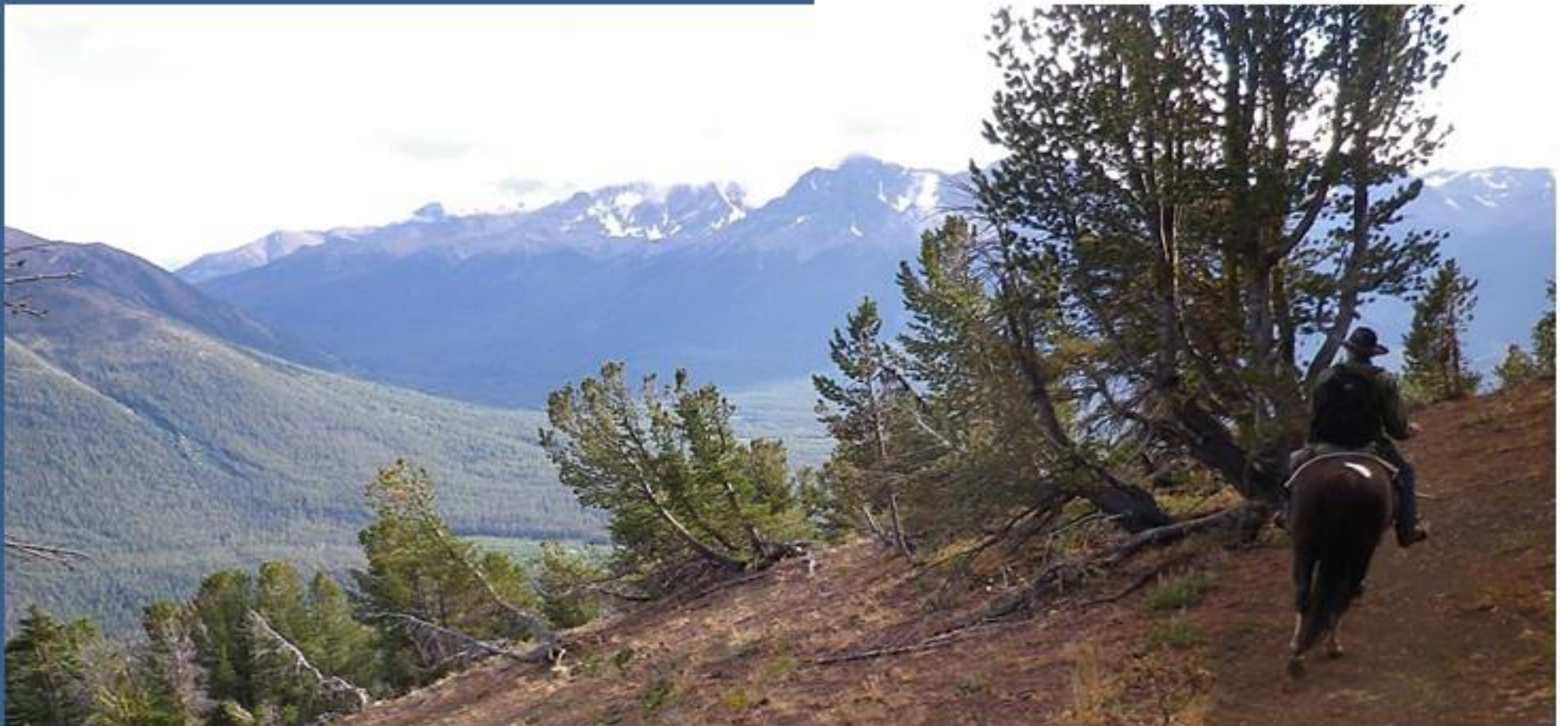

Best Management Practices for Whitebark Pine (*Pinus albicaulis*)

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***This is a working draft version of Best Management Practices for Whitebark Pine. This document will be updated when the Federal Recovery Strategy is finalized, when a provincial implementation strategy is finalized, and/ or when emerging knowledge warrants updates.

Why Best Management Practices?

Whitebark pine, a keystone tree species in many high-elevation forests across Canada and the United States, is currently facing an unprecedented suite of threats in the form of an invasive pathogen, native insects, and a changing fire regime; all with climate change acting to both exacerbate these stressors and acting as a stressor itself. Due to the scale and impact of these stressors over the course of the last 30 years, whitebark pine has been listed as an endangered species under Canada's Species At Risk Act (SARA) and is currently listed as Threatened under the United States' Endangered Species Act.

In BC, Whitebark pine occurs across a vast area of the landscape where it directly interfaces with land uses that may conflict with whitebark pine recovery, including forestry, mining, pipelines, transmission lines, communication towers, ski areas, recreation, and range use. Without effective guidance, these land uses will continue to have negative impacts on whitebark pine. This is not a 'how to recover whitebark pine' document, but rather a management practices guide to help mitigate the impact of human land uses and to potentially redirect some of these impacts into recovery gains. Higher level recovery activities such as screening for white pine blister rust resistance, seedling production, and prescribed burning or land use decisions are beyond the scope of this document.

The objective of developing Best Management Practices (BMPs) for whitebark pine is two-fold:

1) **To reduce direct impacts caused by humans to whitebark pine populations**

   While human-caused impacts are not as significant as those caused by white pine blister rust or mountain pine beetle, direct human impact still exceeds those gains achieved through recovery actions. For example, an estimated 60,000 whitebark pine seedlings were planted over 100 ha between 2011 and 2020,in British Columbia; during this same time period thousands of hectares of whitebark pine habitat have been affected by mining, logging, and other industries resulting in a net negative impact by humans.

2) **To create a method of practice whereby land use activities directly contribute to whitebark pine recovery**

   Land-use practices can directly contribute to whitebark pine recovery given effective management guidance and subsequent cooperation from stakeholders. To illustrate, a proposed mine site with a highly blister rust-infected whitebark pine stand that is not ecologically functioning could contribute to more widespread recovery efforts if the mining company were permitted to cut the trees and develop the mine but were required to invest in developing and planting rust resistant seedlings as part of mitigation activities. Additionally, a forest company that retains mature whitebark pine on site following harvest, and permits whitebark pine regeneration to occur, may contribute to the development of a forest stand that is better suited to aiding whitebark pine recovery than the pre-harvest condition of the stand where regeneration of whitebark pine was highly unlikely.

Who is this document for?

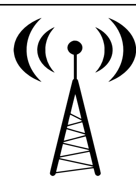
This document was written for all resource users and professionals who may encounter whitebark pine during field-based activities; including those specializing in whitebark pine recovery, personnel working in forestry, mining, pipeline development, ski area management, recreation and range management. It is intended as a guide for practitioners, consultants and managers in all aspects of forest management.

How to Use this Document

This document is primarily written from the perspective of forest management, though many activities are applicable to other industries. For example, forest harvest guidelines may apply to clearing activities associated with mineral exploration or ski run development. Some industry specific modifications may be required to adapt practices to specific industries.

For each practice discussed, a summary table will be provided to identify relevance to that specific industry or sector (Table 1).

Table 1. Summary table used to highlight relevance to each industry in document sections.

Forestry	Mining and Mineral Exploration	Linear Development: Pipelines and, Powerlines	Communication Towers	Ski Areas	Trail Based Recreation (Non-motorized and motorized)	Range Use
						

First Nations Collaboration

It is important to consider how projects, team members, or agencies can contribute to First Nations individuals, communities, or organizations as part of a successful two-way relationship with respect to whitebark pine conservation and management – the first step is understanding the need to meaningfully engage first, then plan. It is recommended that every whitebark pine recovery project begin with engagement and communications with local First Nations before substantial planning occurs. Goals for engagement should be to build an effective relationship, to demonstrate respect for First Nations deep connections to the land and demonstrate an awareness of possible capacity limits for engagement. Although projects may already have ***information sharing requirements*** with local First Nations, engagement provides information within the context of a respectful relationship with mutually beneficial outcomes. Respectful engagement is beneficial because many First Nations in BC may already have capacity or projects related to whitebark pine recovery, have a desire to build or add to capacity for the species, and may have conducted Traditional Ecological Knowledge (TEK) studies that include whitebark pine. Whitebark pine inventory is generally poor or non-existent throughout the Province, so working to build a relationship with those First Nations who are able or willing to share local knowledge can be a critical element to project delivery and success. Finally, there are several BC First Nations that operate greenhouse facilities and are able to produce whitebark pine seedlings, critical for recovery of the species.

For further guidance on engagement with First Nations, please see:

https://www.ictinc.ca/blog/3-rs-of-an-effective-indigenous-pre-engagement-strategy

https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/consulting-with-first-nations

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The Whitebark Pine Ecosystem Foundation of Canada (WPEF-C) is devoted to the conservation and stewardship of whitebark and limber pine ecosystems. Registered under the Society Act in BC and extra-provincially in AB, WPEF-C is a sister agency to the Whitebark Pine Ecosystem Foundation based in Montana.

Best Management Practices for Whitebark Pine

Table of Contents

1 Introduction

1.1 Species Description

Whitebark pine (*Pinus albicaulis*) is a long-lived subalpine tree characterized by five-needle bundles and egg-shaped cones. The needles of the whitebark pine are bluish-green in colour, slightly curved and generally clustered around the ends of the branches. Whitebark pine is typically 5-20 metres (m) tall and may display an irregular crown with curved and twisted stems when open-grown, to a straighter growth form when growing among competitors (Ogilvie, 1990; Committee on the Status of Endangered Wildlife in Canada (COSEWIC), 2010; Alberta Whitebark and Limber Pine Recovery Team, 2014). Initially, whitebark pine bark is thin, smooth and gray-white, becoming thicker with age as it forms narrow, brown, scaly plates (Arno and Hoff, 1989; Farrar, 1995; Alberta Whitebark and Limber Pine Recovery Team, 2014). The cones grow at right angles to the branches and house large wingless seeds approximately 7-11 millimetres (mm) in length. Mature cones remain on the branches with seeds enclosed unless removed by wildlife. Whitebark pine may survive more than 500 years, with initial cone production occurring around 30-50 years of age; however, sizable crops do not occur until 60-80 years of age (COSEWIC, 2010).

1.2 Distribution and Habitat

Whitebark pine can survive the unrelenting wind, snow, and soil conditions of the subalpine where it is commonly a co-dominant to dominant component of the forest (Farnes, 1990; Pigott et al., 2015a). It occurs in very dry to moderately moist environments at or near treeline in the high-elevation forests of Canada and the USA (COSEWIC, 2010). The Canadian distribution accounts for approximately 56 percent of its global range, extending from the Canada-USA border north beyond Ft. St. James in the west and Jasper in the east (Figure 1). The low elevation limit of whitebark pine ranges from a low of 765 m near Morice Lake to a more common low of approximately 1700 m in the southern portions of its range. Whitebark pine ranges upwards in elevation to treeline and into the alpine as krummholz (Ogilvie 1990, S. Haeussler pers. comm.).

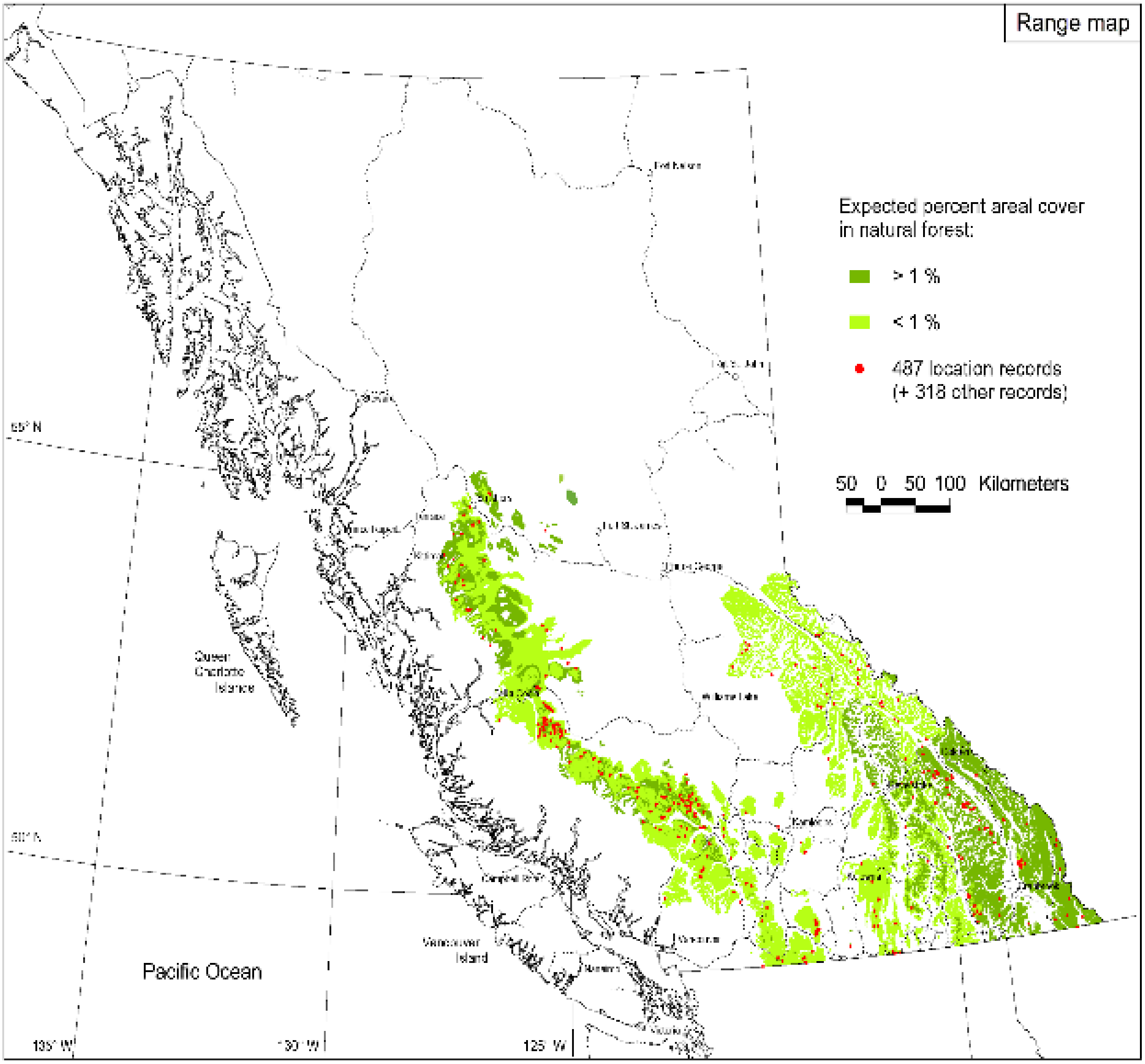


Figure 1. Canadian Range of Whitebark Pine.

1.3 Ecological Importance

Figure 2. Clark's nutcracker (*Nucifraga columbiana*) collecting whitebark pine seeds. Photo by Ian Routley.

Whitebark pine is a **foundation** and **keystone** species of high elevation ecosystems. The deep, spreading root system of the whitebark pine stabilizes slopes, reducing erosion and helps to regulate snowpack and runoff (Arno and Hoff, 1989; Farnes, 1990; COSEWIC, 2010). Other important ecosystem services include providing wildlife with habitat and a nutritious food source. Both birds and mammals forage on the seeds of the whitebark pine. The Clark's nutcracker (*Nucifraga columbiana*) (Figure 2) co-evolved with the whitebark pine and is the tree's only effective seed disperser (Lanner, 1990; Tomback, 1982a, 1982b; Lorenz et al. 2008; COSEWIC, 2010). Clark's nutcrackers extract the seeds, store them in a special throat pouch, then cache them in many different locations. Seeds may be cached up to 32 kilometres (km) away and a Clark's nutcracker may remember up to 16,000 cache locations; forgotten or uneaten cached seeds may later germinate to produce new whitebark pine seedlings (Lorenz et al., 2011; Pigott et al., 2015a), and it is through this critical process that a whitebark pine is regenerated.

In addition to foraging birds, red squirrels (*Tamiasciurus hudsonicus*) harvest the whitebark pine cones and store them in underground middens; black bears (*Ursus americanus*) and grizzly bears (*Ursus arctos*) may raid these stores as an easy source of pre-denning food; conversely in many areas both species of bears have been observed climbing the trees to access the cones. Whitebark pine seeds are highly nutritious, containing about 52% fat, 21% carbohydrates and 21% protein, which make them a highly valuable food source for these animals (Lanner and Gilbert 1994).

1.4 Threats and Conservation Status

Greatly accelerated rates of decline have been observed in whitebark pine due to four main threats: **white pine blister rust** (caused by *Cronartium ribicola*), **mountain pine beetle** (*Dendroctonus ponderosae*), **fire exclusion**, and **climate change** (COSEWIC, 2010). Consequently, whitebark pine has been listed federally as Endangered (species facing imminent extirpation or extinction) under the *Species At Risk Act* (*SARA*), while in BC it has been blue-listed (special concern).

Figure 3. White pine blister rust.

White pine blister rust is the primary cause of declining whitebark pine populations (COSEWIC, 2010) (Figure 3). Native to Europe, it was introduced to British Columbia in 1910 and attacks all 5-needle (white pines), including western white pine and limber pine. The fungus enters the needles and travels down the branch to the main stem where it girdles and eventually kills the tree (Pigott, 2012). Throughout this process, cone production may be greatly reduced as branches individually succumb to the rust prior to full tree mortality. Since its introduction, the disease has spread throughout the entire range of the three 5-needle pine species in British Columbia and caused wide-spread mortality. To complete its lifecycle rust requires an alternate *Ribes* host for certain life stages. Further evidence suggests that whitebark pine, stressed by rust infection, is increasingly susceptible to attack from mountain pine beetle (Arno, 1986; Six and Adams, 2007; Bockino and Tinker, 2012; Alberta Whitebark and Limber Pine Recovery Team, 2014).

Figure 4. Mountain pine beetle (*Dendroctonus ponderosae*). Photo by Associated Press.

Mountain pine beetle is a native bark beetle that typically attacks mature trees, causing girdling of the host tree by developing galleries in the phloem and disrupting the connectivity of the water transport system (Figure 4). Beetle survival, growth and reproduction have been enhanced with current climate trends towards warmer winters and longer growing seasons (Carroll et al., 2003; Taylor et al., 2006; Pigott et al., 2015a), such that the mountain pine beetle epidemic observed in BC resulted in the killing of healthy, potentially rust-resistant, whitebark pines (E. Campbell pers. comm.; Pigott et al., 2015a). Warmer winter temperatures have also facilitated the expansion of the beetles into the higher elevation whitebark pine habitat (Logan and Powell, 2001; Bentz et al., 2010).

Fire suppression and exclusion also threatens easily out-competed whitebark pine populations by maintaining shade-tolerant sublapine fir and spruce that are less fire-resistant. Whitebark pine often grows in forest stands alongside Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*), which eventually outcompete it in the absence of fire.

Climate change is gradually changing the distribution and availability of whitebark pine habitat. Climate change is affecting the distribution of competing species, allowing subalpine fir, alpine larch and spruce to better survive and compete at higher elevations currently occupied by whitebark pine (Bentz et al., 2010; Logan and Powell, 2001). While new habitat may become available at the northern limit of the range, occupying this habitat will rely on seed dispersal by Clark's nutcrackers, which will require suitable nutcracker habitat and the availability of critical alternate nutcracker food sources.

