Promoting Whitebark Pine Recovery in British Columbia

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April 28, 2015

Executive Summary

> The Chilean poet-diplomat Pablo Neruda once said," *If you haven't been in a Chilean forest you don't know this planet"*. The same can surely be said for whitebark pine forests. They are the centre-piece in one of the most spectacular, diverse ecosystems in Canada. However, due to impacts from a suite of agents, their decline has occurred unabated. Without intervention this decline will likely accelerate.

Whitebark pine is an endangered species threatened by white pine blister rust (*Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*), fire suppression, and global climate change. More direct human impacts also contribute to the decline, but it is also human inaction that is contributing to the lack of any real recovery gains. This document outlines possible means to alleviate this decline including biological, economic, policy and practice options. From a biological perspective, considerations include deploying a greater number of seedlings, namely rust resistant stock. This approach is widely held as the primary pathway to whitebark pine recovery and requires the development of a rust screening facility. Five potential ways to develop a screening facility in BC are presented including:

- develop a new facility,
- modify an existing facility,
- a hybrid option relying on the expertise of multiple facilities,
- coordinating a facility with Alberta, and
- continued contract work with US based facilities.

The economic barrier to whitebark pine recovery is a result of it being a non-timber species with little commercial value and its potential impediment to resource extraction or development as a species-at-risk. Recovery work must then rely on grant opportunities or a change in industry values. As well, if industrial-scale planting of whitebark pine occurred, many activities such as seed collections and rust screening would likely become more cost effective. Policy and practices limiting recovery are broad and range from ground level forestry practices to the lack of any formal species at risk legislation in BC. Minor changes in existing policies may yield great rewards in deploying whitebark pine and promoting recovery. To facilitate and expedite recovery, several key points and recommendations were made including:

- Any work to support whitebark pine recovery will have a negligible impact on timber supply
- If screening parent trees for rust resistance is to expand, regardless of method or location, we will need to embark on an extensive parent tree selection and cone collection program as soon as possible
- Produce a development and marketing plan for the screening process selected to engage as many potential funders as possible
- Resolve seedling deployment barriers to enable more widespread deployment, including resolving seed registration, seed transfer guidelines, the suitability of whitebark for planting within the merchantable forest, and other whitebark-forest industry issues

- Develop and deploy a significant outreach plan to target a range of stakeholders but particularly those who may make decisions regarding conditions on industrial permit applications and policy decisions
- Develop consistent unified mitigation offset options for industry so that a collective action fund or other approach may be developed to support broader whitebark recovery
- Pursue legal and legislative options to provide greater protection for whitebark pine including bringing awareness to federal requirements of the province and provincial avenues such as forest stewardship plans, government actions regulation, and identified wildlife management strategy
- Create a seed collection fund to allow rapid reaction to years of large cone production
- Identifying regions requiring long-term blister rust monitoring plots
- Identifying regions with higher relative rust incidence and fewer seed collections to date
- Develop a recovery team to coordinate the breadth of activities across the geographic expanse of whitebark pine's range in BC.

Kickinghorse Pass

Acknowledgements

We would like to thank the many people who have made valuable contributions to the production of this report, provided us with many useful comments, and provided us with valuable background information.

These people included; Joanne Vinnedge, Michael Murray, John DeGagne, Jodie Krakowski, Charlie Cartwright, Richard Sniezko, Angelia Kegley, Vicky Berger, Jim Kusisto, Nick Ukrainetz, Patti Kagawa, Sybille Haeussler, Adrian Leslie, Dave Enns, Allan Powelson, Dave Weaver, Louise Bight, Laura Darling, John King, Mary Francis Mahalovich, Jack Woods, Brian Barber, Lindsay Robb, Dave Kolotelo, Wyn Hans-Byl, Nathan Robertson, Brad Jones, Melissa Jenkins, Stefen Zeglen, Brenda Sheppard, Elizabeth Campbell, Mark Wong and many others.

We would also like to give heartfelt thanks to Joanne Vinnedge for entrusting us with this document and her continued support. Also special thanks to Alana's mom for babysitting baby Teslin.

Alana Clason, Randy Moody, & Don Pigott

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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 and work by the B.C. Forest Genetics Council and its cooperators.

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

ELITE TREE: A tree verified as superior or desirable by appropriate testing.

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.

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.

IN SITU: On site; within the natural habitat.

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

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: A tree or genotype selected on the basis of its outstanding single-copy performance, but not yet clonally tested or progeny tested.

PUTATIVE RESISTANCE: Appears to be resistant to a disease.

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.

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.

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.

1 Background

Whitebark pine (*Pinus albicaulis* Engelm) is an endangered tree species occurring in the mountainous regions of British Columbia, Alberta, and the USA (British Columbia "blue-listed", BC CDC 2015; COSEWIC 2010; Environment Canada 2012). In British Columbia, whitebark pine ranges over an estimated 145 000 km^2 from the USA border to as far north as 55˚N near Takla Lake (BC-CDC 2015). Whitebark pine is remarkable for its ability to thrive within the unrelenting climatic conditions of the subalpine where it serves to moderate snow and soil conditions (Farnes 1990), thus enabling the establishment of diverse plant communities (Arno and Hoff 1989). Its large nutritious seeds feed an array of birds and mammals including red squirrels (*Tamaisciurus hudsonicus*; Hutchins and Lanner 1982), black and grizzly bears (*Ursus* spp.; Mattson et al. 2001), and most importantly, Clark's nutcrackers (*Nucifraga columbiana*; Tomback 2001); a bird on which the tree is entirely dependent for seed dispersal (Figure 1). Whitebark pine seeds have also supported the high-elevation traditional economies of Aboriginal peoples throughout its range, likely for many thousands of years (Adams 2010; Mellott 2010; Turner 2014).

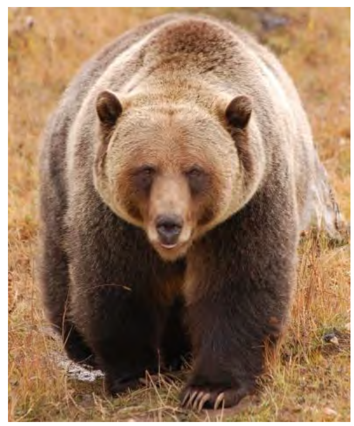

Figure 1. Clark's nutcracker and grizzly bear, two important foragers of whitebark pine seeds.

Whitebark pine is one of three five-needle pine species (five needles per fascicle `needle bundle') in British Columbia (King and Hunt 2004). It has a rounded crown, swooping branches and large purple or brown cones. Its growth form ranges from stunted and twisted krummholz trees (~5 m tall) found at treeline, to tall, erect trees (~20 m) found in lower elevation closed-canopy forests (Douglas et al. 1998). Individual whitebark pines regularly live from 500 (Arno and Hoff 1989) to 1000 years, typically becoming reproductive by the age of 20 to 50 years and peaking in cone production at 250 years (COSEWIC 2010).

Whitebark pine depends exclusively on Clark's nutcrackers to disperse its seeds (Hutchins and Lanner 1982). Clark's nutcrackers extract the seeds from cones, storing up to 150 seeds in a specialized sublingual ('under the tongue') pouch (Lanner 1996). They carry the seeds to caches located anywhere from several hundred meters to 32 km from the source (Lorenz et al. 2011). Over its lifetime a single Clark's nutcracker may cache between 22,000 and 98,000 seeds in up to 7,500 locations (Hutchins and Lanner, 1982). New whitebark pine trees seedlings grow from unexploited seeds in these caches and will occasionally appear multi-stemmed when several seeds within a cache germinate in close proximity (Tomback 2001).

Recently, whitebark pine populations have been decimated by the combined impacts of white pine blister rust (*Cronartium ribicola*) (Campbell and Antos 2000; Zeglen 2002; Smith et al. 2008) and to a lesser degree mountain pine beetle (*Dendroctonus ponderosae*) (Bartos and Gibson 1990; Campbell and Antos 2000). Fire exclusion has also substantially decreased suitable habitat for recruitment (Arno and Hoff 1989; Arno 2001; Arno and Fiedler 2005; COSEWIC 2010). Climate change is expected to play an increasingly important role for future populations, which may result in shifts in suitable habitat locations. Population declines as high as 97% have been estimated for the Waterton Lakes area and 78% in the remaining Rocky Mountain region of its Canadian range (COSEWIC 2010).

