# Whitebark Pine Restoration Plan for Mount Robson Provincial Park 2015 – 2019

**Prepared for:**
**The Society for Ecosystem Restoration in North Central British Columbia**

**Prepared by:**
**Adrian Leslie, MSc., RPBio.**
**White Bark Consulting**
**150 Suncrest Rd.**
**Pass Creek, BC**

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# 1. Introduction

Whitebark pine (*Pinus albicaulis*) is a keystone tree species in sublapine forests of western North America that is declining throughout its range. In 2013, a Tactical Plan for the Recovery of Whitebark Pine in the Omineca Region was written for the Society for Ecosystem Restoration in North Central British Columbia (SERNbc) that included recommendations for restoration planning (Clason, 2013). The tactical plan outlines the status of whitebark pine (federally listed as endangered), provides reasons for the decline (white pine blister rust, mountain pine beetle, fire suppression and climate change), argues for the need for restoration and makes recommendations for restoration planning in the Omineca region.

The tactical plan demonstrated that there was little information on the specific location or health status of whitebark pine stands in the region and concluded that while filling information gaps was needed, initiating on the ground recovery action should not be delayed (Clason, 2013). In 2014, SERNbc decided to build on the tactical plan with field work that identified whitebark pine stands that would benefit from restoration, and prepare a detailed restoration plan. Mount Robson Provincial Park was chosen for this project because it is one of the few areas in the region where whitebark pine is known to exist in several locations and recent forest health surveys showed high levels of infection by white pine blister rust within and adjacent to the park. In Mt. Robson, access to some stands is relatively good, but the extent of the stands as well as their abundance, health and reproductive status was poorly understood. There are also many parts of the park where the presence or absence of whitebark pine has not been confirmed.

The field work for this project involved surveying and mapping whitebark pine stands. This report recommends stand level restoration priorities within Mt. Robson Provincial Park based on field work and using established restoration techniques. This is the next logical step in restoration planning for whitebark pine in northern BC, could be used as a template for restoration planning in other parks and will provide the necessary detail for restoration activities to begin in Mount Robson Provincial Park in 2015.

## Scope

This document provides a restoration plan for whitebark pine for Mount Robson Provincial Park. Specific details for restoration actions and monitoring activities are described for 2015 - 2019. The current status of whitebark pine in Mt. Robson is described, and to provide context, whitebark pine ecology, threats and legal status are briefly summarized. For a more comprehensive summary of the most current information available on whitebark pine, see the tactical plan for the recovery of whitebark pine in the Omineca Region (Clasen, 2013) or the range-wide restoration strategy (Keane et al. 2012).

The range-wide strategy provides the restoration framework upon which this plan is based, and it follows the ten actions suggested (table 1): assess current condition; plan activities; reduce disturbance impact; gather seeds; grow seedlings; protect seed sources; implement treatments; plant seeds and seedlings; monitor activities; and conduct research (Keane et al. 2012).

Table 1: Summary and timing of the recommended actions described in this plan.

| Restoration Actions | year | details |
|---|---|---|
| Action 1: Assess the current condition | 2014 | Complete. Details can be updated as monitoring and research activities continue. |
| Action 2: Plan activities | 2014, update in 2016 | Detailed activities are planned for 2015 and 2016. Plans for the following year should be updated and modified following each field season. |
| Action 3: Reduce disturbance impact | 2015 - ongoing | Train staff and contractors to remove competing tree species around healthy whitebark pine during regular trail maintenance and fire proofing |
| Action 4: Gather seeds | July - September 2015 | Collect seeds from healthy trees in Mt. Robson; partner with Parks Canada and White Bark Consulting to collect seeds in the Columbia and Rocky Mountains |
| Action 5: Grow seedlings | 2015 - 2018 | Using the seeds collected in 2015, partner with FLNRO to screen seedlings for rust resistance. |
| Action 6: Protect seed sources | 2015 - ongoing | Protect cone collection trees from pine beetle using verbenone |
| Action 7: Implement treatments | August 2015; August 2016 | Carry out prescribed thinning treatments above Berg Lake. Explore prescribed burning options with Parks Canada and other organizations |
| Action 8: Plant seeds and seedlings | September 2016 (seeds) and 2018 (seedlings) | Sow seeds and seedlings grown from seeds collected in 2015 in Moose lake burn and above Berg Lake |
| Action 9: Monitor Activities | August 2015 | Monitoring plots should be set up prior to implementing thinning (baseline), and immediately following treatments. |
| Action 9: Monitor Activities | September 2016 | Monitoring plots should be set up during direct seeding activities |
| Action 10: Conduct Research | 2017 - 2019 | Assess germination success and survival of planted seeds, compare to survival of seedlings |
| Action 10: Conduct Research | 2020 - ongoing | Assess health and growth of spaced and planted trees every 5 years |

## *Brief Overview of Whitebark Pine*

In the Canadian Rocky Mountains, whitebark pine extends from the border to 54 degrees north (WPEF 2014). It is an extremely long-lived species, with specimens in Canada found to be over 1100 years old (Luckman and Youngblut 1999). Whitebark pine seeds have a high nutritional value and form a major component of the diets of many birds and mammals, including Clark's nutcracker (*Nucifraa columbiana*), red squirrels (*Tamiasciurus hudsonicus*), and grizzly bears (*Ursus arctos*) (Vander Wall and Hutchins 1983, Mattson *et al*. 2001, Lorenz *et al*. 2008).

Whitebark pine is a seral species at upper subalpine elevations, where it establishes following fire with the help of Clark's Nutcrackers where it often facilitates the establishment of other tree species. It is a climax species at tree line, where the conditions are too harsh for other species (Callaway 1998). The pine also plays an important role in slowing snowmelt, regulating spring runoff and stabilizing soils at high elevations (Farnes 1990).

The rapid decline of whitebark pine is well documented in the United States (Kendall and Keane 2001; Keane *et al*. 2012) and in Canada (Wilson 2007; Smith *et al*. 2012). This decline is due to several anthropogenic factors. The successful fire suppression practices of the last century have reduced the availability of burned areas for regeneration and promoted successional development of more shade tolerant species, such as Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) (Kendall and Keane 2001). In the past, mountain pine beetle attacks on whitebark pine stands sporadically caused severe damage in some areas (Kendall and Keane 2001). Now, the interaction of warming climatic conditions and fire suppression appears to be allowing pine beetle to expand its range and further endanger whitebark pine stands (Raffa *et al*. 2008).

The greatest concern for the survival of whitebark pine as a species is white pine blister rust which is caused by the fungus, *Cronartium ribicola*. (Kendall and Keane 2001). This non-native disease has killed up to 60% and infected up to 97% of the trees in some areas in the Canadian Rocky Mountains (Smith *et al*. 2012). Over several years, the infection spreads from needles, into the branches and proceeds towards the main stem. Once the infection kills the upper cone-bearing branches by choking off nutrients the tree's ability to reproduce is eliminated, although it may be many years before the tree completely dies (Keane and Morgan 1994). While most trees become infected or are killed by blister rust, there is a very small percentage of trees that show some natural resistance to the blister rust and this resistance is heritable.

The impacts of losing whitebark pine on the landscape are manifold. The heavy reliance by grizzly bears and Clark's nutcracker on whitebark seeds will result in reduced habitat value of high elevation forests (Tomback and Kendall 2001). The loss of this food source may increase negative human – bear interactions by forcing bears to search for other sources of food at lower elevations where human densities are much higher (Mattson *et al*. 1992). The loss of whitebark could change forest structure by altering successional development at lower elevations (Keane and Morgan 1994). At treeline, whitebark pine often initiates krummholz tree islands, so their loss could result in fundamental changes to vegetation structure (Resler and Tomback 2008).

### *Conservation Status*

In April of 2010, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated whitebark pine as an endangered species with "a high risk of extirpation from Canada" (COSEWIC 2010) due to the combined impacts of white pine blister rust, mountain pine beetle, climate change and fire exclusion/suppression. As a result of the COSEWIC assessment, in the spring of 2012, the federal government added whitebark pine to Schedule 1 to the List of Wildlife Species at Risk under the Species at Risk Act (SARA).

In British Columbia, whitebark pine is blue listed, and the BC Ministry of Forests Lands and Natural Resource Operations (FLNRO) has suggested voluntary conservation measures. However, on both provincial and private lands there is no legal protection, whitebark pine continues to be harvested in logging operations and is often ignored in reforestation efforts.

### *The Downward Spiral to Extirpation*

There have been recent studies that suggest there is a threshold density of somewhere between 5.0 and 2.0 $m^2$/ha or 25 stems per hectare of mature, cone bearing whitebark pine trees, below which the population is no longer self-sustaining (McKinney et al. 2009; Barrenger *et al*. 2012; Mahalovich, pers com. 2014). A positive feedback loop occurs where increased infection and mortality leads to fewer cones produced, leading to a greater proportion of remaining seeds being predated upon pre-dispersal, leading fewer seeds being dispersed, followed by reduced regeneration and accelerated decline and finally, local extirpation (McKinney *et al*. 2011). Lower densities of whitebark pine also lead to less pollen in the air and reduced fertilization of the female cones, leading to fewer viable seeds per cone. The recent blister rust introduction has resulted in a vastly reduced population size and density which suggests that there is a real possibility that whitebark pine will eventually become extirpated from Robson without restoration efforts.

