

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



*Prepared by:*  
Randy Moody , Keefer Environmental Services Ltd.  
Don Pigott, Yellow Point Propagation Ltd.  
*March, 2017*

\*\*\*This is a draft version of Best Management Practices for Whitebark Pine, which should be updated when the Federal Recovery Strategy is finalized or when a provincial strategy is developed to reflect any requirements within those documents.

## Why Best Management Practices?

Whitebark pine occurs across a vast area of 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 a negative impact 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 potentially aid in species recovery. 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 nowhere 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, in 10-years of whitebark pine recovery work in British Columbia, only an estimated 60,000 seedlings have been planted over 150 ha; during this period thousands of hectares of whitebark pine habitat has been affected by mining and logging 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 stakeholder. To illustrate, a proposed mine site with a highly blister rust-infected whitebark pine stand that is not in an ecologically functional condition could contribute to more widespread recovery efforts if the mining company were required to invest in seeking rust resistance for seedlings to be deployed during 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.

## Who is this document for?

This document was written for resource users and professionals who may encounter whitebark pine during field-based activities **but who are not fully engaged in whitebark pine recovery**; including personnel working in forestry, mining, pipeline development, ski area management, recreation and range management.

# Best Management Practices for Whitebark Pine

## Table of Contents

Why Best Management Practices? .....	2
Who is this document for?.....	2
Best Management Practices for Whitebark Pine .....	3
1 Introduction .....	6
1.1 Species Description .....	6
1.2 Distribution and Habitat .....	6
1.3 Ecological Importance.....	6
1.4 Threats and Conservation Status .....	8
1.5 Current Conservation Planning .....	9
1.6 How to Use this Document .....	9
2 The Mitigation Hierarchy .....	11
3 Training .....	12
3.1 Whitebark Pine Identification .....	12
3.2 White Pine Blister Rust Identification .....	15
3.3 Clark’s Nutcracker Identification.....	21
4 Establishing Baselines: Surveys and Inventory .....	22
4.1 Reporting Data .....	22
4.2 Ecosystem Mapping.....	23
4.3 Vegetation Resources Inventory (VRI) .....	23
4.4 Timber Cruising .....	23
4.5 Silviculture Surveys .....	24
4.6 Whitebark Pine Specific Surveys .....	25
4.6.1 100 Tree Surveys.....	25
4.6.2 Permanent Monitoring Transects .....	25
4.6.3 Rare Plant Surveys .....	27
5 Timber Harvest .....	29
5.1 Layout .....	29
5.2 Buffering .....	30
5.3 Tree Falling and Retention .....	31

5.4	Skidding.....	33
6	Stand Tending .....	34
6.1	Pruning.....	34
6.2	Thinning .....	36
7	Reforestation .....	39
7.1	Cone Collections .....	39
7.1.1	Collection Plans.....	39
7.1.2	Seed Transfer Guidelines for Whitebark Pine.....	40
7.1.3	Seed Registration .....	40
7.1.4	Collection Obligations, Permits and Ethics.....	41
7.1.5	Cone Crop Forecasting .....	41
7.1.6	Stand Selections.....	42
7.1.7	Tree Selection .....	44
7.1.8	Constructing Cone Cages .....	45
7.1.9	Caging Cones.....	45
7.1.10	Cone Harvest Timing.....	48
7.1.11	Marking and Identification.....	49
7.1.12	Cone Handling.....	50
7.1.13	Field Handling and Transportation.....	51
7.1.14	Interim Storage .....	51
7.2	Seedling Planting.....	53
8	Additional Practices for Restoration .....	56
8.1	Verbenone Application .....	56
8.2	Transplanting or Salvage.....	56
8.3	Public Education.....	57
8.4	Involvement in Higher Level Recovery.....	58
8.4.1	White Pine Blister Rust Resistance Screening.....	58
8.4.2	Seed Production Areas.....	60
8.4.3	Prescribed Fire .....	60
9	Offsetting .....	61
9.1	Financial Contributions .....	62
10	Linking Best Management Practice with the Federal Recovery Strategy .....	63
10.1	Addressing Threats or Limitations .....	63

10.2	Operations Within Critical Habitat.....	66
10.2.1	Appropriate Identification of Critical Habitat .....	66
11	Applying Best Management Practices .....	68
11.1	Forestry.....	70
11.2	Mining and Mineral Exploration .....	72
11.3	Pipelines, Powerlines, and Towers.....	74
11.3.1	Pipelines.....	74
11.3.2	Powerlines.....	75
11.3.3	Towers.....	76
11.4	Ski Areas.....	79
11.5	Trail Based Recreation .....	81
11.6	Range Use .....	83
12	Literature Cited .....	85
13	Glossary.....	89
14	Appendices .....	92
14.1	Identification of Limber Pine, Whitebark Pine, and Western White Pine.....	92
14.2	Appendix 1: Blister Rust Survey and Monitoring Data Sheet.....	95
14.3	Appendix 2: Seedlot Registration Form .....	97

# 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. The 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. The cones remain on the branches unless removed by animals. 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 2). 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.).

## 1.3 Ecological Importance

Whitebark pine is a **foundation** and **keystone** species in high elevation ecosystems. The deep, spreading root system of the whitebark pine stabilizes slopes, reducing erosion and helping 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 1) 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



Figure 1. Clark's nutcracker (*Nucifraga columbiana*) collecting whitebark pine seeds. Photo by Ian Routley.

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. 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 (Pigott, 2012).

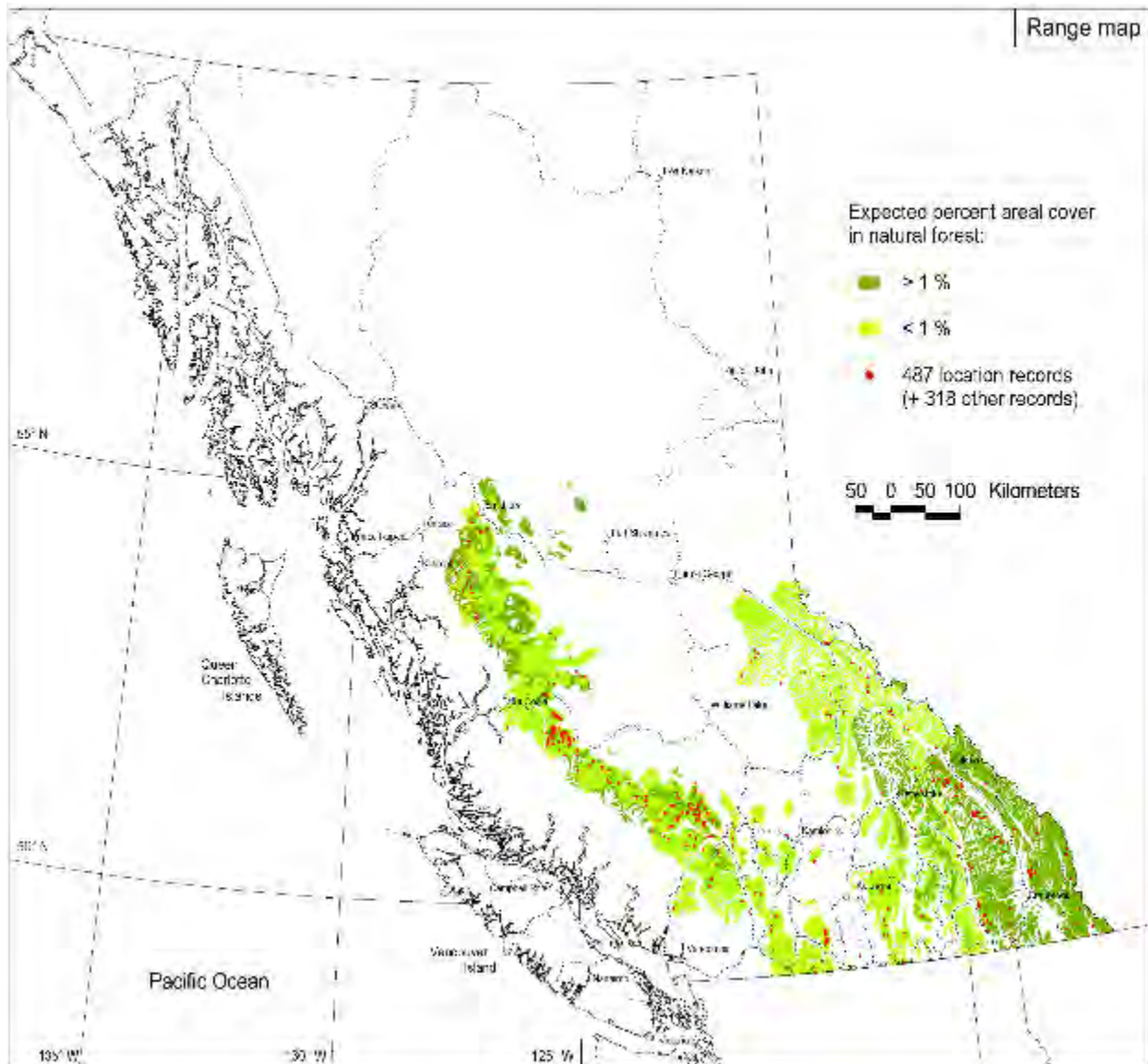


Figure 2. Canadian Range of Whitebark Pine.

## 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. 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 true 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. Whitebark pine are likely to be pushed higher in elevation, but on many sites, it already occupies the highest ground or higher elevation sites have poorly developed soils and provide poor habitat for whitebark pine. Climate change is also affecting the distribution of competing species, allowing subalpine fir, alpine larch and spruce to better survive and compete at higher elevations (Bentz et al., 2010; Logan and Powell, 2001). While new habitat may become available at the northern limit of the species range, occupying this habitat will rely on seed dispersal by Clark's nutcrackers, which 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 (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, particularly once 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 (2009)
- Promoting Whitebark Pine Recovery in British Columbia (2015)

### Alberta

- Alberta Whitebark Pine Recovery Plan 2013-18

### Canada







- Recovery Strategy for Whitebark Pine (*Pinus albicaulis*) in Canada [Proposed]
- Identification of Whitebark Pine Critical Habitat [Proposed]

## 1.6 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	Pipelines, Powerlines, and Towers	Ski Areas	Trail Based Recreation (Non-motorized and motorized)	Range Use
					

## 2 The Mitigation Hierarchy

The Province of BC has established an Environmental Mitigation policy to aid in mitigating environmental impacts during industrial development (Province of BC, 2014) [[www2.gov.bc.ca/assets/gov/environment/natural-resource-policy-legislation/environmental-mitigation-policy/em\\_procedures\\_may27\\_2014.pdf](http://www2.gov.bc.ca/assets/gov/environment/natural-resource-policy-legislation/environmental-mitigation-policy/em_procedures_may27_2014.pdf)]. The mitigation hierarchy follows a process from lowest environmental impact to greatest environmental impact, from Avoid to Offset. 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.

