriers to new occupation. This information is required such that critical habitat can be completely identified.	2017-2022
Research on the composition, density, and structure of Whitebark Pine stands necessary for long-term persistence and maintenance of genetic diversity across the species' range.	Maintaining habitat for lower-density Whitebark Pine stands will be important to long-term genetic diversity and persistence across the species' range. Currently there is inadequate information to identify critical habitat in connective, lower density Whitebark Pine stands.	2017-2022

7.3 Activities Likely to Result in the Destruction of Critical Habitat

Understanding what constitutes destruction of critical habitat is necessary for the protection and management of critical habitat. Destruction is determined on a case by case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from a single or multiple activities at one point in time or from the cumulative effects of one or more activities over time.

There are unknowns regarding the feasibility of recovery of Whitebark Pine. Specifically, it is unknown whether the primary threats to the species and its habitat (particularly White Pine Blister Rust, climate change, and Mountain Pine Beetle) can be avoided or mitigated. Notwithstanding, human-related activities associated with lower-impact threats can (cumulatively, and/or individually) degrade the species' resilience to primary threats, if left unchecked. In other words, if these activities continue without consideration for Whitebark Pine, the likelihood and feasibility of the species' survival and recovery will be reduced. Table 6 outlines human-related activities that are most likely to result in the destruction of critical habitat for Whitebark Pine. Appendix B provides additional information pertaining to the management of these activities. Destructive activities are not limited to those listed.

Table 6. Examples of activities likely to result in the destruction of critical habitat for Whitebark Pine in Canada. IUCN Threat numbers are in accordance with the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system (CMP 2010).

Description of effect (on biophysical attributes) in relation to function loss of critical habitat	Examples of activities resulting in the destruction of critical habitat	Details of Effect (refer to Appendix B for additional information)
Loss or damage to biophysical attributes of critical habitat by: • reducing the density of cone-bearing and/or non-terminally infected Whitebark Pine • removal, replacement, or damage to substrate (i.e., root area, microsites for cached seeds, and/or seedlings), such as through compaction of soil and/or microsite destruction	Development and/or conversion of lands for industry (e.g. logging and wood harvesting, creation and operation of quarries, mines, mineral exploration, oil and gas development), recreation (e.g. ski glading or off-road ATV trails), or commerce (e.g., road building, erecting permanent structures such as communication towers, backcountry lodges, etc.) **Note:** Selective removal of competing conifer species and/or other encroaching vegetation may be able to be achieved without damage to the attributes described	Related IUCN Threats: # 1, 3, 4, 5, 6.1 Seed dispersal habitat is required for continued natural dispersal (i.e., use by Clark's Nutcracker). Availability of suitable microsites within and proximal to seed dispersal habitats are required for recovery, and regeneration. The prevalence of industrial, recreational, and/or commercial impacts will be site-specific. Individually most of the related threats are of negligible impact however logging is characterized as a low-impact threat in BC. These activities generally occur at the local scale, but can have cumulative impacts at the broader scale. It is not possible to determine thresholds at this time; however direct and cumulative effects are likely to be increasing.
	High-intensity or stand replacing fires; non-selective forest fuel control activities Some types of low- to mixed-intensity and/or targeted burns.	Related IUCN Threat # 7.1, 8.1 As a result of fire suppression, many mixed severity fire regimes have been altered to high severity fire regimes. As such, the re-introduction of fire into these altered ecosystems must be implemented in such a way that biophysical attributes are protected, for example by controlling the spread of lower- elevation burns upslope into Whitebark Pine critical habitat. Low to mixed-intensity and/or targeted burns are less likely to result in destruction of critical habitat, where care is taken to avoid damage to biophysical attributes. High-intensity or stand replacing burns are more likely to result in destruction of critical habitat as reduction in density of cone-bearing and/or non-terminally infected Whitebark Pine, as well as damage to existing substrate