## *2. Whitebark Pine Restoration Strategy*

The threat to whitebark pine was first recognized in the 1990's, and a growing number of researchers and managers over the past two decades have been developing restoration techniques. This work has culminated in the Range Wide Restoration Strategy for Whitebark

Pine published by the U.S. Forest Service with contributions from several Canadian scientists (Keane *et al*. 2012). This restoration plan for Mount Robson Provincial Park has been structured to follow the four main principles and ten associated actions which form the basis of the range-wide strategy.

The four principles are:

1) **Promote rust resistance:** Since white pine blister rust represents the greatest threat to the survival of whitebark pine the first principle is to increase the frequency of trees that are genetically resistant to white pine blister rust on the landscape.
2) **Conserve genetic diversity:** To ensure that the full range of genetic diversity is not lost when selecting rust-resistant seedlings for propagation a wide variety of genetic material must be archived in the form of pollen, seeds and clone banks.
3) **Save seed sources:** Those trees that show rust resistance must be protected from bark beetles, fire and logging. This will ensure a source of seeds can continue to be collected from these individuals for restoration purposes in the future.
4) **Employ restoration treatments:** Initiate proactive restoration efforts where whitebark pine forests are declining.

Three of the four principles of the range wide strategy are employed in this restoration plan. The second principle (conservation of genetic diversity) is being managed by the Genetic Conservation Technical Advisory Committee (GCTAC) of the BC Forest Genetics Council, as outlined in their Genetic conservation strategy for whitebark pine in British Columbia (GCTAC 2009). If desired, a small subset of seeds collected from Robson may be provided to GCTAC to help meet their objectives, but this restoration plan focuses on landscape level management within Mt. Robson.

The tactical plan for the Omineca region makes recommendations similar to the range wide restoration plan for whitebark pine: seed collection, seedling production, rust screening, planting seedlings and site treatments (Clasen 2013). This document includes detailed plans on how each of these activities should be carried out to restore whitebark pine in Mt. Robson, starting in 2015.

## *Mt. Robson Restoration Objective and Goals*

The primary objective of this restoration plan is to initiate management activities that will lead to a healthy, self-sustaining population of whitebark pine in Mount Robson Provincial Park. The first priority for restoration is to increase the number of whitebark pine that are genetically resistant to white pine blister rust on the landscape (Clasen 2013; GCTAC 2009; Keane *et al*. 2012). This will be achieved through creating, maintaining and enhancing refugia of healthy whitebark pine stands in all age classes across the landscape that include trees and seedlings that are genetically resistant to white pine blister rust.

Specific short term goals to attain this objective are:

1) Collect seeds from healthy whitebark pine trees in Mt. Robson, the Rocky Mountain National Parks and the Columbia Mountains for direct seeding in recent high elevation burns and in the upper treeline in Mt. Robson.
2) Remove competing tree species from around healthy whitebark pine trees in identified young (50 - 70 year old) stands that will increase their chances of survival and enhance their cone production in the medium and long term.

The long term vision is that the trees in the refugia will produce seeds and pollen that can be used to restore other areas both inside and outside Mount Robson. This spread of rust resistant genetic material can be assisted by continued management actions in the short and medium term, or by natural seed dispersal and wind pollination in the long term.

## *Assisted Migration*

The ongoing decline of whitebark pine in Mt. Robson due to white pine blister rust is the greatest threat, and can only be met by increasing the frequency of genetically resistant traits to blister rust within the population. The looming threat to whitebark pine in Mt. Robson is climate change which may result in current populations becoming maladapted to climatic conditions in the coming decades and centuries. These two threats can be addressed through assisted migration of resistant seeds and seedlings from more southerly portions of the range. Bower and Aiken (2008) suggest a unidirectional seed transfer and mixing of seeds from different sources. They suggest that this may increase the chances that at least some of the trees will survive, with little chance of outbreeding depression (Bower and Aiken 2008).

When discussing the assisted migration of tree species, Pedlar *et al*. (2012) make a distinction between species rescue assisted migration where the aim is at conserving species facing climate change where species are moved beyond their current range, and forestry assisted migration where populations are moved within their range to maintain forest health and productivity. This plan recommends the less controversial forestry assisted migration where seeds will be moved from areas to the south of Mt. Robson into existing whitebark pine habitat within the park. This will serve dual purposes: to increase the level of genetic diversity within the park, with a focus on selecting seeds carrying naturally occurring resistance to blister rust, and increase the number of individuals growing in suitable areas under changing climatic conditions.

Mt. Robson is currently at the northern end of the range of whitebark pine (Figure 1), and species distribution models for whitebark pine suggest that Mt. Robson will provide suitable climate through 2085 (McLeane and Aitken 2012). This suggests that the park is a good candidate location for restoration, where restoration can be expected to remain effective into

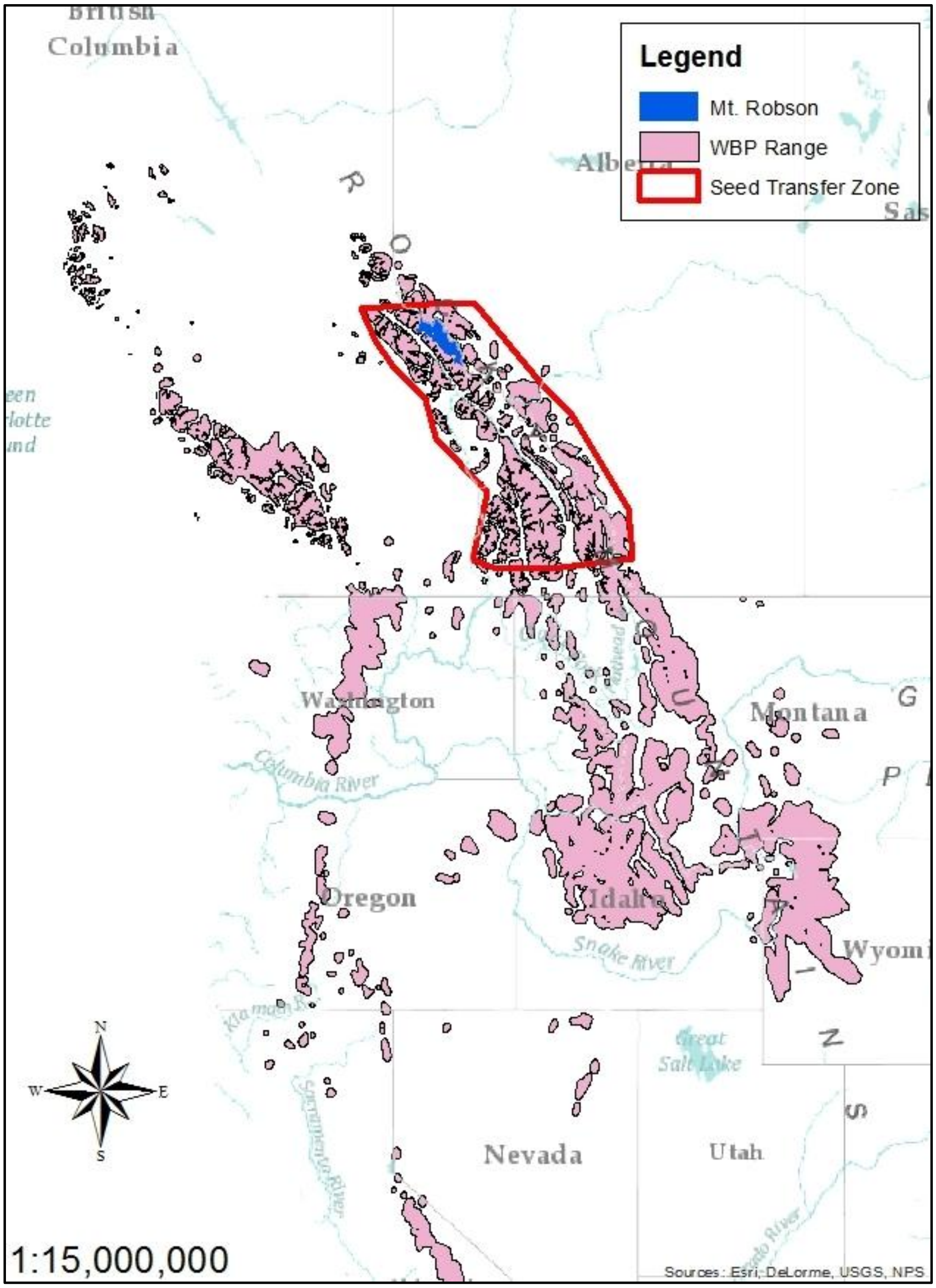


Figure 1: Range of whitebark pine (WPEF 2014), and seed transfer zone for Mt. Robson

the foreseeable future. It is likely that the higher elevation zones within the park will become suitable as the climate changes, above its current range, and the current lower limit of whitebark pine will no longer be suitable. Therefore, restoration efforts will be focused on the higher elevation whitebark pine stands and at the upper limit of the current treeline.