Although this process outlines procedural step, 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; however, they are generally allocated where they are most applicable. Guidelines for offsetting may include activities described in earlier sections of the hierarchy in addition to guidelines specific to the offsetting section.

Prior to initiating work and applying the principles of the mitigation hierarchy, the appropriate 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.

Avoid	<ul style="list-style-type: none"><li>• Buffers</li><li>• Layout</li></ul>
Minimize	<ul style="list-style-type: none"><li>• Pruning</li><li>• Thinning</li><li>• Timber Harvest</li><li>• Skidding</li><li>• Transplanting</li></ul>
Restore	<ul style="list-style-type: none"><li>• Cone Collections</li><li>• Seedling Planting</li></ul>
Offset	<ul style="list-style-type: none"><li>• Verbenone Application</li><li>• White Pine Blister Rust Resistance Screening</li><li>• Seed Orchards</li><li>• Seed Production Areas</li><li>• Seedling Production</li><li>• Prescribed Fire</li><li>• Public Education</li><li>• Financial Contributions</li></ul>

## 3 Training



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

- 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 or 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 has several distinguishing characteristics:

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

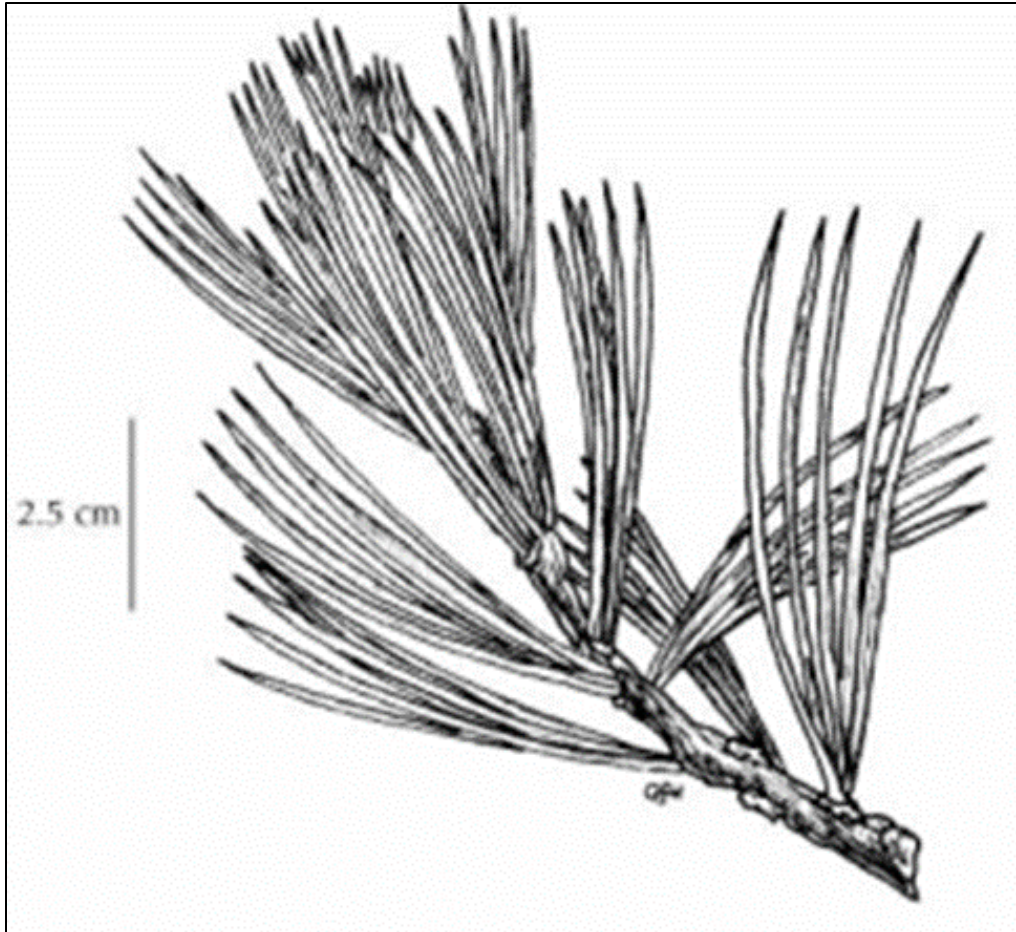


Figure 5. Whitebark pine needles in bundles of five (Illustrated Flora of BC. 1998).



Figure 6. Mature cones are egg shaped and purplish-brown in colour.



Figure 7. 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 8. 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 9) 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 10). 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 11). Over the next year or two, the fungus spreads toward the branches and trunk (Figure 12). 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 12). The white fruiting bodies in turn produce orange aeciospores that will be disseminated by the wind in spring, infecting *Ribes* plants (Figure 13). 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 10).

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 12, Figure 13);
- 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 14);
- 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 13, Figure 15);
- 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 16);
- 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 17).

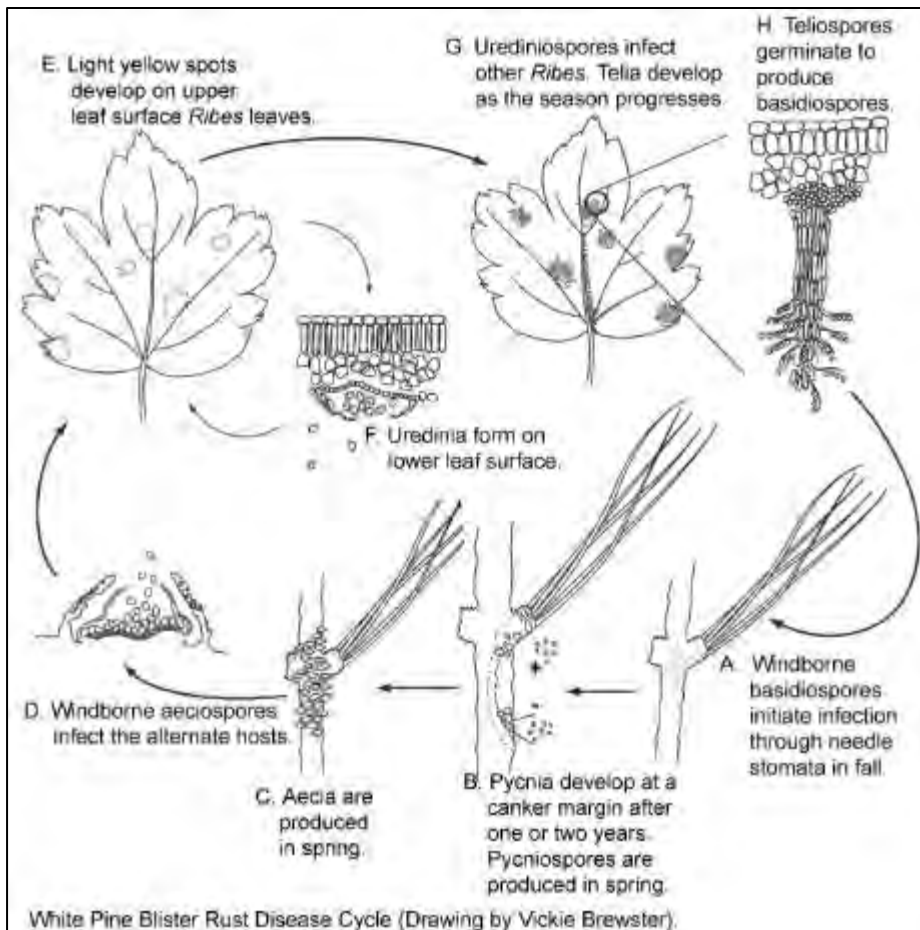


Figure 9. White pine blister rust life cycle (Drawing by Vickie Brewster)



Figure 10. Infected *Ribes* leaf showing telial columns.



**Figure 11. Initial infection via the needles.**



**Figure 12. Branch infection.**



Figure 13. Infection that has progressed to the stem.



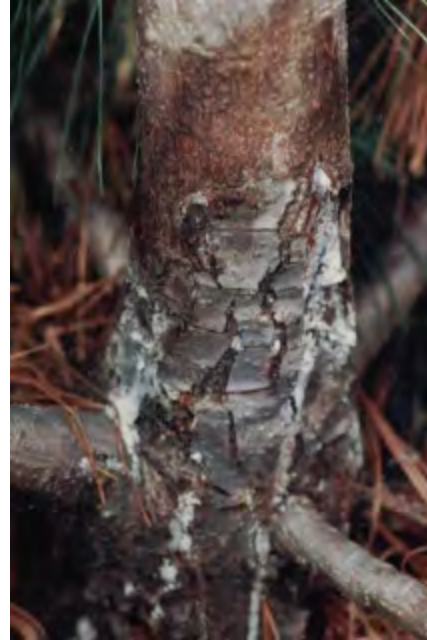
Figure 14. Diamond shaped white pine blister rust infection



**Figure 15. Old infection with roughened bark.**



**Figure 16. Chewing of rust by squirrels; in some cases, this chewing may kill the fungus and save the tree.**



**Figure 17. 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



The Clark's nutcracker (*Nucifraga columbiana*) is a medium-sized member of the Crow 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 18). 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.



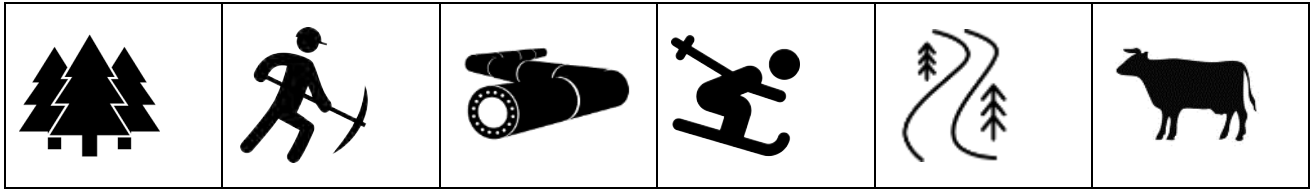
One of three species of nutcrackers worldwide, the Clark's nutcracker co-evolved with whitebark pine. These birds are specialist consumers and the primary disperser of whitebark pine seeds (Dohms and Davidson, 2015). They may range widely, searching for suitable cones for harvest and may be absent from 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.).