		attributes may be unavoidable. It is acknowledged that the ecology of Whitebark Pine is complex in relation to fire management, and there could be specific ecological circumstances where prescribed high-intensity or stand replacing prescribed burns can be demonstrated to support the survival and recovery of the species.
	Inappropriate levels of livestock grazing can result in direct and/or cumulative damage to habitat. **Note:** Grazing may be able to take place without net damage to the attributes described, e.g., in established stands (i.e. where the average height of Whitebark Pine is ≥2 m); however seedlings should be protected. Grazing in regeneration or recovery habitats (where average height of Whitebark Pine is <2 m) should be avoided.	Related IUCN threat # 2.3 Soil disturbance and compaction may interrupt drainage, limit tree rooting, and damage seedlings. Where appropriately managed, cattle use may provide some benefit to Whitebark Pine in established stands by limiting ingrowth of competing species and keeping areas open for regeneration.
Permanent destruction or conversion of regeneration habitat	Deliberately planting seedlings of any other competing tree species (particularly Lodgepole Pine) in suitable Whitebark Pine regeneration habitat. **Note:** Some amount of reforestation with fast-growing conifers may be able to take place without net damage to the attributes described, e.g., by strategic planting.	Related IUCN Threat: # 5.3, 8.2 Deliberately planting seedlings of any other competing tree species (particularly Lodgepole Pine) may eliminate Whitebark Pine regeneration on a local scale. This activity increases the likelihood of encroachment by competing species and forest succession within areas containing critical habitat.
	Creation of trails, roads, or corridors through suitable regeneration habitat. **Note:** Construction of roads, trails and corridors may able to take place without destruction to biophysical attributes of critical habitat, by appropriate sighting (i.e., avoiding Whitebark Pine trees and direct damage to substrates required for regeneration), and by adhering to best management practices for use of clean equipment.	Related IUCN Threat #1.3, 4, 8.1 This activity increases the likelihood of encroachment by competing species (including fast-growing conifers, and invasive plants) and forest succession within areas containing critical habitat.

Critical habitat for Whitebark Pine is most likely to be destroyed through a reduction in the density of cone-bearing and/or non-terminally infected Whitebark Pine comprising seed dispersal habitat, and by the removal, replacement, or damage to substrate in these habitats that comprise microsites for cached seeds or seedlings. Regeneration and seed dispersal habitat are also likely be destroyed by competitive exclusion and succession.

Whitebark Pine stand-density reduction and/or damage to substrate in seed dispersal habitat is most likely to occur by industrial, recreational, or commercial activities, inappropriate fire management and/or inappropriate levels of livestock grazing. However, depending on implementation (see also Appendix B), these activities may be compatible with protection of critical habitat for Whitebark Pine. For example, hand-cutting or brush-cutting of competing conifer species and/or other encroaching vegetation within high-density stands may be able to be achieved without damage to the biophysical attributes of critical habitat. Similarly, low-intensity and/or targeted burns and/or some level of grazing may be able to take place in high-density stands without negative impacts to biophysical attributes of critical habitat (although regeneration or recovery habitats should be avoided).

Loss of regeneration habitat and seed dispersal habitat by encroachment of competing species including forest succession is most likely to occur by Lodgepole Pine seedling planting or forest successional ingrowth of Subalpine Fir. In many areas timber harvest has replaced wildfire as the main forest disturbance. In some circumstances such as where allowing wildfires to burn is unacceptable (due to policies, jurisdictions, values at risk, public safety), the loss of regeneration habitat owing to historical fire suppression could be mitigated by including the needs of Whitebark Pine in landscape-level plans (e.g., by deliberate creation of suitable openings, and/or inclusion in post-harvest stocking standards, and potentially by specific management of alternate nutcracker food sources).

Creation of trails, roads, or corridors can result in increased introduction/establishment of invasive plants, and reduced competitive success of Whitebark Pine. Noxious weeds commonly invade disturbed areas including burned sites, particularly where soil erosion has occurred. Actions may be taken to avoid destruction of critical habitat by effective burn planning and implementation, as well as by limiting soil disturbance, ensuring equipment is clean, and burning in areas with limited vehicle, foot, or horse access. Similarly, in landscapes where off-road vehicles or trail creation activities occur, particular configurations of these activities may be achievable such that destruction of Whitebark Pine critical habitat is avoided.

8. Measuring Progress

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives:

1) Population decline is mitigated by the cessation of human-related activities causing population loss, and by the application of broad strategies promoting regeneration and recovery of rust-resistant individuals.
2) Stand densities that can support healthy populations of Clark's Nutcracker (allowing for natural dispersal and regeneration of seedlings) are maintained on the landscape.
3) The Canadian population of Whitebark Pine maintains a size large enough to maintain genetic diversity and one that minimizes genetic drift and inbreeding depression. Genetic and geographical connection between higher-density stands is maintained through the persistence of intermittent suitable habitat and/or lower-density stands.
4) Appropriate regeneration habitat is maintained on the landscape.

9. Statement on Action Plans

One or more action plans for Whitebark Pine will be posted on the Species at Risk Public Registry by 2022.