Whitebark pine is not particularly rare at present, with an estimated population of 200 million mature individuals in Canada (COSEWIC 2010); however, it is anticipated that its population will decline across its range by 57% over the next 100-years (COSEWIC 2010). Thus, it is important to protect and preserve representative whitebark pine ecosystems throughout their natural range, and the full range of species which depend upon it for their own survival.

1.5 Current Conservation Planning

As a species at risk at both Federal and Provincial levels, several whitebark pine plans have been developed and implemented across and within jurisdictions. These management plans form the basis for this Best Management Practices document and ***the actions described herein may be revised over time to reflect changes in management policy, or when the Federal Recovery Strategy is finalized and a provincial response has been developed.*** Existing management plans include:

British Columbia

- Genetic Conservation Strategy for Whitebark Pine in British Columbia (GCTAC, 2009)
- Promoting Whitebark Pine Recovery in British Columbia (Pigott et al., 2015a)
- A Tactical Plan for the Recovery of Whitebark Pine in the Omineca Region (Clason, 2013)

Alberta

- Alberta Whitebark Pine Recovery Plan (Alberta Environment and Parks, 2020)

Canada

- Recovery Strategy for Whitebark Pine (Pinus albicaulis) in Canada [Proposed] (Environment and Climate Change Canada, 2017)
- Identification of Whitebark Pine Critical Habitat [Proposed] (Environment and Climate Change Canada, 2017)
- COSEWIC assessment and status report on the Whitebark Pine (Pinus albicaulis) in Canada. Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2010).
- 5-Needled Pine Recovery Planning. (Parks Canada, 2018)

2 The Mitigation Hierarchy

The Province of BC has established an Environmental Mitigation policy to aid in mitigating environmental impacts during industrial development (Government of BC, 2014). The mitigation hierarchy follows a process from lowest environmental impact to greatest environmental impact, from avoid to offset (Figure 5). All feasible actions at one level should be considered before moving to the next level. For example, all options to avoid impacts to whitebark pine should be considered prior to moving to other stages in the mitigation hierarchy.

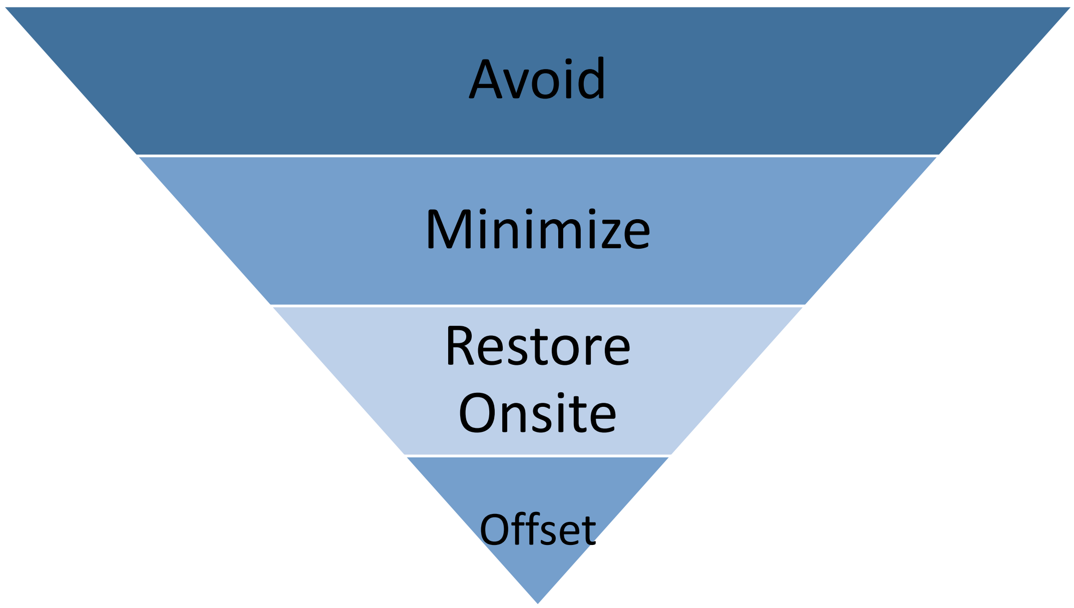
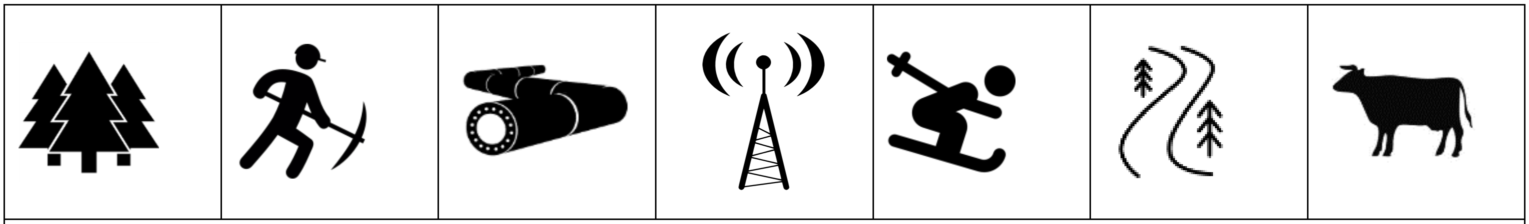


Figure 5. Mitigation hierarchy displaying the priority of actions.

Although this process outlines procedural steps, there is little explanatory language regarding 'how to' conduct mitigation. Even though mitigation may be implicitly self-explanatory, it is a complex process, particularly for workers unfamiliar with whitebark pine biology or recovery needs. The following best management practices sections describe practices which may be applied using the Environmental Mitigation hierarchy. Some activities may apply to several categories of the mitigation hierarchy depending on the context in which they are applied.

Prior to initiating work and applying the principles of the mitigation hierarchy, the appropriate baseline surveys should be conducted to identify baseline conditions and to aid in determining management needs. **Applying the topics from this document to the mitigation hierarchy are described for each industry in Section 11**. Prior to embarking on any large scale projects requiring mitigation it is recommended that proponents review the mitigation policy (http://gov.bc.ca/environmental-mitigation-policy) and contact government representatives (email: mitigate@gov.bc.ca).

3 Training



- Personnel in all industries should have some training on species identification

The initial step prior to the implementation of any BMP is the appropriate training of field workers regarding:

All following fieldwork can be greatly improved simply by ensuring practitioners are trained in whitebark pine identification.

- Whitebark pine identification,
- Cone crop evaluation,
- White pine blister rust identification,
- Evaluating white pine blister rust severity, and
- Clark's nutcracker identification.

Training field workers to correctly identify whitebark pine is critical in both mitigating impacts to whitebark pine and enabling potential species recovery gains. Workers are best field trained in a variety of settings to understand the variety of growth forms whitebark pine may assume. Identification of rust and rust impacts is important to ensure accurate assessments of rust infection levels.

3.1 Whitebark Pine Identification

Whitebark pine is a fairly distinct species that may on occasion be confused with other five-needled pines such as limber pine and less frequently western white pine. For a more detailed comparison of the three species of five needle pines in BC (**See Appendix 1**); whitebark pine has several distinguishing characteristics:

- Needles in bundles of 5 (like western white pine and limber pine) (Figure 6);
- Bright red male flowers;
- Egg-shaped purple-brown cones that do not open to release seeds. (Figure 7);
- Variable tree form, ranging from tall tree form on productive closed forest sites to shrubby, krummholtz form on exposed high elevation sites (Figure 8); and
- Smooth, light-coloured bark when young, becoming darker grey and scaly as it ages (Figure 9).

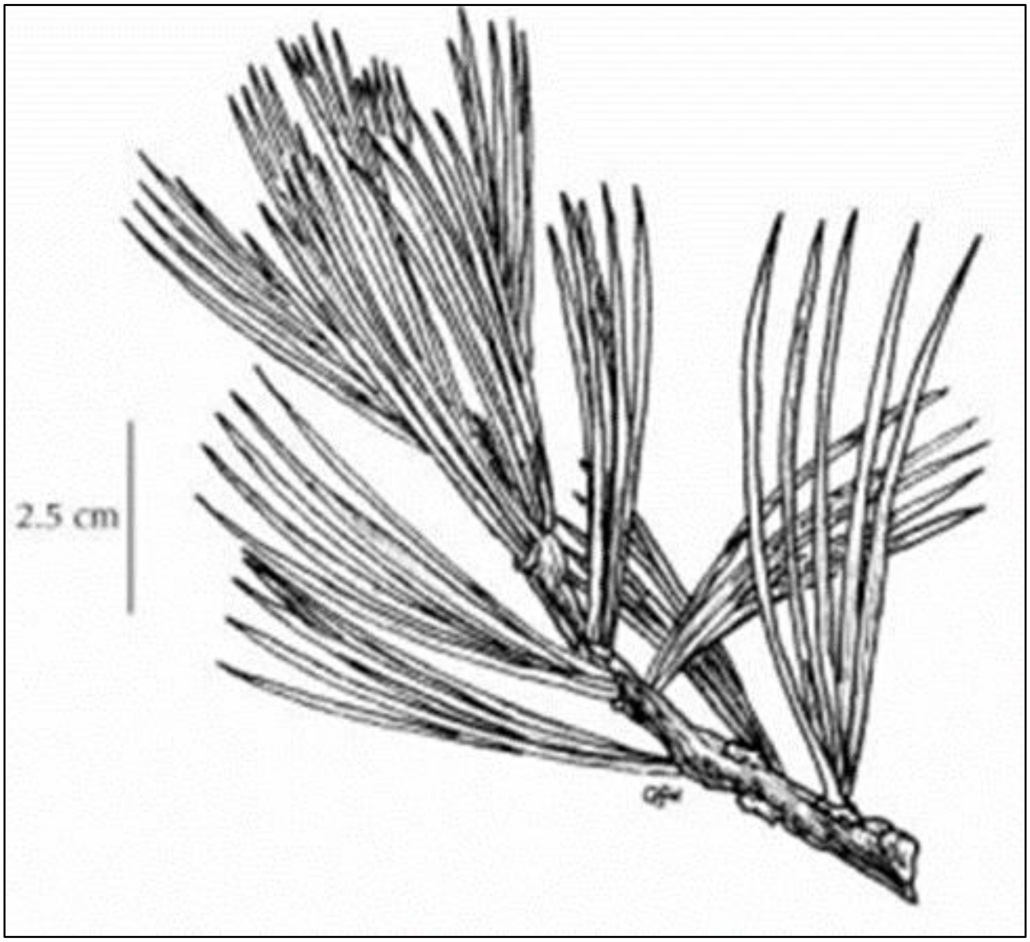


Figure 6. Whitebark pine needles in bundles of five (Illustrated Flora of BC. 1998).

Figure 7. Mature cones are egg shaped and purplish-brown in colour.

Figure 8. Trees may occur in various shapes and sizes depending on local site conditions and competition levels. Upper l, open grown tree; upper r, closed forest tree, bottom l, open shrub form; bottom r, krummholz form.

Figure 9. Bark varies in colour and texture as the tree ages starting out thin, smooth and gray-white (l) and becoming thicker with age as it forms narrow, brown, scaly plates (r).

3.2 White Pine Blister Rust Identification

Workers should be able to identify blister rust at various life stages and be able to identify the post-infection impacts on live and dead trees. Understanding this disease (Figure 10) is critical for effective whitebark pine management and recovery.

White pine blister rust alternates between all five-needle pines and *Ribes* species (currants and gooseberries, Figure 11). The wind-disseminated fungus first infects the needles of whitebark pine in the fall and many tiny yellow dots appear on these needles the following spring (Figure 12). Over the next year or two, the fungus spreads toward the branches and trunk (Figure 13). In mid-summer, orange pustules develop on the bole and exude a liquid containing pycniospores. The following spring, these spores cause white blisters to form on the bark. The white fruiting bodies give rise to a canker that keeps growing. The foliage above the canker yellows and then turns reddish brown (Figure 13). The white fruiting bodies in turn produce orange aeciospores that will be disseminated by the wind in spring, infecting *Ribes* plants (Figure 14). Finally, in late summer or early fall, some filamentous fruiting bodies develop on the *Ribes* leaves where teliospores are produced to transmit the disease back to other whitebark pines (Figure 11).

Louseworts (*Pedicularis* sp.) and paintbrush (*Castilleja* sp.) have been reported as minor hosts in several Western States. Certainly, at high elevations in BC there may be significant amounts of both paintbrush and louseworts. Eradication of *Ribes* species has not proven effective; where planting is prescribed, avoid high hazard sites supporting abundant *Ribes*.

Some key attributes of white pine blister rust include (R. Hunt, Pers. Comm.):

- Most stem infections start as branch infections that grow down the branch into the stem (Figure 13, Figure 14);
- Once in the stem the fungus readily grows up and down the phloem cells but more slowly around the stem, resulting in a classic diamond-shaped infection (Figure 15);
- Infection levels increase near *Ribes* sources. *Ribes* generally prefer cooler wetter sites;
- White pine blister rust causes bark ruptures during aeciospore production, providing access for various secondary insects and fungi that kill branches, causing characteristic “flags” (Figure 14, Figure 16);
- Squirrels and other rodents are attracted to the sugars concentrated in infections. Their gnawing may reduce the sporulating surface area and subsequently prevent or inhibit the growth of infections (Figure 17);
- Because secondary organisms kill white pine blister rust in branches, the success of an infection reaching the stem diminishes the farther the infection is initiated from the stem;
- As a rule, no infection that originates 60 cm from the stem will be successful. Infections within this 60cm zone are called “threatening cankers”;
- “Resistant bark reactions” on the stem produce necrotic sunken tissue at the margins that prevent the fungus from growing into the diamond shaped pattern (Figure 18).

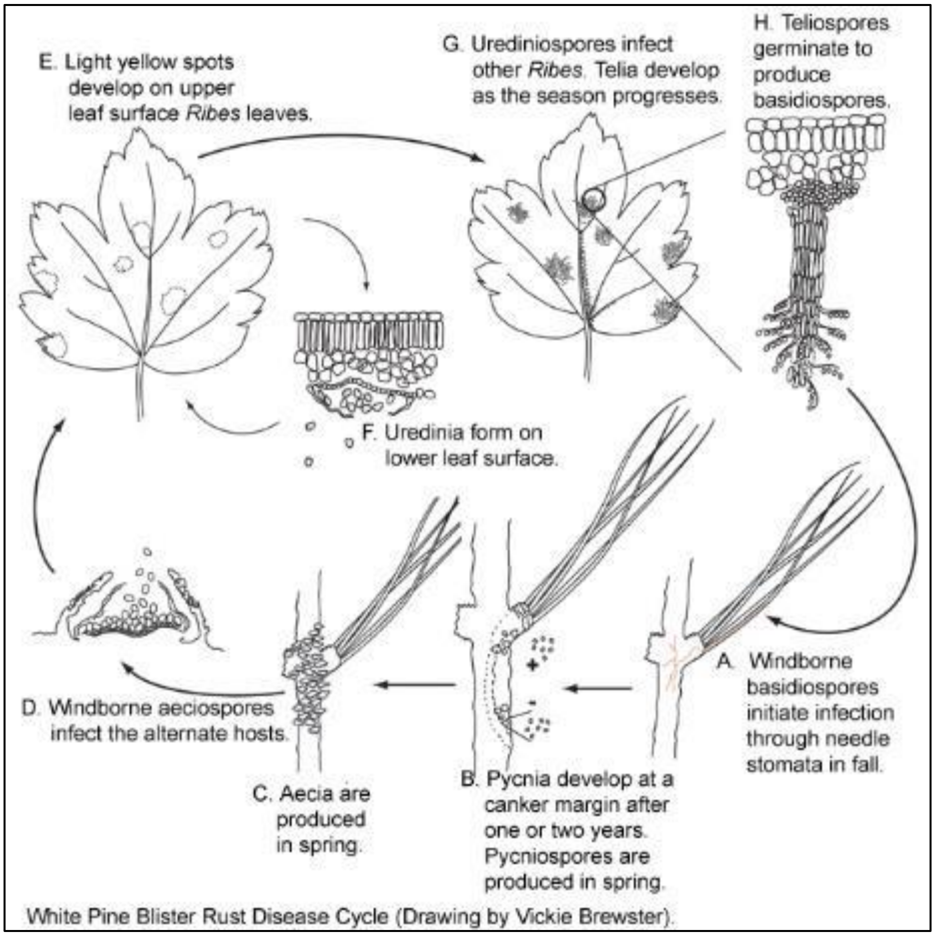


Figure 10. White pine blister rust life cycle (Drawing by Vickie Brewster)

Figure 11. Infected *Ribes* leaf showing telial columns.

Figure 12. Initial infection via the needles.

Figure 13. Branch infection.

Figure 14. Infection that has progressed to the stem.

Figure 15. Diamond shaped white pine blister rust infection

Figure 16. Old infection with roughened bark.

Figure 17. Chewing of rust by squirrels; in some cases, this chewing may kill the fungus and save the tree.

Figure 18. Terminal stem rust infection on left and a tree exhibiting a 'resistant bark reaction' on the right where new healthy tissue leaves the necrotic tissue cracked and looking like mature bark.

3.3 Clark's Nutcracker Identification

Figure 19. Clark's nutcracker.
Photos by Ian Routley and Glenn Bartley.

The Clark's nutcracker (*Nucifraga columbiana*) is a medium-sized member of the Crow and Jay family that inhabits montane coniferous forests throughout western North America. The bird has a gray body with distinctive white and black wings and tail (Figure 19). Clark's nutcrackers have a long, straight, pointed bill to aid in extracting seeds. The first sign of a nutcracker is often its distinctive "kraaaa" call. The only species which may be confused with the Clark's nutcracker is the gray jay (*Perisoreus canadensis*), also known as Canada jay or whiskey jack. It is a smaller bird with a smaller bill that lacks the distinctive white nutcracker wing and tail patches.

One of three species of nutcrackers worldwide, the Clark's nutcracker co-evolved with whitebark pine. These birds are specialist consumers and the primary disperser of whitebark pine seeds (Dohms and Davidson, 2015). They may range widely, searching for suitable cones for harvest and may be absent from whitebark pine stands with reduced cone availability. Ponderosa pine and Douglas-fir provide critical alternate food sources during periods when whitebark cone crops are reduced or unavailable (A Clason, Pers. Comm.; Lorenz et al. 2011; Schaming 2015).

3.4 Public Education

Supporting public education and outreach may be effective, particularly where the audience may directly contribute to whitebark pine conservation and recovery. It is recommended that outreach consist of three components:

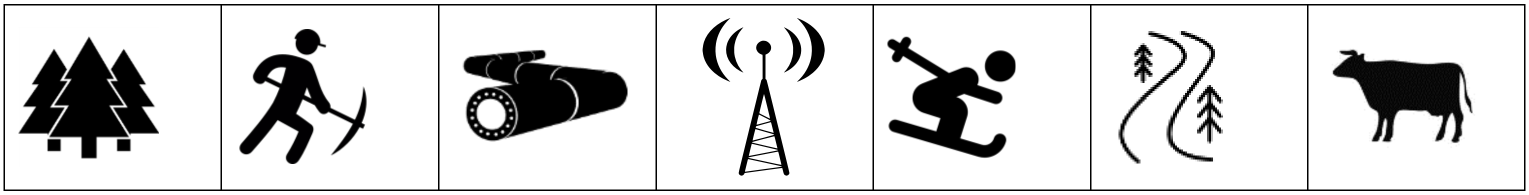
- The ecological significance of whitebark pine;
- Conservation issues; and
- What can be done to support recovery?