Figure 18. Clark's nutcracker.  
Photos by Ian Routley and Glenn Bartley.

#### TRAINING BMP'S

- 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: Surveys and Inventory



The objectives of surveys and inventory are to:

- Improve existing inventories;
- Improve whitebark pine distribution mapping;
- Improve whitebark pine habitat mapping;
- Improve the knowledge of stand health; and
- Improve utilization of existing inventories to improve awareness of potential whitebark pine at work sites.

Prior to any work in whitebark pine habitat, managers should first access existing survey data to determine if whitebark pine has already been documented in the study area.

Some existing survey methods may be utilized to capture whitebark pine information, with additional whitebark-specific surveys designed to assess stand health. Survey categories include:

- 1) Ecosystem Scale
  - i. Predictive Ecosystem Mapping (PEM);
  - ii. Terrestrial Ecosystem Mapping (TEM);
- 2) Mature Tree Scale
  - i. Vegetation Resources Inventory (VRI);
  - ii. Timber Cruising
- 3) Regeneration and Recruitment Scale
  - i. Silviculture Surveys;
- 4) Whitebark Pine Specific
  - i. 100 Tree Surveys;
  - ii. Permanent Monitoring Transects.

*Surveys and inventories can be greatly improved simply by ensuring whitebark pine is appropriately captured.*

### 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 [cdccdata@gov.bc.ca](mailto:cdccdata@gov.bc.ca) prior to data collection and submission to ensure appropriate data submission protocols are followed.

## 4.2 Ecosystem Mapping

Ecosystem mapping may involve either Predictive Ecosystem Mapping (PEM) or Terrestrial Ecosystem Mapping (TEM). Large landscape-scale projects may be less likely to capture sufficiently-detailed whitebark pine information, whereas mapping at smaller scales, say for example that of a mine development, is more likely to capture whitebark pine information at a more detailed level. PEM is often conducted using models which may not differentiate whitebark vs. non-whitebark ecosystems, whereas TEM projects are undertaken using detailed air-photo interpretation and a level of ground-truthing. 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. This is an important step as it will aid in identifying whitebark pine ecosystems during office classification. The potential for whitebark pine occurrence within specific BEC site series as well as the VRI is important information to review prior to field sampling and classification. This is particularly important prior to classification and inventory work within the elevational range of whitebark pine.

## 4.3 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 industrial companies are under pressure to better manage and protect the species. Currently, designation of critical habitat under SARA is linked to the basal area of whitebark pine within stands. Although it is not practical to rely on VRI to designate stands of critical habitat, it may be used to identify potential critical habitat that could then be confirmed following more detailed surveys.

VRI field crews should familiarize themselves with whitebark pine identification, particularly where it is a component of merchantable stands and may display good form.

## 4.4 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. This does little to inform resource managers about whitebark pine occurrences and importantly, the data to be gained from a cruise related to whitebark pine management can differ from the original objective of the cruise. Cruise data can be used to develop better whitebark pine information to aid in both recovery and timber harvest planning, as location of high density whitebark pine stands can be identified and specific recovery prescriptions developed.

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

Whitebark pine can be compiled separately (as Pa) but must be combined with lodgepole pine at the appraisal stage. Complete and accurate whitebark pine data capture would require an amendment to the Province of B.C. Coast or Interior Appraisal Manuals. Like lodgepole pine, whitebark pine should be ‘cruised’ at 12.5 cm DBH.

## 4.5 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. An improvement in silviculture survey practices that better record whitebark pine occurrence information is suggested. 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 more 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 (PI). Since Clark’s nutcrackers tend to cache seeds against stumps, rocks, or logs, surveyors should scan these locations for whitebark pine seedlings (Figure 19). Further, whitebark pine often grow in clusters due to nutcracker caching habits, so surveyors should watch for multiple seedlings in a single grouping.



Figure 19. Whitebark pine seedling in a typical caching location against a snag.

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.

## 4.6 Whitebark Pine Specific Surveys

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

### 4.6.1 100 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 trees are visually surveyed and cone collections made from the healthiest cohort in the stand.

### 4.6.2 Permanent Monitoring Transects

The Whitebark Pine Ecosystem Foundation has developed a broadly accepted means of establishing health monitoring transects to determine baseline health levels and to facilitate change-monitoring into

the future (Figure 20) (Tomback et al. 2005) [[www.whitebarkfound.org/wp-content/uploads/2013/10/Methods-for-Surveying-and-Monitoring-Whitebark-Pine-for-Blister-Rustx.pdf](http://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 pest increases;
- Develop realistic restoration success goals – without resistant stock can we expect restoration to be more successful than trends observed in local stands?
- Allow for targeted trend-based management; and
- Prioritize management actions where needed most (when transects are established across a broad landscape)



**Figure 20. Permanent monitoring transect established in the subalpine.**

The methods for transect establishment are detailed in Tomback et al. (2005). In general, transects are established along a 50m length, with 5 m strips on either side. The transect should be permanently marked to assist with future re-measurement. Along the transect, all trees greater than 1.4 m tall have height and diameter (DBH) recorded and are tagged for future monitoring (Figure 21). Health attributes are documented for all whitebark pine; including status of blister rust, mountain pine beetle, or other agents. To assist with remeasurement, standard protocols should be followed, such as always tagging trees on a given side or always sampling trees on the upper side of the transect. A sample Blister Rust

Survey and Monitoring Data Sheet is provided in Appendix 1: Blister Rust Survey and Monitoring Data Sheet.



Figure 21. Tree tag on permanently marked whitebark pine tree.

### 4.6.3 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](http://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.

## **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 ecosystem mapping, familiarize yourself with whitebark pine ecosystems in local subzones prior to field work and office classification;**
- **In timber cruises measure all whitebark pine over 12.5 cm DBH;**
- **Conduct some whitebark pine specific surveys at a regional scale to develop some assessment of regional health trends;**
- **Monument and map any tree that may be a candidate plus trees (display superior health relative to the stand); and**
- **Use surveys to determine if stands meet Critical Habitat Criteria as described in Section 10.**

## 5 Timber Harvest



Timber harvest in whitebark pine stands can negatively impact whitebark pine through direct tree removal or damage to retained healthy trees, but 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. Caution must be taken to limit stand conversion to non-whitebark species following harvest. 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. When harvesting in whitebark pine stands, care must be taken to implement management to maintain retained whitebark pine trees 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. 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 22);
- Ribbon out high-density areas as wildlife tree patches for retention;
- Map trees to assist in planning (Figure 23);
- Identify candidate plus trees in a unique manner to ensure retention on site;
- Align roads to avoid healthy whitebark pine;
- Design retention areas to ensure retained whitebark pine remain windfirm and are protected from damage during harvest.

*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.*



Figure 22. Whitebark pine trees marked by layout crew. note old verbenone patch on tree to left.

## 5.2 Buffering

Once whitebark pine have been identified and mapped, a plan should be made to buffer specific trees for retention. A buffer should be made around plus or candidate plus trees that keeps machinery off root zones of trees and to protect trees from mechanical damage caused by tree falling. When designing buffers, it may be best to buffer around small stands or patches as opposed to individual trees. Buffers are not required around terminally infected trees.

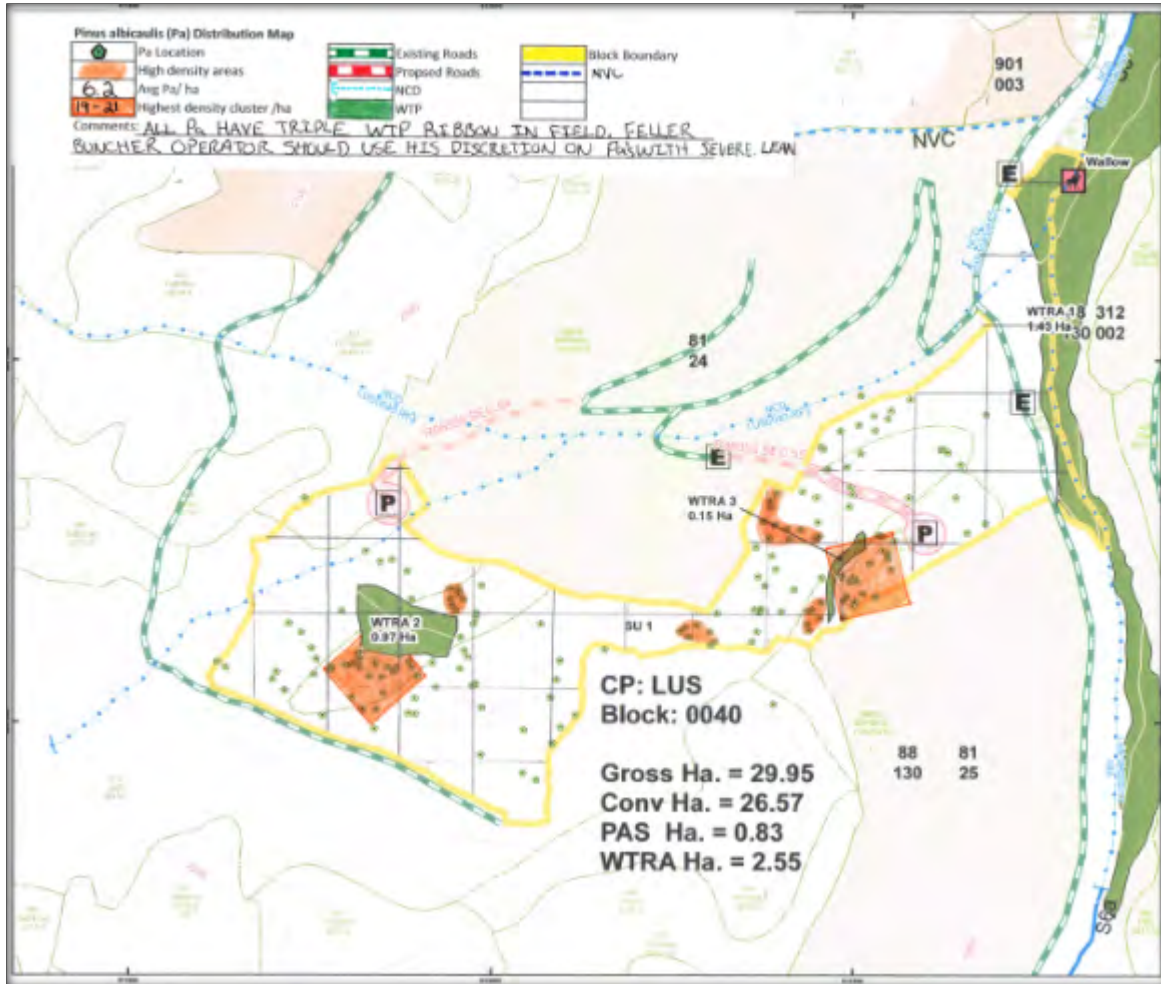


Figure 23. Map showing whitebark mapped during cutblock layout. Green areas are no-harvest reserves; orange blocks are high density whitebark pine; note tree marking and machinery operator notes. Layout map courtesy of Canfor.