There are currently no seed transfer guidelines for whitebark pine. The Canadian portion of the range in the Rocky and Columbia Mountains north of Crowsnest pass forms a continuous population that share a common evolutionary history (Richardson *et al*. 2002). Genetics data shows that there are differences between populations north and south of the Crowsnest Pass, with those to the south adapted to warmer climates (Krakowski pers. com. 2014). Given the increasing rate of change already observed in Mt. Robson, and that it is only 375 km north of the latitude of Crowsnest pass, seeds can be transferred from anywhere within the eastern portion of its range north of Crowsnest pass in Canada (Figure 1). If there is screened resistant material (seeds or scion - see below) from areas to the south of this line they should be used in Mt. Robson because the positives of using genetically resistant material outweigh the negatives of maladapted traits for growing characteristics (Krakowski, pers com. 2014).

The movement of the upper treeline in Mt. Robson is visible at the top of the current treeline (Figure 2), and at the toes of retreating glaciers (Figure 3). Tree ring studies in Mt. Robson paint a dynamic picture where the treeline has fluctuated over the past several thousand years during glacial advances and retreats (Luckman 1993; Luckman 1995). The rate of retreat appears to have been increasing over the past century, where Park Ranger records of the Robson glacier show an average retreat of 17.3 m/yr between 1911 and 1996, then up to 22.2 m/yr between 1997 and 2013, followed by a 35 meter retreat in 2014 (Milner and Zimmerman, unpublished data, 2014).

Figure 2: Whitebark pine establishing at the top of the treeline

Figure 3: Whitebark pine establishing behind the retreating Robson glacier

In the 1980's a park ranger discovered a whitebark pine stump that was exposed by the retreating Robson Glacier in a lateral moraine 3.5 km up the valley from the current snout of the glacier (Luckman, 1993). This stump was dated to 3100-3300 BP and was over 300 meters higher than the current treeline, indicating that whitebark pine historically existed far above its current range and helps tell the story of a fluctuating climate and treeline.

## Target Ecosystems

The dynamic nature of the upper subalpine ecology in Mt. Robson over both the recent and distant past, combined with the expected changes due to climate change begs the question of what target ecosystem we should be restoring to. Continually changing conditions mean that restoring to past ecosystem structure is no longer feasible. Recommendations contained here are designed to restore a functioning ecosystem that will be able to survive and thrive in both current and future climate scenarios rather than restore to a specific past ecosystem. The main impediment to whitebark pine establishment is the decline to the existing seed sources by the introduced pathogen, white pine blister rust, resulting in a lower than expected proportion of whitebark pine (relative to subalpine fir and Engelmann spruce) re-colonizing burned areas or colonizing recently exposed and climatically suitable habitat. The reality is that blister rust will not be eradicated from the new system, so in order to survive, the system must adapt to make blister rust a minor disturbance agent as opposed to a threat to destroy the system. Therefore, the target ecosystems for this restoration plan are systems that contain the proportion of whitebark pine that would have developed in the coming decades had blister rust not been introduced.

# 3. Restoration Actions

## Action 1: Assess the current condition - Whitebark pine in Mt. Robson and the need for restoration

The Vegetation Resources Inventory (VRI) proved somewhat helpful in locating whitebark pine stands but could not be relied upon to accurately predict stand locations, structural characteristics or species composition. Figure 4 shows polygons where whitebark pine was mapped by the VRI where some stands were accurately mapped as containing whitebark pine and others were not. For example, the VRI indicated that whitebark pine was the dominant species in the stand directly to the west of Berg lake but in reality, it was only a minor component of the mapped stand. Another stand to the north of Rearguard mountain

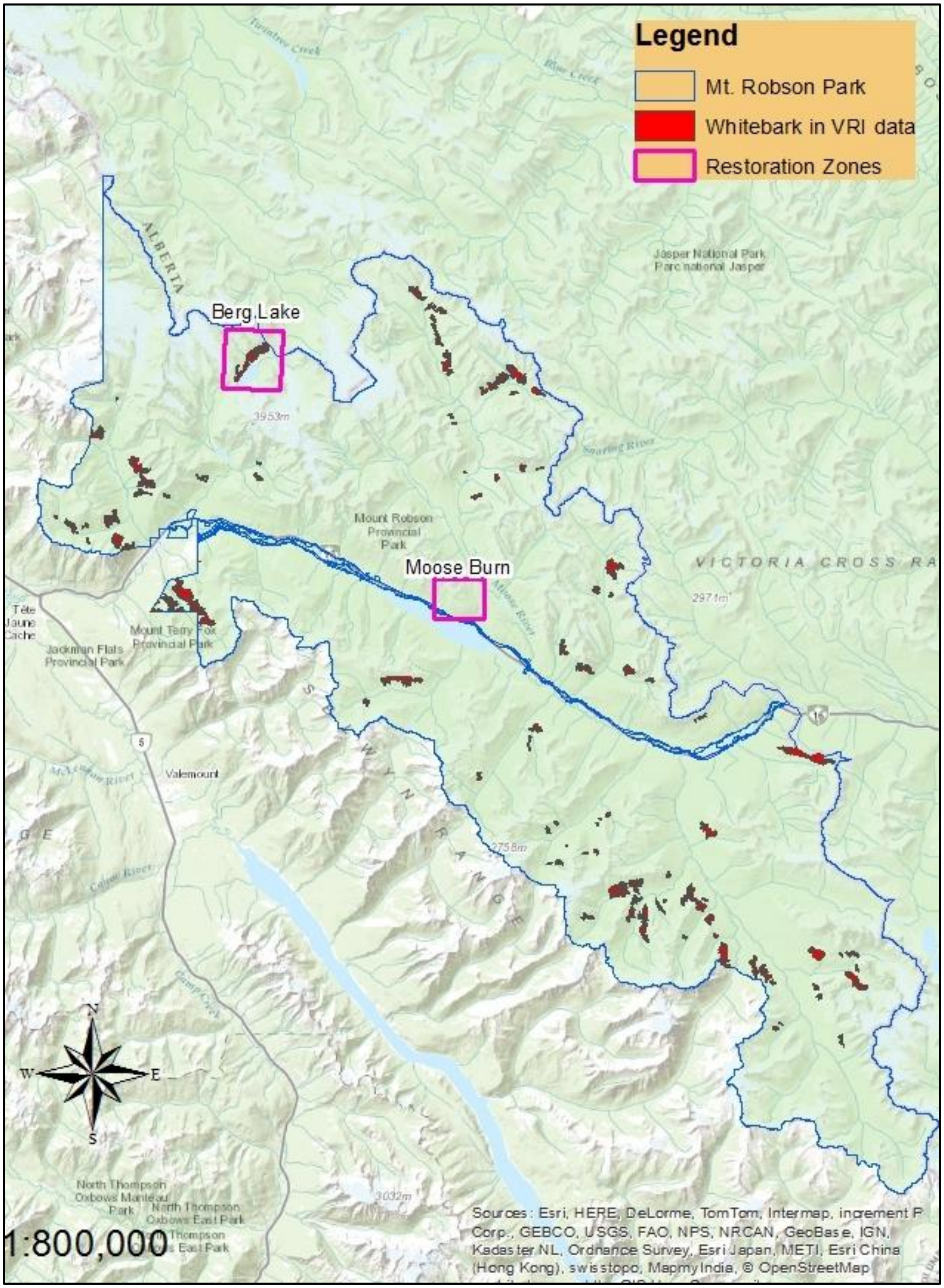


Figure 4: Whitebark pine stands mapped in the Vegetation Resources Inventory

(UTM 11U 359500 5891120) was mapped as 100% subalpine fir but was in fact about 50% whitebark pine, 40% subalpine fir, and 10% Engelmann spruce (Figure 5). The area targeted for direct seeding above Moose Lake showed no whitebark pine in the VRI (Figure 4), but live whitebark were found along the perimeter of the fire, and burnt snags were clearly visible throughout the upper portions of the burn. This indicates that there may be stands in more inaccessible areas in the park not identified in the VRI.

Figure 5: Mixed stand that was mapped as 100% subalpine fir in the VRI

Figure 6: Open parkland where whitebark pine is a climax species

When assessing restoration options, access to the stands is a key consideration since the cost of both the assessment and restoration activities will increase with the need for additional helicopter support and access time. This project therefore targeted areas with the best access. Access to high elevation forests where whitebark is typically found is very challenging throughout Robson due to the lack of logging roads and limited number of hiking trails. Chris Zimmerman, a recently retired park ranger who worked in Mt. Robson for several decades was consulted prior to field work to determine the most likely areas to access whitebark pine stands. He indicated that the area around Berg Lake was by far the best spot to focus efforts. The other accessible area that initially showed some promise (VRI data showed whitebark as the third species after fir and spruce) was up the Mt. Fitzwilliam trail, but Chris indicated that he never recalled seeing any whitebark pine there, and analysis of air photos did not show any whitebark pine trees. There are parts of Mt. Robson, particularly in the southern portion, where there are no trails making access very difficult without helicopter support and should be assessed whenever the opportunity arises. For example, there are stands to the west of the Ramparts that have whitebark in the VRI data, the air photos appear promising and large individual whitebark have been recorded at UTM 11U 409500 5839500 (Brenda Shepherd, unpublished data 2014), but it is several days hike to access the area.