At present, white pine blister rust is the primary cause of decline in whitebark pine populations (COSEWIC 2010) (Figure 2). The pathogen, which affects all species of white pines, was introduced to North America from Eurasia in the early 20th century (Peterson and Jewel 1968). It occurs throughout the range of whitebark pine in Canada (Zeglan 2002; Smith et al. 2008; COSEWIC 2010) and is estimated that 52% of trees in the Rocky Mountains (Smith et al. 2008; COSEWIC 2010) and 28% of trees in British Columbia west of the Rocky Mountains are infected with the disease (Zeglan 2002; COSEWIC 2010).

The disease infects the needles of white pines, growing into a tree's branch or stem and disrupting the movement of nutrients and sugars (McDonald and Hoff 2001). Two to four years after infection cankers will erupt on the bark's surface, causing direct damage to the tree's tissues, and the attraction of rodents which feed on the sugar-rich wounds creating further damage (Wilson and Stuart-Smith 2002). The loss of vascular tissue and invasion by secondary pathogens are the main causes of death (COSEWIC 2010). Infection does not always equate to mortality and low frequencies of individuals in wild populations have demonstrated resistance to the disease (Hoff et al. 2001). Even so, mortality caused solely by blister rust has been estimated to reach 57% across Canada by the early 22nd century (COSEWIC 2010).

The impact of white pine blister rust is intensified by the interacting effects of mountain pine beetle, fire exclusion, and climate change. Mountain pine beetle is a native species that has co-existed with North American pine species for 8500 years (Brunelle et al. 2008). In recent years, mountain pine beetle has become epidemic in British Columbia (Natural Resources Canada 2015) partially due to forest management, increasing the number of lodgepole pines on the landscape that are within the age class susceptible to mountain pine beetle attack (COSEWIC 2010). Warmer winters and longer growing seasons associated with climate change have also enhanced mountain pine beetle survival, growth, and reproduction (Carroll et al. 2003; Taylor et al. 2006). Under endemic conditions, mountain pine beetle will generally only kill trees weakened by blister rust infection; however, under epidemic conditions mountain pine beetle will kill healthy, potentially rust-resistant trees as well (E. Campbell pers. comm.).

In addition to tree mortality resulting from white pine blister rust, loss of habitat resulting from fire exclusion and climate change has also affected whitebark pine populations. Fire exclusion has greatly reduced the frequency of low-intensity fires that produce suitable habitat for whitebark pine regeneration (Arno and Hoff 1989). This is particularly important for lower elevation populations where whitebark pine tends to otherwise be outcompeted by shade-tolerant conifer species (Arno and Hoff 1989). Climate change is expected to facilitate the movement of the treeline to higher elevations which will result in a substantially smaller region of suitable higher elevations habitat (Lenoir et al. 2008; COSEWIC 2010) and increased competition with subalpine fir (*Abies lasiocarpa*) and Englemann spruce (*Picea englemannii*) at lower elevations (Schrag et al. 2007; COSEWIC 2010). According to current climate models, the amount of whitebark pine habitat in BC will remain constant; however, its location will shift and current habitat will be lost (Hamman and Wang 2006). Although new habitat is anticipated to compensate for this shift, the ability to colonize it is unknown, and the inability of whitebark pine to remain competitive on current sites as new tree species invade is speculative.

1.1 Need for Blister Rust Screening

There is little hope that white pine blister rust will be eradicated from North American white pine populations (Samman et al. 2003). Attempts to eradicate or supress the disease through the 20th century failed (Maloy 1997; Schoettle and Sniezko 2007). The persistence of all white pines, including whitebark pine, will depend on fostering co-existence with the disease in natural populations (Samman et al. 2003). Co-existence can be achieved through white pine blister rust screening, which involves exposing seedlings produced from putatively resistant trees ('trees that are believed but not confirmed to be resistant') to blister rust spores and monitoring these seedlings over time for infection by the fungus. The locations of parent trees are permanently marked in order to facilitate future seed collections should their progeny demonstrate rust resistant mechanisms. Blister rust screening does not create or seek immunity (no infection); rather it seeks resistance or tolerance of the disease, as seedlings must become infected to display most forms of resistance (M.F. Mahalovich pers. comm.). The purpose of rust screening is to increase the frequency of individual trees within natural populations that can withstand infection, thereby supporting the longevity and health of these populations and the species as a whole.

There is a long history of successful white pine blister rust screening in the USA and Canada for commercial white pine species such as western white pine (*Pinus monticola*) and sugar pine (*Pinus lambertiana*) (Samman et al 2003; Sniezko 2006; Hunt 2009). Following the success of these programs, blister rust screening for whitebark pine was initiated in the USA (Schoettle and Sniezko 2007; GCTAC-FGC 2009). In British Columbia, blister rust screening has been identified as a key goal for whitebark pine conservation (GCTAC-FGC 2009) and was identified as a necessary action in 2004 (King and Hunt 2004). However, presently there exists no dedicated facility to conduct screening within British Columbia. While it is possible for British Columbia to send seed to screening facilities in the USA, the cost and challenges of transferring infected materials across borders will be prohibitive (GCTAC-FGC 2009), especially considering the large number of trees that must be tested in order to produce rust resistant seedlings.

White pine blister rust resistance is unlikely to develop in whitebark pine populations without intervention (Shoettle and Sniezko 2007). With the current and predicted widespread decimation of whitebark populations throughout Canada and the USA (COSEWIC 2010) the impacts of postponement or inaction toward the development of blister rust resistance is readily apparent (Schoettle and Sniezko 2007). Whitebark pine has played an enduring ecological and cultural role in subalpine ecosystems for thousands of years. As a keystone species of the subalpine, the loss of whitebark pine will have cascading impacts on the myriad of plant and animal species that depend on whitebark pine for food and shelter. A multi-faceted approach that addresses white pine blister rust, mountain pine beetle, fire exclusion, and climate change is imperative for whitebark pine's long-term survival. At present, blister rust screening – with proven results in other species of white pines such as western white pine and sugar pine – provides a critical action that addresses the most imminent threat to whitebark pine's survival and contributes to a broader plan for the long term conservation of the species.

Figure 2. Whitebark pine infected with white pine blister rust.

2 Collecting Seed and Producing Whitebark Pine Seedlings

The conservation and timely restoration of whitebark pine hinges on quality seed collections. To identify and produce blister rust resistant seedlings, seed collections should be well documented, with consideration of where and how collections are made and tracked over time. The idea is to collect seed from putatively resistant trees, produce seedlings that are deliberately or naturally exposed to rust, monitor seedling health, and ultimately identify the level of rust resistance that might be partially attributed to a given parent tree. If the seedlings produced from a parent tree show some form of resistance, the parent tree may be re-visited to collect seed for the production of seedlings for restoration activities, and to collect scion material for grafting to establish a seed orchard.

There are 4 primary stages to whitebark pine seedling production:

1. Seed collection
2. Seed processing and stratification
3. Sowing and germination
4. Seedling Culture

2.1 Seed Collections

Collecting seed from natural stands requires careful consideration of location, access constraints, cone quantity, stand size, stand health, and individual tree health. There are many known collection sites across the province that cover a broad ecological gradient, occurring across many seed planning zones (SPZ) with variable access constraints. In general, seed should be collected when and where possible as crops normally only occur every 3-5 years. As a masting species, cone crops will vary year to year and region to region, so it is important to capitalize on large cone crops when and where they occur (Figure 3). Collections made in years when crops are poor or less abundant may have seed quality issues including lack of pollination, poorly formed embryos, insect damage, poor yield and low germination.

Figure 3. Image of mature cone cluster, note immature cones for following year's cone crop.