### 5.3 Tree Falling and Retention

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 24).

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 must 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 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 24. 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 25). 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 25. Young whitebark pine growing against a decaying log.**

## 5.4 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, 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:

- Ensure machine-free zones designated for whitebark retention are clearly marked and mapped;
- Winter harvest to limit disturbance to roots and understory whitebark pine;
- Use higher stumps or rub trees to protect retained whitebark pine trees.

### **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 around plus trees and candidate plus trees.

#### **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.

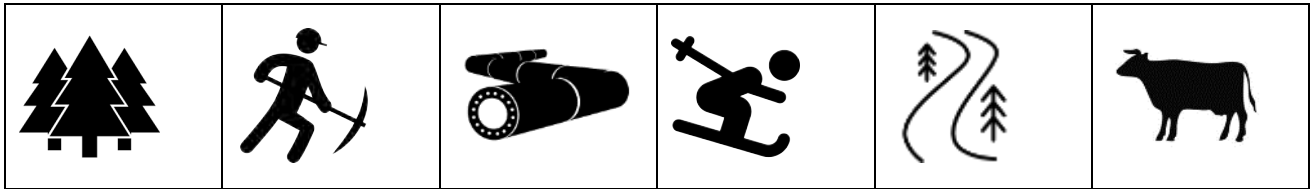
#### **TREE FALLING AND RETENTION**

- Train machinery operators to identify whitebark pine and develop protocols to ensure the retention of plus and candidate plus tree;
- Numerous heavily 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;
- Impact to advanced regeneration must be limited.

## 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 26). 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).



**Figure 26. Pruning on western white pine saplings.**

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:

- 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.

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 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 27).

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 27. Photo showing proper pruning cut around branch collar.

## 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; 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 28). 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.



**Figure 28. 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. The forest industry will have similar multiple options, as well as the potential to prescribe specific stocking standards to help achieve species management and 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.

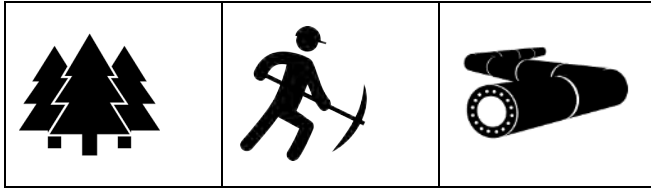
## **BEST MANAGEMENT PRACTICES FOR PRUNING**

- **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 27);**
- **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.**

## **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 the best trees as opposed to a certain density or basal area;**
- **Opening stand may expose retained trees to rust spores so do not thin on high rust hazard sites; 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. Whitebark pine seeds are highly preferred forage for Clark’s nutcrackers and squirrels, who will target cones prior to seed maturity. To protect cones from this significant foraging risk, they must be caged by employing the protocols described in the following section.

#### 7.1.1 Collection Plans

Prior to embarking on a seed collection project, there are several factors to consider:

- The volume of seeds or cones that you require to fulfill your needs. (Table 3);
- Current existing seed availability;
- Can your needs be combined with the needs of other potential users?
- 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.

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

**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 <sup>1</sup>	Cones per 1000 seedlings* <sup>2</sup>
50	8	50	2	1.3	3077	20	<b>52</b>
50	8	50	3	1.3	2051	20	<b>78</b>

<sup>1</sup>Cones required for 1000 seeds = 1000 ÷ avg. no. seeds per cone.

<sup>2</sup>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

The requirements and regulations with respect to seed registration, deployment and seed transfer are not clear, and are currently under review. The reasons include;

- Of the less than 60,000 whitebark pine seedlings planted in British Columbia to date, most have been planted in research trials and there has not been a strong requirement to resolve seed transfer issues;
- Under Sec 43 of the *Forest and Range Practices Act*, seed transfer rules and the requirements for seed registration only apply where the intent is to establish a free growing stand; no planting has been done for this purpose to date ;
- In BC, data is lacking to support seed transfer guidelines for whitebark pine. While trials have been established, currently, the default guidelines for seed transfer are relegated to the "Other species" (Table 4).

**Table 4. Current and proposed 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	Snetsinger (2010)
Interim Recommendations		+300	-400 <sup>1</sup>	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).								

<sup>1</sup>May be transferred lower if no suitable seed sources exist.

### 7.1.3 Seed Registration

Depending on how Section 43 is interpreted, 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 2: Seedlot Registration Form.

Seed collections for registration must meet the following criteria (Snetsinger, 2010):

- 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.

#### 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. In most years, it is near-impossible to have a negative impact on the number of cones available to wildlife, but in years where crops are not abundant, limit the number of cones collected.

#### 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 29). 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 29. Young conelets (l) and mature cones (r).

### 7.1.6 Stand 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. Mahalovich (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 30). 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. However, some believe that taller trees at lower elevations produce more cones with more viable seeds per cone. 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.



Figure 30. Heavily infected stand with high mortality; healthy trees in this stand are strong candidates for cone collection.

### 7.1.7 Tree Selection

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. To identify trees for selection

where blister rust pressure is low, selection criteria among rust-free individuals was simplified to: a minimum of 30% healthy, live green crowns, and bearing cones (Mahalovich, pers. comm.).

### 7.1.8 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 (Figure 31).

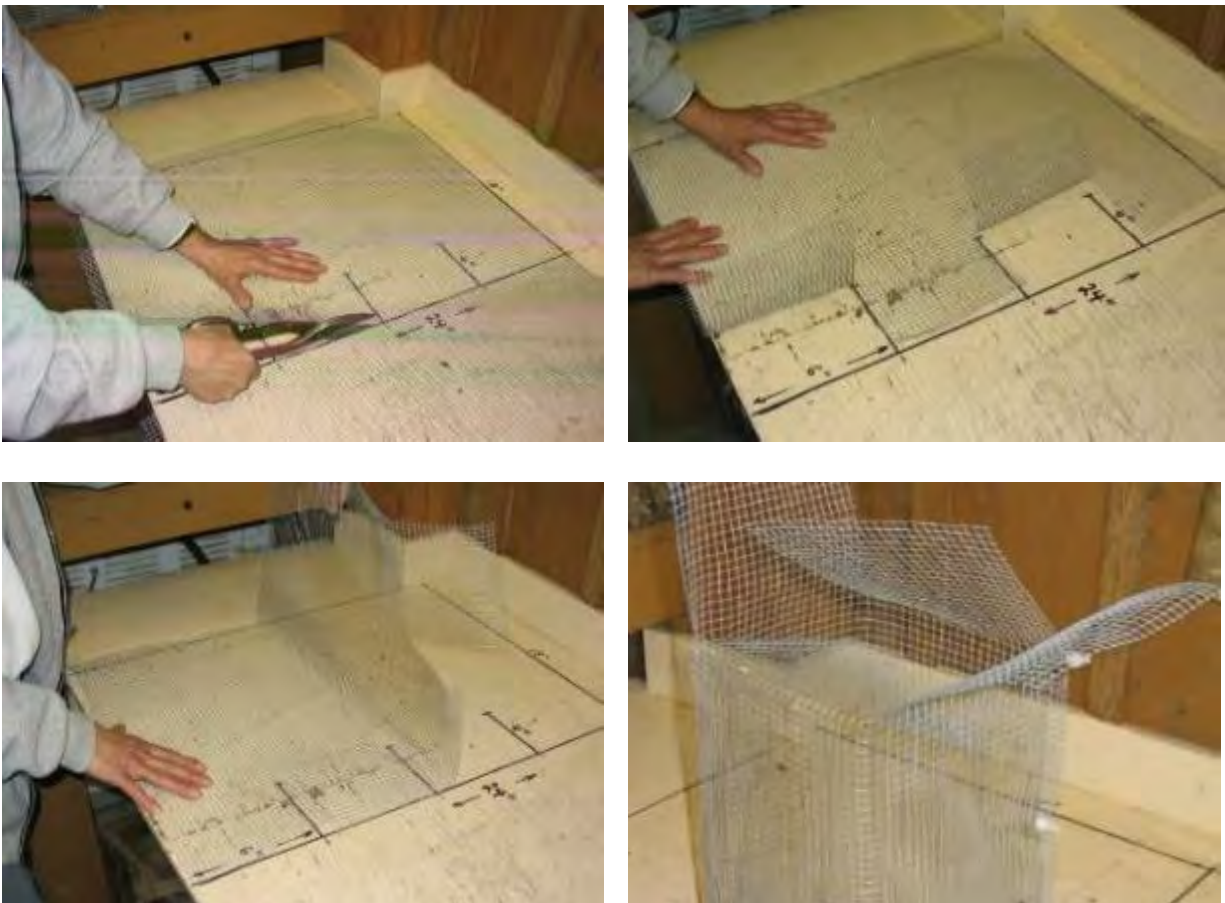


Figure 31. Constructing whitebark pine cages, note cut locations and depths.

### 7.1.9 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.

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 32, Figure 33). Try to minimize damage to the branch through abrasion.



**Figure 32. 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 33. 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 34);
- **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;
- **Tree tongs** - In the USA, cages have been installed with tongs from the ground. There has been mixed success with these cages as they tend to blow off in the wind;

- **Squirrel Caches** - Collecting cones from squirrel caches has been frowned upon, due to concerns about soil borne diseases, and uncertainty about from which trees the cones were collected. When seed supplies are in a critical short supply, and there are no other options. Squirrel caches are easily spotted by the abundance of cone scales and debris. Sometimes cones are visible on the surface of the cache or slightly buried.



**Figure 34.** Ladder used to gain access to tree top for cone collections; ladders such as this are only useful where there is good access.

#### **7.1.10 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 35). Seeds are mature enough to collect once the embryo fills 75-80% of the seed cavity, provided they are properly handled after harvest.



Figure 35. Cone knife used to evaluate the number of filled seeds and seed maturity.

#### 7.1.11 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 36). 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. 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](http://www.whitebarkpine.ca)).



Figure 36. Caged whitebark pine tree, with flagging and paint for marking; this tree was also tagged with a unique metal tag.