Within Mt. Robson, there are two broad categories of whitebark pine stands: lower elevation (1400 - 2000 meter) seral stands, and upper elevation (2000 – 2150 meter) climax stands. Whitebark pine is a seral species in upper subalpine forests where it occurs in increasing frequency as part of the main canopy and grows with subalpine fir, Engelmann spruce, and lodgepole pine starting around 1400 up to 2000 meters. Above 2000 meters it is a climax species, it co-dominates with subalpine fir and has a more stunted growth form where the closed canopy forest transitions to open parkland (Figure 6).

All age categories are represented within Mt. Robson for both the seral and climax stands, ranging from recently burned areas where whitebark is beginning to establish, to climax stands where whitebark pine is almost completely excluded due to competition from spruce and fir.

### *White Pine Blister Rust*

The first published information on white pine blister rust in Mt. Robson was from 2002, when little was known about the distribution or health of whitebark pine populations in Canada. Of 150 trees surveyed within the park, 44% were infected with white pine blister rust and 10% had already been killed by blister rust (Zeglen 2002).

A long term study was initiated by Parks Canada in 2003, where 115 permanent white pine blister rust plots were established throughout the Rocky Mountains (Smith *et al*. 2012). When the plots were re-measured in 2009, they found an alarming 3% per year average increase in mortality. There were two plots established above Berg Lake in Mt. Robson in 2009, the plot in the older stand had 94% of live trees infected by blister rust (an increase from 88% in 2003) and the younger stand had 29% infected. There were also two plots just inside Jasper above Adolphus lake, where 56% of live trees were infected by blister rust, and 19% were already dead (Brenda Shepherd, unpublished data, 2014). All these plots were re-measured by Parks Canada staff in 2014, but the data was not available at the time of writing.

Additional surveys for this project in 2014 found over 90% infection rates in the polygon where burning should be considered, and adjacent to the 'Direct Seeding 1' area above Berg Lake (see Action 7 section below). This indicates that white pine blister rust has already seriously impacted whitebark pine in Mt. Robson, and increased infection and mortality is expected.

### *Mountain Pine Beetle*

Although there is an ongoing outbreak of mountain pine beetle in the lower elevation lodgepole pine forests in Mt. Robson, none were observed in any whitebark pine. There have been extensive outbreaks of pine beetle in whitebark pine stands to the south in the both the Rocky and Columbia Mountains (Leslie, 2013), and beetle killed whitebark pine have been observed in nearby areas outside the park in BC.

### *Regeneration*

Whitebark pine cannot typically regenerate under closed canopies. Within Mt. Robson, seedlings are either establishing in recent fires between 1400 and 2000 meters, or at the upper edge of the treeline where gaps in the canopy remain. However, a field assessment of the 2004 Moose Lake burn in 2014 showed very little whitebark pine regeneration, and fewer than expected seedlings were establishing at the treeline when compared to subalpine fir. This is likely a result of the greatly diminished availability of seeds due to blister rust.

**Recommendation:** Completed in 2014, but should be updated annually as the project proceeds and monitoring plots are established.

## *Action 2: Plan activities*

Field work and research during 2014 has laid the groundwork for operational restoration activities in 2015 and 2016 and are outlined in this document.

**Recommendation:** Following each field season, as new information becomes available and as opportunities emerge, specific details of the plan for the following field season should be updated. It is expected that only minor operational adjustments may be needed.

## *Action 3: Reduce disturbance impacts*

The Range Wide Restoration Strategy (Keane *et al*. 2012) suggests the implementation of proactive measures to reduce the risk of blister rust, mountain pine beetle and other disturbances on whitebark pine forests.

### *Blister rust*

There are limited options for reducing blister rust in Mt. Robson. It is a fungus whose spores are ubiquitous throughout western Canada and it is impossible to eliminate. The action that has been suggested to reduce the impacts of blister rust is to prune infected branches or remove infected individuals. However, removing infected branches is unlikely to be successful in the long term because the tree is clearly susceptible to blister rust, and will most likely be infected again. An argument could be made that pruning would be counterproductive because by allowing a tree that is not resistant to blister rust to persist on the landscape, it may pass on this undesirables trait to future generations. Pruning is not recommended here.

The only option that will result in a long-term solution to the introduction of blister rust into North American ecosystems is an increase in the number of whitebark pine trees that can either survive an infection of blister rust or not become infected in the first place. That is the objective of the selective breeding program and other management options described in the following sections.

### *Mountain Pine Beetle*

Although no mountain pine beetle has yet been observed on whitebark pine within the park, the ongoing outbreak at lower elevations, just below whitebark pine stands and observations just outside the park indicate that pine beetle attack could occur at any time. Although widespread protection of whitebark pine from mountain pine beetle is not operationally feasible, individual trees can be protected. The circumstances for protecting individual trees are described in Action 6: Protect seed sources.

### *Trail Maintenance and fire proofing*

Ongoing maintenance of trails and fire proofing around buildings could either benefit or damage whitebark pine depending on how the work is carried out. If possible, no healthy whitebark pine trees should be removed during any of these activities. Opportunities to benefit whitebark pine may arise where mixed stands of whitebark pine, spruce, lodgepole pine or subalpine fir exist. If these competing tree species are removed (either to reduce fire risk or clear trails) and whitebark pine is retained, the residual whitebark pine would likely benefit. By being careful about which trees are removed during maintenance activities, whitebark pine can be enhanced.

> **Recommendation:** All staff and contractors carrying trail maintenance and fire proofing should be trained to identify whitebark pine and white pine blister rust and instructed to leave all healthy trees.

## *Action 4: Gather seeds*

A small percentage of trees do carry some genetic traits that allow them to resist blister rust; the cornerstone of restoration work that has been initiated elsewhere is to collect seeds from trees that are phenotypically rust resistant and test them for genetic resistance. Seeds are collected from the few healthy trees within heavily infected stands. Heavily infected stands are chosen because it increases the likelihood that the healthy trees have been exposed to blister rust, but have survived due to natural genetic resistance to the fungus.

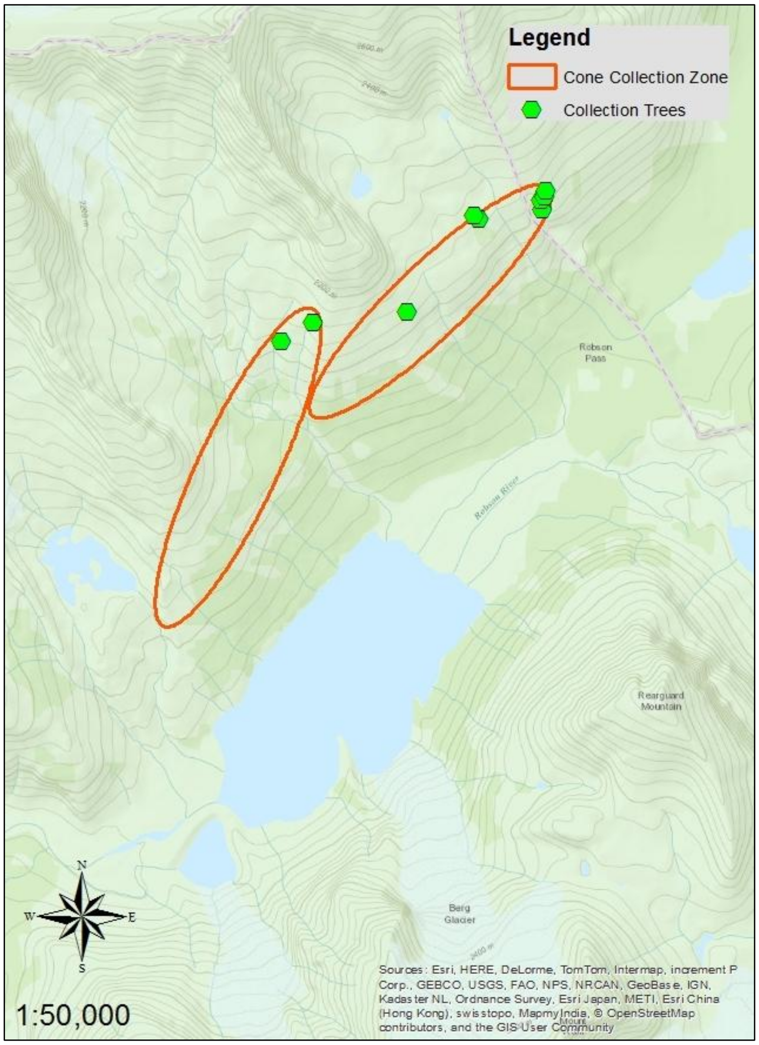


Figure 7: Cone collection areas above Berg Lake

It is challenging to collect viable whitebark pine seeds due to the high rates of cone harvest by Clark’s nutcracker prior to seed maturation and because cones grow at the end of the uppermost branches. Therefore, trees that are free of any blister rust cankers, are safe to climb and have cones developing are selected for collections. It is very important that an experienced assessor helps select the healthy trees as it can be very challenging to identify blister rust cankers for the untrained eye. These trees are climbed before late August and protective coverings are placed over the cones. Once the cones are fully mature in late September or October, the tree must be climbed again, the cages carefully removed to avoid damaging the tree and the cones collected. When collecting cones in the fall, the number of next year's cones (very small cones that will develop the following spring) should be carefully counted to aid in planning for the following year’s collections.