2.1.1 Cone Crop Forecasting and Reconnaissance

Cone crop forecasting, reconnaissance (recces), and evaluation are an indispensable part of any cone collecting operation. Like all members of the *Pinus* genus, the cones of whitebark pine mature about 15 months after pollination in May-June. The immature conelets are visible shortly after pollination which can provide an early indication of a potential crop (forecast) for the following year. A more detailed survey, usually conducted in June-July, occurs to cage the cones to protect them from predation. The cones are usually mature enough to harvest in mid to late September. Surveys can be done by ground, which can be time-consuming when multiple sites are to be evaluated over large areas, or by helicopter, which is quick but more expensive (Table 1). Identifying crops well in advance of caging and collection is necessary to ensure there is adequate time to prepare for a cone harvesting program.

Table 1. Costs to conduct cone crop forecasting and reconnaissance by area (see Figure 9 for map of seed planning zones (SPZ) in BC).

Seed Planning Zone (SPZ)	Comments	Estimated cost
Bulkley, Central Plateau, Chilcotin (north), Mt Robson	Remote and difficult access, helicopter reconnaissance	$7500
Big Bar, Chilcotin (south)	A few good areas for short helicopter reconnaissance	$4000
Thompson Okanagan	Easy access, good volunteer network	$2000
West Kootenay	Moderately easy access	$3000
East Kootenay, Bush	Easy access	$2000

2.1.2 Other Cone Collection Rationales

In addition to collecting cones for white pine blister rust screening, collections may be undertaken to meet other objectives including restoration activities and ex-situ gene conservation. Although rust screening is the cornerstone of species recovery, restoration and ex-situ collections are commonly conducted without contributing seed to rust screening efforts.

2.1.2.1 Cone Collection for Restoration Activities

Seed needs for restoration plantings are immediate, and because of the lengthy delay to identify resistant seed sources, it is necessary to have less stringent standards for seed collection. Trees collected from should be the healthiest present, but not necessarily free from blister rust. Collections should be made from at least 10 individuals per stand, preferably spaced 30 metres apart, and as many cones per tree as possible should be caged (Shoal et al. 2008; Mary F. Mahalovich, pers comm.). Although collections such as this may seem misguided when considering intensive rust screening approaches, it should be underscored that it is not financially feasible to screen every parent tree used for seedling production; in parts of the US, putative resistance in parents forms a sufficient case for seedling production and planting (M. Jenkins pers. comm.).

2.1.2.2 Cone Collection for Ex- Situ Gene Conservation

The majority of whitebark pine cone collections in BC have been made for ex-situ gene conservation. The standard protocol has been to collect seed from at least of 10 trees in each stand, spaced a minimum of 50 metres apart. The goal was to collect a minimum of 1000 viable seeds from each population. Originally, little attention was paid to selecting for resistance to white pine blister rust. However, for the past 4 years there has been an attempt to select suitable candidates for blister rust screening. In the past year the target number of trees per stand has increased to 20, and the number of viable seeds per stand increased to 40,000. This goal, although admirable, is usually unachievable.

2.1.3 Cone Production Methods

As collections progress over time and more is learned about the prevalence and geographic distributions of resistance mechanisms, the locations and degrees of management in collection stands is likely to increase. At present, all collections begin in unmanaged *natural stands* where the most suitable parent trees present are selected; ideally this will move to *selected stands, seed production areas*, and ultimately *seed orchards* (Figure 3) as the level of knowledge and management regarding whitebark pine increases. Within each of these stand types, additional steps of parent tree selection and cone collection will be required prior to seedling production.

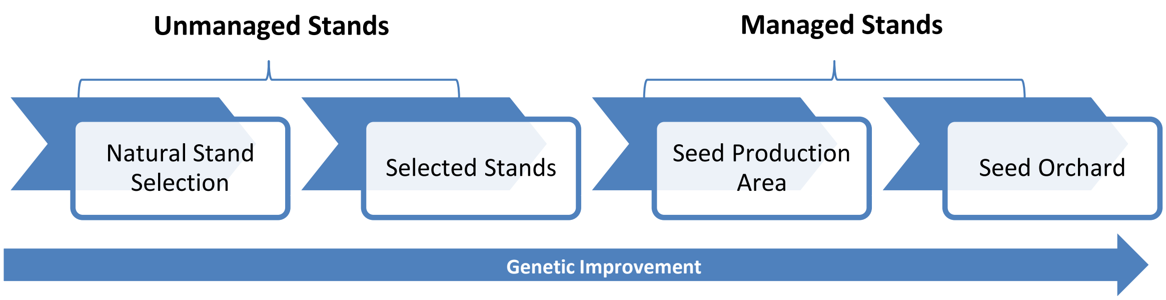

Figure 4. Schematic of the relationship between seed collection stand types and genetic improvement.

2.1.3.1 Unmanaged Stands

Unmanaged stands for seed collection include both natural stands and selected stands; in both cases no intervening management has occurred to enhance the stand for seed production and collection. Natural stands represent the starting point for most collections where little is known about the stand and they are selected for collection based on factors such as access, tree size, and the presence of a cone crop; selected stands are comparable to natural stands, however some level of natural selection has been operating resulting in a stand where putatively resistant parents may be prevalent within the population.

Natural Stand Selection

To select candidate natural stands for collection, a number of traits should be present including:

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

ii) *High 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. Health can be assessed using different methods, but the Whitebark Pine Ecosystem Foundation (Tomback et al., 2006) standards are recommended (Appendix 2 – Health Survey Methods). 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.).

iii) *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 for cone collections. Due to this trait, trees with high branch densities and low crowns are preferred; however, collections from large, high crowned trees can be made using skilled tree climbers. In general, trees growing at higher elevations are easier to climb than those growing lower on the slope in more productive stands and these high elevation trees are easier to assess for blister rust infection. However, some believe that taller trees at lower elevations produce more cones and have more viable seeds in each cone.

iv) *Good access* – To adequately collect 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 (Pigott 2004). As each of these visits may be impaired by snow, good access is paramount. Further, a site visit one year prior to identifying cone crop potential for the following year is a recommended approach. Stands where such visits may easily occur are preferred. Helicopter access could be cost-efficient when a helicopter base is located near a potential collection site.

Selected Stands

Selected stands are natural stands with a history of good cone production, easily harvestable cones, good site access, and in the case of whitebark pine, have some indication that natural selection for rust resistant traits is occurring. Stands that fit these criteria will typically occur in areas where incidence of rust infection is high, as will the number of putatively-resistant individuals persisting on the landscape. In addition, some regions may yield many parent trees that appear to be blister rust-resistant, such as those in Washington that have been identified through the rust screening process as having “superior provenances” for that region (Sniezko pers. comm.; Sniezko et al. 2007).

2.1.3.2 Managed Stands

Managed stands for seed collection represent those where some form of management intervention has been undertaken to improve the quality and quantity of seed produced at a given site. The two types described here include seed production areas, which are natural stands enhanced to improve seed production; and seed orchards, which are intensive stands commonly established through clonal or seedling means to improve the availability of rust resistant seed.

Seed Production Areas

Seed production areas (SPA) are natural stands of trees that are at or near seed-producing age. These stands are thinned by removing non-target trees in order to increase the productivity for the target whitebark pine trees to produce higher quality seed. Competing tree species, such as subalpine fir or lodgepole pine, may be removed, along with diseased whitebark pine trees. This management intervention may increase seed production or reduce time to seed production in remaining target trees by maximizing on-site productivity. The cost to establish these areas is low, and it may result in cost saving over time as trees are cultured to facilitate seed collections. Further, by managing and observing trees over time, it may be easier to select candidate resistant trees from such stands. Many of these seed production areas could be established across BC to meet local seed requirements. Currently, there is only one 2-hectare seed production area in the East Kootenay, established in 2012 (Figure 5).

Figure 5. Whitetail Lake seed production area near Canal Flats, East Kootenay.