### 7.1.12 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 (not pillow cases as they don't tend to breathe). Every attempt should be made to keep the cones well ventilated and dry at the collection site, and during transport. Try to get them to an interim storage site as soon as possible.

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.

### 7.1.13 Field Handling and Transportation

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 37).



Figure 37. Racks in pickup truck to allow for air flow during transport.

### 7.1.14 Interim Storage

If cones must be kept in storage for any period of time, store in a covered, well ventilated area (Figure 38). 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 38. Interim cone storage on racks to allow ventilation.

## **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;
- 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

Objectives for seedling planting include:

- Increasing the deployment of whitebark pine seedlings;
- Improving the survival of whitebark pine seedlings;
- Improving the vigour of planted seedlings; and
- Increasing the frequency of desirable genes linked to White Pine blister rust resistance, on the landbase.

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 at present as whitebark pine seed is rarely collected and it often does not meet the standards of more broadly collected merchantable species. To overcome some existing barriers, the following avenues may be considered:

- **A Free Growing Stand is Not Being Established** - According to Section 43 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: 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% need not comply. (Government of BC 2018).

Whitebark pine seedlings are not been broadly available for purchase, and to date all planting of seedlings have required cone collections by the proponent. Additionally, no confirmed blister rust-resistant seedlings are available, and any seedling production requires a complex stratification phase followed by a longer-than-normal production period.

Planting whitebark pine seedlings is one of the top whitebark pine recovery actions, whether following timber harvest, during mine reclamation, 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 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.

*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.*

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
<b>Confirmed Resistance</b>	Seedling produced from seed harvested from a seed orchard consisting of multiple tested resistant parents, allowed to cross breed.	<b>High</b> – Both parents have demonstrated resistance.	Unavailable in foreseeable future (10 – 15 Years: 2028 – 2033)	Highest
<b>Suspected Resistance</b>	Seedlings produced from seed harvested from the original parent trees (plus trees) showing resistance traits in screening programs.	<b>Moderate to High</b> – Some resistance is likely present in population; only maternal genetics are controlled.	Limited (10 Years – 2028: Possibly less in some populations)	High
<b>Putative Resistance</b>	Seedlings produced from seed harvested from the original parent trees (plus trees) that appears to have resistance traits, but testing is incomplete or non-existent.	<b>Moderate to High</b> – Some resistance is likely present in population; some escapes may be part of this planting stock.	High (2019)	Moderate - High
<b>Bulk Collection</b>	Seedlings produced from bulk seed. Little may be known about individual parents.	<b>Low to High</b> – 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 (2019)	Lowest

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). Whitebark pine management goals must be reflected in the Silviculture Prescriptions. 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 400 stems/ha; which can be used to determine seedling numbers for a set area. Stocking standard could 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.

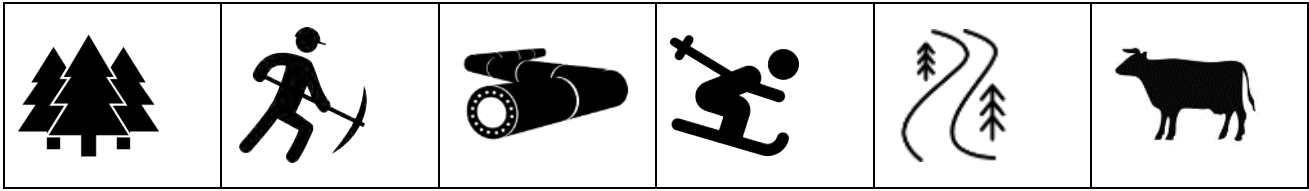
To improve non-rust related mortality, planting should be done to limit drought stress by selecting mesic sites or sites protected from desiccating winds, and high sun exposure (Figure 39) (McCaughey et al. 2009). Sites should be free of competition and swales subject to frost should be avoided ((McCaughey et al. 2009).The addition of mycorrhizal inocula in the nursery or at the time of planting may improve growth.



#### **BEST MANAGEMENT PRACTICES FOR PLANTING WHITEBARK PINE**

- **Plan planting well in advance, seedling production may take 2 years;**
- **Plant large, hardy seedlings;**
- **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;**
- **Plant well-spaced seedlings to site series specific densities;**
- **Plant in low operability sites 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;**
- **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 400 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](http://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 40).

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; may not yield surviving trees and little is known of the tree's genetics – it is likely being moved because it is a whitebark pine, not because it has demonstrated resistance. Seedlings production and planting are generally superior to transplanting;

however, there are some cases where transplanting in conjunction with other restoration work may be desirable.



Figure 40. 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 Public Education**

Supporting public education and outreach may be an effective means of offsetting, 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.

## 8.4 Involvement in Higher Level Recovery

Many whitebark pine recovery activities are led by provincial land managers or other higher-level practitioners and are unsuitable for licensees or tenure holders to unilaterally undertake. The following activities contribute to higher level species recovery and should be implemented in conjunction with provincial authorities.

### 8.4.1 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 of 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.

#### 8.4.1.1 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, or from grafted trees where the scion has come from the tested parents. 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.

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. 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 41). 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 41. 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 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 42).



**Figure 42. 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 technician 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.

### 8.4.2 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 43) (Pigott et al, 2015b).



Figure 43. 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 are established in areas that have been identified as resistant populations, significant gains can be realized via natural breeding.

### 8.4.3 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.

## 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; 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 often 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 the ability of a site to support a comparable stand of whitebark pine.
- **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 and habitat protection generally has low recovery gain for whitebark.
- **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 the currency is habitat, a multiplier to increase area is less important than ensuring the habitat is 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.

- **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. With respect to whitebark pine, this should include individuals or groups involved in rust screening.

## 9.1 Financial Contributions

In some cases, making financial contributions to whitebark pine recovery programs may be the best means to mitigate impacts, as these funds can be directed at programs or projects with strong recovery value. In some cases, mitigating local impacts may have minimal recovery gains which can be increased by providing financial support to projects with greater gains. To make financial contributions, funds can be sent to the BC Conservation Foundation (BCCF.com) under the guidance of the Whitebark Pine Ecosystem Foundation of Canada ([www.whitebarkpine.ca](http://www.whitebarkpine.ca)).

## 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	<ul style="list-style-type: none"> <li>Increase the frequency of trees with genetic resistance to blister rust.</li> </ul>	<ul style="list-style-type: none"> <li>Monitor stands for White Pine Blister Rust levels, identify environmental and stand-level characteristics that may indicate rust hazard levels;</li> <li>Protect putatively-resistant trees (enable the development and application of legal tools on provincial land),</li> <li>Collect seed for propagation and screening</li> <li>Support breeding and production programs to screen and propagate rust-resistant seedlings</li> <li>Use putatively-resistant seedlings in restoration plantings</li> </ul>	<ul style="list-style-type: none"> <li>Surveys and Inventory</li> <li>Layout</li> <li>Buffering</li> <li>Tree Falling and Retention</li> <li>Cone Collections</li> <li>Seedling Production</li> <li>Seedling Planting</li> <li>White Pine Blister Rust Resistance Screening</li> <li>Seed Orchards</li> <li>Seed Production Areas</li> </ul>
	Necessary	<ul style="list-style-type: none"> <li>Maximize stand-level resilience to blister rust epidemics</li> </ul>	<ul style="list-style-type: none"> <li>Plant resistant or putatively resistant seedlings on a range of sites representing a range of ecological conditions.</li> <li>Maintain a range of Whitebark Pine age classes across the landscape and within appropriate stands</li> </ul>	<ul style="list-style-type: none"> <li>Seedling Planting</li> <li>Buffering</li> <li>Tree Falling and Retention</li> <li>Pruning</li> <li>Thinning</li> </ul>
8.2 Mountain Pine Beetle	Necessary	<ul style="list-style-type: none"> <li>Minimize losses of Whitebark Pine trees and genetic diversity to mountain pine beetle.</li> </ul>	<ul style="list-style-type: none"> <li>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</li> <li>Assess Whitebark Pine genotypes for beetle resistance Identify Whitebark Pine stands currently</li> </ul>	<ul style="list-style-type: none"> <li>Surveys and Inventory</li> <li>Verbenone Application</li> </ul>

Threat or Limitation	Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches	Best Management Practices to Address Threat or Limitation
			or at-risk for infestation for the purpose of identifying high value trees.	
7.1 Fire and Fire Suppression	Necessary	<ul style="list-style-type: none"> <li>Minimize negative impacts of wildfire and/or prescribed fire in areas deemed important to Whitebark Pine recovery; facilitate recruitment and productivity.</li> </ul>	<ul style="list-style-type: none"> <li>Include Whitebark Pine in Fire Management Plans</li> <li>Identify and protect Whitebark Pine critical habitat in the vicinity of planned prescribed fire</li> <li>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</li> <li>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</li> <li>Plant Whitebark Pine seedlings post-burn</li> </ul>	<ul style="list-style-type: none"> <li>Surveys and Inventory</li> <li>Thinning</li> <li>Cone Collections</li> <li>Seedling Planting</li> </ul>
	Beneficial	<ul style="list-style-type: none"> <li>Assess the role of fire in promoting recruitment of Whitebark Pine within different forest types</li> </ul>	<ul style="list-style-type: none"> <li>Assess the response of Whitebark Pine to fire across forest types by monitoring seedling establishment and survival following fire</li> <li>Assess the reliance of Whitebark Pine to fire by characterizing recruitment opportunities within forest types and successional stages</li> </ul>	<ul style="list-style-type: none"> <li>Surveys and Inventory</li> </ul>
11 Climate Change	Necessary or Beneficial	<ul style="list-style-type: none"> <li>Ensure a sufficient amount of suitable habitat persists across current and potential range of Whitebark Pine</li> </ul>	<ul style="list-style-type: none"> <li>Identify suitable, or potentially suitable habitat that is unoccupied (present, future projections as indicated by climate models).</li> <li>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.</li> <li>Monitor and identify any new pest organisms that may become problematic.</li> </ul>	<ul style="list-style-type: none"> <li>Surveys and Inventory</li> <li>Cone Collections</li> <li>Seedling Planting</li> </ul>