### *Options for seed sources*

There are no commercially available whitebark pine seedlings  so all restoration work in Mt. Robson must rely on collecting seeds specifically for this purpose. Thus far, no seeds have been collected in Mt. Robson; the most promising stands are to the west of Berg Lake where there is high blister rust infection (over 90%), and the trees are stunted along the treeline. Locations were recorded for several candidate trees in 2014 that had cones accessible from the ground, requiring a pole with a hook on the end to access the branch tips (Figure 7). An encouraging sign is that all of the assessed trees had more of next year's cones than mature cones in 2014, indicating that 2015 may be an excellent cone crop in Mt. Robson. More trees that have cones accessible either by climbing the tree (using ropes and appropriate tree climbing equipment) or from the ground could certainly be located in the 'cone collection zones' (Figure 7) by an experienced crew carefully searching the area.

There are three main options for obtaining seeds in the short term: to collect them within Mt. Robson; to partner with Parks Canada and collect from other parks in the Rocky Mountains; and to partner with White Bark Consulting and collect cones in the Columbia Mountains. The three options are not mutually exclusive and there are advantages and disadvantages to each option (Table 2).

Table 2: The pros and cons of collecting cones in Mt. Robson, partnering with Parks Canada in the Rocky Mountain National Parks, and partnering with White Bark Consulting in the Columbia Mountains

| | **Mt. Robson** | **Rocky Mountains** | **Columbia Mountains** |
|---|---|---|---|
| keep all seeds | yes | no | No |
| share risk, funding and resources | No | Yes | yes |
| seeds adapted to current climatic conditions | Yes | likely | likely |
| seeds adapted to future climatic conditions | less likely | likely | likely |
| Increases level of genetic diversity in the park | No | yes | Yes |
| seed collection sites are known | some | some | yes |
| early rust screening showing positive results | n/a | n/a | yes |
| Collections planned for 2015 | No | yes | yes |
| Willing to collaborate in 2015 | n/a | yes | yes |

Parks Canada initiated a 5 year collection program in 2014, and are collecting cones in Jasper, Banff, Yoho, Kootenay, Glacier and Waterton National Parks. Additionally, seeds from dozens of Ftrees have been collected in the Columbia mountains since 2011, 40 of which are currently being screened for rust resistance by FLNRO.

Partnering with other organizations for the purpose of collecting seeds is strongly recommended for three reasons:

1) It is often possible to collect several thousand seeds from an individual tree, which may be more than the needs of a single project. For example, if seeds are being collected only for rust screening, approximately 500 seeds are needed and the rest are surplus. If seeds are being collected for other restoration activities, all seeds could theoretically be used, but increasing the number of parent trees would be preferable. In this situation, both Mt. Robson and the other organization would benefit from sharing resources by being able to collect from a greater number of trees.
2) Collecting seeds from regions to the south of Mt. Robson would mean that this restoration project would increase the genetic diversity of rust-resistant traits within the park and assist the northward migration of a species that may be moving too slowly for rapid climate change.
3) Whitebark pine cone crops are highly variable from year to year within portions of their range, meaning, for example, that one year there may be a bumper cone crop in Mt. Robson (as appears to be the case for 2015), but virtually no cones in Kootenay National Park. The opposite situation could occur the following year. By looking for cones across a larger area than just Mt. Robson, the chances of finding stands with good cone crops are greatly increased. Therefore, cone collection efforts should be flexible for any given year and resources should be allocated to collecting cones in the areas with the best cone crops.

Both Parks Canada and White Bark Consulting have secured funding for cone collection in 2015, and have expressed a willingness to collaborate and share seeds (Brenda Shepherd, pers. com. 2014).

Another option to increase genetic diversity within the park is to graft cone bearing branches collected from genetically resistant trees outside the park onto accessible trees within the park. While this has not yet been attempted on an operational scale, in several years time, once individual trees have been screened and shown to be genetically resistant, it may prove to be a viable restoration option.

**Recommendation:** A cone collection crew should be hired to collect cones from Mt. Robson park in 2015. Partnerships should be established with White Bark Consulting and Parks Canada to collect cones from the Columbia and Rocky Mountains. The target number of seeds for collection is 100,000. If insufficient seeds are collected in 2015, continue the collection program in 2016.

## *Action 5: Grow seedlings*

While commercial greenhouses have limited experience growing whitebark pine seedlings, several in BC have been learning how to grow them for restoration purposes in recent years. Nursery techniques have been established, and continue to be improved upon. Depending on the availability of funding and seeds, up to 10,000 seedlings should be grown from seeds collected in 2015. Planting seedlings must be combined with direct seeding (planting stratified seeds directly in the ground) because the very rocky ground in the identified restoration sites. The rocky soils are typical of sites where whitebark thrives but it would be extremely challenging find enough microsites with enough soil to plant a plug properly. Direct seeding allows for establishing seedlings in very rocky sites, and trials have shown positive results in the Columbia Mountains, in an assisted migration trial in northern BC and several trials in the US (Leslie, 2013; McLane and Aitken, 2012; Schwandt et al., 2011; Schwandt, unpublished data, 2014).

The Ministry of Forests, Lands and Natural Resource Operations started a small rust screening program in 2011. The only way to assess if a parent tree is resistant to blister rust and this resistance is heritable is to grow seedlings from seeds collected from the parent tree.  This is typically done in a greenhouse under controlled conditions. Once the seedlings are 2 or 3 years old, they are exposed to blister rust spores, and if they do not get infected or they are capable of surviving the infection, the resistance is genetic and heritable.

In 2011, seeds from 40 trees (families) from the Columbia Mountains were provided to FLNRO and sent to the Kalamalka Research Station near Vernon to be grown in the greenhouse and then tested for rust resistance. The ministry has plans to continue to screen 40 families each year, and has indicated a willingness to partner with this project to screen trees collected in Mt. Robson (Michael Murray, pers. com. 2014). The ministry is currently exploring options to increase the capacity for rust screening in BC, so there is potential for increased numbers of trees screened in future years.

Also in 2011, an additional ten families from the Columbia Mountains were sent to the Dorena Genetic Resource Center in Oregon for testing. They were exposed to blister rust spores in 2013, and after one year, early results indicate that all 10 of these seedlots have some resistance, and some at a very high level (Sniezko, pers comm, 2014). In 2015, collections from these 10 trees (and several dozen new trees) will be made by White Bark Consulting for direct seeding and growing seedlings for planting at restoration sites in the Columbia Mountains. There is an opportunity for SERNbc to partner with this project and share these resistant seeds for restoration work in Mt. Robson.

If seeds are collected from Mt. Robson in 2015, a subset of up to 500 seeds per tree should be provided to FLNRO from as many parent trees as they will accept for rust screening purposes. The benefits of sharing seeds with FLNRO are:

- they will grow the seedlings for screening at no cost for the project
- they will screen the seedlings for rust resistance which will result in the identification of genetically resistant parent trees within Mt. Robson, which will help inform future restoration work
- if there are excess seedlings grown (more than they require for the greenhouse screening), they can be planted at identified restoration sites as long as a suitable experimental design is established so that each seedling can be followed over time to monitor rust resistance (field trials for rust resistance). This has occurred in the past, with several thousand excess seedlings planted at five separate sites.

**Recommendation:** From seed collections in 2015, provide up to 500 seeds per parent tree to FLNRO to grow in greenhouses for rust screening. In 2015, grow up to 10,000 seedlings for planting in 2017 or 2018. All remaining seeds should be planted directly in the ground in 2016 (see Action 8: Plant seeds and seedlings).

## *Action 6: Protect seed sources*

Any potentially rust resistant trees from which cones are collected should be protected from mountain pine beetle and fire (Clasen, 2013). Verbenone is an anti-aggregation pheromone that decreases the chances that individual trees will be attacked by mountain pine beetle. Protecting trees involves accessing each tree as soon as the snow melts in early summer before the pine beetles emerge and placing two verbenone pouches on the north side of the main stem. This protects these high value individual trees for one season from mountain pine beetle attack (Kegley and Gibson 2004). Verbenone application should be a part of all cone collecting activities to ensure that trees identified as healthy and cone bearing will be able to continue to provide a secure source of possibly resistant seeds.