Seed Orchards

A seed orchard is a stand of trees, usually of at least several hundred, grown and managed primarily for early and abundant production of ‘superior’ seed. In this case, the goal is to more rapidly produce seed from parent trees that have been tested and demonstrate superior rust resistance. Orchards can either by established from (1) seedlings grown from the seed of the superior parent trees, or (2) grafts from the scion of the superior parent trees (Figure 6). In natural stands, whitebark pine normally does not reach sexual maturity until about 40 years of age (COSEWIC 2010). In comparison, grafted trees usually have scion material that is physiologically much older, thus can likely produce seed earlier. However, regardless of origin (grown from seed or grafted material), whitebark pine will still grow relatively slowly even under cultivation. As a result of the slow growth and lack of established orchards in North America, particularly in BC, seed production from orchards will not be available for some time. Grafting of whitebark pine is uncommon and experience with growth, flowering and seed production is almost non-existent in BC. It is unknown if graft incompatibility would be a problem with whitebark pine, as it is with Douglas-fir. There is little experience with minimizing graft incompatibility between root-stock and grafting scion, which can cause serious losses in orchards.

Site selection for seed orchards may be important and affect the results of more abundant and earlier seed production. In Montana, three orchards have been established at over 2500m in elevation (Konen 2013). While this is suitable natural whitebark pine habitat and may be good for cone production, growth is likely to be slow, and there could be a considerable delay in flowering. At the Dorena Tree Improvement Station in Oregon, vigorous 12-year old whitebark pine tree grafts grown at 240 m in elevation have produced good filled seed when supplemental pollinated.

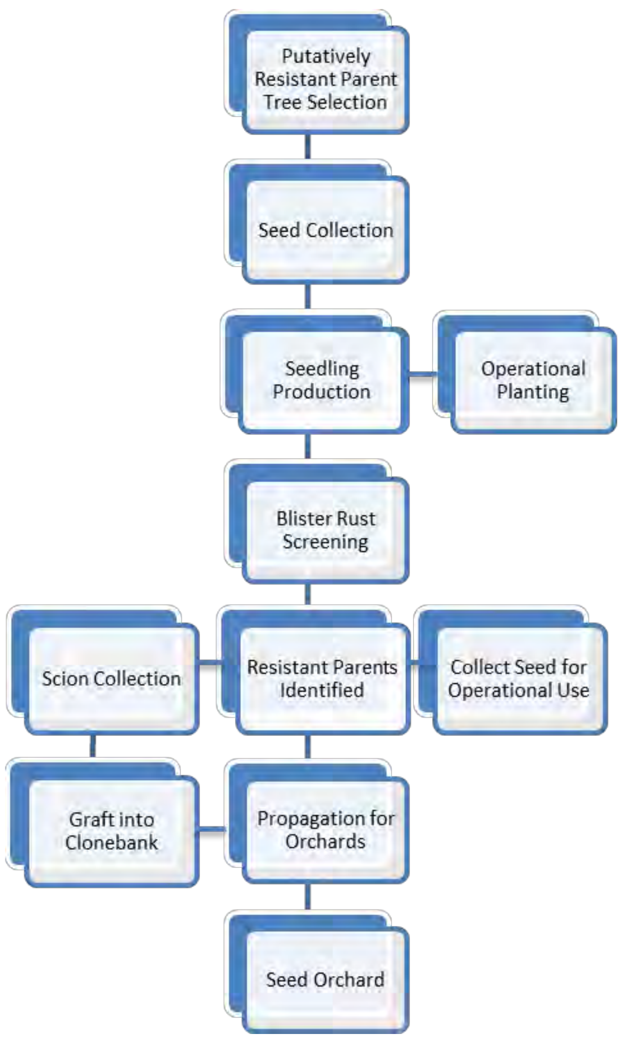

Figure 6. Summary of process to establish a seed orchard.

To establish seed orchards, with a goal of a minimum of 25 parents in each orchard, 250 wild parent trees would need to be screened. This is based on other parent tree selection programs for five-needle pines, where one in ten families screened was used to establish a seed orchard. Currently, MFLNRO is planning to screen 500 families between two estimated "breeding zones" in BC (Charlie Cartwright pers. comm.), with approximately 250 families screened per zone. More zones may be advisable as there is strong support for the use of local seed sources. However, the cost of screening enough putatively resistant trees to supply more zones would increase the costs proportionally. Five zones could be considered for BC which would address geographic interests and possible concerns: (1) East Kootenay; (2) West Kootenay-Bush; (3) Thompson-Okanagan (both Arid and Dry); (4) Big Bar-Chilcotin (south); and (5) Bulkley, Central Plateau (north), Mt Robson. If costs are a limiting factor, it could be advisable to first establish orchards for the regions that have the highest priority for recovery.

The number of individuals (ramets) of each parent required to produce a given annual seed requirement for each zone needs further investigation, but in Table3 we have given our best-guess for the purpose of planning and discussion.

The establishment of seed orchards from tested parent trees will not happen until enough putatively selected parents have been screened to provide at least 25 families per breeding zone. This could mean testing 250 trees based on the success rate for western white pine in BC (10%); albeit much higher rates (48%) have been reported in the Inland NW US (Mahalovich 2006). For planning purposes it is better to plan on testing more parents than less. Improved material from seed orchards to meet provincial needs is unlikely to be available for at least 10-15 years.

There have been four whitebark pine seed orchards established in the US from parents screened for resistance to white pine blister rust at the Coeur d'Alene Nursery in Idaho. Below is some data on two of the orchards established between 2011-2013 (Konen 2013, Murphy 2014). It is interesting to note that the estimates of annual seed production per ramet (tree) for both orchards are radically different (Table 2). The estimate for the Lewis and Clark orchard is 236 grams of seed per ramet per year, while for the Gallatin orchard it is only 46 grams per ramet per year. Both orchards are located at reasonably high elevations. Although whitebark pine will undoubtedly thrive and flower at these elevations, there may be concern about slow growth, slow crown development where flower buds occur, and possibly pollen contamination if the adjacent stands have whitebark pine. In BC, trials regarding site selection related to growth, and flower production prior to any orchard established would be beneficial.

Table 2. Summary of two seed orchards in the United States (Konen 2013; Murphy 2014).

Location	Elevation (m)	Area (Ha)	Spacing (m)	No. of trees	Annual Planting Supported(ha)	Annual Needs (Kg)	Expected Age of Seed Production (years)
Lewis and Clark National Forest	2225	0.61	6.1x 6.1	165	184	39	10-15
Gallatin National Forest	2660	2.83	6.1x 6.1	1000	364-384	46	10-15

No goals or targets have been established for the planting of whitebark pine in BC at this time. In the absence of real targets, we have used 100,000 as the arbitrary production baseline. In Table 3 we estimate the orchard needs to produce 100,000 seedlings at two different sowing levels (2 and 3 per cavity). Based on 5 grams of seed per cone, the Lewis and Clark orchard would need an average of 47 cones per ramet per year, while the Gallatin orchard would only require 9 cones per tree per year. The Lewis and Clark orchard numbers may be very optimistic in the early years. If we consider the lower of these two estimates of production, and our own observations, we estimate the following orchard requirements:

Table 3. Summary of BC seed orchard requirements to produce 100,000 seedlings.

Seedling Needs	Sowing seeds/cavity	Cones required	Ramets required (10 cones/tree/yr.)	Spacing (m)	Area Required (ha)
100,000	2	5200	520	5x5	1.3
100,000	3	7800	780	5x5	1.95

Alternatively, we need at least two seed orchards to supply the needs based on differences in mean annual temperature (Cartwright et al. 2013). Technically, the number of ramets could be divided between these orchards, but given uncertainties around seed production, and having a smaller pollen cloud in orchards with less numbers; larger orchards are probably more prudent. The cost of grafting is also relatively inexpensive ($7.50 per graft, J. Kusisito, pers. comm.).

2.1.4 Tree Level Selection

2.1.4.1 Parent Tree Selection for Blister Rust Resistance Testing

Once a stand is selected, individual trees are identified for collection (Figure 7). Selected whitebark pine trees should be healthy relative to the stand composition (= 'Putatively Resistant' parent trees, Table 4, Table 5). In order of preference, trees for collection should have (1) no cankers, (2) inactive cankers or bark reactions, and lastly (3) 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. In order to discriminate trees for selection where rust pressure is low, selection criteria among rust-free individuals was simplified to: healthy, live green crowns in excess of 30%, and bearing cones (Mahalovich pers. comm.).