Threat or Limitation	Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches	Best Management Practices to Address Threat or Limitation
Limited spatial data on extent of occurrence	Essential	<ul style="list-style-type: none"> <li>• Improve mapping and inventory data in order to meet objectives and address other threats</li> </ul>	<ul style="list-style-type: none"> <li>• Identify and map extent of White Pine Blister Rust infection and/or risk to infection across the species' range (and any other pathogens that are or may become problematic, e.g. Mountain Pine Beetle).</li> <li>• 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.</li> <li>• Update modeling and mapping to identify quality and quantity of existing or potentially suitable habitat as new climate data and technology become available.</li> <li>• Analyze spatial mapping data to identify any populations at-risk due to genetic isolation.</li> <li>• 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).</li> </ul>	<ul style="list-style-type: none"> <li>• Surveys and Inventory</li> </ul>
Loss of Genetic Diversity	Essential	<ul style="list-style-type: none"> <li>• Conserve genetic diversity represented among and within populations that may be lost by</li> <li>• rapid population decline and/or</li> <li>• increasing isolation of stands</li> </ul>	<ul style="list-style-type: none"> <li>• Develop and achieve targets for implementing ex-situ genetic conservation activities</li> <li>• including collections from across the range of the species.</li> <li>• Collect seed from Whitebark Pine in areas where it is at risk of extirpation and/or where stands are isolated.</li> </ul>	<ul style="list-style-type: none"> <li>• Surveys and Inventory</li> <li>• Cone Collections</li> </ul>

## 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<sup>2</sup>/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
<b>A) Stand of polygon with high density of whitebark pine of at least 2 m<sup>2</sup>/ha of healthy whitebark pine (high density whitebark pine polygon) (Seed Dispersal and Regeneration Habitat)</b>	<ul style="list-style-type: none"> <li>• Surveys and Inventory                             <ul style="list-style-type: none"> <li>- Timber Cruising</li> <li>- VRI</li> </ul> </li> <li>• Timber Harvest</li> <li>• Silviculture</li> </ul>	<ul style="list-style-type: none"> <li>• Do not harvest within self-replacing whitebark stands;</li> <li>• CH may be improved by harvest where competition levels are high and healthy whitebark are retained and protected.</li> </ul>
<b>1. Within high density whitebark pine polygon: Cone-bearing and/or non-terminally infected whitebark pine (CH – Seed Dispersal Habitat);</b>	<ul style="list-style-type: none"> <li>• Training</li> <li>• Layout</li> <li>• Buffers</li> </ul>	<ul style="list-style-type: none"> <li>• Flag trees meeting criteria and ensure retention;</li> <li>• Collect cones from putatively-resistant trees.</li> </ul>
<b>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)</b>	<ul style="list-style-type: none"> <li>• Surveys and Inventory                             <ul style="list-style-type: none"> <li>- VRI</li> <li>- Ecosystem Mapping</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Avoid soil disturbance in root zone around trees identified in b)</li> <li>• Maintain windfirmness.</li> </ul>
<b>3. Polygons with parkland opening greater than 0.5 ha, ecologically suited to whitebark pine, and within 2 km of a stand meeting criteria A (CH – Regeneration Habitat).</b>	<ul style="list-style-type: none"> <li>• Surveys and Inventory                             <ul style="list-style-type: none"> <li>- Timber Cruising</li> <li>- VRI</li> <li>- Ecosystem Mapping</li> </ul> </li> <li>• Seedling Planting</li> </ul>	<ul style="list-style-type: none"> <li>• Do not plant with non-whitebark pine species.</li> <li>• Reflect in silviculture prescriptions.</li> </ul>

Recovery Habitat		
<p><b>B) Research, monitoring, and recovery activities within the range of whitebark pine (CH – Recovery Habitat)</b></p>	<ul style="list-style-type: none"> <li>• Surveys and Inventory</li> <li>- Permanent Monitoring Transects</li> <li>• Thinning</li> <li>• Seedling Planting</li> <li>• Seed Orchards</li> <li>• Seed Production Areas</li> <li>• Prescribed burn areas</li> </ul>	<ul style="list-style-type: none"> <li>• Perform whitebark pine recovery activities.</li> </ul>

## 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 44). 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 as grizzly bear and caribou.



Figure 44. Graphic showing constraints that must be considered when developing or implementing BMPs.



Figure 45. Clark's nutcracker in a whitebark pine tree.

## 11.1 Forestry



Whitebark pine generally occurs in high-elevation, non-productive forests, but may still occur within areas of the timber harvesting landbase and be damaged or harvested as ‘by-catch’ with the primary species. 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.

Forest professionals operating regularly in whitebark pine stands should consider activities listed in the Whitebark Pine Dedicated Management tab in addition to those listed in the Planning and Operations tabs.

Mitigation Hierarchy	Inventory	Harvest	Silviculture
<b>Avoid</b>	<ul style="list-style-type: none"> <li>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.</li> </ul>	<ul style="list-style-type: none"> <li>Flag all trees and patches that must be retained during harvest;</li> <li>Buffer all plus trees and high density regeneration to protect trees and rooting zones;</li> <li>Create good tree maps for operators;</li> <li>Train operators to identify healthy whitebark pine;</li> <li>Move road locations around whitebark pine.</li> </ul>	<ul style="list-style-type: none"> <li>Do not cut whitebark pine during thinning or brushing operations.</li> </ul>
<b>Minimize</b>	<ul style="list-style-type: none"> <li>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.</li> </ul>	<ul style="list-style-type: none"> <li>Layout crews must map and mark all healthy whitebark pine for retention and identify infected trees permitted for removal;</li> <li>Roads must be routed around healthy whitebark pine, unhealthy trees may be removed;</li> <li>Conduct winter harvest to reduce impacts to regen and rooting zones.</li> </ul>	<ul style="list-style-type: none"> <li>Collect local seed to maintain genetic diversity when some trees must be harvested;</li> <li>Promote alternate food sources for the Clark’s nutcracker, namely Douglas-fir and Ponderosa Pine;</li> <li>Pruning may be an alternative to cutting whitebark pine when the low branches impeded clearance;</li> </ul>

Mitigation Hierarchy	Inventory	Harvest	Silviculture
			<ul style="list-style-type: none"> <li>Minimize competition around planted or advanced regen whitebark pine.</li> </ul>
Restore	<ul style="list-style-type: none"> <li>Use surveys and inventories to identify plus trees for cone collections to be used in restoration programs;</li> <li>Establish rust monitoring transects to determine expected baselines for restoration success levels.</li> </ul>	<ul style="list-style-type: none"> <li>Use harvest as a restoration tool by retaining mature healthy whitebark pine and creating recruitment opportunities by harvesting competing tree species.</li> </ul>	<ul style="list-style-type: none"> <li>Retain primarily healthy whitebark pine during thinning operations;</li> <li>Document whitebark pine in silviculture surveys to determine seedling needs;</li> <li>Collect cones from putatively resistant parent trees;</li> <li>Plant whitebark pine seedlings in designated and ecologically suitable standards units to limit competition, future harvest, and to facilitate seedling survival monitoring;</li> <li>Where appropriate, plant alternate food sources for the Clark's nutcracker, namely Ponderosa Pine and Douglas-fir.</li> </ul>
Offset			<ul style="list-style-type: none"> <li>Remove competition from around whitebark pine trees;</li> <li>Plant whitebark pine seedlings in non-harvest areas such as old burns or whitebark pine stands with high rust or mountain pine beetle mortality;</li> <li>Support rust screening programs;</li> <li>Establish seed production areas;</li> <li>Support habitat restoration programs.</li> </ul>

## 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
<b>Avoid</b>	<ul style="list-style-type: none"> <li>• Train all field workers;</li> <li>• review existing TEM and VRI mapping to identify likelihood of encountering whitebark pine in exploration areas;</li> <li>• Drill pads must avoid healthy whitebark pine;</li> <li>• Roads must be routed around healthy whitebark pine.</li> </ul>	<ul style="list-style-type: none"> <li>• Ensure whitebark pine is identified;</li> <li>• Identify patches or individual whitebark pine to avoid during operations;</li> <li>• Identify areas of Critical Habitat.</li> </ul>	<ul style="list-style-type: none"> <li>• Route access roads around whitebark pine.</li> </ul>	<ul style="list-style-type: none"> <li>• Route access roads around whitebark pine.</li> </ul>	
<b>Minimize</b>	<ul style="list-style-type: none"> <li>• Prune trees to accommodate access and development as opposed to tree cutting.</li> </ul>		<ul style="list-style-type: none"> <li>• Identify high density whitebark pine stands during mapping and avoid impacts to these areas for as long as possible;</li> <li>• Transplant healthy whitebark pine saplings;</li> <li>• Retain alternate food species such as Douglas-fir and Ponderosa Pine,</li> </ul>		

Mitigation Hierarchy	Exploration	Assessment	Construction	Operations	Closure and Reclamation
			where appropriate; <ul style="list-style-type: none"> <li>Plan any tree removal for after cones have been harvested by wildlife.</li> </ul>		
<b>Restore</b>	<ul style="list-style-type: none"> <li>Conduct progressive reclamation by planting whitebark pine on roads and pads where mine development is not going to occur.</li> <li>Document habitat area and number of healthy trees impacted to ensure restoration is sufficient.</li> </ul>	<ul style="list-style-type: none"> <li>Identify areas of Critical Habitat and number of plus trees to be disturbed during mine development.</li> </ul>	<ul style="list-style-type: none"> <li>Collect seed from local trees prior to removal;</li> <li>In high rust areas collect scion material from the healthiest cohort if tree removal is required.</li> </ul>	<ul style="list-style-type: none"> <li>Plan for restoration by collecting seed, conducting field trials and participating in rust resistance screening programs;</li> </ul>	<ul style="list-style-type: none"> <li>Map reclamation to identify ecologically suitable sites for whitebark pine planting;</li> <li>Collect seed and grow seedlings;</li> <li>Plant whitebark pine seedlings;</li> <li>Participate in rust screening programs;</li> <li>Establish nutcracker cues on sites such as rocks and stumps;</li> <li>Plant alternate food sources including Douglas-fir and Ponderosa Pine, where appropriate.</li> <li>Establish health transects in planting area and adjacent undisturbed habitat to determine if planting survival is within normal variability.</li> </ul>
<b>Offsetting</b>	<ul style="list-style-type: none"> <li>Document habitat area and number of healthy trees impacted to ensure restoration is sufficient.</li> </ul>				<ul style="list-style-type: none"> <li>Some offsetting is required to compensate for temporal losses;</li> <li>Compare initial baselines to planted whitebark pine areas to determine spatial changes;</li> <li>Identification of rust resistant stock may be viewed as a net positive impact (NPI).</li> </ul>

## 11.3 Pipelines, Powerlines, and Towers



Pipelines, powerlines, and towers present unique scenarios as they tend to be more discrete with respect to their impact on whitebark pine habitat but may cumulatively have significant impacts on whitebark pine and its habitat. Unlike forestry and mining, these installations, should be viewed as permanent.