This form of outreach may be especially beneficial at areas with high public visitation such as ski areas and can consist of a range of delivery mechanisms such as signage or summer field programs.

BEST MANAGEMENT PRACTICES FOR TRAINING

- **Train field staff on the identification of whitebark pine, in all growth forms;**
- **Train field staff on white pine blister rust identification;**
- **Train field staff on Clark's nutcracker identification.**

4 Establishing Baselines: Mapping, Surveys, and Monitoring



Establishing baselines for where whitebark pine occurs, where it could occur; and where present, the nature of these populations in terms of health, age, and density, are key to prioritizing restoration sites as well as guiding mitigation actions for industrial development proponents.

Practitioners should recognize that they may be using existing data products; gather whitebark data incidental to already establishing standard forest surveys; or establish specifically targeted whitebark pine plots. Mapping and survey methods described here include:

1) Forestry Surveys
    i. Ecosystem Mapping (PEM) (TEM)
    ii. Vegetation Resources Inventory (VRI)
    iii. Timber Cruising
    iv. Silviculture Surveys

2) Whitebark Pine Specific Surveys
    i. 100 Tree Surveys
    ii. Permanent Monitoring Transects
    iii. Rare Plant Surveys
    iv. 100% Stand Inventory
    v. Fixed Radius Plots
    vi. Critical Habitat Survey
    vii. Citizen Science

Prior to any work in whitebark pine habitat, practitioners should review existing map and survey data such as VRI or the Conservation Data Centre's Species and Ecosystem Explorer to determine if whitebark pine has already been documented in the study area.

4.1 Reporting Data

Improving the provincial database regarding whitebark pine occurrences is a key outcome of improved surveys, which will improve existing range and location data. When conducting any of the surveys described below, whitebark pine location data should be submitted to the B.C. Conservation Data Centre (CDC); the CDC should be contacted at cdcdata@gov.bc.ca prior to data collection and submission to ensure appropriate data submission protocols are followed.

4.2 Forestry Surveys

There already exists a series of industry standard surveys used by the forestry sector. Modifications to these or simply gleaning existing data from these surveys may be useful in identifying whitebark pine occurrences and habitat.

4.2.1 Ecosystem Mapping

Ecosystem mapping may involve either Predictive Ecosystem Mapping (PEM) or Terrestrial Ecosystem Mapping (TEM). Given the Endangered status of whitebark pine, it is practical for mappers to familiarize themselves with whitebark pine ecosystems to ensure they are being mapped to an acceptable standard. This should occur at both the office and field levels.

In the field, the identification and sampling of whitebark pine stands may include full plots, visual plots, or air calls (helicopter surveys); field staff should be well trained in the identification of whitebark pine. Fieldwork is an important step as identified locations will be extrapolated over greater area during office classification. The potential for whitebark pine occurrence within specific BEC site series and at specific locales should be reviewed by referencing against known locations using VRI and the CDC's Species and Ecosystem Explorer.

4.2.2 Vegetation Resources Inventory (VRI)

VRI is an inventory of forest resources gathered through a combination of field sampling and photo interpretation. VRI is a dynamic inventory, which is regularly updated following timber harvest, insect or disease kill, or other activities that alter the structure and composition of forested landscapes. Improving VRI capture of whitebark pine will assist in whitebark pine recovery as it will improve our knowledge of the distribution and demographics. VRI is often the first level of screening many practitioners use to determine if whitebark pine may be present in an area; thus it is crucial that whitebark pine is properly captured in VRI mapping exercises. VRI field crews should familiarize themselves with whitebark pine identification, particularly where it is a component of merchantable stands and may display good form.

Data is publicly available accessed through the provincial VRI database.

4.2.3 Timber Cruising

Timber cruising is undertaken to determine the volume and quality of timber within a proposed cutblock. Since whitebark pine is of little commercial value and often of poor form, it is not always categorized to species and only recorded as pine of poor form. The data to be gained from a cruise related to whitebark pine management can differ from the original objective of the cruise for other species; cruise data can be used to identify high density whitebark pine stands and used to develop specific recovery prescriptions. Whitebark pine is often not an option on all cruise software and is often tallied as simply pine. Users should determine if whitebark is an option on software and properly record whitebark pine when possible. If whitebark pine is not an option, users should develop consistent surrogates such as consistently using the generic pine code exclusively for whitebark pine. Like lodgepole pine, whitebark pine should be 'cruised' at 12.5 cm DBH.

Timber cruising is the most logical step at which to determine if a stand meets the Critical Habitat criteria of $2m^2$/ha of healthy whitebark pine trees.

Data is generally not publicly available, though licensees may provide data at the request of users.

4.2.4 Silviculture Surveys

Whitebark pine is rarely counted in silviculture surveys as it is seldom recognised as a preferred or acceptable species; this limits the utility of silviculture surveys for identifying whitebark presence. Recent changes to government stocking standards in BC permits whitebark pine to be counted as preferred or acceptable on additional site series (Table 2) (MacKillop and Ehman 2016). These changes should also permit planting of whitebark pine on these sites.

Table 2. Biogeoclimatic Subzones and specific site series where whitebark pine has been identified as a preferred or acceptable species.

Subzone	Preferred	Acceptable
MSdc2	-	02, 03
ESSFdc	-	03
ESSFdc1	102, 103	-
ESSFdc2	-	03
ESSFdcw	102	103
ESSFmh	-	102
ESSFwc4	102	103
ESSFwcw	102, 103	-
ESSFwh1	-	102, 103
ESSFwh2	-	102, 103
ESSFwh3	-	102, 103
ESSFwm2	102, 103	104
ESSFwm3	102, 103	-
ESSFwm4	-	102
ESSFwmv	102, 103	-
ESSFxv1	02, 03, 04, 05	01
ESSFxv2	02	01, 03, 04, 05

Ensuring accurate identification of whitebark pine by field surveyors is the critical first step to improving the accuracy of silviculture and inventory information on a site. Whitebark pine (Pa) is most often misidentified and recorded in inventory labels as lodgepole pine (Pl). Since Clark's nutcrackers tend to cache seeds against stumps, rocks, or logs, surveyors should scan these locations for whitebark pine seedlings (Figure 20). Further, whitebark pine often grow in clusters due to nutcracker caching habits, so surveyors should watch for multiple seedlings in a single grouping.

Additionally, surveyors can include whitebark pine as an Unacceptable Species where it is well-spaced from preferred or acceptable species, and there are insufficient preferred or acceptable stems to fill the plot. Although Unacceptable species are not desired on surveys, surveyors should be made aware of this possibility to ensure inclusion of whitebark where it fits the survey. Further, whitebark pine may be counted as a ghost tree that, when present at a great enough density, should be included on the inventory label.

Data is available in the RESULTS database.

Figure 20. Whitebark pine seedling in a typical caching location against a snag.

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4.3 Whitebark Pine Specific Surveys

Whitebark pine specific surveys are purposely designed to document whitebark pine presence and health and are often directly tied to other management actions such as cone collections, monitoring, and restoration.

During Whitebark Pine specific surveys we are often seeking trees displaying some form of resistance to rust, these trees may be referred to in several ways depending on what we know of their resistance capacity:

CANDIDATE PLUS TREE: A tree identified as potentially being a plus or putatively resistant tree but not confirmed as the technician may not be highly skilled in rust identification, there was insufficient time to properly scrutinize the tree, or a full view of the tree was obscured.

PLUS TREE/ PUTATIVELY RESISTANT PARENT TREE: A relatively healthy, permanently identified tree from a stand with high infection levels of blister rust and mortality. The tree is a candidate for resistance screening. The terms plus and putative are often used interchangeably.

ELITE TREE (resistant seed source): A plus tree confirmed through resistance screening to have heritable (genetic) resistance (or reduced susceptibility) to blister rust.

4.3.1 100 Tree Surveys

The 100 Tree Survey is a means to rapidly assess and ascertain rust levels to aid in selection of plus trees, or trees suitable for cone collections. In general, this survey is intended to gain insights on the general condition of a stand to ensure cone collections reflect the healthiest stand cohort. There are several modifications of this protocol but in summary, 100 reproductive trees are visually surveyed and tallied in categories of healthy, infected, or dead from rust and rapidly interpreted to make cone collection decisions regarding the stand; cone collections made from the healthiest cohort of trees can be used for blister rust screening, restoration activities, reforestation, or other research trials.

Data is generally project specific and not publicly catalogued though limited amounts may be available through the CDC. If gathering this data yourself for a project, consider sharing the findings with the BC CDC.

4.3.2 Permanent Monitoring Transects

The Whitebark Pine Ecosystem Foundation has developed a universally accepted means of health monitoring via permanent transects used to determine baseline health levels and to facilitate change-monitoring into the future (Figure 21) (Tomback et al. 2005) [www.whitebarkfound.org/wp-content/uploads/2013/10/Methods-for-Surveying-and-Monitoring-Whitebark-Pine-for-Blister-Rustx.pdf]. Data forms for establishing these plots are provided in Appendix 2. Establishing these transects within or adjacent to a workzone may aid in the management of whitebark pine for several reasons including:

- Aid in prioritizing trees for cone collections (healthiest trees in the most infected stands);
- Allow for early detection of increasing pest levels;
- Set a benchmark rust level that may be monitored over time and linked with restoration success levels (for example, if planted trees undergo a high rust infection, check if these levels pair with benchmark levels)and
- Prioritize management actions where needed most (when transects are established across a broad landscape).

Data is held by Parks Canada for all transects.

Figure 21. Permanent monitoring transect established in the subalpine.

Figure 22. Tree tag on permanently marked whitebark pine tree.

4.3.3 Rare Plant Surveys

In BC rare plant surveys are frequently conducted prior to significant development to identify any rare or endangered species growing on-site. Methods for conducting rare plant surveys are documented here (www.ibis.geog.ubc.ca/biodiversity/eflora/ProtocolsforRarePlantSurveys.html). It is essential that surveyors are familiar with whitebark pine identification and are aware of its varying growth forms.

Data is generally held by the proponent; may be available through the proponent, Environment and Climate Change Canada, or the CDC.

4.3.4 100% Stand Inventory

On federal lands, a full 100% inventory may be required where subsequent actions may involve the cutting or removal of whitebark pine trees. Section 32(1) of SARA indicates "No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species." As such any proposed damages to whitebark pine of all size classes should be properly documented so it may be appropriately mitigated. Proponents of projects not on federal lands but requiring a federal impact assessment should contact federal authorities to determine if this level of inventory is required.

Note: A 100% inventory of mature trees should also be undertaken within timber harvest areas; this is further described in the Layout section (5.1).

Data is generally held by the proponent; may be available through the proponent, Environment and Climate Change Canada, or the CDC.

4.3.5 Fixed Radius Plots

In some cases, proponents may need to characterize the whitebark pine population but not to the same rigour as in the 100% stand inventory; cases where this may be required is large projects on provincial lands. To inventory the population a series of fixed radius plots may be established in a manner similar to Silviculture Surveys or Timber Cruising. The key difference however is these whitebark pine dedicated plots should generally be larger 11.28 m fixed radius plots to better sample the often patchily distributed whitebark pine. It is recommended that a minimum of five of these plots be established with a homogeneous sample stand. These plots may be used to characterize the health and demographics of a population and to determine Critical Habitat. The metrics captured within each plot may vary based on user need.

Data is generally held by the proponent; may be available through the proponent, Environment and Climate Change Canada, or the CDC.

4.3.6 Critical Habitat Surveys

Within the federal recovery strategy, three forms of Critical Habitat (CH) were identified to ensure the recovery of the species (Environment and Climate Change Canada 2017); these habitats and appropriate survey methods include:

- Seed Dispersal Habitat – Characterized by the presence of >2m^2/ha basal area of non-terminally infected whitebark pine within a VRI polygon. Appropriate means of survey include Timber Cruising (4.4) and 100% Stand Inventory (4.6.4).

- Regeneration Habitat – Open stands within 2 km of Seed Dispersal Habitat and characterized by >0.5 ha in size; suitable substrates for whitebark pine regeneration; not encroached by excessive competition; and occur within the known or projected range of whitebark pine. Appropriate surveys for this type of CH includes silviculture surveys (4.5) using a planting shovel to determine the planting potential for the site, GPS mapping to determine the area, as well as the survey described for Seed Dispersal Habitat to confirm the proximity of a seed source to the site.

- Recovery Habitat – Recovery habitat is areas where recovery actions or research has occurred on the landscape; this is most likely to include planting areas, thinned stands, cone collection trees and may also include permanent monitoring transects. The location of each of these features should be submitted to the Conservation Data Centre and

Prior to conducting any surveys for Critical Habitat, it is advised that practitioners review the recovery strategy as it was a proposed version at the time of developing this document.

Data is generally held by the proponent; may be available through the proponent, Environment and Climate Change Canada, or the CDC.

4.3.7 Citizen Science

Given the widespread distribution of whitebark pine in remote regions of the province, employing citizen science methods can greatly aid in contributing to our knowledge around the distribution of the species. These methods can be employed by professionals, naturalists, and youth. Several cell phone-based apps may be used to gather this data. The preferred apps are:

- iNaturalist (inaturalist.org) - users can gather data along with georeferenced photos to support user descriptions regarding tree size and health, and
- eBird (ebird.org) - users can contribute to Clark's nutcracker occurrence data.
- If apps are not a preferred approach, naturalist clubs can maintain a local registry of whitebark pine locations.

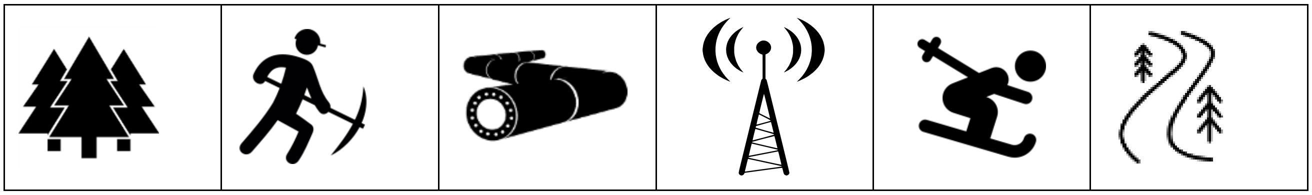
Data may be accessed by users on the iNaturalist or eBird websites.

Not all data collected in the above surveys is reported to publicly available databases. Where practical, surveyors are encouraged to report data to the Conservation Data Centre (CDC), or Whitebark Pine Ecosystem Foundation of Canada (WPEFC).

BEST MANAGEMENT PRACTICES FOR SURVEYS AND INVENTORIES

- **Consult existing inventories to determine if the area of interest has been identified as having, or potentially having, whitebark pine;**
- **Improve the identification and documentation of whitebark pine;**
- **Report all data to the BC Conservation Data Centre;**
- **When conducting any currently used survey method, familiarize yourself with whitebark pine and their associated ecosystems, to ensure whitebark pine is properly sampled in the field;**
- **In timber cruises measure all whitebark pine over 12.5 cm DBH;**
- **Conduct some whitebark pine specific surveys at a regional scale to assess regional health trends;**
- **Monument and map any tree that may be a plus trees (display superior health relative to the stand); Candidates should be submitted the Seed orchard Sub-committee of the Whitebark Ecosystem Foundation of Canada who are responsible for the delivery of the Whitebark pine tree improvement program;**
- **A 100% inventory is suggested for Federal Lands and potentially for projects requiring a Federal Permit;**
- **Use appropriate surveys to determine if stands meet Critical Habitat Criteria;**
- **Utilize citizen science apps to bolster technical surveys or to gather additional data while recreating.**

5 Timber Harvest



Timber harvest in whitebark pine stands can negatively impact whitebark pine through direct tree removal, damage to retained healthy trees, and damage to soil substrates either around retained trees or within habitat to support post-harvest recruitment; however, a well-planned harvest may benefit whitebark pine recovery through the removal of competing species and the creation of suitable regeneration habitat. Whitebark pine-leading stands should be evaluated for health prior to decisions regarding harvest as the presence of whitebark pine alone should not be a determining factor; practitioners should also factor in stand health and seral replacement risk when considering a whitebark pine stand for harvest. Caution must be taken to limit stand conversion to non-whitebark species following harvest. When harvesting in whitebark pine stands, care must be taken to implement management to maintain retained whitebark pine trees, soil layer integrity, and support recruitment on-site. Harvest only works as a restoration tool if whitebark pine regeneration is supported.

5.1 Layout

Cutblock or road layout may be the most critical field-based point for whitebark pine conservation in the context of forest management as it is where potentially rust resistant trees for retention will be identified and roads will be laid out to minimize risk to retained trees and damage to local soils. Layout crews should:

- Be well trained in the identification of whitebark pine and in assessing blister rust infection levels of individual trees;
- Mark each live whitebark pine to be retained using a known and consistent method such as a specific paint or ribbon colour (Figure 23);
- Mark areas of high-density as wildlife tree patches for retention;
- Map trees to assist in planning (Figure 24);
- Identify candidate[1] plus trees in a unique manner to ensure retention on site; and
- Align roads and landings to avoid healthy whitebark pine and their rooting area.

Note: Layout should be conducted prior to any development in whitebark habitat to ensure candidate plus trees are protected. This includes any activity leading to tree removal, trail routing, drill pad establishment, ski run creation, etc.

[1] For this activity the healthiest trees are referred to as 'candidate plus trees' as surveyors may not fully trained in evaluating trees for severity of rust infection, the typical objective here is to map and retain as many mature trees as possible, thus a lengthy evaluation of each tree may not be within the workplan at time of layout.

Figure 23. Whitebark pine trees marked by layout crew. Note old verbenone patch on tree to left.

5.2 Protecting Trees During Harvest

Once whitebark pine have been identified and mapped (Figure 24), a plan should be made to retain specific trees. A buffer should be made around these trees to avoid any incidental damage during harvest; this includes keeping machinery off root zones of trees and protecting trees and associated soils from mechanical damage caused by direct contact by machinery or from falling trees. When designing buffers, it may be best to buffer around small stands or patches as opposed to individual trees; when individual trees must be buffered practitioners should account for root area and not just stem impacts, buffers larger than the dripline area are preferred. Buffers are not required around terminally infected trees.