Figure 7. Parent tree marked with paint.

Table 4. Whitebark pine plus-tree selection criteria (Mahalovich and Dickerson 2004).

Stand level criteria	Individual-tree level
Vigorous and representative of the species	Dominant or co-dominant trees
Habitat type where species normally occurs	Minimum of 100 m between selected trees to avoid relatedness
Provides a broad sample of both the geography and range of elevations	Free of insects and diseases
Overall composition has a high proportion of living or dead whitebark pine, well represented throughout the stand	Have a history or the potential to bear cones
Uniformly and heavily infected with blister rust (10 or more cankers per tree on the average)	Be within 100 to 200 m from the nearest road or trail
Confirmed blister rust infection of 90 percent rust infection, limited selected trees to no more than five cankers	No more than three of the best candidates in any given stand
	No squirrel cache collections

Table 5. Acceptable canker limits for individual plus-trees based on stand averages (Mahalovich and Dickerson 2004)[1].

Stand Average (cankers/tree)	Plus Tree Limits
10 – 20	No cankers
21 – 40	1 canker
41 – 75	2 cankers
76 – 150	3 cankers
151+	4 or 5 cankers

2.1.4.2 Seed Collection

Once a candidate parent tree has been selected, seeds are collected from the tree in a two-part process. First, cages made of wire or plastic mesh are placed over clusters of cones on each tree in early July (Figure 8). This caging is required to protect the cones from foraging Clark's nutcrackers and red squirrels. To form the most effective barrier, wire cages are preferred and the tops and bottoms of cages should be securely closed using cable ties. In late September these cages, and the cones they were protecting, can be removed from the tree. Rigorous record keeping and adherence to protocol is essential as trees that show signs of rust resistance following screening of the seedlings may be re-visited for additional seed or scion collection.

Appropriate care must be taken from the time seed is harvested until it is extracted. Cones must be collected in clean sacks made of burlap, cloth, or other porous material. Every effort must be made to keep the cones well ventilated and dry at the collection site and during transport. They should be taken to an interim storage site as soon as possible. The cones should be as free as possible from excessive debris as it can encourage mould, contribute to lethal temperatures in the sacks, and compromise seed cleaning.

If cones must be kept in storage for any period of time, they must be kept in a covered, well ventilated area. It is necessary to eliminate threats from rodents or birds. Carports or well ventilated garages work well. Household fans can improve aeration in closed areas. The cones should be off the ground on a pallet or racking, and turned occasionally to enhance after-ripening and drying.

[1] These standards are likely only applicable to the area where they were developed based on cankers/tree averages

Figure 8. Caged whitebark pine cones on Mt. Davidson, central interior, BC.

2.1.4.3 Protection of Parent Trees

Efforts should be made to preserve all collection sites containing parent trees (whether natural stands or managed production areas) for future work. This is to support recollection of seed from parent trees whose offspring show potential resistance during blister rust screening trials, as well as preserving areas that may have high value for operational use. Protecting the stand should occur in the field and within a chosen policy or legislative designation where possible.

In BC, there is increasing adoption of a common numbering system for all whitebark pine parent trees (coordinated by the Whitebark Pine Ecosystem Foundation of Canada) using pre-assigned numbered metal tags. This is a dedicated tagging system with each tree having a unique identifying number across the province. These metal tags should be affixed to a tree branch or the tree stem in a visible location. Flagging can be useful for re-locating, but is relatively short-lived in harsh environments. The tree number can also be painted on the stem. Blue marking paint stands up the best; however, painting may not be acceptable in some locations (parks). Information must be collected regarding the size, health, vigor, and location of each parent tree. Information on parent trees and collections should be forwarded to the Cone and Seed Improvement Officer at the Tree Seed Centre in Surrey (Appendix 1 – Parent Tree and Stand Data: Collection Sites).

Field protection of parent trees may include both awareness and biological protection:

- *Awareness* may include a sign explaining the significance of the stand, reducing the likelihood of inadvertent cutting or damage.
- *Biological protection* includes the deployment of verbenone to lower the risk of attack from mountain pine beetle if it is deemed a threat in a given area.

Legislative protection of parent trees may be achieved through measures (See Policy Section) such as:

- Protecting the tree/area for gene resources under Section 158 of FRPA;
- Designating the area as a research installation or experimental plot; or
- Recognizing whitebark pine as an endangered species under Section 13 of Government Actions Regulation

Each of these approaches has some limitations but affords some protection in the near-term. Further, it is important that each of these levels of protection be communicated to fire managers so they are included in district fire management plans.

Registering the collection site as a resource installation or an experimental plot (EP) will generate referrals from development proponents. The 'notations' that appear in i-Map do not protect the installation as they are not reserves that identify potential resource conflicts (Wyn Hans-Byl, Manager Technical Services-Knowledge Management Branch pers. comm.). These notations vary for Crown Land within and outside Provincial Forests.

2.2 Seed Availability

There is little high quality seed currently available for whitebark pine in the province. Currently, only three whitebark pine seedlots are registered on SPAR (Seed Planning and Registration System), which are owned by MFLNRO, but they are reserved for the seed bank. These three registered collections are between 20 and 36 years old and of very poor quality (Table 6). The potential number of seedlings the registered seedlots could yield, based on current sowing rules, is only 4,900[2].

Table 6. Seedlots currently registered in SPAR (Seed Planning and Registration System). Germination rates were tested as an indication of quality, with low germination across all SPAR seedlots.

Seedlot	Seed Planning Zone	Location	Collection Year	% Germination	Kg of Seed	Potential Trees
39347	Big Bar (BB)	Lime Mt	1994	10	2.404	2,300
03366	East Kootenay (EK)	McNeil Creek	1978	6	2.148	2,000
03347	East Kootenay (EK)	Summit Lookout	1978	1	0.562	600

Although increasing quantities of seed have been collected across the province, and more seedlings produced in the last 5-7 years, each of these collections is for a specific project; for instance, ex situ

[2] Current standard sowing practices is 2 seeds/cell

conservation, blister rust screening trials, or restoration plantings. Fifty-four kg of seed is in storage for ex-situ gene conservation. An additional 30.3 kg are being stored for specific clients including Parks Canada, BC Parks, BC Timber Sales, the Bulkley Valley Research Centre, New Gold Mine, and the Wetzin'Kwa community forest. None of this seed is registered on SPAR, nor has it been tested. SPAR is where an industrial proponent would seek available whitebark pine seed for reforestation purposes. The 30.3 kg of seed owned by the other six agencies could potentially yield up to 93,000 seedlings[3]. These numbers include transplanted germinants, which occurs when 2 seeds germinate in one cell. One seed can be removed and re-sowed in another cell, increasing the total potential seedlings. Although there is a lack of seed available on SPAR, extensive collections have been conducted throughout the range of whitebark pine in BC (Figure 9,Table 8), yet none of this seed is available at present. Despite the increase in collections, there remain large areas where whitebark pine seed has not been collected (Table 7).