The threat of fire may be more difficult to guard against, but there are three options that could help reduce the risk:

1) Once cones are collected from trees within the park, managers should be made aware of their specific locations so they can take this into consideration when managing wildfires in the area.

2) The area immediately surrounding the collection tree should also be fire-proofed to the greatest extent possible. This might mean simply removing dead and dry material below the mature tree at the time of collection.
3) If there are several collection trees within a specific stand, thinning the stand to reduce the risk of a high severity burn should be considered. As there have been no cones collected anywhere within Mt. Robson as of yet, no specific recommendations for fire proofing are provided here.

Once trees go through the rust screening program and are shown to be genetically resistant to blister rust, protection with verbenone and fire proofing becomes even more important. Once these trees are identified, specific prescriptions for their protection should be developed that provide details on the special care that should be taken to ensure that these trees are protected and as many additional cones are collected as possible each year.

**Recommendation:** While collecting cones in 2015, the threat of wildfire to each parent tree should be assessed and threats should be mitigated in 2016. Starting in 2016, all trees from which cones were collected should be protected from mountain pine beetle using Verbenone.

## *Action 7: Implement treatments*

It is important to have a wide range of age and size classes throughout the park to increase resilience to future mountain pine beetle outbreaks (Schoettle et al. 2012) and provide a consistent source of seeds over time.  Therefore, treatments need to improve the health and vigour of stands in all age classes.  The Range Wide Strategy suggests implementing treatments that include creating nutcracker caching habitat, reducing competing vegetation, and decreasing surface and canopy fuels (Keane *et al*. 2012).

### *Fire*

There are pockets of late successional stands whitebark pine forests in Robson where the mature whitebark trees are dying out due to competition and blister rust. In the absence of stand replacing disturbance, these stands will soon become climax communities that exclude whitebark pine. In these areas, if whitebark pine is to be restored, the stand may need to be reinitiated by fire.

Fires can be either prescribed burns, controlled wildfires, or uncontrolled wildfires.  Prescribed burns require extensive planning, are expensive and can have unintended negative consequences to both built infrastructure and ecological values. For example, the dwindling herds of mountain Caribou, another federally endangered species, use whitebark pine habitat and may be negatively impacted by fire in the portions of the park where they may be found. The advantage of prescribed burns is that they can take place under desired conditions which can result in optimal regeneration potential. For example, if there are healthy cone-bearing whitebark pine within the burn area, fuels surrounding the individual can be removed mechanically prior to the fire. The burn can then take place under conditions that ensure it won't get so hot as to kill the healthy tree but at the same time create openings for natural regeneration or planting of seedlings.

In Mt. Robson, while there are late successional forests that may benefit from burning, other early seral stands have been identified for higher priority, lower cost and lower risk treatments. As Clasen (2013) points out, restoring recently burned areas should be prioritized over burning new areas. Since there are large areas recently burned that are appropriate for restoration in Mt. Robson, these areas are where efforts should be focused first.

Prescribed burns are a low priority of this restoration plan, and specific prescriptions were not prepared, but should be considered in future planning and as additional potential areas are identified. Jasper National Park is actively involved in prescribed burning for whitebark pine restoration and is interested in partnering on future projects that may span the continental divide (Dave Smith, pers com. 2014). For example, the 423 hectare stand identified as 'Potential Burn Area' (Figure 8) is on the boundary with Jasper, and is in very late successional stage where almost all of the whitebark pine has died out. This stand is several hundred years old and in the ESSFmm1 BEC zone (Engelmann Spruce Subalpine Fir moist mild) where infrequent stand initiating events is the natural disturbance regime, and would benefit from fire. Working with Jasper in this area should be explored further. Other more remote areas of the park that are not accessible on foot that may contain good candidate stands for prescribed burns and may be suitable for cross-border collaboration are on Upright Pass (where surveys have found high levels of blister rust infection in Jasper and VRI data shows whitebark in Robson), Colonel Pass, and Centre Pass. Opportunities may arise where these areas could be assessed by helicopter in partnership with Jasper NP (Dave Smith, pers. com. 2014).

A likely scenario is that at some point unplanned wildfires will occur in these late successional habitats or potential whitebark pine habitat. Following each fire season, all burns should be screened for whitebark pine suitability. Generally speaking, based on the regeneration occuring in the fire above Moose Lake (see section on planting, page 30) any area burned over 1900 meters elevation should be assessed more closely for potential restoration opportunities. Should a wildfire fire occur in suitable habitat, every effort should be made to plant either seeds or seedlings 3 – 10 years following the fire. It is not advised to plant immediately following fire because recently burnt and exposed soils will result in soil creep that can rip seedlings out of the ground. By allowing some growth to establish will stabilize the soils and moderate surface temperatures (burnt black substrates can get extremely hot in the sun, killing recently germinated seedlings) (Keane pers. com. 2014). The very slow successional process in these high elevation sites means that waiting up to 10 years to plant will not adversely affect survival.

### *Thinning*

Recent studies have shown that removing competing trees from around individual whitebark pine improved the growth rate of the released trees (Keane *et al*. 2012) and therefore the health and vigour of those trees. It has been shown that open grown trees produce an open canopy capable of producing more cones than closed canopy trees (McCaughey *et al*. 2009). Removing competing shade-tolerant subalpine fir around the shade-intolerant whitebark pine will result in a larger canopy capable of producing more cones available for collection and natural distribution by nutcrackers. Similar projects were carried out in both BC and Idaho, which both and show promising early results (Keane *et al*. 2007; Leslie 2013; Keane pers. com 2014).

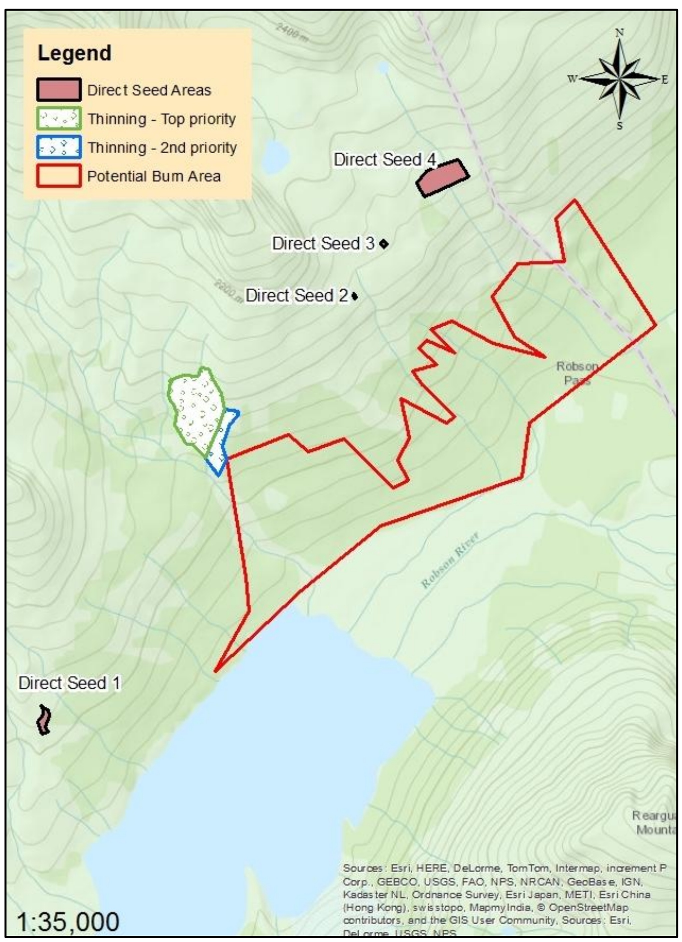


Figure 8: Recommended treatment areas above Berg Lake

The 24.5 hectare stand labeled ‘Thinning – Top priority’ in Figure 8 has ideal conditions for a thinning treatment. It is a mixed stand of whitebark pine, subalpine fir and Engelmann spruce, the trees are approximately 53 years old (an age where they would release following thinning) and the whitebark pine are just starting to produce cones. It is in the ESSFmmp (Engelmann Spruce Subalpine Fir moist mild parkland) BEC zone, where most whitebark pine stands are found in the park. The aspect is perfect for whitebark pine growth ($210^0$) and the slope is steep enough for good whitebark growth, but not too steep for a crew to work in (30%) and the access is relatively good.

Figure 9 provides an excellent example of a typical tree that would benefit from thinning: it is about 20 cm dbh, just starting to produce cones, free of blister rust and has 14 subalpine fir within 3 meters of its base. Without removing the competing trees, this individual may survive, but it would have to put all its energy into growing straight up, resulting in a vertical growth form (carrot shaped crown) that would support few cone bearing branches. If the competing trees are removed, it would increase the likelihood of survival, increase its vigour and it would grow out more resulting in a bushy growth form (broccoli shaped crown - Figure 10) that typically support several times more cone bearing branches. Removing competing trees will result in a more open stand that is capable of producing more cones and is less likely to carry a stand replacing crown fire.