Note: All whitebark pine planned for retention should be noted in site plans as reserved for biodiversity or silviculture purposes to avoid being classified as 'standing waste.' https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/timber-pricing/residue-and-waste/waste_manual_interior.pdf

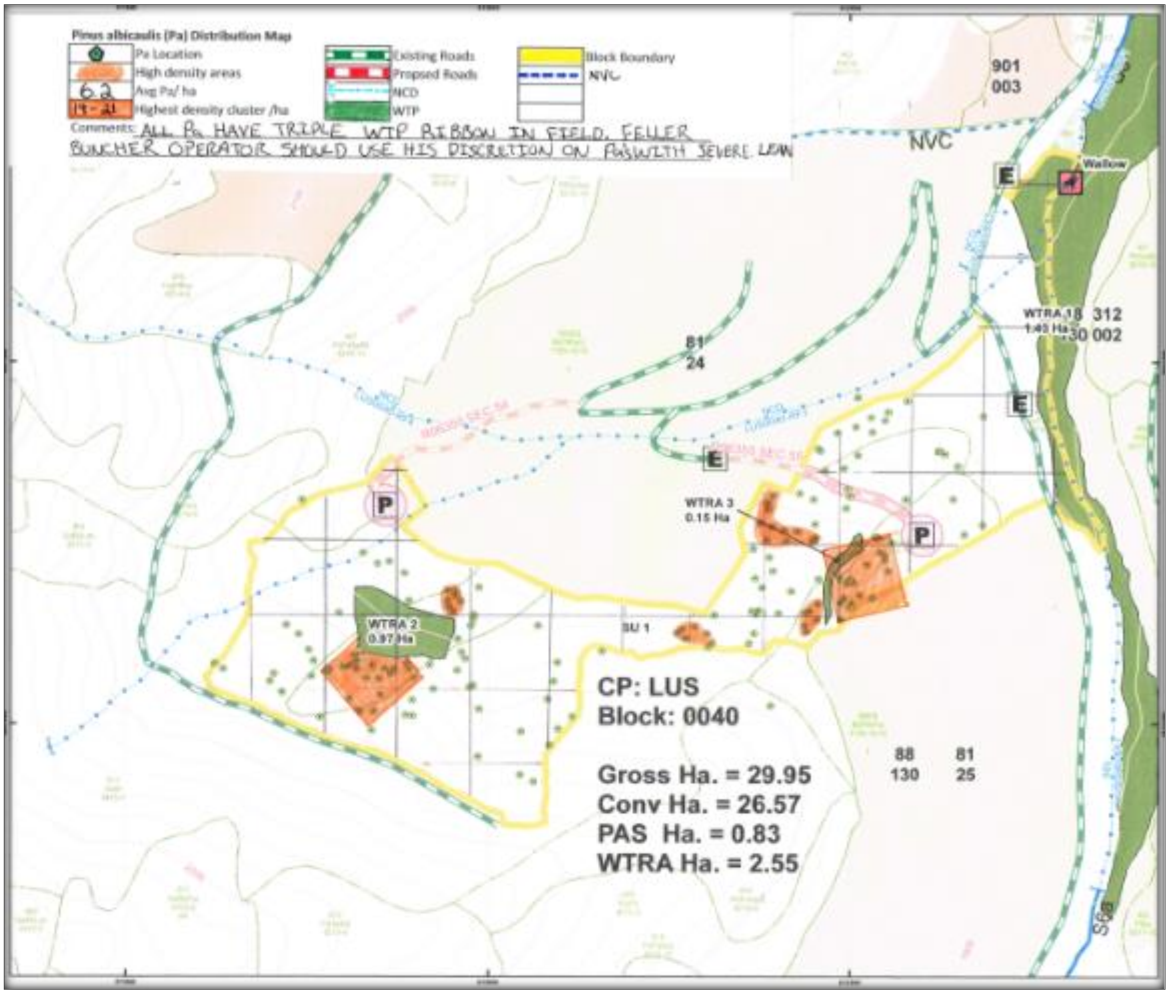


Figure 24. Map showing whitebark mapped during cutblock layout. Green areas are no-harvest reserves; orange blocks are high density whitebark pine; note tree marking and machinery operator notes. Layout map courtesy of Canfor (2016).

Tree falling may be conducted by hand or using feller bunchers. Operators and ground crews must be trained in the identification of white pine blister rust and whitebark pine and understand the value and need to avoid or protect trees. Candidate plus trees must be clearly identified for retention and protection (Figure 25).

In some cases, fallers and machine operators will be permitted to cut some whitebark pine for safety or access reasons, however trees must be pre-marked and mapped to clearly identify those healthy trees that <u>must</u> be retained during harvest. In these cases, operators should only be permitted to cut down terminally infected trees, it is better to cut numerous terminally infected whitebark pine vs. cutting a single healthy one. Care must be taken to ensure that retained whitebark pine trees are not damaged during harvesting and remain windfirm. The use of machine free zones to protect roots and high stumps or 'rub' trees during skidding is recommended where conditions permit. Ensure protection of both retained trees and any advanced regeneration being promoted on site.

Figure 25. Whitebark pine trees retained following harvest near Radium Hot Springs.

Following harvest, sufficient logs, stumps, and sound snags should be retained on site to provide seed caching habitat for the Clark's nutcracker (Figure 26). Most seed caches in the soil occur close to a tree or other object, which provides some form of cover (USDA 2011). Retaining coarse woody large debris on site provides caching security cover and caching cues. The amount of coarse woody debris required is not known, rather some retention of logs, stumps, and sound snags should be made to provide improved caching conditions. This practice should also be communicated to skidder operators.

Figure 26. Young whitebark pine growing against a decaying log.

5.3 Skidding

Logging systems may greatly impact post-harvest site conditions, levels of retention, and subsequent impact to whitebark pine. Cable yarding is likely to have the lowest impact on whitebark pine regeneration retention and on forest soils, but this system is rarely used in the BC interior where whitebark pine is most common. Although feller bunchers and log skidding may have greater site impacts, well crafted practices may yield benefits to whitebark pine. The following practices should be followed when operating logging machinery in whitebark pine harvest areas:

- Properly train operators to identify whitebark pine;
- Ensure machine-free zones designated for whitebark retention are clearly marked and mapped;
- Winter harvest to limit disturbance to roots, soils, and understory whitebark pine;
- Use higher stumps or rub trees to protect retained whitebark pine trees; and
- Consider soil disturbance when skidding, noting that it may both assist in soil preparation by exposing mineral soil but may also harm soil through compaction and disturbance of advanced regen.

BEST MANAGEMENT PRACTICES FOR TIMBER HARVEST

LAYOUT

- Train crews to identify whitebark pine, with emphasis on candidate plus tree identification;
- Mark whitebark pine to be retained with a pre-determined system of paint and ribbon;
- Ensure candidate plus trees requiring retention are distinctively marked and mapped.; and
- Re-route roads to avoid retained trees and their rooting zones.

BUFFERS

- Buffer plus trees, and candidate plus trees to protect root zone and avoid damage to tree;
- Recall that selective and careful removal of other tree species may create better growing conditions by reducing competition and creating improved recruitment conditions;
- If removing other tree species to benefit whitebark pine, rooting areas must be protected through buffering or working over snow;
- Buffers are not required for terminally infected trees; and
- Unless a dedicated whitebark pine planting program is planned, buffers should be established around large patches of advanced regeneration.

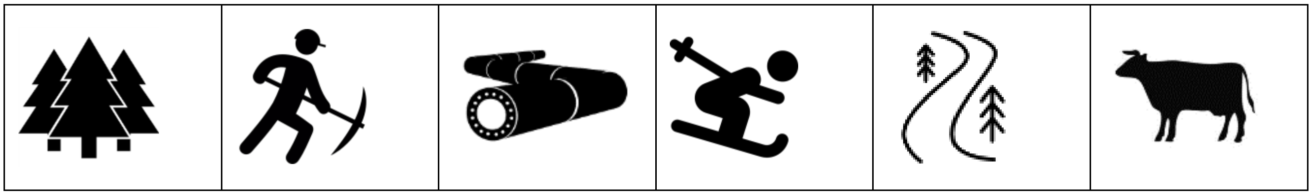
TREE FALLING AND RETENTION

- Train machinery operators to identify whitebark pine and develop protocols to ensure the retention of plus and candidate plus tree;
- Numerous heaviliy and terminally infected trees may be cut down to ensure the protection of plus and candidate plus trees; and
- Retain stumps and debris on site to serve as caching cues for Clark's nutcrackers.

SKIDDING

- Educate operators on locations of machine-free zones designated for whitebark retention;
- Winter harvest is preferable to limit impacts to roots and understory whitebark pine;
- Some exposure of mineral soil may improve conditions for planting;
- Use higher stumps and other tactics to protect retained trees including advanced regeneration; and
- Recognize that skidding may have both positive and negative soil impacts; operators should limit compaction, avoid rooting zones of retained trees, but create exposed mineral soil where possible.

6 Stand Tending



In this section, guidance and practices to minimize impacts to whitebark pine from stand tending activities are discussed. These may include both pruning and thinning practises.

6.1 Pruning

The objectives for pruning include:

- Increasing the longevity of whitebark pine where rust is restricted to specific branches by removing those branches; and
- Increasing whitebark pine retention by providing an alternative to whole tree removal.

While there is little experience pruning whitebark pine to reduce infection by white pine blister rust, pruning western white pine is a common management tool. A commonly held view is that white pine blister rust is often too dispersed throughout whitebark pine crowns to make pruning effective. Although this may be true in many cases, managers should not discount pruning as a tool to retain whitebark pine for a longer period on the landbase by removing rust from infected branches, or by providing an alternate means of managing trees in areas where retention is important.

Pruning has been used to control white pine blister rust in stands of western white pine for many years. In western white pine 85 % of cankers occur within 1.5 metres of the ground, so removing lower branches early should reduce mortality (Schnepf and Schwandt 2006, Zeglen 2008) (Figure 27). Branch cankers that are more than 15 cm from the stem are generally considered non-lethal, and the removal of those branches will have a positive influence on survival (Government of BC 1996). In whitebark pine, infections can occur scattered throughout the crown, and pruning is likely less effective than in western white pine (Goheen et al. 2002). Pruning whitebark pine can still be considered as:

- Pruning may extend the life of trees by preventing rust from spreading to the bole, allowing more trees to reach cone production age and maintaining an important ecological role;
- Reduction of ladder fuels may reduce risk during low intensity ground fires;
- There is some evidence that pruning and daylighting may have a positive effect in reducing attacks by mountain pine beetle. (Sturdevant et al. 2015);
- Pruning may be compatible with other objectives for recreation, such as improving visibility and access for treed ski runs and along trails; and
- In some cases, pruning may achieve similar results to full tree cutting by removing portions of the tree that were interfering with work.

Figure 27. Pruning on western white pine saplings.

For seedlings and small saplings, all but two or three branch whorls can be removed. For natural larger trees, branches can be removed for up to 2 metres from the ground, or 50% of tree height. Cankers on branches above that height can be removed where practical, or if there is some compelling reason to ensure the survival of the tree. Trees with obvious lethal cankers need not be pruned (See Training Section). Pruning should ideally be conducted by experienced crews, although in many cases the small amount of pruning required to maintain a stand will result in inexperienced individuals conducting the work; these individuals should familiarize themselves with best management practices for pruning (Figure 28).

Canker excising involves removing the live bark and cambial tissue 5 cm past the leading side edge of a stem canker, but this has not proven to be overly effective.

Figure 28. Photo showing proper pruning cut around branch collar.

BEST MANAGEMENT PRACTICES FOR PRUNING

- **Become familiar with whitebark pine ecosystems prior to field and office classification;**
- **Train crew to recognize White Pine blister rust and evaluate tree for effectiveness of pruning;**
- **Prune to the branch collar, do not leave a large stub (**Figure 28**);**
- **Limit the amount of damage to the tree; cut in stages if needed**
- **Use proper pruning equipment**
- **Train the crew to know that the orange colour is masses of fungus tissue and the unseen pathogen could be 5 cm beyond the orange colour (and even further on larger branches); thus, cuts should allow a wide margin beyond the rust site**
- **Although infections within 10-15 cm of the stem may have reached the stem, prune these branches as the actual location of the fungus is unknown**
- **Do not create slash piles as these may create fire hazard or attract Ips beetles.**

6.2 Thinning

The objectives for thinning include:

- Improving the growth of the individual whitebark pine trees;
- Allowing a fuller crown to develop that will support more cones;
- Increasing the availability of seed-caching sites for Clark's nutcracker;
- Reducing the severity of low and medium intensity wildfires;
- Managing whitebark pine when thinning for timber objectives; and
- Potentially lowering the incidence of mountain pine beetle attacks.

Thinning to remove whitebark pine competitors may be beneficial, particularly in younger stands. Whitebark pine is relatively shade-intolerant and can be out-competed by shade-tolerant species such as subalpine fir and Engelmann spruce; removing these species early in the growth-cycle can enhance whitebark pine vigour (Figure 29). When thinning for whitebark pine ovbjectives, thinning may involve multiple objectives; to remove non-whitebark pine competitors, remove all declining trees badly infected with white pine blister rust or mountain pine beetle, or create openings suitable for whitebark pine recruitment. Thinning may open canopies creating better light conditions for cone production and attracting Clark's nutcrackers for seed dispersal (Murray and Krakowski. 2013). Care must be taken as opening stands may also increase exposure to blister rust spores, thus this activity is not suggested for areas with high rust hazard (abundant *ribes*).

Figure 29. Examples of mature (L) and immature (R) stands where thinning may benefit whitebark pine

While objectives for thinning in whitebark stands may vary by industry, the whitebark pine objective is always consistent; to reduce competition and enhance growing conditions for whitebark pine. Ski hill operators may want to improve both runs and trails to enhance skiing opportunities for their clients. Removal of non-whitebark pine species as well as pruning whitebark, can achieve both business and recreation, as well as species recovery goals. Debris from thinning can either be removed from the site and burned or lopped and scattered. Leaving debris in piles may create suitable conditions for Ips beetles, which may move to weakened whitebark pine trees. Retaining a specific basal area, or spacing, is much less important than retaining all live, healthy, trees

When thinning for timber management objectives (non-whitebark pine objectives), whitebark pine should be treated as a 'ghost tree,' that is retained in the stand regardless of proximity to target trees or size of the tree.

BEST MANAGEMENT PRACTICES FOR THINNING

- **Train crew to recognize terminally-infected trees that may be suitable for removal;**
- **Girdling other competing species may be an appropriate thinning technique on certain sites;**
- **Ensure crew can properly identify whitebark pine;**
- **Focus on retaining putatively resistant trees as opposed to retaining a certain density or basal area;**
- **Opening stand may expose retained trees to rust spores so do not thin on high rust hazard sites;**
- **Remove non-whitebark competitors,**
- **Treat whitebark pine as a ghost tree when thinning a stand for other objectives; and**
- **Do not pile debris to limit potential for Ips outbreak.**

7 Reforestation

In this section, guidance and practices to restore whitebark pine following disturbance is discussed. These include cone collections in preparation for seedling production, and seedling planting.

7.1 Cone Collections

Whitebark pine cone collections are a critical step prior to initiating any program involving the removal of mature trees, planting, or blister rust screening. Collecting whitebark pine cones is a complex process due to the masting habit of the species resulting in years of high cone abundance followed by years of dearth; their high desirability as a food source by many species of wildlife; the basic recovery needs of selecting potentially rust resistant trees; and the transferability of the seed within the province of BC. To ensure the above factors are accounted for during collections, the following collection process is recommended.

7.1.1 Collection Planning

Tree seed is the foundation for all reforestation programs including whitebark pine, and the goal is to use the best possible seed available. For whitebark pine this means seed that is best suited ecologically and climatically to the planting site with consideration to climate change and has the highest degree of resistance to white blister rust available. In BC, the parent tree selection and rust screening program has identified enough parents have been identified suitable to initiate a seed orchard. The first seed orchard will be planted in the spring of 2021. It is unlikely that this orchard or subsequent orchards will produce enough seed to meet current demands for at least 15 years. In the interim cone collections from natural stands must continue using approaches to prioritize genetic improvement (Figure 30).

Natural Stands: Unselected natural stands with little or no information on stand blister rust incidence or susceptibility of individual trees. Many of the earlier collections were of this type.

Selected Stands: Stands that have been surveyed and > 50% of the trees are infected. Cones are only harvested from uninfected trees, or if the infection levels are extremely high (>80%), cones can be collected from trees with low numbers of cankers.

Seed Production Areas: Seed production areas are younger stands that are close to, or at seed producing age. (30-40 years.) They have been thinned and rogued to eliminate poor quality or blister rust infected individuals, and to encourage flowering, and cone production. As some trees become severely infected they are removed to continually improve the stand. There could be some inbreeding, but usually inbred individuals are removed in the nursery, or they fail to be successfully fertilized or develop normally.

Untested Parent Trees: Collections are made in natural stands from individual parent trees that have either no evidence of white pine blister, or low numbers of cankers relative to the stand average, but have not yet been tested. The seeds from these individuals would be good candidates for testing in the screening programs, but if cones were collected from enough parents in a stand to meet requirements under the Chief Forester's Standards for Seed Use, the seedlot is likely to have a moderate degree of resistance. It is desirable to attempt to collect from parents at least 30-50 metres apart to reduce the risk of inbreeding. As in the selected stands category, collections from good trees in heavily infected stands are the best choices.

Tested Parent Trees: Collections are made from parent trees in natural stands and undergone screening for white pine blister rust either at a rust screening facility, or in field trials where they have exhibited good resistance characteristics. Currently this is the best option for capturing resistance until the seed orchards start producing. However, if seed is collected from tested parent trees to create a seedlot that do not conform to the Chief Forester's Standards for Seed Use, (i.e. All parents are not within an 8 km radius) then an application to the Chief Forester for an alternative to the standards).

Seed Orchards: Seed orchards provide the greatest opportunity for improvement and resistance to white pine blister rust. Unfortunately seed production to meet current demands will not be available for 15-20 years.

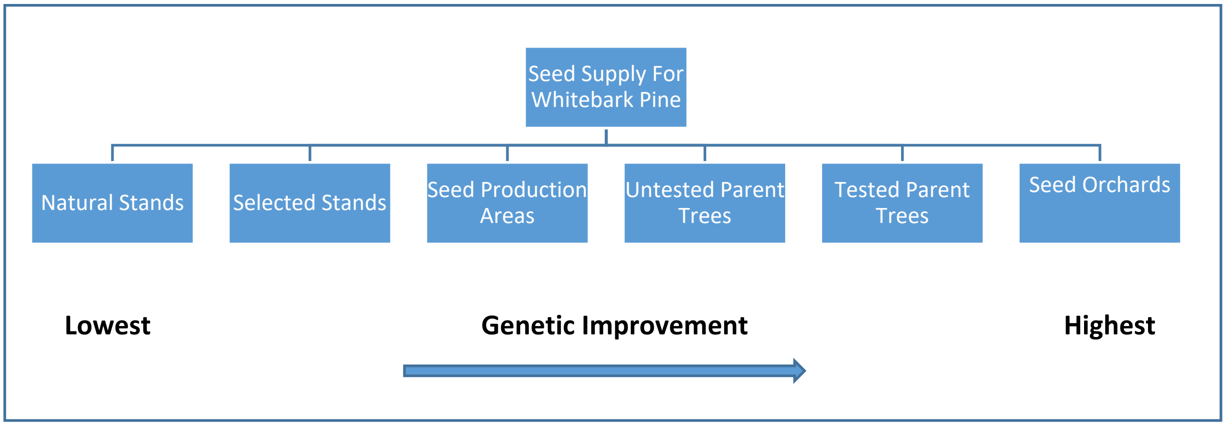


Figure 30. Priority of seed collection sites.

As whitebark pine seed collections are very labour intensive, it is important that planning account for the seed needs of the project; collectors or collection agencies should consider the following:

- The volume of seeds or cones that you require to fulfill your needs (Table 3);
- Existing seed availability on the provincial Seed Planning and Registry application (SPAR) ;
- Consider collaborative efforts, seed is expensive to collect.
- The areas you need the seed for, and how far from those areas can you collect the seed. It is important to collect seed from areas that have a similar climate, ecology, and elevation to ensure that the seed collected is well-adapted and hardy enough for the intended planting site.