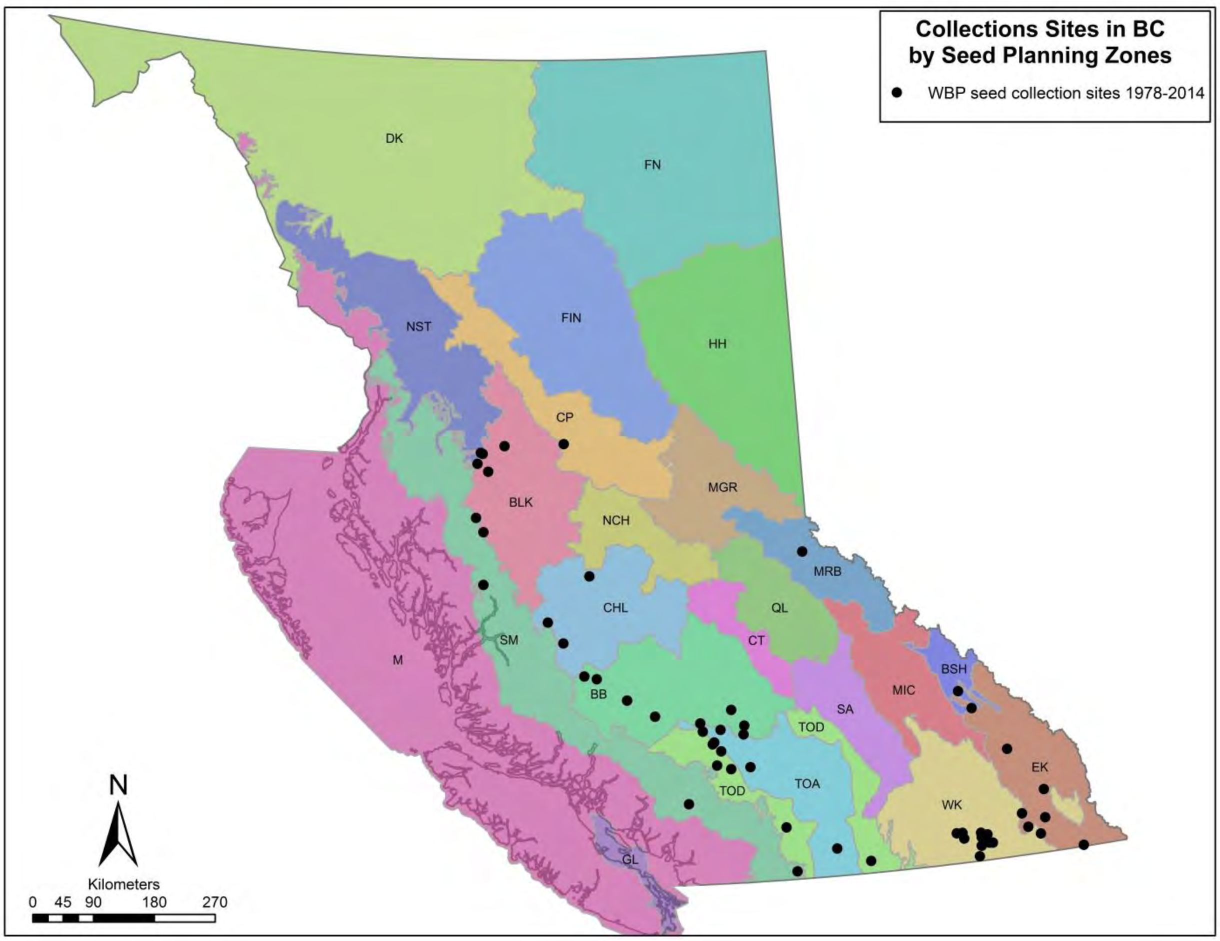

Figure 9. Known whitebark pine collection sites in BC in relation to Seed Planning Zones (SPZ). See Table 8 for more collection site information and Table 7 for the list of Seed Planning Zones.

[3] Based on a 50% germination rate, and 10 seeds/gram, 2 seeds/cell and 30% oversow (30% extra cells are sowed)

Table 7. Seed Planning Zones (SPZ) where whitebark pine is known or likely to occur.

SPZ Code	SPZ Name	Collected	SPZ	SPZ Name	Collected
BB	Big Bar	✓	MRB	Mt Robson	✓
BLK	Bulkley	✓	NCH	Nechako	×
BSH	Bush	×	NST	Nass Skeena Transition	✓
CHL	Chilcotin	✓	QL	Quesnel Lakes	×
CP	Central Plateau	✓	SA	Shuswap Adams	×
CT	Cariboo Transition	×	SM	Submaritime	✓
EK	East Kootenay	✓	TOA	Thompson Okanagan Arid	✓
MGR	McGregor	×	TOD	Thompson Okanagan Dry	✓
MIC	Mica	×	WK	West Kootenay	✓

Table 8. Historical whitebark pine seed collection sites in BC from 1978-2014.

Coll. ID	Location	Latitude	Longitude	Mean Elevation	SPZ	BEC Subzone/ Variant	Years	Access	Site Quality[2]
1	***Apex Mountain****	49.367	-119.917	2110	TOA	ESSFxcw, xcp	1999, 2006, 2007	4x4	2
2	***Blackcomb****	50.083	-122.900	1893	SM	CMAunp, ESSFmw, MHmm2	2000, 2006, 2007	4x4	4
3	***Blackwell Peak****	49.106	-120.759	1995	SM	IMAunp, ESSFmw	2005, 2007, 2013	2wd	4
4	***Burnette****	49.282	-116.881	2170	WK	ESSF wcw	2011, 2012	4x4	3
5	***Darcy****	50.534	-121.580	1800	TOA	ESSFxc2	2003	4x4	3
6	**Downton**	50.580	-122.277	2006	TOD	ESSFdvw	2014	Hike	2
7	**Duthie Mine**	54.784	-127.348	1491	BLK	ESSFmc	2013	2wd/Hike	3
8	**Eagle Pass**	54.878	-126.804	1544	BLK	ESSFmc, mcp	2011	2wd/Hike	4
9	**Elizabeth Mine**	51.038	-122.541	2160	TOA	ESSFdvp	2010	4x4	2
10	***Grassie Tops****	49.323	-117.324	1981	WK	ESSFwc4	2007, 2011,2012,2013	4x4	2
11	**Burkholder**	50.865	-122.345	2030	TOD	ESSFdvw	2014	4x4	1
12	***Hudson Bay Mt****	54.771	-127.304	1511	NST	ESSFmc	2007, 2013	2wd/Hike	4
13	***Hunter Basin****	54.535	-127.172	1502	BLK	ESSFmc, mcp	2013	Helicopter	3
14	***Jesmond****	51.308	-121.915	1800	BB	ESSFxc3	2006	4x4	2
15	**Jonas Creek**	54.639	-127.418	1230	BLK	ESSFmc, SBSmc2	2011	4x4/Hike	4
16	**Kappan Mt.**	52.262	-125.473	1807	CHL	ESSFxvp	2013	Helicopter	2
17	***Kicking Horse****	51.279	-117.074	2246	BSH	ESSFdk2, dkp	2010	4x4	2
18	***Kidprice****	53.921	-127.427	976	SM	ESSFmk	2011, 2013	Float plane/ canoe	2
19	**Laib**	49.372	-116.971	2080	WK	ESSF wcw	2012	4x4	3
20	**Larochelle**	50.888	-122.310	2033	TOA	ESSFdvp	2014	4x4	2
21	***Lime Mt****	51.089	-121.659	1880	BB	ESSFxc3, MSxk3	1994, 1999, 2003	4x4	2
22	***McBride Peak****	53.338	-120.129	1866	MRB	ESSFmm1, mmp	2010	4x4	2
23	***McGregor****	49.340	-116.844	2120	WK	ESSF wcw	2011, 2012	4x4	1
24	**McNeil Cr**	49.367	-116.000	2012	EK	MSdk1	2012	Unknown	U
25	**Mission Ridge**	50.765	-122.174	1854	TOD	ESSFdv2, dvw	2010	4x4	3
26	**Molybdenite**	50.522	-121.987	2034	TOD	ESSFdv1, dvw	2010	4x4	2
27	***Moyie Mt****	49.255	-115.765	2078	WK	ESSFdkw	2007	2wd	2
28	***Mt Baker****	49.461	-115.630	2206	EK	ESSFdkw	2007	4x4	2
29	***Mt Sweeney****	53.732	-127.255	1431	BLK	ESSFmc	2013	4x4	1
30	**Mt. Baldy #1**	49.020	-114.940	2079	EK	ESSFdk	2011	Hike	3
31	***Mt. Baldy #2****	49.163	-119.254	2205	TOD	MSdm1, ESSFdcw, dcp	2006, 2010, 2011	4x4	1
32	***Mt. Carson****	50.973	-121.684	2067	BB	ESSFxc3, wcp	2010, 2013	2wd	1