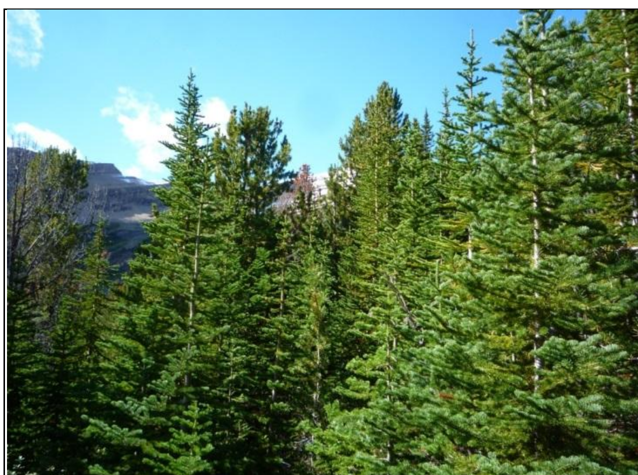

Figure 9: A 53 year old whitebark pine with 14 competing subalpine fir within 3 meters

Figure 10: Open grown whitebark pine that will produce many cones

A priority for 2015 is to hire a crew to remove competing tree species surrounding healthy whitebark pine trees within the ‘Thinning – Top Priority’ stand. Prescription details include:

- Prior to a crew starts removing competing trees, an experience assessor trained in identifying white pine blister rust should walk the stand and flag all trees that are free of blister rust and would benefit from competition removal. GPS coordinates and dbh should be recorded for each tree so it can be followed over time, and to provide the crew with a map of trees to target

- Whitebark pine trees to be thinned around should be healthy, free of cankers, and a minimum of 12cm dbh
- All trees that are not whitebark pine should be removed within a minimum of 3 meters (to a maximum of 5 meters) of all healthy whitebark in the stand
- Competing trees should be cut down and cut into pieces small enough to be dragged away so as to not increase the risk of fire in the short term
- *Ips spp*. beetle has been known to colonize slash piles created during thinning operations, and then move on to kill the live whitebark pine (Keane et al. 2012); if possible, slash piles should be burnt as soon as it can be done safely
- Whitebark pine trees that are infected by blister rust should be ignored – do not thin around them, and do not cut them down if they are within 3 meters of a healthy whitebark
- Trees should be cut as close to the ground as possible, below the lowest live branches
- Care must be taken to not damage the healthy whitebark trees when removing competing trees; if there is a danger of damage, competing trees should be left standing
- Stumps should be left flat to eliminate possible injury to wildlife
- There is no need to remove any shrub species
- If desired by park managers, for visual quality, a 5 meter buffer from all trails that pass through the treatment area can be maintained where no trees are removed
- This treatment should be carried out in August or September to ensure that no active bird nests are disturbed
- The crew and all their gear will have to be flown in to the Berg Lake area and can camp while working
- This work could be carried out in conjunction with cone caging or cone collection activities to save costs.

The distribution of healthy whitebark pine to be thinned around is patchy within the treatment area, but on average, the inter-tree distance for healthy individuals is about 9 meters. This will result in a stand with a density of 150 healthy whitebark pine trees per hectare, each surrounded by a buffer of 3-5 meters without any trees. The patchiness of the distribution of these trees, combined with the relatively large inter-tree spacing will result in a stand that still contains many subalpine fir trees and, to the untrained eye, will not appear significantly different than the surrounding forests.

It is difficult to estimate how long it would take a crew to complete the work due to the unique nature of this treatment. There are three options to deal with this uncertainty:

1) Since it is not necessary that the entire area be treated at the same time, a crew can be hired for 5-7 days to do as much of the work as possible in 2015. The progress they make can be used to determine the time and resources required to complete the task in 2016.
2) Hire a crew with a flexible schedule and work until the task is complete in 2015. The disadvantage of this is that budgeting becomes very challenging.
3) Since there is a lower priority thinning treatment stand adjacent to the top priority stand (Figure 8), a crew can be hired for up to two weeks in 2015, and if they complete stand 1, they can start work on the lower priority stand.

The 'Thinning Treatment Priority 2' stand (Figure 8) is quite similar to the first stand, but it is approximately 80 years old, has higher rust infection rates (and therefore fewer trees to thin around), is crowded out further by spruce and fir and the competing trees are larger requiring more chainsaw work.

**Recommendations:** In 2015, initiate stand thinning operations in 'Thinning Treatment Priority 1' stand. Complete the work in 2016, and consider treating 'Thinning Treatment Priority 2' stand. Explore collaboration opportunities with Jasper National Park for prescribed burns. Following each fire season, assess all fires that occurred within the park over 1900 meters for restoration potential.

### *Action 8: Plant seeds and seedlings*

The range wide restoration strategy calls for planting rust resistant seedlings or sowing seeds directly at restoration sites (Keane et al. 2012). Areas selected for planting within Robson include recent burns and at the upper edge of the treeline (Figures 8 and 13). Recent work has shown that nutcrackers cannot be relied upon to initiate natural regeneration, especially in areas with low numbers of available seeds (Keane and Parsons 2010) as is the case in Mt. Robson, providing additional rationale for planting.

Seeds should be collected in 2015, undergo a warm stratification process to increase germination rates, and planted in the fall of 2016. Seedlings should be grown in greenhouses for planting in 2017 or 2018. Planting of seedlings and seeds should be carried out by a crew trained to identify appropriate microsites. Standard treeplanting techniques for planting seedlings in rocky soils can be employed, while seeds should be planted individually in a small hole 2-4 cm deep, and then covered loosely with native soil. Microsites with less sky exposure produce seedlings that have better growth and survival rates (Tomback, 2013). A good quality microsite should have no overstory or understory vegetative competition and is on the north sides of objects such as snags, logs and rocks that protect from intense sun, wind and snow creep. Microsites are more important than evenly spacing seeds since whitebark pine is accustomed to growing in clumps due to the caching habits of Clark's Nutcrackers, so if there are multiple good microsites in a small area, all should be planted with seeds. The spacing recommendations below are meant only to provide a rough estimate of the number of seeds required for collection purposes, and as a general guide for inter-seed spacing.

Density of seedling and seed planting will depend on the availability of seeds. The target density for mature trees is only 250 sph (acceptable range 150 – 600 sph) to avoid inter tree competition and promote open grown trees that produce the most cones (McCaughey *et al*. 2009). In areas too rocky for seedlings, seeds could be planted at a density of up to 2,000 per ha, allowing for low (25%) germination and survival (50%) rates. This is not an unreasonable expectation as other trials have achieved germination rates of 24 – 72%, and survival of close to 100% after 5 years. In areas with sufficient soils for planting seedlings, they should be planted at 1000 sph, to allow for 50% survival after 5 years. It is expected that blister rust will reduce survival over time and eliminate those individuals without genetic resistance.

To plant all six sites (totaling 47 hectares), if half the sites can be planted with seedlings, and half with seeds, a total of would require 70,500 seeds to be collected, which is possible if sufficient resources are allocated, partnerships are formed and cone crops are good. If fewer seeds are available, the planting density could be decreased to a minimum of 1000 seeds / ha or 3.4 meters inter-seed spacing. The proposed planting sites are also prioritized so that if the number of available seeds is limited, they will go where there will be most benefit.

The 2004 fire that occurred above Moose Lake burned from 1100 meters just above the highway all the way up to the top of the ridge at 2145 meters. Whitebark pine snags can be seen starting at 1830 meters elevation, and become more numerous as the elevation increases (Figure 11). However, between 1830 and 1920 meters, only lodgepole seedlings are regenerating. The first whitebark seedling was not found within the burn until 1920 m elevation, where lodgepole pine seedlings were no longer found. Above 1920 meters, the ground was mostly bare, quite rocky, and with very few whitebark seedlings (less than 30 stems/ha). This apparent movement upslope of the lowest elevation of whitebark pine is an indication that we should focus our efforts on planting seeds in the higher elevation zones.