Table 3. Seed requirements to produce 1000 seedlings.

Seeds/ cone	Seeds /gram	Avg. % Germination	Sow factor	Over sow factor	Seedlings per kg of seed	Cones per 1000 seeds[1]	Cones per 1000 seedlings*[2]
50	8	50	2	1.3	3077	20	**52**
50	8	50	3	1.3	2051	20	**78**

[1]Cones required for 1000 seeds = 1000 ÷ avg. no. seeds per cone.
[2]Cones required for 1000 seedlings = 1000 seedlings x oversow x sowing factor ÷ Avg. no. seeds per cone.

7.1.2 Seed Transfer Guidelines for Whitebark Pine

Science-based seed transfer is the foundation for effective reforestation and genetic adaptation of stock planted as part of B.C.'s sustainable forest management system. Climate Based Seed Transfer (CBST) is an important climate change adaptation strategy to promote healthy, resilient and productive forests and ecosystems through the matching of seedlings/seedlots to future (projected) planting site climates. https://www2.gov.bc.ca › tree-seed › seed-planning-use.

BC is transitioning to Climate-based Seed Transfer CBST) for all species, including whitebark pine, as opposed to the traditional Geographic -Based Seed Transfer standards (GBST). Currently both CBST and GBST can be used. However, the Interim Geographic based recommendations as shown in Table 4.,also can be used during the transition to CBST. This may require applying to the Chief Forester for an alternative to the standards when needed using this guidance as rationale if it is for a free-to grow obligation. To use the CBST system for selectiing existing seedlots for use (seed that is already in storage), or to determine the areas of use for potential collections, there are three options:

1. Refer to the CBST Seedlot Selection Tool 4.0. https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/tree-seed/seedplanning-use/climate-based-seed-transfer/climate-based-seed-transfer-reports-tools
2. Refer to the CBST Areas of Use matrix posted on the Chief Forester's Standards for Seed Use webpage: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/tree-seed/legislation-standards/chief-forester-s-standards-for-seed-use
3. Use the BEC Unit List for CBST Suitable Lot Collection Report feature in SPAR to determine the area of use for a seedlot collection based on the BEC variant of the collection area.

You can also receive assistance from the Seed Resource Specialist: FORHTIP.SEEDHELP@gov.bc.ca

Table 4. Interim seed transfer guidelines for BC.

Location	Year	Elevation		Latitude		Longitude		Source
		Up	Down	North	South	East	West	
BC (Other)	Current	+300	-200	2 ° N	1 °S	2°W	3°W	Nicholls (2018)
Interim Recommendations		**+300**	**-400**[1]	**2°N**	**1°S**	**2°W**	**2°E**	R. Moody, A. Clason, D. Pigott (2015a)
***As this is a bird dispersed species, no requirement for using within the same Seed Planning Zone (SPZ) or Biogeoclimatic Subzone (BGC).**								

[1]May be transferred lower if no suitable seed sources exist.

7.1.3 Seed Registration

Seed registration may or may not be required. However, seed registration regardless of the intended use, keeps options open for all potential users, and is the best means of tracking seed sources that are deployed. Currently, the requirements for registration of whitebark pine seed are the same as for commercial species, but due to the high cost of seed, no destructive tests are used, and other forms of estimates for germination and moisture content are used. A sample seed registration form is provided in Appendix 3**Error! Reference source not found.**.

Seed collections for registration must meet the following criteria (Nicholls 2018):

- Seed must be collected from at least 10 trees;
- Be located within the same natural stand seed planning zone, biogeoclimatic zone, and in a collection area with a radius of no more than 8 km;
- Maximum elevation range between the highest and lowest elevation range of collection area is 250 metres;
- Seed moisture content must be greater than 4% and less than or equal to 9.9%; and
- The lot must be at least 97% pure seed by weight.

You can also receive assistance from the Seed Resource Specialist: FORHTIP.SEEDHELP@gov.bc.ca.

7.1.4 Collection Obligations, Permits and Ethics

- On crown land (including TFL's) permission to collect commercial tree species seed is no longer required from the forest licensee or the Ministry of Forests, Lands, Natural Resource Operations and Rural Development unless there is damage to the tree, for example by felling, cutting of branches etc. However, it should be discussed with Ministry staff and forest licensees prior to commencement.
- Determine if there are any access restrictions, radio-controlled roads or other safety issues within a licensee operating area. Fire hazard may also restrict access.
- Permission to collect cones on private land is always required. Some landowners may charge fees for access, or "botanical forest products".
- Collection in National and Provincial parks is generally not allowed. Scientific or research permits may be obtained from the appropriate authorities.
- To collect on other public lands, (municipalities, regional districts, or cities), permission is always required.
- It is important to respect the land, and landowner's requirements regarding the use of marking paint or ribbon, damage to trees, and debris or garbage.
- As whitebark pine cones are an important food for wildlife, it is important to consider wildlife needs prior to caging.

7.1.5 Cone Crop Forecasting

Whitebark pine cones generally require a 15-16-month maturation period from pollination to seed maturity. Seed pollinated in late spring- early summer will overwinter on the tree before maturing the following year. Cone forecasting may be completed in late summer for cone crops that will mature in the fall of the next year. The immature conelets become visible shortly after pollination, and by the onset of winter are approximately 2x3 cm in size. By the time they reach maturity, cones will be approximately 6 cm wide and 10 cm long (Figure 31). In the early stages they can be difficult to see from the ground even with binoculars but are quite evident from the air (by helicopter), or by climbing the trees.

Cone abundance can vary greatly from year to year. It may be several years until a suitable crop is present, which may stall project progress; thus, it is important to collect when a good cone crop is observed.

Crop size is usually evaluated by estimating the average number of cones per tree, for 6-10 randomly selected trees within the stand. Determining cone and seed quality can be more challenging, as the presence of cone insects may not always be visible from the exterior of the cone. Dissecting cones down the axis can expose any internal seed damage and in the later stages of development, give an indication of the percent of filled seed and collection maturity.

Whitebark pine cone abundance varies from year to year and from one location to another. In "mast years" cones crops can be particularly abundant over large geographic areas. Collecting in mast years is generally the most productive as not only are the cones abundant, but seed yields per cone tend to be higher. Collections in non-mast years may be sporadic and not possible from the most desired trees; thus, in mast years efforts should be directed to maximizing cone collections.

Figure 31. Young conelets (l) and mature cones (r).

7.1.6 Stand and Tree Selections

Most people planning to collect whitebark pine seed for restoration, conservation, or research purposes, may already have a good idea where suitable stands are located. Roads to ski hills, fire lookouts, and communication towers often provide good access to whitebark stands. Contact local naturalists, hiking groups, Ministry of Forests, Lands, Natural Resource Operations and Rural Development District offices and forest companies for possible locations. When planning collections, carefully consider access. Collections require two visits to each site, one to cage the cones, and one to retrieve the cones. Both visits require packing ladders, climbing gear, cages and other equipment.

Once suitable stands with good crop trees are identified, preparations for caging and later collection should be made well in advance of seed predation by birds and mammals.

Ideal candidate natural stands for collection should include:

- ***Sufficient area and density of mature trees*** – The density and area of a given stand should be sufficient to ensure adequate pollination, increase genetic diversity, and meet cone collection protocols. Assessing the density of a stand is generally conducted through an ocular estimate. Maholovich (pers. comm.) reported that 25 mature trees/ha are required for adequate pollination (reported as 10/acre); this minimum density of trees should be present in all cone production stands. The required area for a stand to be selected is dependent on the collection needs; many guidelines require a parent tree spacing of up to 100 meters (Mahalovich pers. comm.; Murray pers. comm.) to improve genetic diversity and collections from a minimum of 10 parents; for operational collections, a spacing of 30 – 50 m may be more practical.

- ***High blister rust infection levels in the stand*** – High stand level rust infection will provide an initial level of resistance selection by increasing the certainty that parent trees have had some exposure to rust spores over time (Figure 32). Health can be assessed using different methods, but the Whitebark Pine Ecosystem Foundation (Tomback et al., 2005) standards are recommended (4.6.2 Permanent Monitoring Transects). One approach to ensure adequate rust exposure for the assessment of putatively resistant trees is to collect from stands that have 50% or more trees infected with white pine blister rust (Mahalovich et al. 2006).

- ***Trees that may be safely climbed to access cones*** – Unlike other species where branches may be cut, trees felled or crowns raked, whitebark pine must be climbed to access cones. Because of this, trees with high branch densities and low crowns are preferred, although collections from large, high crowned trees can be made using skilled tree climbers. In general, whitebark pines growing at higher elevations are easier to climb and assess for blister rust than those growing lower at lower elevations in more productive stands. Tree selection should be made based on the skill of the climber, with safety being a top priority.

- ***Good access*** – To adequately collect whitebark pine cones, several site visits may be required under less than ideal conditions. At the most basic level, a stand must be visited to place cone cages in early summer and re-visited for cage removal and cone collection in early fall. As each of these visits may be impaired by snow, good access is paramount. Ideally, a site visit one year prior to identify cone crop potential for the following year is recommended. Stands with good accessibility are preferred. Helicopter access could be cost-effective when a helicopter base is located near a potential collection site.

- ***Transferability*** – Collections should be made in stands where the level of transferability is high. For example, collections in high elevation parkland ecosystems are not as transferable to lower elevation sites in the region. Low elevation collections are likely the most transferable though collectors should consult the climate-based seed transfer parameters to confirm the transferability of their selected site prior to initiating any work.

There is a tendency for proponents to target collections local to disturbance footprints. Selecting from confirmed or putatively resistant trees is generally a better strategy than selecting solely from a local provenance. Given the high transferability of whitebark pine seed it is generally possible and preferable to select from the healthiest trees from stands with high rust pressure as opposed to local trees from stands with low rust pressure.


Figure 32. Heavily infected stand with high mortality; healthy trees in this stand are strong candidates for cone collection.

Once a stand is chosen, selected whitebark pine trees should be healthy relative to the stand. Many practitioners are now installing rust monitoring transects or conducting 100 tree surveys prior to selecting trees for collection. These surveys provide a means of quantifying the stand to ensure the trees selected for cone collections are representative of the healthiest cohort in the stand.

In order of preference, trees for collection should have:

- No cankers,
- Inactive branch cankers or bark reactions, or
- Low number of active or inactive cankers in relation to stand average.

This is assessed by careful examination of the entire tree for active and inactive blister rust cankers or bark reactions. These are only guidelines and, as mentioned above, should link back to stand characteristics. For example, in areas such as the Kootenay region where infection rates may approach 100% of trees, the individuals with the lowest canker count are most desirable; whereas areas with low infection rates, only those completely free of rust are suited to collection.

7.1.7 Caging Cones

Required preparations include:

- Materials – ladders, climbing gear, safety gear, cages, good gloves, sacks, tags, hook for pulling branches, and necessary equipment for documentation (GPS, pencil, notebook, DBH tape);
- Hand cleaner – cones are sticky! Gojo, or Motomaster hand cleaner; and
- Arrangements for interim cone storage.

Instructions on cage construction are provided in Appendix 4. Cones are usually caged in June- July prior to feeding by Clark's nutcrackers, or squirrels. Caging during this time is most practical as the cones are quite large and visible as they approach maturity. It is usually possible to get a cluster of three or more cones in a single cage, or tie two branches together and cage several clusters. Position the clusters in the middle of the cage if possible. Fold over or crimp the end of the cage to the branch to prevent rodent entry (Figure 33, Figure 34). Try to minimize damage to the branch through abrasion.

As cones are caged, the Seed Collection Parent Tree Form should be completed (Appendix 5).

Figure 33. Placing caged on cones by one worker pulling a branch down using a hook while the other worker places the cage over the cones.

Figure 34. Cone cage placed over cones to protect from foragers; this size of mesh may be too large for areas where foraging pressure is high.

Accessing cones may be highly variable depending on the cone crop in any given year and the stature of a given tree, commonly used methods include:

- **Ground-** Occasionally, particularly in mast years, smaller whitebark pine trees will have cones that can be caged and collected from the ground;
- **Ladders** - Lightweight extension ladders are available up to 20 feet in length. Ladders should be positioned so they are stable, and minimize damage to the tree (Figure 35);
- **Climbing** - Where possible, a professional tree climber should be used such as an ISA-certified arborist. Use soft-soled hiking boots or runners to minimize damage to the tree branches. A long-sleeved shirt and helmet with chin strap will help to protect you from injuries and keep your hair and body free of pitch. Light fall protection harnesses are advisable and may be mandatory. Fall protection should be to industry standards. Some light pruning to make accessing the cones, or installing cages is acceptable. Know your own limitations, or the skill level of those climbing with you;
- **Squirrel Caches -** Collecting cones from squirrel caches has been frowned upon, due to concerns about soil borne diseases, seed maturity, and uncertainty about from which trees the cones were collected.

Figure 35. Ladder used to gain access to tree top for cone collections; ladders such as this are only useful where there is good access.

7.1.8 Cone Harvest Timing

Cone maturity can vary from one site to another, by elevation, or by aspect. We do not have enough experience with whitebark pine to definitively recommend the earliest collection date. However, it is unlikely that you can collect too late in the fall, the only limitation being access or snow. Normally it is safe to collect in mid-September. A cone knife or other sharp knife can be used to section cones to evaluate the number of filled seeds and seed maturity (Figure 36). Seeds are mature enough to collect once the embryo fills 75-80% of the seed cavity, provided they are properly handled after harvest.

Figure 36. Cone knife used to evaluate the number of filled seeds and seed maturity.

7.1.9 Marking and Identification

The importance of good record keeping cannot be over-stressed. After cone caging is complete, it is important to mark the tree in the field and record the location and best means of access (Figure 37). Using GPS coordinates and a good map will aid in locating the tree on your return trip. In many areas it may be helpful to plot the whitebark pines on Google Earth or on some other mapping platform. Mark the tree with either ribbon, or paint where allowed. Blue marking paint seems to last the longest. Attach an identifying tag on the tree with purpose and contact information at eye height. Unique Tree tags for a consistent system are being used throughout British Columbia to ensure a unique identifier for individual trees – for example, there is only one whitebark pine tree #200; to obtain a unique set of tags, contact the Whitebark Pine Ecosystem Foundation of Canada (www.whitebarkpine.ca).

Figure 37. Caged whitebark pine tree, with flagging and paint for marking; this tree was also tagged with a unique metal tag.

7.1.10 Cone Handling

Appropriate care must be taken from the time whitebark pine cones are harvested until the seed is extracted at the seed extraction plant. Collect cones into clean sacks made of burlap or other porous material (avoid pillow cases as they don't tend to breathe well). Every attempt should be made to keep the cones <u>well ventilated and dry</u> at the collection site, and during transport. Try to get them to an interim storage site as soon as possible.

Collecting whitebark pine cones is expensive, protecting that investment by practicing good handling and storage procedures is crucial.

Ensure that the cones are as free as possible from excessive amounts of debris as it can encourage molds, contribute to lethal temperatures in the sacks, and compromise seed cleaning. Some collectors in the US drop the cones onto tarps to avoid contact with soil and possible introduction of seed borne fungi such as *Calochypha fulgens*, *Fusarium spp*., and *Siricoccus spp*. These diseases naturally occur in the soil and water, and infections can be mitigated by careful handling at all post collection stages.

After picking, provide good ventilation and keep dry. Avoid piling sacks of cones in a heap. Keep sacks shaded and well-ventilated during transport. Place cone sacks on a pallet to ensure good ventilation (Figure 38).

Figure 38**. Racks in pickup truck to allow for air flow during transport.**

7.1.11 Interim Storage

If cones must be kept in storage for any period of time, store in a covered, well ventilated area (Figure 39). Take any necessary measures to eliminate threats from rodents or birds. Carports or well-ventilated garages work well. Household fans can improve aeration in closed areas. Raise the cones off the ground on a pallet or racking. Turn occasionally to enhance curing.

Figure 39. Interim cone storage on racks to allow ventilation.

7.1.12 Seed Processing

Whitebark pine cones can be processed any time after collection, but allowing the cones to dry for a few weeks during interim storage usually makes the process easier. Cones can also be further dried in a well ventilated room. A dehumidifier can help remove moisture from the cones as well. Whitebark pine cones do not break down readily and mechanized seed extraction methods have not been very successful.

Once dry, the cones are broken down by hand, and the seeds are separated from the scales, and other debris using hand screens. The final cleaning is done with an air separator to remove the lighter debris and empty seeds. Air separation is often done several times and adjusted teach time to ensure that all empty seeds are removed. Empty seeds can harbour some pathogens, and air separation will result in higher germination rates as the percentage of filled seeds will be maximized. At this point the seeds must be air dried, often for several weeks to reduce the moisture content to a storable condition, between 4% - 9.9%. Care must be taken to protect the seeds from rodents in breathable screened containers.

It is best to consult with professionals that have experience in seed processing, or contract them to do it for you. The Ministry of Forests Tree Seed Centre, or the Whitebark pine Ecosystem Foundation of Canada can provide advice or suggest a specialist who can assist you.

Figure 40. De-scaled whitebark pine cone showing the arrangement of mature seeds.

Figure 41. Air separator to remove debris and unfilled seeds.

7.1.13 Seedling Production

Whitebark pine seedling production is a lengthy process requiring a complex stratification regime to initiate seed germination. At present very few nurseries produce whitebark pine seedlings. When identifying a nursery to produce seedlings, the following should be considered:

- Seed stratification is a six-month process typically beginning in mid-fall;
- Producers should be willing to dibble double germinants and early sprouters to maximize nursery yields;
- Seedlings are generally produced as a 2+0; and
- Artificial light capabilities enhance production;

Figure 42. Whitebark pine seedling grown in a 412b styroblock.

Proponents should be aware that whitebark pine seedlings are not generally available for purchase and require a two-year production period due to slow growth and a long and complex stratification process. This time-lag for seedling production and the potential delays with cone collections, requires that proponents plan well in advance when seedling planting is proposed.

BEST MANAGEMENT PRACTICES FOR CONE COLLECTIONS

- **Determine cone and seed needs prior to initiating a collection;**
- **Collect cones near deployment areas or review seed transfer guidelines to ensure suitability;**
- **Determine if seed registration is required;**
- **Determine if a seed collection permit is required;**
- **Forecast cone crops in the year prior to a collection to ensure the collection effort is appropriate;**
- **Evaluate stands prior to selection by conducting a 100 Tree Survey or by establishing a Permanent Monitoring Transect;**
- **Collect from stands with greater than 50% rust infection;**
- **Select trees with no infection, inactive infection, or with infection lower than the stand average;**
- **In addition to health characteristics, select trees suitable for climbing based on the capabilities of the crew;**
- **Cage cones in early summer, be sure to crimp all openings to the cage;**
- **Cage a minimum of ten cones per tree and ten trees per stand;**
- **Mark and map trees using a pre-determined method to support future relocation;**
- **Store cones in a breathable sack marked with the tree number;**
- **Store cones in a cool location with good ventilation;**
- **Send cones to a nursery or extraction facility with experience in whitebark pine seed extraction and cleaning;**
- **Send seed to the Tree Seed Centre for storage and registration; and**
- **Cone crops are not present every year, be sure to take advantage of when large crops are present.**

7.2 Seedling Planting

Planting whitebark pine seedlings is one of the top whitebark pine recovery actions, whether following timber harvest, during reclamation activies, or simply in suitable habitat as a means of restoration.