Coll. ID	Location	Latitude	Longitude	Mean Elevation	SPZ	BEC Subzone/ Variant	Years	Access	Site Quality[2]
33	***Mt. Davidson****	53.148	-124.887	1751	CHL	ESSFmvp, BAFAun	2013	4x4[1]	2
34	***Mt. Puddingburn****	49.555	-116.089	2340	EK	ESSFdk1,dkw, dmw	1978	4x4	2
35	***Mt. Sidney Williams****	54.906	-125.431	1560	CP	ESSFmv3, ESSFmvp	2007	Helicopter	2
36	***Mt. Stevens****	49.833	-115.574	2308	EK	ESSFdkw, dkp	2012	Hike	4
37	**Mt. Thynne**	49.700	-120.917	1750	TOD	ESSFdcw	1999	4x4	3
38	***Nemahiah Mt****	51.490	-124.122	2016	BB	ESSFxvp	2006, 2013	Helicopter	2
39	***Niut Mt****	51.490	-124.124	2003	BB	ESSFxvp	2006, 2013	Helicopter	3
40	***Panorama****	50.432	-116.210	2074	EK	ESSFdkw, dkp	2011	4x4	2
41	***Perkins Peak****	51.821	-125.028	1940	BB	ESSFxv1, xvp	2006, 2013	Helicopter	2
42	**Poison Mt.**	51.149	-122.587	2010	TOA	ESSFdvw, dvp	2010	2wd	1
43	**Red Mtn.**	49.402	-117.345	2103	WK	ESSFwcw	2013	4x4	2
44	***Ritual****	49.313	-116.968	2046	WK	ESSFwcw	2011	4x4	4
45	**Royce**	49.200	-116.991	2072	WK	ESSFdmw	2012	4x4	4
46	***Sapeye Mt****	51.781	-124.763	1961	BB	ESSFxv1, xvp	2006, 2013	Helicopter	1
47	**Second Creek**	51.050	-122.164	1888	TOA	ESSFxc3	2014	4x4	3
48	***Siwash****	49.353	-117.463	2100	WK	ESSF wcp	2011, 2013	4x4	2
49	***Smoke Mt****	53.035	-127.236	1177	SM	ESSFmc, MHmm2	2013	4x4/Hike	2
50	***Stagleap****	49.064	-117.054	1938	WK	ESSF wc5	2011	Highway	3
51	***Taseko Lake/Mt****	51.265	-123.539	1990	BB	ESSFxvp	2006, 2013	4x4	3
52	**TFL 14 Lookout**	51.033	-116.833	1981	EK	ESSFdk2	1978	Unknown	U
53	***Heckman Pass****	52.540	-125.812	1541	SM	ESSFxv1	2007	2wd	3
54	**Washboard**	49.222	-116.756	1931	WK	ESSF dm	2012	4x4	4
55	**Wood Peak**	49.227	-116.828	2208	WK	ESSF dmw	2012	4x4	3

*****Trees from these locations have been submitted to rust screening programs

[1] Active mine site, access controlled

[2] Collectibility refers to access, number of collectable trees and ease of collection with rankings of: 1=Excellent; 2=Good; 3=Fair; 4=Poor, U=Unknown

2.3 Current Seed Needs

In order to produce seedlings for blister rust screening, access to whitebark pine seed is necessary. There are several options for obtaining seed for seedling production; however, whitebark pine seed is currently limited in its availability as a result of biological and policy barriers. As a result, the solutions for improving seed supply must address these limitations.

Seed is the foundation of any whitebark pine recovery and restoration program. Without seed, there is no need for a white pine blister rust screening facility. Until now, the majority of whitebark pine seed collections have been for *in situ* gene conservation, provenance testing, and specific restoration projects, not rust screening. The primary focus was not to select putatively resistant parent trees for screening but to meet the needs of other programs. There is a limited amount of seed stored at the Tree Seed Centre collected from a wide geographic range in BC, intended solely for *in situ* conservation. Seed has been released for many specific research projects, but there is a limited supply, and again most of the individual parents were not selected for resistance attributes.

Limitations on the availability of whitebark pine seed need to be addressed in order to facilitate both blister rust screening and other uses of whitebark pine seed. These limitations include:

Biological Limitations:

- As a masting species, collections cannot be solely driven by demand, but must occur when the biological opportunity arises. Too often proposals are written to conduct collections at future dates when no knowledge of the future cone crop is known;
- Sparse and/or young trees in areas may limit pollination levels, this issue may increase as populations decline;
- Variable germination by site and by year; and
- Lack of experience in collection and seed handling techniques.

Economic Limitations:

- Two visits to cage and collect;
- Remote locations of many sites; and
- Whitebark pine is not a merchantable species thus collections are often small and rarely benefit from economies of scale.

Policy Limitations:

- No whitebark pine specific seed transfer guidelines;
- Lack of clarity around the need for, and methods of provincial seed registration (SPAR);
- Lack of clear policy on seedling deployment (non-merchantable species), which limits appetite to invest in seedlings and no demand for seed.

If screening parent trees for rust resistance is to be initiated, regardless of method or location, we will need to embark on a parent tree selection program as soon as possible. This will take time, resources, and money. A coordinated plan must be developed to prioritize areas for parent tree selections and seed collection. Standards for selection criteria are required. Targets for the number of trees by stand, region, and seed planning zone are needed. A coordinator or coordinating body is also required. Considering the biological, economic, and policy limitations is paramount to conducting an efficient large-scale seed collection, with some potential solutions to these limitations described below.

2.3.1 Resolving Seed Needs

2.3.1.1 Seed Collection Fund

Costs of seed collection are substantial. The cost of collecting seed from ten parents per stand for gene conservation was approximately $2400 per provenance. However, more rigorous selection standards, and lower numbers of selections per stand will increase cost per tree. In the 1980's, the cost of selection alone (not including seed processing) for the western white pine parent tree program averaged between $400 and $750 per tree. If we planned to select 500 putatively resistant parents and used the average from the 1980's of $575 per tree, collection costs alone would be $287,500, not including seed processing.

Costs for whitebark pine seed can be as high as $10,000/kg, though these costs vary widely depending on the sites visited. Based on experience, regional costs were estimated considering access, tree height, and knowledge of producing stands (Table 9). When a mast year is observed, it is important to have immediate access to funds to enable collections. Collections during a mast year may be far more productive than collections in non-mast years. For example, a collection during a mast year (2010) in the Lillooet region yielded more than 10x the cones collected during a non-mast year (2014). Creating a seed collection fund, which may be accessed on short notice, may be invaluable to facilitate collection during mast years and improving the availability of seed for future work. Collecting during mast years will address the high costs of seed collection as more seed can be collected with similar effort in non-mast years.

In 2015, the total sowing for the MFLNRO will be approximately 59 million seedlings. Of that total, BC Timber Sales (BCTS) is responsible for 41 million, Forests for Tomorrow for 16 million, and the balance for minor uses and tenures. BCTS maintains a substantial seed acquisition and cone collection fund to ensure that it is able to meet their annual seedling sowing requirement. This means having a several years supply in the "bank." They both sell to, and purchase seed from, the MFLNRO, tenure holders, seed orchards, and private seed companies. This fund enables them to take the opportunity to harvest cone crops when reasonable crops occur. BCTS is willing to fund collections of whitebark pine seed on reasonably short notice, provided justification is provided. This seed can also be made available to other potential users on a cost-recovery basis. BCTS has funded whitebark pine collection in the past near Smithers (Patti Kagawa, pers. comm.). Other collections in the province have been funded by Forests for Tomorrow on Mount Sidney Williams, and BC Parks on Blackwell Peak (Manning Park).

Table 9. Estimated seed collection costs for across seed planning zones.

Cone Collection Costs by Area		
Seed Planning Zone (SPZ)	Comments	Estimated cost to collect enough cones for 100,000 seedlings. (5200 cones)
Bulkley, Central Plateau, Chilcotin (north), Mt Robson	Remote and difficult access. Helicopter access.	$324,000 *
Big Bar, Chilcotin(south)	Some good areas for short helicopter access collections. Costs here reflect long flight times between 6 stands where research collections were made. Operation costs in fewer selected stands would be much less .	$80,250 *
Thompson Okanagan-Dry, Thompson Okanagan-Arid.	Easy access, good volunteer network. Many easy areas to collect.	$30,650
West Kootenay.	Moderately easy access.	$30,650
East Kootenay, Bush.	Easy access. Several good areas to collect.	$30,650

*Costs are rough estimate based on actual costs for research collections made in 2013. Costs included helicopter time, travel, labor to cage trees, and re-visit stands to collect cones, as well as cone and seed processing.