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Appendix A: Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[16]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[17] (FSDS) goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

Woodland Caribou occur throughout much of the range of Whitebark Pine in Canada. The Southern Mountain population of Woodland Caribou occur in the Purcell and Selkirk Mountains in the south and expand into the Rocky Mountains near the Banff-Jasper boundary and occur north and west of this point into the Cariboo Mountains. Woodland Caribou also occur through the northern and western range of Whitebark Pine as well. Habitat common to Woodland Caribou and Whitebark Pine includes high-elevation habitat. Caribou generally occupy old-growth habitats, but also utilize areas with up to 40% of cover as young forests or natural openings (Simpson et al. 1994, B.C. Government 2002). These young-forests and natural openings are conducive to Whitebark Pine recruitment; thus some shared habitat niches may exist. Fire management practices in areas where the two species overlap will require consideration of the local needs of both species.

The relationship between Whitebark Pine and the Grizzly Bear is well documented in the Yellowstone Region of the United States (Mattson and Reinhart 1994, Mattson et. al. 2001). In Canada this relationship is more poorly defined; however, numerous observations and research indicate some use by bears (T. McKay pers. comm. 2013, W. McCrory pers. comm. 2013, Y. Patterson pers. comm. 2013). In some areas such as the Chilcotin, Grizzly Bear use of Whitebark Pine seeds may be high when availability of seeds is high (McCrory pers. comm. 2013). Whitebark Pine is likely a component of a preferred food matrix and its importance may vary with relative abundances of other foods. Degradation of Whitebark Pine populations may impact Grizzly Bear habitat use, particularly where other preferred foods are limited. The time period to cone production

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[16] www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[17] www.ec.gc.ca/dd-sd/default.asp?lang=En&n=CD30F295-1

as a result of restoration actions is significant, thus the immediate impact to Grizzly Bears will be through arresting population decline of cone-bearing Whitebark Pine individuals. Some Whitebark Pine restoration actions such as prescribed burning or thinning may create suitable conditions for other Grizzly Bear foods such as *Vaccinium* species. Cone crop abundance has been linked to Grizzly-human interactions (e.g., Mattson *et al.* 1992); maintaining viable populations of mature Whitebark Pine in Grizzly Bear habitat would provide a key food source and may reduce the likelihood of conflicts with humans.

Limber Pine is a COSEWIC-assessed endangered species that is provincially listed in both BC and Alberta. It shares many of the same traits as Whitebark Pine: it has five needles, produces large seeds, grows on many comparable sites, and its seeds are dispersed by the Clark's Nutcracker. The range of the Clark's Nutcracker directly overlaps with the range of large-seed producing pines (e.g. Whitebark Pine, Limber Pine, Ponderosa Pine), thus it is thought that the nutcracker, though not an obligate mutualist of Whitebark Pine, may be an obligate mutualist of large-seeded pine (T. Schaming pers. comm. 2013). Where there are low levels of Whitebark Pine, it may be important to manage these alternate food sources as a way of maintaining the presence of nutcrackers. If Whitebark Pine declines from much the range where it overlaps with Limber Pine, there is potential for increased feeding pressure on Limber Pine. Further, as both tree species are infected by White Pine Blister Rust, higher infection rates of Whitebark Pine may promote higher infection of directly adjacent Limber Pine. Thus a failure to implement recovery actions for Whitebark Pine may impact natural recruitment patterns of both species, owing to seed loss, and stand level rust infection levels.

In summary, Whitebark Pine tends to occur in the same habitat as other species at risk found in high-elevation ecosystems such as Woodland Caribou, Grizzly Bear, Limber Pine, and also possibly the American Badger *jeffersonii* subspecies, and the Rocky Mountain Tailed-Frog. Most recovery activities proposed for Whitebark Pine (e.g. such as planting rust-resistant seedlings) will have a beneficial effect on Grizzly Bear and Limber Pine, because they have generally similar habitat and/or recovery needs. However, it is possible that specific management actions carried out during the course of Whitebark Pine recovery (e.g. landscape scale treatments such as prescribed burning) could potentially have negative effects on associated non-target species occupying different habitats, such as Woodland Caribou. The ability to completely constrain burning treatments to a single habitat type may be limited; potentially resulting in the destruction of habitat for non-target species and/or causing mortality. The chances of negative effects occurring due to recovery activities are considered to be small for non-target species, as prescribed burning is not anticipated to be a widespread recovery practice. In keeping with the principles of adaptive management, an important component of recovery action planning will be anticipating and monitoring potential collateral effects (both positive and negative) on non-target species, communities, and ecological processes, and adjusting management techniques as appropriate.