Although planting rust-resistant stock is the most desirable approach, having this material widely available is over a decade away as seed orchards are just being developed, and deploying the best available seedlings is recommended (Table 5). At present, planting putatively-resistant stock is the preferred approach. Further, in some areas trees may escape rust infection and provide critical ecological services to wildlife despite still being susceptible.

Many former whitebark pine-leading stands have transitioned to other leading species due to whitebark pine prematurely dying due to rust or beetle, giving the false impression that whitebark pine was not a significant component of the stand. Practitioners should note the presence of dead standing whitebark prior to harvest and consider including whitebark pine in the planting prescription even if no live mature whitebark were present pre-harvest.

There is some inclination to rely on Clark's nutcracker seed caching to accomplish reforestation; however, a U.S. study found that only 16% of nutcracker caches were in suitable habitat and that effective dispersal is most likely during mast crops (USDA 2011). A notable problem with relying on nutcrackers is that mast crops are becoming increasingly compromised as whitebark pine populations decline across the landscape and declining cone densities affect nutcracker foraging (Barringer et al. 2012) and may reduce breeding success (Schaming 2015).

- **Table 5. Summary of seedlings types for planting.**

Seedling Type	Production Method	Contribution to Species Recovery	Relative Availability	Planting Priority
Seed Orchard seed **(Confirmed Resistance)**	Seedling produced from seed harvested from a seed orchard consisting of multiple tested resistant parents, allowed to cross breed.	**High** – Both parents have demonstrated resistance.	Unavailable in foreseeable future (15 – 20) Years: 2036 – 2041	Highest
Tested Parent Trees **(Suspected to Partial Resistance)**	Seedlings produced from seed harvested from the original parent trees (plus trees) showing resistance traits in screening programs.	**Moderate to High** – Some resistance is likely present in population; only maternal genetics are controlled.	Limited availability – 2021 on.:	High
Untested Parent Trees	Seedlings produced from seed harvested from the original parent trees (plus trees) that appears to have resistance traits, but testing	**Moderate to High** – Some resistance is likely present in population; some escapes may be	High (2021)	Moderate - High

(Putative Resistance)	is incomplete or non-existent.	part of this planting stock.		
Seed Production Areas	Seedlings produced from a seed production area, a stand of better than average quality that is upgraded and opened up by removal of undesirable trees, and then cultured for early and abundant seed production.	**Moderate to high.** Continual rogued for genetic improvement. Currently only one is established and not yet producing cones.	**High (2025)**	Moderate to high
Selected Stands	Seedlings produced from seed collected from putatively resistant parents in stands where rust survey have been completed.	**Moderate-high**	**High** (2021)	Moderate
Natural Stand **(Bulk Collection)**	Seedlings produced from bulk seed. Little may be known about individual parents.	**Low to High** – Some resistance is likely present in population; some non-resistant individuals may persist to play ecological roles. Useful in areas with low rust levels.	**High** (2021)	Lowest

7.2.1 Regulatory Requirements

A key goal for whitebark pine recovery is to increase the number of seedlings planted in suitable habitats. Currently, this goal has been confounded by a lack of seedling availability and by regulatory barriers to deployment. Regulatory barriers are common as whitebark pine is a biodiversity species, not a merchantable species; thus deployment on the timber harvesting land base (THLB) is not typically a primary objective. To address regulatory requirements, the following avenues may be considered:

- **A Free Growing Stand is Not Being Established -** According to Section 43 Use of Seed of the Forest Planning and Practices Regulation (FPPR) of the Forest and Range Practices Act, seed transfer rules, and the requirement for seed registration only applies where the intent is to establish a free growing stand (Government of BC 2018);

- **A Free Growing Stand is Being Established –** Also in Section 43 of FPPR: Where the establishment of a free growing stand is required, a person or company may apply to the chief forester for an alternative to these standards (Government of BC 2018);

- **5% Rule** - The Chief Forester's Standards states: a person, required to ensure that 95 per cent of the combined total of the number of seedlings and the number of cuttings that are planted during each fiscal year, in a single management unit comply with the requirements of the standards. In other words, 5% could be planted with whitebark pine not meeting the Chief Forester's Standards (Nicholls 2018);

- **Planting Within Parks –** Provincial Parks are not a part of the Timber Harvesting Land Base (THLB) thus do not need to meet the same criteria required to produce a free-growing stand. Planting within a Provincial Park may allow for greater latitude in tree spacing, surveys, and stock selection.

7.2.2 Operational Planning

When planting whitebark pine following timber harvest, it is best to net out a separate standards unit (SU) exclusive to whitebark pine to reduce competition, facilitate monitoring, and limit the risk of large areas being declared not satisfactorily restocked (NSR). Selecting a low operability area of a cutblock is the most advantageous to reduce the risk of future harvest once the whitebark pine has matured. Whitebark pine management goals must be reflected in the Site Plans (SP). Although whitebark pine may survive widespread mixed species planting, it is a poor competitor; thus,mixed planting within a block may result in reduced stocking and limited contribution to whitebark pine recovery. The minimum size of the planting unit should be directly linked to the impact to whitebark pine incurred during harvest and must consider factors such as health of the retained trees, advance regeneration levels, and probability of planted whitebark to succeed.

To determine how many seedlings to plant, a common density planted is 500 stems/ha; which can be used to determine seedling numbers for a set area. Stocking standards may vary depending on objectives such as seeking a free-growing stand vs. a small restoration plantation. Inter-tree spacing should not be fixed but dictated by the availability of suitable microsites; however, a target of 4.5x 4.5 m is suggested. Densities can be adjusted according to expected survivals which will likely be 50% or less.

When selecting a site for planting whitebark pine, managers may use a nature based approach and take cues from Clark's nutcrackers by planting in typical locations such as ridge tops and warm aspect slopes; however in some cases there are opportunities to select more productive sites to establish whitebark pine following timber harvest or fire. In these cases using the presence of mature trees pre-disturbance can be a good indication on the suitability of the site for whitebark pine. Post-fire snags of whitebark pine are generally easy to identify and pre-harvest surveys should confirm the presence of whitebark pine. Sites previously occupied by whitebark pine may still contain the soil fungal community important to seedling establishment and growth.

7.2.3 Planting Recommendations

To improve planting success, the following guidelines were expanded and modified from McCaughey et al. (2009):

- Plant large hardy seedlings with well developed root systems (412b or larger)
- Reduce canopy and overstory competition
- Plant in confirmed whitebark pine habitat
- Avoid planting in burned lodgepole pine stands
- Do not plant in mixed-species plantings
- Plant in low competition areas
- Avoid planting in deep soils with signs of pocket gopher activity
- Avoid low spots where cold air of frost may present an issue
- Provide physical protection based on site needs. Provide protection from snow creep by planting against stable upslope objects; protect from excessive insolation by planting in moderate shade; and protect from excessive winds by planting in the lee side of objects. Sites will need to be scrutinized to determine the protection needs.
- Avoid unstable objects such as unstable snags, which may pull seedlings out of the ground or crush seedlings.
- Plant when moisture is available. This is typically in the fall so seedlings can establish and take full advantage of spring conditions the following year. Spring planting is often not possible due to late lying snow and summer planting may immediately precede drought conditions.
- Plant in mineral soil to create a firm closure around the seedling a limit the risk of frost heaving; if planting into a duff layer, planters should screef off the organics to plant in a slightly depressed mineral layer.
- Plant in soil deep enough that the seedling can be place vertically into the planting hole with the root collar either flush with or slightly below the level of the native soil.

Figure 43. Photos of robust planting stock (l) and good micrositing against protective features (r).

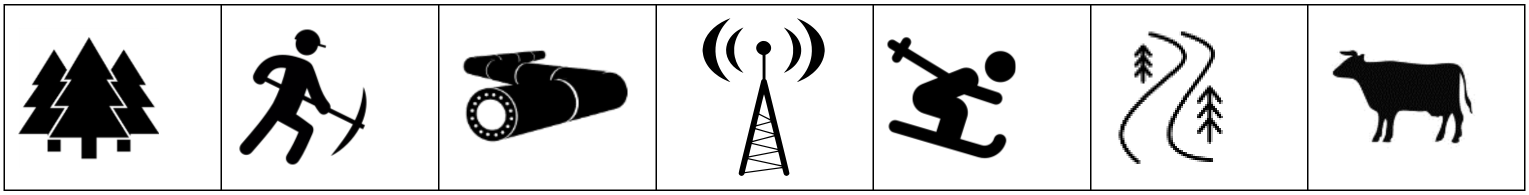
7.2.4 Post-Planting Reporting

All planting on Crown land in BC should be entered into the Reporting Silviculture Updates and Land Status Tracking System (RESULTS) application. Prior to entering planting into RESULTS you require access to the application; contact your Regional Silviculture Forester for more information.

BEST MANAGEMENT PRACTICES FOR PLANTING WHITEBARK PINE

- **Plan planting well in advance, seedling production may take 2 years;**
- **Plant large, hardy seedlings 412b or larger;**
- **Plant the best suited stock (consider registration, disease resistance, transfer guidelines);**
- **When planting stock of unknown resistance, consider rust hazard when selecting sites;**
- **Plant in protected microsites with low competition;**
- **Consider need to protect from frost, insolation, cold air pooling, snow creep, and mass wasting when planting;**
- **Plant well-spaced seedlings to site series specific densities;**
- **Plant in low operability areas of blocks to limit the chance of future harvest;**
- **If planting in a cutblock, net out dedicated SUs exclusively for whitebark pine planting with whitebark management goal reflected in the SP, avoid mixed-species planting;**
- **Plant to limit drought stress by timing or site selection;**
- **If natural recruitment is an objective, net out areas for no planting of any stock;**
- **General stocking densities are 500 seedlings/ha; and**
- **Avoid planting in areas where Ribes is common.**

8 Additional Practices for Restoration



This section describes additional practises that could additionally be used to improve whitebark pine recovery outcomes.

8.1 Verbenone Application

Verbenone is an anti-aggregation pheromone used to deter mountain pine beetle from attacking pine trees. There are several application methods depending on the type of beetle outbreak. Whitebark pine is susceptible to mountain pine beetle, and verbenone may be applied to protect plus-trees displaying some rust resistance mechanisms. This application must be repeated each year.

Verbenone may be purchased from Synergy Semiochemicals (semiochemical.com). As application methods are continually improving, it is suggested you contact your regional entomologist for the most recent updates in application techniques. In addition, other options such as Carbaryl and Green Leaf Volatiles are also used in mountain pine beetle management and should be discussed with the regional entomologist.

8.2 Transplanting or Salvage

In some cases, it is practical to salvage whitebark pine seedlings or small trees from an area to be disturbed and moved to a restoration site; Such activities should only be undertaken when there is a high degree of certainty regarding transplant survival. Historically, transplant attempts of mature trees have not been successful. The high costs and mortality risks associated with moving mature trees would be better allocated to other recovery measures. Seedlings and saplings have been transplanted with a higher level of success at a mine site in central BC (R. Moody, Unpublished Data, D. Pigott, Unpublished Data); these were only 1m tall and were selected based on good health and vigour (Figure 44).

Transplanting is appealing in that it can take 40 years for whitebark pine to begin cone production; transplanting 10-year-old saplings vs. planting 2-year old seedlings may greatly narrow the period to cone production on the restoration site. The drawbacks of transplanting are that it is costly and may not yield surviving trees; it is likely the tree is being moved simply because it is a whitebark pine, not because it has demonstrated resistance. Seedling production and planting is generally superior to transplanting; however, there are some cases where transplanting in conjunction with other restoration work may be desirable.

Figure 44. Large root wad cut around small whitebark pine for transplanting.

BEST MANAGEMENT PRACTICES FOR TRANSPLANTING

- **Evaluate cost-benefit of transplanting and determine if other conservation activities are better suited;**
- **Young open-grown vigorous seedlings or saplings are best suited;**
- **Soil types at donor and translocation sites should be evaluated to ensure good excavation;**
- **A large percent of the root mass should be excavated;**
- **Root pruning and branch pruning may be required.**

8.3 Involvement in Higher Level Recovery

Many whitebark pine recovery activities are led by provincial land managers and are unsuitable for licensees or tenure holders to unilaterally undertake. Collaboration with professionals actively engaged in whitebark pine activities is strongly advised. The Whitebark Ecosystem Foundation of Canada members are an excellent source of information and advice. The following activities contribute to higher level species recovery and should be implemented in conjunction with provincial authorities.

8.3.1 White Pine Blister Rust Resistance Screening

Screening for resistance to white pine blister rust is a complex process requiring a high level of expertise. Rust screening can be both an intensive, highly-controlled process in a nursery setting, and a more extensive system of field-based trials relying on natural inoculum levels. Intensive screening has the advantage of gaining more rapid results (3-5 years) but is very costly and may only select the most superior stock as opposed to some with lower levels or resistance. Field-based trials expose seedlings to a more natural spore load but take longer to demonstrate results.

When considering participation in rust screening programs, it is important that test parents are retained on-site, for if resistance is indicated, subsequent cone or scion collections will want to be made. While trees to be cut in the near-term are not suitable candidates for these programs, for sites where impacts are projected well into the future, a sequence of seedling testing followed by additional collections of seed and scion material may be conducted prior to tree cutting.

8.3.2 Seed Orchards

A seed orchard is a stand of trees, usually several hundred, established and managed primarily for early and abundant production of seed for deployment; with respect to whitebark pine these are usually composed of rust resistant parents. Orchards can be established from seedlings from the original tested parents (forward selection), or from trees where scion material (branch tips) from the tested parent is grafted onto rootstock (backwards selection). In natural stands, whitebark pine normally produce few flowers before 40 years of age. Grafted trees usually have scion material that is physiologically much older and will likely produce seed earlier. However, in both cases the trees will grow relatively slowly even under cultivation. Seed orchards allow for controlled pollination, which is critical to produce rust resistant individuals. Appendix 6 summarizes scion and pollen collection for deployment in seed orchards.

In 2020, the Whitebark PIne Ecosystem Foundation of Canada (WPEFC) proposed that the Foundation take the leadership role in the establishment of whitebark pine seed orchards. This proposal was accepted by stakeholders. A sub-committee of representatives was created to coordinate activities related to orchard development. The committee is comprised of representatives from Parks Canada, FLNRORD, industry, and private consultants, with co-chairs from the WPEFC, and FLNRORD. A seed orchard coordinator has been hired. Funding and support has been received from multiple sources including Parks Canada and FLNRORD. Decisions about orchard or clone bank design and parents should be decided in concert with FIRM geneticist and the Seed Production Officer. The majority of the on-site activities will be contracted out. However, the value of volunteerism will not be discounted. The first seed orchard and clone banks will be established in 2021 with grafted material from trees that have been screened at the Kalamalka Research Centre.

8.3.3 Seed Production Areas

Seed production areas (SPAs) are natural stands of trees at, or close to seed-producing age. They are thinned to improve spacing and undesirable trees are removed to allow the remaining trees to produce more, better quality seed. Undesirable trees would include non-whitebark pine trees and blister rust-infected whitebark pine trees. Although the level of gain is low, the cost is equally low, and could be established in various regions to meet local needs. Currently there is one 2-hectare SPA established in the East Kootenay region above Whitetail Lake near Canal Flats (Figure 45) (Pigott et al, 2015b).

Figure 45. Seed Production Area near Canal Flats.

Seed production areas may be established opportunistically when a cutblock has regenerated naturally with high density whitebark pine; this was the case for the SPA near Canal Flats. SPAs should be protected through a specific land use designation. If SPAs area established in areas that have been identified as resistant populations, significant gains can be realized via natural breeding.

8.3.4 Prescribed Fire

Prescribed fire is a means of habitat restoration that has been deployed extensively in the US. and more recently in Canada's National Parks. Although the deployment of prescribed fire is not likely the mandate of any companies or groups considering the recommendations in this report, implementing a specific whitebark pine burn plan may be conducted by BC Wildfire Service with the financial support and involvement of local industry.

Many of the activities in this section are good recovery activities to participate in and not necessarily Best Practices; most require a significant amount of additional work, though some such as Seed Production Areas may simply present themselves bases on the composition of stands encountered in the field.

9 Offsetting

From time-to-time industrial impacts will be greater than can be effectively compensated for via local implementation of BMPs and post-project restoration; typically projects with significant project footprints and disturbance such mines or pipelines; in these cases, some form of offset may be required to meet a suitable level of compensation. Offsetting may involve implementing restoration at another location; making financial contributions to recovery work; or a combination of the two. Offsetting is considered a last resort in the mitigation hierarchy but may be useful in making key gains for whitebark pine recovery. In general, offsetting is not a clear path from impact to suitable offset level, rather an appropriate scale of offset is negotiated based on the following considerations (Poulton 2014):

- **Equivalency:** There is no perfect equivalency between impact and offset sites; thus the key features that are most important should be identified. For whitebark pine this is a site supporting a stand comparable to the impacted whitebark stand.
- **Currency:** This is the means of measuring impact such as habitat or individual trees. With whitebark pine the currency likely varies by industry. Where habitat is the currency as opposed to individual trees, some accounting for plus-trees should be included.
- **Like for Like:** Do the offsets need to match with impact or are there other objectives, which may result in a better conservation gain? With respect to whitebark pine, a like for like (or better model) is suggested and deviation to other models such as land protection or purchases as compensation for whitebark pine impacts are unsuitable as whitebark pine requires active recovery mechanisms addressing the existential threat of rust and habitat protection generally has low recovery gain for whitebark pine with regards to increasing the frequency of white pine blister rust resistance.
- **Additionality:** The offset work being proposed must be in addition to what would have been conducted without the contributions.
- **Timing and Duration:** The time for a restored ecosystem to reach a comparable stage of the impacted ecosystem may be considerable. Time and duration often confounds negotiations. For whitebark pine, it should be considered that trees do not produce cones until 40 years of age and not in a significant quantity until 80 years of age.
- **Uncertainty and Risk Management:** There are many risks associated with offsets. With whitebark pine these are considerable as the majority of the population is susceptible to white pine blister rust. Monitoring regional impacts due to blister rust may be an important step to determine acceptable levels of uncertainty in offset results.
- **Use of a Multiplier:** A multiplier may be used to manage risk or uncertainty. When the currency being used is individual trees, a multiplier is required to account for mortality of seedlings and time-lag. When habitat is a component of the currency the value of unoccupied regeneration habitat (Critical Habitat) must be considered along with habitat occupied by healthy trees.
- **Offset Availability:** Are the mechanisms to offset available? Whitebark pine occurs almost exclusively on Crown lands, thus land purchases are not an ideal mechanism; fortunately,

whitebark pine is not habitat limited and this approach is not an appropriate offset. The most appropriate offset is supporting identification and deployment of rust resistant seedlings, this may not yield a highly restored area until resistant seedlings are widely available but is a necessary step in recovery and should be considered the primary offset at present.

- **Community and Stakeholder Involvement:** Developing appropriate offsets should not be done unilaterally but should include local stakeholders and groups with expertise in the species or ecosystem in question including local Biologists, Foresters, First Nations, and other groups and professionals. With respect to whitebark pine, this should also include individuals or groups involved in rust screening.

Offsets are generally not viewed as a 'Best Management Practice' as they are viewed as a last resort and proponents only reach this stage when all other mitigation options have been exhausted.