### 11.3.1 Pipelines

Several British Columbia pipelines have been proposed that may potentially traverse areas where whitebark pine occurs. While some have been temporarily postponed or abandoned entirely, it is highly likely that eventually one or more pipeline will be constructed through whitebark pine habitat. Several companies that have proposed and mapped routes for pipelines have identified where whitebark pine occurred on the proposed alignments, and had contacted consultants experienced with whitebark pine, about best management practices.

Pipelines are built using an alignment sheet. This is a blueprint showing the exact route of the pipeline and virtually all the knowledge that existed for that pipeline when built. 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 46. 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 47. Powerline right-of-way in whitebark pine habitat.**

### **11.3.3 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 48 Communication towers in whitebark pine habitat.**

Mitigation Hierarchy	Planning	Clearing	Construction	Restoration
<b>Avoid</b>	<ul style="list-style-type: none"> <li>• Train all field workers</li> <li>• Review VRI maps and ecosystem maps for potential presence of whitebark pine in work area;</li> <li>• Determine if any habitat can be classified as Critical Habitat;</li> <li>• Adjust locations of access roads and development to avoid whitebark pine.</li> </ul>	<ul style="list-style-type: none"> <li>• Flag all healthy whitebark identified for retention;</li> <li>• Adjust locations of access roads and development to avoid whitebark pine.</li> </ul>	<ul style="list-style-type: none"> <li>• Avoid damaging retained trees by buffering or other means of protecting trees and rooting zones.</li> </ul>	
<b>Minimize</b>		<ul style="list-style-type: none"> <li>• Prune trees to accommodate access and development, where feasible.</li> <li>• Plan any tree removal for after cones have been harvested by wildlife.</li> </ul>		
<b>Restore</b>	<ul style="list-style-type: none"> <li>• Collect cones from healthiest trees and initiate rust screening process;</li> <li>• Collect cones to support future restoration program.</li> </ul>	<ul style="list-style-type: none"> <li>• Collect cones and scion material from the healthiest trees prior to clearing;</li> <li>• Collect cones to support future restoration program.</li> </ul>		<ul style="list-style-type: none"> <li>• Plant whitebark pine seedlings on decommissioned roads;</li> <li>• Place rocks and stumps on restoration sites to provide caching cues and protect seedlings;</li> <li>• At towers opportunities for seedling trials may be present.</li> </ul>
<b>Offset</b>	<ul style="list-style-type: none"> <li>• Determine area of Critical Habitat and number of individual healthy trees impacted by development.</li> </ul>			<ul style="list-style-type: none"> <li>• Conduct offsets to compensate for area of habitat not restored, number of mature trees disturbed, and temporal losses in ecosystem services.</li> </ul>

## 11.4 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](http://whitebarkfound.org/ski-area-certification)].



**Figure 49. Whitebark pines tree cut to create more open slopes for skiing.**

Mitigation Hierarchy	Ski Area Maintenance
Avoid	<ul style="list-style-type: none"> <li>• Train workers;</li> <li>• Inventory whitebark pine in ski area and mark plus trees to be retained during all run creation and maintenance activities;</li> <li>• Limit skier impacts by not creating trails or runs in high density stands;</li> <li>• Do not cut whitebark pine to build heli pads..</li> </ul>
Minimize	<ul style="list-style-type: none"> <li>• Remove only terminally infected whitebark pine during glading activities;</li> <li>• Prune branches as opposed to cutting trees to create tree skiing opportunities.</li> </ul>
Restore	<ul style="list-style-type: none"> <li>• Support or permit cone collections in ski area;</li> <li>• Identify and implement restoration that coincides with ski area management such as thinning competition and planting seedlings where appropriate;</li> <li>• Conduct outreach and include volunteers in restoration;</li> <li>• Apply verbenone to protect plus trees..</li> </ul>
Offset	<ul style="list-style-type: none"> <li>• Get certified as a whitebark pine friendly ski area</li> <li>• Assist with additional restoration efforts.</li> </ul>

## 11.5 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](https://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 50. Branch stub left after improper pruning to widen trail access; branch should have been cut to stem.



Figure 51. Mountain biking through whitebark pine stands in the South Chilcotin.

Mitigation Hierarchy	Trail Planning	Trail Building
<b>Avoid</b>	<ul style="list-style-type: none"> <li>Review VRI maps and ecosystem maps to determine if whitebark pine is likely to be present;</li> <li>Train all field workers;</li> <li>Re-route trail around whitebark pine, with enough buffer to protect rooting zones.</li> </ul>	<ul style="list-style-type: none"> <li>Train trail builders;</li> <li>Ribbon trees and patches for retention,</li> <li>Do not excavate in rooting zones.</li> </ul>
<b>Minimize</b>	<ul style="list-style-type: none"> <li>Identify areas where avoidance is not possible and identify ways to minimize impact such as pruning or prioritizing the retention of the healthiest trees.</li> </ul>	<ul style="list-style-type: none"> <li>Prune trees to create openings as opposed to cutting trees.</li> </ul>
<b>Restore</b>	<ul style="list-style-type: none"> <li>Conduct outreach campaign to make public aware that trails were planned to retain whitebark pine.</li> </ul>	<ul style="list-style-type: none"> <li>Place educational signs regarding whitebark pine.</li> <li>Provide locations of candidate plus trees to recovery practitioners.</li> </ul>
<b>Offset</b>		<ul style="list-style-type: none"> <li>Assist with additional restoration efforts.</li> </ul>

## 11.6 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 pine 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	<ul style="list-style-type: none"> <li>Review VRI maps to identify potential areas where range use overlaps with whitebark pine;</li> <li>Restrict cattle from whitebark pine habitat through the use of fencing, particularly where seedlings and saplings may be trampled,</li> <li>Horse outfitters should be trained to identify whitebark pine and not cut for firewood or use for backcountry infrastructure.</li> </ul>
Minimize	<ul style="list-style-type: none"> <li>Restrict cattle from whitebark pine habitat through the use of salt block placement and watering;</li> <li>Prune whitebark pine to create open areas.</li> </ul>
Restore	<ul style="list-style-type: none"> <li>Guide outfitters should report locations of healthy whitebark pine trees to recovery personnel;</li> <li>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.</li> </ul>
Offset	<ul style="list-style-type: none"> <li>Assist with additional restoration efforts.</li> </ul>



Figure 52. Cattle grazing in whitebark pine stands near Lillooet.

## 12 Literature Cited

- Alberta Whitebark and Limber Pine Recovery Team. 2014. Alberta Limber Pine Recovery Plan 2014-2019. Alberta Species at Risk Recovery Plan No. 35. Alberta Environment and Sustainable Resource Development, Edmonton, AB.
- Arno, S.F. and R.J. Hoff. 1989. Silvics of Whitebark Pine (*Pinus albicaulis*). Gen. Tech. Rep. INT-253. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.
- Arno, S. F. 1986. Whitebark Pine Cone Crops – A Diminishing Source of Wildlife Food? *Western Journal of Applied Forestry*, 1:92-94.
- Barringer, L.E., D.F. Tomback, M.B. Wunder, and S.T. McKinney. 2012. Whitebark Pine Stand Condition, Tree Abundance, and Cone Production as Predictors of Visitation by Clark's Nutcracker. *PLoS One*, 7(5): e37663.
- Bentz, B.J., J. Régnière, C.J. Fettig, E.M. Hansen, J.L. Hayes, J.A. Hicke, R.G. Kelsey, J.F. Negrón, and S.J. Seybold. 2010. Climate Change and Bark Beetles of the Western United States and Canada: Direct and Indirect Effects. *Bioscience*, 60(8): 602–613.
- Bockino, N.K. and D.B. Tinker. 2012. Interactions of White Pine Blister Rust and Mountain Pine Beetle in Whitebark Pine Ecosystems in the Southern Greater Yellowstone Area. *Natural Areas Journal*, 32(1): 31-40.
- Canfor SWP. 2016. Standard Work Procedure for: Whitebark Pine.
- Carroll, A.L., S.W. Taylor, J. Régnière, and L. Safranyik. 2003. Effects of Climate Change on Range Expansion by the Mountain Pine Beetle in British Columbia. In: T.L. Shore, J.E. Brooks, and J.E. Stone (Editors). *Mountain Pine Beetle Symposium: Challenges and Solutions*. October 30-31, 2003, Kelowna, British Columbia. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Information Report BC-X-399, Victoria, BC. pp. 223-232.
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2010. Assessment and Status Report on the Whitebark Pine *Pinus albicaulis* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON.
- Dohms, K.M. and Davidson, P.J.A. 2015. Clark's Nutcracker in Davidson, P.J.A., R.J. Cannings, A.R. Couturier, D. Lepage and C.M. DiCorrado (eds.). *The Atlas of the Breeding Birds of British Columbia, 2008-2012*. Bird Studies Canada, Delta. B.C.  
<http://www.birdatlas.bc.ca/accounts/speciesaccount.jsp?sp=CLNU&lang=en>
- Farnes, P.E. 1990. SNOTEL and Snow Course Data Describing the Hydrology of Whitebark Pine Ecosystems. In: W.C. Schmidt, K.J. McDonald (Compilers). *Proceedings Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource*. Gen. Tech. Rep. INT-270. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT. pp. 302-304.
- Farrar, J. L. 1995. *Trees in Canada*. Fitzhenry and Whiteside Ltd. and the Canadian Forest Service, Natural Resources Canada, Ottawa, ON.

Genetic Conservation Technical Advisory Committee. 2009. Genetic Conservation Strategy for Whitebark Pine in British Columbia. Forest Genetics Council of BC. <http://www.fgcouncil.bc.ca/GCTAC-WhitebarkPine-GenConsStrat-BC-2009.pdf>.

Goheen, E.M., D.L. Goheen, K. Marshall, R.S. Dancho, J.A. Petrick, and D.E. White. 2002. The status of whitebark pine along the Pacific Crest National Scenic Trail on the Umpqua National Forest. General Technical Report-Pacific Northwest Research Station, USDA Forest Service. 2002(PNW-GTR-530).

Government of BC. 1996. Pine Stem Rust Management Guidebook. Forest Practices Code Guidebook.