Appendix B: Additional information for landscape management to prevent the destruction of critical habitat

The content below summarizes and provides additional information and qualifiers pertaining to the management of human-related activities that are most likely to result in destruction of critical habitat (i.e., that which is identified as critical habtiat at a local scale, by agencies and individuals who are responsible for landscape management, as per Figure 4 a,b).

This information is for general guidance purposes only. Applying principles of this guidance does not guarantee that critical habitat will not be destroyed; rather, destruction of critical habitat will need to be assessed on a case-by-case basis.

Avoid or minimize activities likely to result in destruction

- Development and/or conversion of lands for industry, recreation, or commerce
  - Avoid cutting Whitebark Pine trees that are not terminally infected and/or that are cone-producing.
  - Identify, georeference, mark, and report Whitebark Pine trees that are putatively rust-resistant.
  - Avoid machine operation within identified critical habitat that results in damage to any pre-existing Whitebark Pine trees and/or the soil layer that supports them.
  - Avoid planting competitive conifer species/seedlings (e.g., Lodgepole Pine, Spruce, Fir) in critical habitat identified for Whitebark Pine.
  - Prevent introduction of alien invasive vegetation by ensuring equipment is clean[18].

- Fire and fire suppression
  - Avoid high severity fires within, or adjacent to, critical habitat areas.
  - Prevent wildfire spreading into critical habitat areas.
  - Protect Whitebark Pine trees that are not terminally infected and/or cone-producing during prescribed burns.
  - Ensure any fire prescriptions include: a) burning during seasons/conditions when stands and/or organic soil layer still contain higher degrees of moisture (early spring, late fall); b) specific actions to control spread (e.g. applying water, burning ladder fuels prior to main unit implementation, pruning/thinning of adjacent dense late seral stands); and c) monitoring and control of alien invasive vegetation prior to prescribed fire implementation.
  - Prevent the spread of alien invasive vegetation by avoiding prescribed burns in areas with high levels of vehicle, foot, or horse access.

  Effective burn planning and implementation is required to avoid destruction of critical habitat. High severity fires within critical habitat areas should be avoided, and

[18] E.g. see "Best Management Practices for Invasive Plants in Parks and Protected Areas of British Columbia"

low-moderate prescribed fires within critical habitat should avoid damage to biophysical attributes, including Whitebark Pine trees that are not terminally infected and/or that are cone-producing. Damaging fires are those that burn deep into the organic soil layer, resulting in mortality of cached seeds, and destruction of ground stabilizing vegetation, leading to increased erosion. High severity fire (within, or adjacent to, critical habitat areas) may result in bare mineral soil being exposed for a longer period of time following the fire, thereby increasing the potential recruitment of alien invasive vegetation.

- Livestock Grazing

  Where cattle have the potential to destroy Whitebark Pine critical habitat, projected effects should be avoided and mitigated in range management plans. In areas identified as critical habitat:

  - Where the average height of Whitebark Pine is ≥ 2 m, it is unlikely that low-moderate grazing levels will produce any net damage to the biophysical attributes described; however any individual Whitebark Pine seedlings less than this height should be protected.
  - Grazing or horseback riding in critical habitat where average height of Whitebark Pine is <2 m (e.g., regeneration or recovery habitats) should be avoided.

- Recreation and road creation

  In landscapes where off-road vehicles or trail creation activities occur, particular configurations of these activities may be achievable such that destruction of Whitebark Pine critical habitat is avoided, e.g., via development of appropriate access management plans. In areas identified as critical habitat:

  - Avoid creation of new roads or trails (including ski runs).
  - Where new activities take place: limit soil disturbance, and use clean equipment to prevent the spread of alien invasive vegetation.
  - Where activities are ongoing, protect Whitebark Pine trees that are not terminally infected and/or cone-producing to the extent possible.

Environment and Climate Change Canada will work with all of its partners to refine and update information pertaining to management of human activities causing destruction of critical habitat, for the purpose of conserving the Whitebark Pine across its range and to incorporate multi-species requirements and management in these subalpine and treeline ecosystems. As available, refined and/or updated information on the management of activities to prevent degradation or destruction of critical habitat will be posted on the species' profile page on the Species at Risk Public Registry: http://www.registrelep-sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=1086.