10 Linking Best Management Practice with the Federal Recovery Strategy

The federal recovery strategy for whitebark pine highlights several key points fundamental to the recovery of whitebark pine (Environment and Climate Change Canada 2017). These are detailed in the recovery planning table and in the description of critical habitat. How these points are addressed by BMPs is described in Table 6.

10.1 Addressing Threats or Limitations

Table 6. Table linking BMPs to the Recovery Planning Table in the proposed recovery strategy (Environment and Climate Change Canada, 2017); portions in grey are directly from the recovery planning table, portions in white are BMPs to address the strategies and approaches.

Threat or Limitation	Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches	Best Management Practices to Address Threat or Limitation
8.1 White Pine Blister Rust	Essential	• Increase the frequency of trees with genetic resistance to 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 • Support breeding and production programs to screen and propagate rust-resistant seedlings • Use putatively-resistant seedlings in restoration plantings	• Surveys and Inventory • Layout • Buffering • Tree Falling and Retention • Cone Collections • Seedling Production • Seedling Planting • White Pine Blister Rust Resistance Screening • Seed Orchards • Seed Production Areas
	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	• Seedling Planting • Buffering • Tree Falling and Retention • Pruning • Thinning
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	• Surveys and Inventory • Verbenone Application

			• Identify Whitebark Pine stands currently or at-risk for infestation for the purpose of identifying high value trees.	
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 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	• Surveys and Inventory • Thinning • Cone Collections • Seedling Planting • Prescribed Fire
	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	• Surveys and Inventory
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.	• Surveys and Inventory • Cone Collections • Seedling Planting • Thinning of competing species that may be moving up in elevation
Limited spatial	Essential	• Improve mapping	• Identify and map extent of White Pine Blister Rust	• Surveys and Inventory

data on extent of occurrence		and inventory data in order to meet objectives and address other threats	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.	• Surveys and Inventory • Cone Collections

10.2 Operations Within Critical Habitat

10.2.1 Appropriate Identification of Critical Habitat

In the federal Recovery Strategy, Critical Habitat is defined at the scale of VRI polygons, whereby the basal area of whitebark pine must exceed $2m^2$/ha over the polygon area (Environment and Climate Change Canada 2017). In many cases this scale is inappropriate, particularly at higher elevations where VRI polygons tend to be broader scale reflecting the non-productive forest cover; in these cases, high density whitebark pine patches are 'diluted' due to the large size of the polygon. When identifying Critical Habitat, it is best to use polygons that reflect the real distribution of whitebark pine and capture the often patchy distribution of the tree.These may include TEM polygons or modified VRI polygons, with whitebark pine stands netted out into separate sub-polygons. Means to identify and operate within Critical Habitat are described in Table 7.

Table 7. Summary of Critical Habitat (CH) Descriptions and Applying BMPs to Critical Habitat.

Seed Dispersal and Regeneration Habitat	Best Management Practices to Identify and Protect Critical Habitat	Industry Considerations for Operations in Critical Habitat
A) Stand of polygon with high density of whitebark pine: of at least 2 m^2/ha of healthy whitebark pine (high density whitebark pine polygon) (Seed Dispersal and Regeneration Habitat)	• Surveys and Inventory - Timber Cruising - VRI • Timber Harvest • Silviculture	• Do not harvest within self-replacing whitebark stands; • CH may be improved by harvest where non-whitebark competition levels are high and healthy whitebark are retained and protected.
1. Within high density whitebark pine polygon: Cone-bearing and/or non-terminally infected whitebark pine (CH – Seed Dispersal Habitat);	• Training • Surveys and Inventory - Timber Cruising • Layout • Buffers • Pruning	• Flag trees meeting criteria and ensure retention; • Collect cones from putatively-resistant trees; • Prune infected branches to prevent infection from reaching the stem.
2. Within high density whitebark pine polygon: Substrate near other whitebark pine, open at surface layers, and well to rapidly draining soils (CH – Regeneration Habitat)	• Surveys and Inventory - VRI - Ecosystem Mapping	• Avoid soil disturbance in root zone around trees • Maintain windfirmness.
3. Polygons with parkland opening greater than 0.5 ha, ecologically suited to whitebark pine,	• Surveys and Inventory - Timber Cruising	• Do not plant with non-whitebark pine species.

and within 2 km of a stand meeting criteria A (CH – Regeneration Habitat).	- VRI - Ecosystem Mapping • Seedling Planting	• Reflect in silviculture prescriptions.
Recovery Habitat		
B) Research, monitoring, and recovery activities within the range of whitebark pine (CH – Recovery Habitat)	• Surveys and Inventory - Permanent Monitoring Transects • Thinning • Seedling Planting • Seed Orchards • Seed Production Areas • Prescribed burn areas	• Perform whitebark pine recovery activities as prescribed by recovery specialists.

11 Applying Best Management Practices

The guidelines and BMPs described above can be applied to specific industries and circumstances. This section describes industry-specific examples of when the guidelines may be applied to limit impacts to whitebark pine within the context of the mitigation hierarchy and promote management actions to support recovery.

To apply the BMPs described in the above sections, proponents must consider the broad spectrum of constraints that ultimately guide the application of whitebark pine BMPs. When applying BMPs it is recognized that the best practices must also balance other needs of the proponent such as policy constraints, operational constraints, financial constraints, and biological constraints (Figure 46). Consider the BMPs for reforestation - planting whitebark pine is limited biologically by site factors; policy-wise by factors such as seed transfer and whether it is an acceptable species; operationally by production limitations in the greenhouse (it must be ordered at least a year prior to other species); and financially by the high cost of seedlings relative to other species. Biological constraints should also consider the management or recovery goals of other species occurring within the ecosystems such grizzly bear and caribou.

Figure 46. Graphic showing constraints that must be considered when developing or implementing BMPs.

Mitigating appropriately for impacts to whitebark pine can be complex. Recall that white pine blister rust is the primary threat to the species; often leading to trade-offs in mitigation. Approaches that avoid and retain terminally infected trees may not be preferred as high impact activities that are likely to require mitigation work leading to involvement in higher level activities that may support rust screening efforts will have an overall higher contribution to species recovery.

Figure 47. Clark's nutcracker in a whitebark pine tree.

11.1 Forestry

Whitebark pine often occurs in high-elevation, non-productive forests, but is also present on the timber harvesting land base and can be damaged or harvested as 'by-catch' during harvesting operations. Specifically, logging in higher elevation spruce-fir and lodgepole pine stands can result in unintended cutting or damage to whitebark pine. Removing live whitebark pine trees results in reduced seed supply, which decreases availability of an important nutritional food source for wildlife, and adversely impacts regeneration and species recovery. As well, trees which were removed may have been genetically resistant to blister rust. Small adjustments can be made within forest management operations to prevent and reduce impacts to whitebark pine populations.

Mitigation Hierarchy	Inventory	Harvest	Silviculture
Avoid	• Identify high density whitebark pine stands during VRI mapping or timber cruising and avoid future harvest in areas with high density whitebark characterized by good health and low competition levels.	• Flag all trees and patches that must be retained during harvest; • Buffer all plus trees and high density regeneration to protect trees and rooting zones; • Create good tree maps for operators; • Train operators to identify healthy whitebark pine; • Move road locations around whitebark pine.	• Do not cut whitebark pine during thinning or brushing operations.
Minimize	• Identify high density whitebark pine stands during VRI mapping or timber cruising and allow entries into stands where a restoration gain may be made via removal of non-whitebark species.	• Layout crews must map and mark all healthy whitebark pine for retention and identify infected trees permitted for removal; • Roads must be routed around healthy whitebark pine, unhealthy trees may be removed; • Conduct winter harvest to reduce impacts to regen and rooting zones.	• Collect seed from appropriate provenances to maintain genetic diversity when some trees must be harvested; • Promote alternate food sources for the Clark's nutcracker, namely Douglas-fir and Ponderosa Pine; • Pruning may be an alternative to cutting whitebark pine when the low branches impeded clearance; • Minimize competition around planted or advanced regen whitebark pine.

Mitigation Hierarchy	Inventory	Harvest	Silviculture
Restore	• Use surveys and inventories to identify plus trees for cone collections to be used in restoration programs; • Establish rust monitoring transects to determine expected baselines for restoration success levels.	• Use harvest as a restoration tool by retaining mature healthy whitebark pine and creating recruitment opportunities by harvesting competing tree species; • Scatter logs and debris across the site to serve as caching cues for Clark's nutcrackers and as protected planting habitat.	• Retain primarily healthy whitebark pine during thinning operations; • Document whitebark pine in silviculture surveys to determine seedling needs; • Collect cones from putatively resistant parent trees; • Plant whitebark pine seedlings in designated and ecologically suitable standards units to limit competition, future harvest, and to facilitate seedling survival monitoring; • Where appropriate, plant alternate food sources for the Clark's nutcracker, namely Ponderosa Pine and Douglas-fir.
Supplementary Practices			• Remove competition from around whitebark pine trees; • Plant whitebark pine seedlings in non-harvest areas such as old burns or whitebark pine stands with high rust or mountain pine beetle mortality; • Support rust screening programs; • Establish seed production areas; • Support habitat restoration programs.

11.2 Mining and Mineral Exploration

Like forestry, mining applications are undertaken by a range of specialists at various stages of mineral exploration, development and operation. As such, mining is summarized here by stages in the mining life cycle. Further to this, an "Offset" section presents activities that may be required under permit that are not directly related to the mine footprint, to compensate for impacts that cannot be effectively mitigated.

Mitigation Hierarchy	Exploration	Assessment	Construction	Operations	Closure and Reclamation
Avoid	• Train all field workers; • review existing TEM and VRI mapping to identify likelihood of encountering whitebark pine in exploration areas; • Drill pads must avoid healthy whitebark pine; • Roads must be routed around healthy whitebark pine.	• Ensure whitebark pine is identified; • Identify patches or individual whitebark pine to avoid during operations; • Identify areas of Critical Habitat.	• Route access roads around whitebark pine.	• Route access roads around whitebark pine.	
Minimize	• Prune trees to accommodate access and development as opposed to tree cutting.		• Identify high density whitebark pine stands during mapping and avoid impacts to these areas for as long as possible; • Transplant healthy whitebark pine saplings; • Retain alternate food species such as Douglas-fir and Ponderosa Pine,		

Mitigation Hierarchy	Exploration	Assessment	Construction	Operations	Closure and Reclamation
			where appropriate; • Plan any tree removal for after cones have been harvested by wildlife.		
Restore	• Conduct progressive reclamation by planting whitebark pine on roads and pads where mine development is not going to occur. • Document habitat area and number of healthy trees impacted to ensure restoration is sufficient.	• Identify areas of Critical Habitat and number of plus trees to be disturbed during mine development.	• Collect seed from local trees prior to removal; • In high rust areas collect scion material from the healthiest cohort if tree removal is required.	• Plan for restoration by collecting seed, conducting field trials and participating in rust resistance screening programs; • Plant seedlings as a component of progressive restoration	• Map reclamation to identify ecologically suitable sites for whitebark pine planting; • Collect seed and grow seedlings; • Plant whitebark pine seedlings; • Participate in rust screening programs; • Establish nutcracker caching cues on sites such as rocks and stumps; • Plant alternate food sources including Douglas-fir and Ponderosa Pine, where appropriate. • Establish health transects in planting area and adjacent undisturbed habitat to determine if planting survival is within normal variability.
Offsetting	• Document habitat area and number of healthy trees impacted to ensure restoration is sufficient.	• Identify areas for potential offsets.			• Some offsetting may be required to compensate for temporal losses; • Compare initial baselines to planted whitebark pine areas to determine spatial changes;

11.3 Linear Developments: Pipelines and Powerlines

Pipelines and, powerlines, and towers present unique scenarios as unlike forestry, these installations should be viewed as permanent. Many portions of these developments are to remain unvegetated in the future to support maintenance activities.

11.3.1 Pipelines

Several British Columbia pipelines have been proposed that may potentially traverse areas where whitebark pine occurs. Pipelines are built using an alignment sheet, a blueprint showing the exact route of the pipeline and virtually all the knowledge regarding the route. The information includes:

- Jurisdiction
- Land Ownership/Disposition
- Land Use
- Socio-Economic and Agricultural Considerations
- Heritage/Traditional Land Use
- Wildlife and Wildlife Habitat
- Forest types
- Vegetation - Indicates **rare plants**, lichens and liverworts, and rare ecological communities encountered along the pipeline corridor
- Wetlands
- Fish Habitat Sensitivity
- Hydrology
- Soil Parent Material

The potential environmental issues which may result in adverse effects along the pipeline corridor are identified, and environmental protection measures are developed. More detailed information related to specific disciplines is identified in the Environmental Protection Plan (EPP). The EPP is required by the National Energy Board for pipeline right-of ways and applies to all phases of construction. It is a comprehensive document that covers all environmental protection procedures, mitigation, and measures and monitoring commitments. Under the Vegetation component, rare plant species are identified as recognized by *SARA*, COSEWIC, and the BC CDC.

Figure 48. Pipeline development showing size of pipe and common width of clearing.

11.3.2 Powerlines

In British Columbia, BC Hydro has over 18,200 km of transmission lines of varying widths. Additionally, there are numerous smaller lines for independent power projects, and service lines to other utilities. Most often it is the smaller or narrower lines that traverse whitebark pine habitats. Whitebark pine is a relatively slow growing species, and transmission wires can often be strung over stands, particularly younger stands, without concern that trees will grow into the lines quickly. The right-of-ways for transmission or service lines that have previously been established and cleared through stands of whitebark pine, often have excellent whitebark regeneration. Likely, adjacent whitebark trees produce more abundant cone crops, and the cleared areas provide good conditions for some natural seed fall, and good seed-caching sites for Clark's nutcrackers. Potentially, these areas could be managed for seed production, as Seed Production Areas.

Figure 49. Powerline right-of-way in whitebark pine habitat.

Mitigation Hierarchy	Planning	Clearing	Construction	Restoration
Avoid	• Train all field workers • Review VRI maps and ecosystem maps for potential presence of whitebark pine in work area; • Conduct appropriate field inventory of whitebark pine to confirm presence; • Determine if any habitat can be classified as Critical Habitat; • Adjust locations of access roads and development to avoid whitebark pine and associated root area where possible.	• Flag all healthy whitebark identified for retention; • Adjust locations of access roads and development to avoid whitebark pine and associated root area.	• Avoid damaging retained trees by buffering or other means of protecting trees and rooting zones.	
Minimize		• Prune trees to accommodate access and development, where feasible. • Plan any tree removal for after cones have been harvested by wildlife.		
Restore	• Collect cones from healthiest trees and initiate rust screening process; • Collect cones to support future restoration program.	• Collect cones and scion material from the healthiest trees prior to clearing; • Collect cones to support future restoration program. • Apply verbenone to protect plus trees		• Plant whitebark pine seedlings on decommissioned roads and on appropriate restoration sites; • Place rocks and stumps on restoration sites to provide Clark's nutcracker caching cues and protect seedlings; • Apply verbenone to protect plus trees
Offset	• Determine area of Critical Habitat and number of individual healthy trees impacted by development.			• Conduct offsets to compensate for area of habitat not restored, number of mature trees disturbed, and temporal losses in ecosystem services.

11.4 Towers 

In British Columbia, particularly in the southern third of the province, communication infrastructures are common on mountains or ridges over 1800 metres and located in whitebark pine habitat. In fact, these locations are a key target when trying to locate easily accessible whitebark pine stands for research and cone collection. While most locations host only one or two individual structures and the footprint is quite small, other locations may have a much larger footprint. Presumably when most construction and access road building took place whitebark pine was considered nothing more than “scrub” pine and in the absence of any guidelines, many trees were destroyed or damaged. Wind farms could possibly have a similar impact on whitebark pine. However, the establishment of wind farms is administered by the Ministry of Lands, Forests, Natural Resources, and Rural development, and all Project Development Plans must identify rare plants, ecosystems at Risk, and both red and blue-listed species.

Figure 50 Communication towers in whitebark pine habitat.

Mitigation Hierarchy	Tower Establishment and Maintenance
Avoid	• Avoid cutting whitebark pine • If possible avoid cutting whitebark pine under guy-lines
Minimize	• Prune whitebark pine under guy lines
Restore	• Replant seedlings in region to reflect numbers cut during construction and maintenance
Offset	• Assist with additional restoration efforts by permitting cone collections and other recovery related work facilitated by the access to the site. .

11.5 Ski Areas

Ski areas present a novel case for applying whitebark pine management guidelines. Despite the general tree-free state of most ski runs, ski areas provide good access, have high public visitation, and usually have areas where forest cover may be quite extensive. The Whitebark Pine Ecosystem Foundation has a 'Whitebark Pine Friendly Ski Area" certification program and many of the activities listed below will directly contribute to achieving this certification [whitebarkfound.org/ski-area-certification].

Figure 51. Whitebark pines tree cut to create more open slopes for skiing.

Mitigation Hierarchy	Ski Area Maintenance
Avoid	• Train workers; • Inventory whitebark pine in ski area and mark plus trees to be retained during all run creation and maintenance activities; • Limit skier impacts by not creating trails or runs in high density stands; • Do not cut whitebark pine to build heli pads..
Minimize	• Remove only terminally infected whitebark pine during glading activities; • Prune branches as opposed to cutting trees to create tree skiing opportunities.
Restore	• Support or permit cone collections in ski area; • Identify and implement restoration that coincides with ski area management such as thinning competition and planting seedlings where appropriate; • Conduct outreach and include volunteers in restoration; • Apply verbenone to protect plus trees..
Supplementary Practices	• Assist with additional restoration efforts.

11.6 Trail Based Recreation

As with ski areas, recreation tenures may provide novel opportunities for whitebark pine recovery. Development of recreation improvements should incorporate guidelines for whitebark pine conservation. For the purposes of this document, it is assumed that recreation refers to trail creation and maintenance. Good trail building and placement is an essential prerequisite to provide excellent recreational opportunities, while still protecting the environment. The Provincial Government has developed trail management standard, which should be the basis of all trails whether in whitebark pine habitat or not [sitesandtrailsbc.ca/documents/manual/chapter10.pdf]. The principles are applicable for biking, hiking, horseback riding, and some motorized use. Some specific recommendations should be adapted for trail construction and placement in whitebark pine habitat.

Figure 52. Branch stub left after improper pruning to widen trail access; branch should have been cut to stem.

Figure 53. Mountain biking through whitebark pine stands in the South Chilcotin.

Mitigation Hierarchy	Trail Planning	Trail Building
Avoid	• Review VRI maps and ecosystem maps to determine if whitebark pine is likely to be present; • Train all field workers; • Re-route trail around whitebark pine, with enough buffer to protect rooting zones.	• Train trail builders; • Ribbon trees and patches for retention, • Do not excavate in rooting zones. • Place educational signs regarding whitebark pine.
Minimize	• Identify areas where avoidance is not possible and identify ways to minimize impact such as pruning or prioritizing the retention of the healthiest trees.	• Prune trees to create openings as opposed to cutting trees. • Place educational signs regarding whitebark pine.
Restore	• Conduct outreach campaign to make public aware that trails were planned to retain whitebark pine.	• Provide locations of candidate plus trees to recovery practitioners.
Supplementary Practices		• Assist with additional restoration efforts.