Government of BC. 2018. Chief Forester's Standards for Seed Use. Amendments to the Standards 2018. [www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/tree-seed/legislation-standards/chief\\_foresters\\_standards\\_for\\_seed\\_use\\_april\\_6\\_2018\\_amendments.pdf](http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/tree-seed/legislation-standards/chief_foresters_standards_for_seed_use_april_6_2018_amendments.pdf)

Government of BC. 2014. Procedures for Mitigating Impacts on Environmental Values (Environmental Mitigation Procedures) Version 1.0. [https://www2.gov.bc.ca/assets/gov/environment/natural-resource-policy-legislation/environmental-mitigation-policy/em\\_procedures\\_may27\\_2014.pdf](https://www2.gov.bc.ca/assets/gov/environment/natural-resource-policy-legislation/environmental-mitigation-policy/em_procedures_may27_2014.pdf)

Government of BC. 2018. Forest and Rang Practices Act. [Act Current to March 14, 2018]. [http://www.bclaws.ca/Recon/document/ID/freeside/00\\_02069\\_01](http://www.bclaws.ca/Recon/document/ID/freeside/00_02069_01)

Illustrated Flora of BC. 1998. Douglas, G.W., G.B. Straley, D.V. Meidinger, and J. Pojar (editors). *Volume 1: Gymnosperms and Dicotyledons (Aceraceae Through Asteraceae)*. B.C. Ministry of Environment, Lands & Parks and B.C. Ministry of Forests. Victoria.

Lanner, R.M. 1990. Biology, taxonomy, evolution and geography of stone pines of the world. pp. 14–23, in W.C. Schmidt and K.J. McDonald (compilers). Symposium on whitebark pine ecosystems: ecology and management of a high–mountain resource. USDA Forest Service, General Technical Report GTR–INT–270.

Logan, J. A. and J.A. Powell. 2001. Ghost forests, global warming, and the mountain pine beetle (Coleoptera: Scolytidae). *American Entomologist* 47:160-173.

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

Lorenz, T. J., K.A. Sullivan, A.V. Bakian, and C.A. Aubry, 2011. Cache-site selection in Clark's Nutcracker (*Nucifraga columbiana*). *The Auk*, 128: 237-247.

MacKillop, D.J. and A.J. Ehman. 2016. Land Management Handbook 70. A field guide to site classification and identification for southeast British Columbia: The south-central Columbia Mountains; also includes a supplement for four Biogeoclimatic Subzones/Variants in the Boundary Okanagan. BC Ministry of Forests, Lands, and Natural Resource Operations.

Mahalovich, M. F., K.E. Burr, and D.L., Foushee, 2006. Whitebark pine germination, rust resistance, and cold hardiness among seed sources in the Inland Northwest: planting strategies for restoration. USDA forest service proceedings RMRS-P-43, 91-101.

McCaughey W, Scott GL, Izlar KL. 2009. Technical note: whitebark pine planting guidelines. *Western Journal of Applied Forestry*. Jul 1;24(3):163-6.

Murray, M.P. and J. Krakowski. 2013. *Silvicultural Options for the Endangered Whitebark Pine*. [http://www.fgcouncil.bc.ca/Whitebark\\_Pine\\_Silviculture\\_2013.pdf](http://www.fgcouncil.bc.ca/Whitebark_Pine_Silviculture_2013.pdf).

Ogilvie, R.T. 1990. Distribution and ecology of whitebark pine in Western Canada. pp. 54–60, in W.C. Schmidt and K.J. McDonald (compilers) *Symposium on whitebark pine ecosystems: ecology and management of a high mountain resource*. USDA Forest Service, General Technical Report GTR–INT–270.

Pigott, D. 2012. *Whitebark Pine in British Columbia*. Forest Genetics Council of BC. Retrieved from [http://www.fgcouncil.bc.ca/Factsheet1-WhiteBarkPine\\_2011.pdf](http://www.fgcouncil.bc.ca/Factsheet1-WhiteBarkPine_2011.pdf).

Pigott, D., R. Moody, and A. Clason. 2015a. *Promoting Whitebark Pine Recovery in British Columbia*. Prepared for: The Society of Ecosystem Restoration of North Central BC and BC Ministry of Forests, Lands, and Natural Resource Operations.

Pigott, D, R. Moody, and M. Murray. 2015b. Whitetail Lake whitebark pine seed production area. TIC Talk, Forest Genetics Council of BC. [http://www.fgcouncil.bc.ca/TICTalk2015\\_Vol12\\_Feb18\\_2015.pdf](http://www.fgcouncil.bc.ca/TICTalk2015_Vol12_Feb18_2015.pdf)

Poulton, D.W., 2014. *Biodiversity offsets: A primer for Canada*. *Browser*.

Schaming, T.D., 2015. Population-Wide Failure to Breed in the Clark's Nutcracker (*Nucifraga columbiana*). *PloS one*, 10(5), p.e0123917.

Schnepf C., Schwandt J.W. 2006. *Pruning western white pine: a vital tool for species restoration*. University of Idaho Cooperative Extension System.

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

Snetsinger, J. 2010. *Chief Forester's Standards for Seed Use*. BC Ministry of Forests, Lands, and Natural Resource Operations.

Sturdevant, N., B. Lockman, C. Anibaldi, B. Erickson, S. Kegley and C. Hayes, 2015. *Reducing Individual Tree Susceptibility to Mountain Pine Beetle by Pruning and Daylighting; a Case Study at Mink Peak, Superior Ranger District, Lolo National Forest, Montana*. USDA Forest Service, Northern Region, Forest Health Protection.

Taylor, S.W., A.L. Carroll, R.I. Alfaro, and L. Safranyik. 2006. Forest, climate and mountain pine beetle outbreak dynamics in western Canada. pp. 67–94, in L. Safranyik and W.R. Wilson (eds), *The Mountain Pine Beetle: a synthesis of biology, management, and impacts on lodgepole pine*. Canadian Forest Service, Pacific Forestry Centre, Victoria, BC.

Tomback, D. F., R. E. Keane, W. W. McCaughey, and C. M. Smith. 2005. *Methods for surveying and monitoring whitebark pine for blister rust infection and damage*. Whitebark Pine Ecosystem Foundation, Missoula, Montana. 30 pp. <http://whitebarkfound.org/wp-content/uploads/2013/07/Methods-for-Surveying-and-Monitoring-Whitebark-Pine-for-Blister-Rust.pdf>.

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

Tomback, D.F. 1982b. The central role of Clark's Nutcracker in the dispersal and establishment of whitebark pine. *Oecologia* 55: 192–201.

USDA. 2011. Caching at the Microsite Scale: Clark's nutcracker cache site selection, Part III. United States Department of Agriculture. Forest Service. Pacific Northwest Region.

Zeglen, S. 2008. Pruning of Western White Pine in British Columbia. In: *Proceedings of 3rd Western White Pine Management Conference*. Vernon, BC. June 17-18, 2008. M. Cleary Editor.



## 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.

**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.

**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 seed 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

### 14.1 Identification of Limber Pine, Whitebark Pine, and Western White Pine

Characteristic	Whitebark pine	Limber pine	Western White pine
<b>Tree form</b>	Single stem when with competition. Multi-stem when open grown, and at higher elevations. Mature trees can be 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
<b>Seed Cones</b>	Roundish cones that do not open when dry. Very hard, 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.
<b>Seeds</b>	Wingless seeds, ovoid Light brown color. 1 cm diameter	Wingless, light brown seeds. Oblong, more pointed. Often a dark spot on the seed. 1 cm length	Seeds have wings. Smaller than limber or whitebark pine. Slightly rounder.
<b>Pollen Cones</b>	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.
<b>Needles</b>	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
<b>Bark</b>	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.
<b>Habitat</b>	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

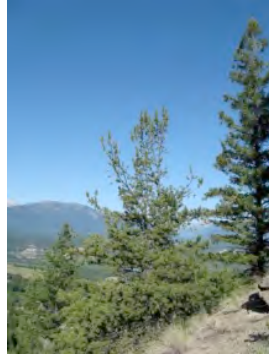


Immature



Mature

## Limber pine



Immature

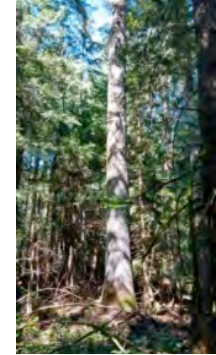


Mature

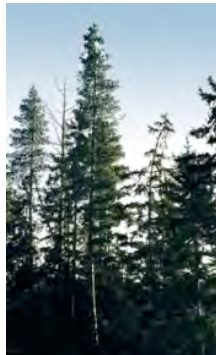
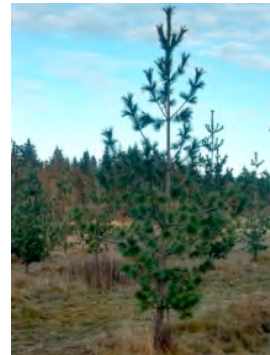
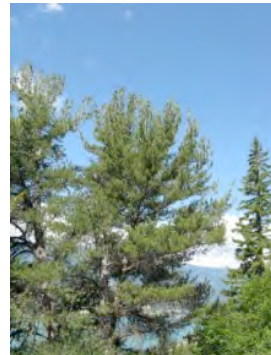
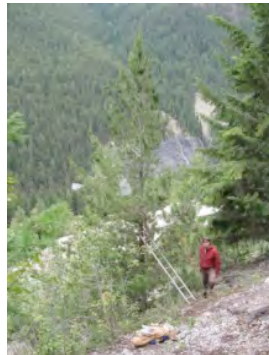
## Western White pine



Immature



Mature



## 14.2 Appendix 1: Blister Rust Survey and Monitoring Data Sheet

**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
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											
31											
32											
33											
34											
35											
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											
46											
47											
48											
49											
50											
51											
52											
53											
54											
55											

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

## 14.3 Appendix 2: Seedlot Registration Form

Seed Planning and Registry System Seedlot Registration Report			
<b>Interim Number :</b>		<b>Seedlot Number:</b>	
<b>General Lot Information</b>			
To Be Registered: (Y/N)		Status:	
SPECIES:		Genetic Class:	
Superior Provenance: (Y/N)		BC source: (Y/N)	
<b>Applicant Information</b>			
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: <input type="checkbox"/> <10 <input type="checkbox"/> 10-50 <input type="checkbox"/> 50+
Comments:			
Cone Collection Agency:		Collector Address:	
Ownership:			
Owner Agency:   Owner   Reserved   Surplus (%)		Funding Source:	Method of payment
<b>Interim Cone Storage:</b>			
Interim Agency:		Storage Location:	
Storage Facility Type:	Interim Storage From:	Interim Storage To:	
<b>Extraction:</b>			
Extraction Agency:	Extraction Start Date:	Extraction End Date:	
<b>Temporary Seed Storage</b>			
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.			