Figure 11: Whitebark snags but no seedlings

Figure 12: *Vaccinium* and rocky soils

The top priority for planting seeds is the upper portion of the polygon labelled 'Priority 1' in Figure 13). The area totals 25.2 hectares and ranges in elevation from 1965 m to 2145 at the top of the ridge. The ground cover is currently dominated by *Vaccinium membranacium*, which is an excellent sign because there appears to be a positive association between *Vaccinium* species and whitebark pine regeneration. The rockiness of the area will make it very challenging to plant seedlings in sufficient density (very difficult or impossible to get a plug in – Figure 12), so direct seeding is recommended where necessary. If ample seeds are available, and the areas above Berg Lake (described below) are already planted, then the 'Priority 2' area in the Moose Lake burn can also be planted. This area is similar to Priority 1, and goes from 1980 to 2100 meters and covers an additional 12.7 hectares

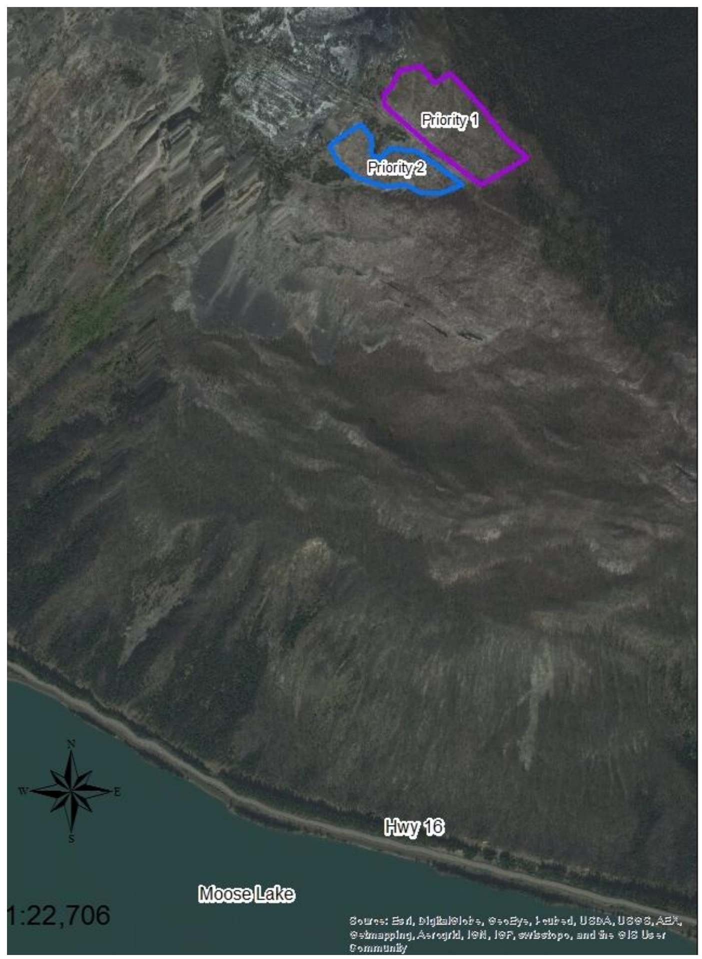


Figure 13: Direct seeding areas above Moose Lake

There are four additional areas along the treeline to the west of Berg lake that are appropriate for direct seeding (Figure 8) totaling 9.4 hectares. There are a few microsites at each location where seedlings could also be planted.

The top priority stand is labelled 'Direct Seed 4' and covers 7.8 hectares just above the trail at the top of the treeline (Figure 8). Here there is scattered whitebark and subalpine fir seedlings with plenty of open ground for planting seeds (Figure 14). The treeline appears to be advancing upslope but the proportion of whitebark seedlings compared to subalpine fir is lower than would be expected due to blister rust killing 90% of the seed source just below.

The second priority is a smaller 1.3 hectare area labeled 'Direct Seed 1' and is in a burn that occurred several decades ago adjacent to Hargreaves glacier (Figure 8). This small patch is surrounded by a mature whitebark pine (over 90% infected) and subalpine fir stand and includes some natural regeneration of whitebark but far less than would be expected in the estimated 25+ years since this fire (no record of this fire was found in the provincial database). There are many burnt whitebark stumps and few seedlings (figure 15)

|  |  |
|---|---|
| Figure 14: The top priority 'Direct Seed 4' area at treeline above Berg Lake | Figure 15: Second priorty 'Direct Seed 1 area' in an old burn |

Two very small areas (0.1 to 0.2 ha each) could also be planted with seeds and are labeled 'Direct Seed 2' and 'Direct Seed 3'. Both of these areas are along the trail, have good planting sites, some miniature shrubs and a couple of whitebark seedlings.

Due to the low levels of existing natural regeneration and expected continued natural establishment, seed planting densities for all four areas above Berg Lake is 1000 seeds/ha or half the density recommended for the burn above Moose Lake.

**Recommendations:** In 2016, plant all available seeds at identified restoration sites above Berg Lake. When seedlings are ready in 2017 or 2018, plant the highest priority area above Moose Lake, and supplement with available seeds. If additional seedlings are available, they can be planted at the restoration sites above Berg Lake.

### *Action 9: Monitor activities*

Monitoring restoration success is an important component of each activity:

- All parent trees from which cones are collected should be marked for future reference in the event that the tree produces rust resistant progeny and additional seed collections are warranted
- A detailed blister rust survey should be completed within each collection stand
- The number of cones available and collected each year should be recorded from each parent tree
- Efficacy of the previous year's verbenone treatments can be easily assessed each spring when new verbenone packets are applied
- Whenever seedlings and seeds are planted on the same site, permanently marked plots should be established to determine the efficacy of the various planting prescriptions
- Plots should be established measuring the growth, vigour and cone production to monitor the thinning sites where competing trees have been removed

**Recommendation:** Ensure that monitoring plots are set up at each cone collection site, thinning treatment, and direct seeding area.

### *Action 10: Conduct research*

All of the monitoring activities mentioned above will be used to assess the germination and survival of planted seeds and seedlings, the survival of young trees around which competing trees were removed, and survival of the parent trees that seeds were collected from.

By following the growth and survival of trees established from various seed sources, we will be able to determine which parent trees carry genetic resistance to blister rust (i.e. the lack of blister rust on the parent tree is due to heritable genetic traits) and which regions produce the best adapted traits for growth in Mt. Robson.

**Recommendations:** Use the data collected from the monitoring plots to assess the efficacy of each treatment and help prioritize and improve future efforts.

## *4. Recommendation Summary and Conclusion*

This paper provides a detailed restoration plan for whitebark pine in Mt. Robson Provincial Park in 2015 and 2016. There are ten actions of the restoration strategy, and recommendations accompanied each of the ten actions:

**Action 1: Assess current condition**. Completed in 2014, but should be updated annually as the project proceeds and monitoring plots are established.

**Action 2: Plan activities**. This paper provides a detailed plan for the 2015 and 2016 field season. Each subsequent year, as new information becomes available and as opportunities emerge, specific details of the plan for the following field season should be updated. It is expected that only minor operational adjustments may be needed.

**Action 3: Reduce disturbance impacts**. All staff and contractors carrying trail maintenance and fire proofing should be trained to identify whitebark pine and white pine blister rust (this can be accomplished quite quickly) and instructed to leave all healthy trees.

**Action 4: Gather seeds**. A cone collection crew should be hired to collect cones from Mt. Robson park in 2015. Partnerships should be established with White Bark Consulting and Parks Canada to collect cones from the Columbia and Rocky Mountains. The target number of seeds for collection is 100,000. If insufficient seeds are collected in 2015, continue the collection program in 2016.

**Action 5: Grow seedlings**. From seed collections in 2015, provide up to 500 seeds per parent tree to FLNRO to grow in greenhouses for rust screening. In 2015, grow up to 10,000 seedlings for planting in 2017 or 2018. All remaining seeds should be planted directly in the ground in 2016 (see Action 8: Plant seeds and seedlings).

**Action 6: Protect seed sources.** While collecting cones in 2015, the threat of wildfire to each parent tree should be assessed, and threats should be mitigated in 2016. Starting in 2016, all trees from which cones were collected should be protected from mountain pine beetle using Verbenone.

**Action 7: Implement treatments.** In 2015, initiate stand thinning operations in 'Thinning Treatment Priority 1' stand. Complete the work in 2016, and consider treating 'Thinning

Treatment Priority 2' stand. Explore collaboration opportunities with Jasper National Park for prescribed burns. Following each fire season, assess all fires that occurred within the park over 1900 meters for restoration potential.

**Action 8: Plant seeds and seedlings** In 2016, plant all available seeds at identified restoration sites above Berg Lake. When seedlings are ready in 2017 or 2018, plant the highest priority area above Moose Lake, and supplement with available seeds. If additional seedlings are available, they can be planted at the restoration sites above Berg Lake.

**Action 9: Monitor activities.** Ensure that monitoring plots are set up at each cone collection site, thinning treatment, and direct seeding area.

**Action 10: Conduct research.** Use the data collected from the monitoring plots to assess the efficacy of each treatment and help prioritize and improve future efforts.

## *Prioritizing Actions*

### *Ranked Priority Actions - 2015*

1) Initiate a cone collection program in Mt. Robson and with partners in the Columbia and Rocky Mountains
2) Initiate thinning treatment above Berg Lake - 'Thinning – Top priority' stand

### *Ranked Priority Actions - 2016*

1) If required, collect more seeds independently and with partners
2) Direct seeding in rocky areas unsuitable for seedlings above Moose Lake – 'Priority 1'
3) Complete thinning treatment - 'Thinning – Top priority' polygon
4) Direct seeding above Berg Lake - 'Direct Seed 4' polygon
5) Direct seeding above Berg Lake – 'Direct Seed 1' polygon
6) Direct seeding above Berg Lake – 'Direct Seed 2' and 'Direct Seed 3' polygons
7) Thin around cone collection trees if required to reduce the probability of damage or death during a fire
8) Initiate thinning treatment above Berg Lake – 'Priority 2' polygon
9) Place verbenone on all cone collection trees

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