11.7 Range Use

Grazing has occurred in British Columbia for over 170 years, even at higher elevations and in whitebark pine ecosystems. Cattle or horse use in whitebark pine habitats can result in the trampling of whitebark seedlings, and ecosystem changes can include the introduction of invasive species and effects on understory fuels and natural fire regimes. Sheep or goats may graze whitebark pine. When too many animals occupy a site, damage to trees from grazing and rubbing, soil compaction and erosion can occur.

Mitigation Hierarchy	Range Management
Avoid	• Review VRI maps to identify potential areas where range use overlaps with whitebark pine; • Restrict cattle from whitebark pine habitat through the use of fencing, particularly where seedlings and saplings may be trampled, • Horse outfitters should be trained to identify whitebark pine and not cut for firewood or use for backcountry infrastructure.
Minimize	• Restrict cattle from whitebark pine habitat through the use of salt block placement and watering; • Prune whitebark pine to create open areas.
Restore	• Guide outfitters should report locations of healthy whitebark pine trees to recovery personnel to aid in identifying potential trees for screening; • Thinning stands for forage production may serve as restoration if whitebark are retained, care must be taken to ensure cattle do not impact retained whitebark pine trees.
Supplementary Practices	• Assist with additional restoration efforts.

Figure 54. Cattle grazing in whitebark pine stands near Lillooet.

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13 Glossary

This **glossary of forest genetics and silviculture terms** draws on a glossary terms from Dr. W. J. Libby for the Inland Empire Tree Improvement Co-operative, Restoration Management Actions for Whitebark Pine Ecosystems: Best Management Practices, and work by the B.C. Forest Genetics Council and its cooperators. It has been edited to improve relevance to whitebark pine recovery.

CANDIDATE PLUS TREE: A tree identified as potentially being a plus or putatively resistant tree but not confirmed as the technician may not be highly skilled in rust identification, there was insufficient time to properly scutinize the tree, or a full view of the tree was obscured.

CLONE: (a) A group of vegetatively-propagated organisms consisting of an ortet and its ramets.

ELITE TREE (resistant seed source): A seed or plus tree confirmed through resistance screening to have heritable (genetic) resistance (or reduced susceptibility) to blister rust.

EX SITU: Off-site; away from the natural habitat.

FAMILY: A group of seedlings for which one or both parents are known. When only the female parent is known, it is called a "half-sib" family; when both parents are known, it is a "full-sib" family.

FOUNDATION SPECIES: In ecology, the term *foundation species* is used to refer to a *species* that has a strong role in structuring a community.

GENETIC RESISTANCE: Genetic resistance to blister rust is both polygenic in whitebark pine and relative to specific populations. Because polygenic resistance segregates in seedling progeny, managers must determine which screened trees provide the best (highest) proportions of resistant offspring among the trees tested, particularly in comparison to the most susceptible (least resistant) genotypes. The resistance level needs to be balanced against finding a sufficient number of trees considered to have some resistance in order to provide adequate genetic diversity for restoration actions. Seed orchards through controlled pollination enable improvement in the proportion of progeny with resistance.

GENETIC GAIN: The average (heritable) change from one generation to the next as a result of selection.

GHOST TREE: Trees that, for a specified reason, will not count towards the stocking of the stand but has an impact on the development of the regeneration.

GRAFT INCOMPATIBILITY: A destructive interaction between tissues of the stock and scion, often resulting in starvation and death of the scion.

IMPROVED RESISTANT SEED: Seeds harvested from a seed orchard. Controlled pollination can increase resistance and the proportion of genetically resistant progeny.

IN SITU: On site; within the natural habitat.

INBREEDING: A reduction in average heterozygosity resulting from a mating between relatives.

KEYSTONE SPECIES: A *keystone species* is a plant or animal that plays a unique and crucial role in the way an ecosystem functions. Without *keystone species*, the ecosystem would be dramatically different or cease to exist altogether.

MASTING: The production of many seeds by a plant every two or more years in regional synchrony with other plants of the same species.

ORTET: The initial individual (usually from a zygotic embryo) that is vegetatively propagated to produce a clone. *See ramet*.

PARENT TREE: A genetically unique tree of a known source that is: a) selected for a specific trait; and b) bred or cloned for the purpose of producing seeds or vegetative material.

PHENOTYPE: The observed expression of a trait in an individual that is the result of a developmental interaction of the individual's genotype and its environment.

PLUS TREE (putatively resistant tree): A relatively healthy geo-referenced and tagged tree from a stand with high infection levels of blister rust and mortality. The tree is a candidate for resistance screening.

PUTATIVE RESISTANCE: Appears to be resistant to a disease.

PUTATIVELY RESISTANT SEEDLINGS: Seedlings grown from seeds from plus trees, with the assumption of some degree of resistance. Often seeds are combined into a bulked lot with unknown resistance**.**

PROGENY TEST: Generally a common-garden test in which the breeding values of parents are evaluated and ranked on the basis of the performance of their offspring. *See progeny trial, provenance test*.

PROVENANCE: The geographic origin of a population. Most often refers to the natural origin, implying where the population evolved prior to human intervention.

PROVENANCE TEST: A common-garden test in which population samples from stands of known evolutionary origins are grown together to compare.

RAMET: All vegetative propagules of an ortet are ramets. A clone is composed of the ortet and its ramets.

RESISTANT SEEDLINGS: Seedlings grown from seeds from elite trees, or a mix of elite trees and plus trees. Survival in resistant seedling may be 50% or lower because of cross-pollination or recombination.

ROOTSTOCK: For grafting, the material on which the scion is grafted.

SCION: The desired clonal plant part, often a twig, that is grafted onto the root-bearing part of another plant. *See rootstock*.

SEEDLOT: A quantity of cones or seeds having uniformity of species, source, quality, and year of collection.

SEED ORCHARD: An orchard consisting of clones or seedlings from selected trees, isolated to prevent or reduce pollination from outside sources, and cultured for early and abundant production of seeds for reforestation.

SEED PRODUCTION AREA: A seed production area is defined as a stand of better than average quality that is upgraded and opened up by removal of undesirable trees, and then cultured for early and abundant seed production.

SEED SOURCE: The geographic origin of a seed. If the seed is from a native stand, this is equivalent to provenance.

SEED TREE (unknown resistance): A healthy tree selected from an area of low to no blister rust for seed collection. The tree has not yet undergone screening for blister rust resistance.

SELECTED STAND: Natural stands with a history of good cone production, easily harvested cones, and possibly superior rust resistance.

SPAR: SPAR (Seed Planning and Registry Application) is the provincial web-based information management system in BC. It provides clients with direct online access to a provincial registry of forest tree seeds and a comprehensive seedling request system to meet annual reforestation needs. It serves as an online catalogue where clients can search for available seedlots of each species to meet their needs.

SUPERIOR PROVENANCES*:* These are natural stand seed sources that have been field tested, and shown to exhibit better than average resistance to White pine blister rust.

14 Appendices

Appendix 1: Identification of Limber Pine, Whitebark Pine, and Western White Pine

Characteristic	Whitebark pine	Limber pine	Western White pine
Tree form	Single stem when with competition. Multi-stem when open grown, and at higher elevations. Mature trees can be can up to 2 m diameter and 31 m tall.	Single stem with competition. Often multi-stem when open grown. Mature trees can be up to .60 m diameter and 20 m tall.	Single stem. Very fast growing on better sites. Trees up to 1.3 m diameter, and 49 m tall have been recorded
Seed Cones	Roundish cones that do not open when dry. may look like a hand grenade. Purple, turning dark brown with maturity. Does not open on maturity. 5-10 cm length.	Larger elongated cones that open when mature and shed seeds, Green when immature, brown when ripe. Wingless seeds. Often with slight curl. Opens upon maturity. Cones 6-16 cm long.	Large cylindrical cones. 12-30 cm long. Often slightly curled. Cones hang noticeably from branch tips. Cones open and disperse seeds in late August-September.
Seeds	Wingless seeds, ovoid Light brown color. 1 cm diameter	Wingless, light brown seeds, although some have a vestigial wing which is essentially non-functional for wind dispersal. Oblong, more pointed. Often a dark spot on the seed. 1 cm length	Seeds have wings. Smaller then limber or whitebark pine. Slightly rounder.
Pollen Cones	Red. Ripens and are apparent in late June to early August.	Yellow. Ripens and are apparent in late June to early August.	Yellow to light brown. Ripens and are apparent in early to late June.
Needles	Bundles of five. 4-8 cm long. Stomata on one side only.	Usually bundles of five, occasionally four. 4-10 cm long. Stomata on each of three sides of needle.	Bundles of five. 5-12 cm long. Usually bluish-green color
Bark	White to gray. Pitch blisters on young trees. Scaly when mature.	Smooth and pale gray on young trees, scaly and plate-like when older or mature.	Smooth and gray when young. Pitch blisters on young trees. Bark is thick and divided into square plates when mature.
Habitat	Most abundant on drier exposed south facing slopes at higher elevations. Fresh to moist sites at lower elevations, where often mixed with Engelmann spruce, Lodgepole pine, subalpine fir and alpine larch.	Warmer aspects. Calcareous slopes, talus slopes, and limestone outcrops. Occurs with Douglas fir, and Rocky Mt juniper.	Widespread throughout range, from bogs, to well drained sites from valley bottom to subalpine, occasionally 1100 m.

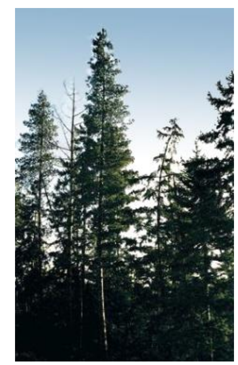
Whitebark pine	Limber pine	Western White pine
		
	Pollen cones	
		
	Seed cones	
		
	Bark	

Whitebark pine

Limber pine

Western White pine

Immature **Mature** **Immature** **Mature** **Immature** **Mature**



Appendix 2: Blister Rust Survey and Monitoring Data Sheets

Blister Rust Survey and Monitoring Data Sheet
Belt Transect Plot Description and Understory Survey

Plot No: ________ Start Monument Tag #: _ _ _ End Monument Tag #: _ _ _

Date (mm/dd/yyyy): _ _ _ _ _ _ _ _ Field Team: ______________________________

State/Province (2-letter code): _ _ Administrative Unit: ______________________________

Specific location: ____

Units of measurement (check): Metric ( ) English ( ) Topo Map ID: ____________________

Type: Transect ( ) Circle ( ) Rectangle ( ) Length (nearest 1.0 m or 1.0 ft): ____________

Center of plot: Elev: _____ m ft (circle one) Slope: ___ % deg (circle one) Aspect (to 10°): _____

Start GPS: NAD: _ _ Zone: _ _ Easting/Long: ________ Northing/Lat: __________ Accuracy: __

End GPS: NAD: _ _ Zone: _ _ Easting/Long: ________ Northing/Lat: __________ Accuracy: __

Compass direction of transect (True North): at Start: _______ at Center: __________

Successional status (C, L, M, E): _____

Habitat type: ____________________________ Cover type: ______________________________

Reference for above: ____

Estimated percent of each tree species in overstory: ______________________________________

____

Undergrowth dominants: ____

____

Photo info. (roll/number): Along transect from origin: ______ End of right belt: ______

Along transect toward origin: _______ End of left belt: _______ Other:______________________

Rust resistant candidate trees (plus trees), tag # and GPS location: ___________________________

____

Comments (cone production, nutcracker activity, etc.): ___________________________________

____

____

____

____

UNDERSTORY SURVEY: trees < DBH 4.5 ft (1.4 m)
Complete this tick mark matrix for all LIVE understory whitebark pine within the belt transect.

Height < DBH	Active Cankers	Inactive Cankers	No Cankers	Other
≤ 50 cm (20 in)				
> 50 cm (20 in)				

Plot No.: Date:

Tree No.	Tag # or Dist Along/From Tape	Clump letter a,b,…	DBH	Stem Cankers A,I,N,U,O	Branch Cankers A,I,N,U,O	Canopy Kill % class	Bark Strip N,L,M,H	MPB Pres. √	Tree status H,S,R, D	Cause of Death R,B,U	Notes
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Cankers: A=active (spores), I=inactive, N=none, U=uncertain, O=other; Tree status: H=healthy, S=sick, R=recently dead, D=dead
Canopy kill classes: 1(0-5), 2(6-15), 3(16-25), 4(26-35), 5(36-45), 6(46-55), 7(56-65), 8(66-75), 9(76-85), 10(86-95), 11(96-100)
Bark stripping: N=none, L=light, M = moderate, H= heavy; Cause of tree death: R=rust, B=beetle, U=unknown/other

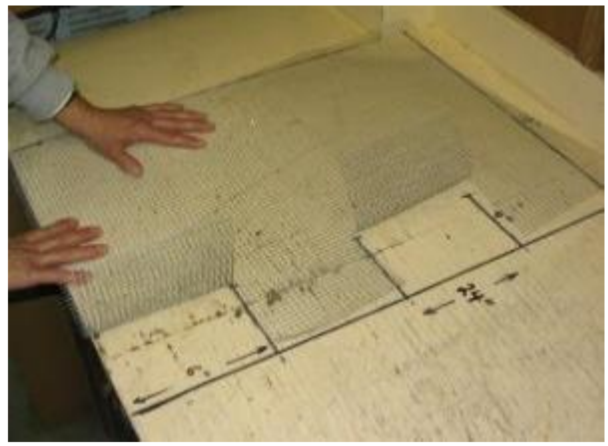
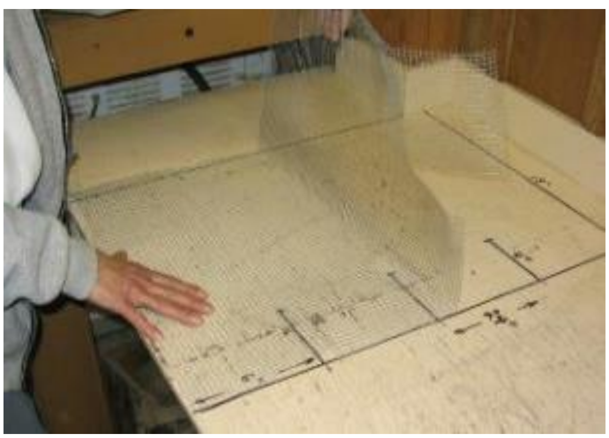
Appendix 3: Seedlot Registration Form

Seed Planning and Registry System
Seedlot Registration Report

Interim Number :		**Seedlot Number:**	
General Lot Information			
To Be Registered: (Y/N)		Status:	
SPECIES:		Genetic Class:	
Superior Provenance: (Y/N)		BC source: (Y/N)	
Applicant Information			
Applicant Agency:			
Applicant Address:		Applicant's Email Address:	
Collection From Natural Stand (Y or N):			
Collection Org Unit:			
Location:		Collection Provenance:	
Chief Forester's Standards App. 5 met (Y/N): (If applicable)		Genetic Worth Growth: Density: Resistance: MGR:	
Collection Latitude (Mean): (Deg/ Min/Sec)	Collection Longitude. (Mean): (Deg/Min/Sec)		Collection Elevation: Mean/Min/Max
Radius of Collection (km):		Capture Method:	
Seed Planning Zone:	Geographic Area:		Is the collection all within the same SPZ (Y or N)
BGC Zone/Subzone/Variant:		Is the collection all within the same BGC? (Y or N)	
Collection Methods:	Collection Start Date:		Collection End Date:
No. of Containers:	Volume per container: (Hl)	Total Volume (Hl):	No of Trees Collected From: ☐ <10 ☐ 10-50 ☐50+
Comments:			
Cone Collection Agency:		Collector Address:	
Ownership:			
Owner Agency: Owner (%) Reserved Surplus	Funding Source:	Method of payment	
Interim Cone Storage:			
Interim Agency:		Storage Location:	
Storage Facilty Type:	Interim Storage From:		Interim Storage To:
Extraction:			
Extraction Agency:	Extraction Start Date:		Extraction End Date:
Temporary Seed Storage			
Seed Storage Agency:	Storage From Date:		Storage To Date:
Comments:			
Declaration: I hereby declare that the information provided in this application is true and correct and that I am the owner of the lot or have been authorized by the owner(s) of the lot to submit this application. ______________________			

Appendix 4: Constructing Cone Cages

The cages used to protect cones from seed predators are constructed out of either 1/4” or 1/8” hardware cloth. The hardware cloth is cut into pieces 18” wide and 24” long. Most rolls of cloth are 3 feet (36”) wide but can be cut in half using a band or table saw with a metal cutting blade. Slots are cut into the cloth on the long side at 6” intervals and 4” deep. The cloth is then folded at each of the 3 slots to form a box. The “open” side and the top is then closed using cable ties. .


Appendix 5: Seed Collection Parent Tree Form

Parent Tree Record

SPECIES: .__________ STAND NAME & NO. __________________________ Name (completed by): _________________ Date: ______________

Biogeoclimatic Zone & Subzone: ______________ Ecosystem Association: ______________ Species Composition: __________________
Age & Distribution of Ages: ______________
Stand History: ______________________________________ Landform & Terrain: ____

Site/Stand Comments: ____

Blister rust Survey: Yes, No? Method: __________________ Level of Infection: ____

Marked by: __________________________

TREE NO.	LATITUDE	LONGITUDE ±3m	ELEV [m]	DBH [cm]	HT. [m]	Age	Active Branch cankers	In-active Branch cankers	Active Stem Canker	Inactive Stem cankers	Cages	Cones	Comments/vigor.0-10

Appendix 6: Collecting Scion and Pollen

Scion material is usually collected in winter when trees are completely dormant, but if extreme care is taken, scions can be collected in the fall when the cones are harvested, then grafted immediately of following cold storage. Scion material should preferably be taken from the upper part of the crown where cone production occurs. It is collected by climbing and clipping, pole pruners, or sometimes by shooting. The size of the material collected is usually dependant on the size of the rootstock where grafting is done. As rootstock calipers are often variable, a range of scion material sizes is prudent. At the time of grafting, the scions are usually trimmed from 10-20 cm in length depending on grafting technique. Scion material should be wrapped in moist, not wet, newspaper or paper towel as soon as possible after collection and placed in a plastic bag with good identification of the parent tree (Figure 55). Store the plastics bags in a cooler with snow, ice, or cooler packs during transport. Store at 2-5° C. (fridge) prior to delivery to the propagation facility.

Figure 55. Suitable size and location on tree for scion collection (l); collected material wrapped in moist newspaper prior to grafting (r).

Once “plus trees” have been selected, screened for resistance, and archived in seed orchards, pollen may be required from some of the original parents in the field. Pollen buds can be collected in the late spring just when they are almost ripe enough to shed, and then taken to a lab where they are dried to release their pollen. Sometimes when trees are difficult to access and the visit to harvest the buds is too early, whole branches (30-40 cm long) are taken back to a lab where they are placed in vases of water to force the buds to open and shed their pollen. Pollen is then applied to female flowers soon after, or dried and stored for future breeding (Figure 56).

Figure 56. Whitebark pine pollen cones (l); and extracted, cleaned, and dried pollen (r).

Both scion collections and pollen collections are specialized activities, and should be done at the request of, and direction of, one of the scientists, or technicians involved in the propagation or breeding, usually coordinated through the Ministry of Forests, Lands, and Natural Resource Operations and Rural Development (FLNRORD) Tree Improvement Branch.