2.3.1.2 Increase Seedling Deployment

Increased seedlings deployment may be achieved by encouraging industry to utilize whitebark pine where possible. This broader use of whitebark pine should aid in reducing the high costs associated with seed collection and seedling production by creating an economy of scale. Education of industrial proponents and statutory decision makers, where possible, is recommended.

2.3.2 Policy Limitations

According to Section 43 of the Forest and Range Practices Act, (FRPA) seed transfer and registration rules <u>only apply where the intent is to establish a free growing stand</u>. Regardless, certain users of whitebark pine seed request registered seedlots, whether they are pursuing free to grow standards or not. This results in a need to fulfill requirements of registration and seed transfer guidelines. In other cases, where seed is not registered, it is still important to develop reasonable guidelines for seed collection and planting in order to ensure that well-adapted material is planted, that the seedlots have a reasonable genetic base, and there is a system in place to track deployment. It is also important to educate potential users on which requirements and guidelines should be followed in any given situation.

2.3.2.1 Lack of seed transfer guidelines specific to whitebark pine

The objective of reforestation is to establish plantations that can yield their genetic potential within the environmental limits of climate, weather and soil. To achieve this goal, we quantify a 'match' of planting stock with the environment where the trees are suitably adapted. Seed transfer guidelines are one tool that facilitates this goal. Administratively, the current seed transfer guidelines are a set of statements that delimit the geographic range bounded by latitude, longitude, and elevation, within which a seed source may be used for reforestation (Ying and Yanchuk, 2006).

Without guidelines specific to whitebark pine, there could be unnecessary barriers to seed movement. The elevation movement restrictions with respect to these guidelines may be especially limiting when considering several factors including: i) the objective of whitebark pine planting is related to tree health and species recovery, not tree growth; and ii) most seed is collected at the upper elevation limits, yet most registered seed users will deploy at lower elevations. Without refining seed transfer guidelines, artificial limitations may be created based on uncertainty about where seed can be moved. These guidelines apply to registered seed, but with minor modification, could be recommended for movement of whitebark pine seed across the province.

Throughout the range of whitebark pine, different agencies have used many different seed transfer guidelines (Table 10). In British Columbia whitebark pine has been relegated to the 'Other' category in the absence of any scientific evidence to support separate guidelines for the species. It is generally accepted that broad seed transfer rules can be used (Mahalovich and Dickerson 2004; Bower and Aitken 2008). There is also some evidence to suggest that some geographic areas may exhibit superior resistance to blister rust, such as the Selkirk Region of northern Idaho. If further research validates this, it may be possible to use seed from these provenances over larger areas (Sniezko, pers. comm).

The argument for broad seed transfer guidelines are best summed up in "Strategies for Managing Whitebark Pine in the Presence of White Pine blister Rust." (Hoff et al. 2001):

> "Four main factors support broad transfer rules for whitebark pine:
>
> First, the environment over the range of whitebark pine is so uniformly severe that the genetic structure among populations, even populations separated by long distances, will likely be similar.
>
> Second, many whitebark pine germinants survive the hot, dry conditions resulting from a site that has been burned.
>
> Third, whitebark pine trees can tolerate summer frost that would kill or severely damage other tree species.
>
> Fourth, whitebark pine seeds are bird-dispersed. Gene flow of bird-dispersed seeds is faster and farther than that of wind-dispersed seed."

Table 10. Summary of seed transfer guidelines from across the range of whitebark pine.

Location	Year	Elevation		Latitude		Longitude		Source
		Up	Down	North	South	East	West	
*BC	Current	+300 m	-200 m	2° N	1° S	2° E	3° W	Chief Forester's Standards for Seed Use (Gov of BC 2010)
BC	2008	Not specified		Favour movement of seed from milder to colder climates to a max. of 1.9°C M.A.T.				A.D. Bower & Aitken.
Washington-Oregon	2008	unlimited		By seed zone		By seed zone		Aubry and all.
Inland West - USFS	2001	unlimited		No more than 80 km from seed origin.				Ray Hoff, and others.
" " "	2006	unlimited		By seed zone		By seed zone		Mahalovich and Dickerson
" " "	2011	Unlimited, *unless cold hardiness is an issue?*		By seed zone		By seed zone		Mahalovich
USFS-Flathead Nat. Forest	2015	unlimited		By seed zone		By seed zone		Melissa Jenkins, Silviculturist, pers.com.
Interim Recommendation		**+300 m**	**-400 m**	**2° N**	**1° S**	**2° E**	**3° W**	R. Moody, Alana Clason, D. Pigott.
		May be transferred lower when no suitable seed sources exist.						
As this is primarily a bird dispersed species, no requirement for using within the same SPZ or BGC.								

* Can be used within the SPZ of origin, or other SPZ if used within the same BGC of origin.

In BC, the elevation range of whitebark pine is from 900 metres in the north (BLK, NST), to more than 2300 metres further south. From 1978- 2014, seed collections have been made at fifty-five locations across the range. Seventy-six percent of those collections were above 1800 metres. In the vast majority of cases, the most productive, and practical sites for cone collection will meet the seed needs for restoration using elevation transfer guidelines of ± 300m, and that should be encouraged. However, some lower elevation sites will not meet those guidelines. Guidelines should not be an impediment to, or hamper restoration. Given the overwhelming support for broad elevation transfer guidelines in other jurisdictions, and the immediate need for restoration work, we recommend the elevation transfer movement shown in

Table 10 until provenance trials indicate otherwise.

2.3.2.2 Seed registration requirements

According to the FRPA, seed does not need to qualify for registration to be used for restoration activities. However, it is important to be able to track where seed and seedlings have been deployed, and how they have performed, particularly if they have been selected for putatively resistant traits. Currently, the Cone and Seed Improvement Officer with the MFLNRO has created a data base in cooperation with the Whitebark Ecosystem Foundation of Canada (WPEFC) to record all whitebark pine seed collections made in the province. Where possible, each parent tree has been assigned a number, and field personnel actively collecting seed have been assigned blocks of numbers to use, and avoid duplication.

The Tree Seed Centre (TSC) registers all tree seed destined for Crown land reforestation. As part of this process, the TSC ensures that seedlots meet applicable collection criteria specified in the *Chief Forester's Standards for Seed Use* (**http://www.for.gov.bc.ca/code/cfstandards/**), which includes minimum requirements for genetic diversity and physical quality of seedlots. Collection origin information is also used to guide seed transfer. Registration information and data integrity is maintained in a web-based Seed Planning and Registry System (SPAR) that provides clients with direct online access to a provincial registry of forest tree seeds and a comprehensive seedling request system to meet annual reforestation need.

This system also allows clients to apply for registration online and to view up-to-date testing, ownership, history of use and seed or seedling equivalent availability information for registered seedlots. The steps to register seed are as follows:

1. Received request for registration *(paper or electronic*)
2. Received cones and/or seed
3. Blend seedlot
4. Test seedlot
5. Confirm moisture content & purity results are within range
6. Confirm germination & potential seedlings
7. Confirm seedlot weight
8. Confirm germination & potential seedlings

It is possible to register and store whitebark pine seedlots that do not conform to the standards on a *conditional* basis (D. Kolotelo, S. Reitenbach, pers. comm.). The advantage of even conditional registration on SPAR is that the seed can be viewed as potentially available, which could encourage potential users to submit requests for sowing. The rationale for this includes the following:

- There may be less than 10 putatively resistant parents in a stand

- The amount of seed available is often limited, and some current tests use a disproportionate amount of seed
- It may be desirable to plant individual families in the field and track resistance
- Clients may be eager to use the seed soon after collection, before lengthy tests are completed

To date, whitebark pine collections have had difficulty meeting registration requirements, for instance, in the case where cones are collected from less than 10 putatively resistant parents in one stand (Table 11). The primary problem with registration is the mechanics of SPAR. If all the requirements for registration are not met, registration is denied. However it may be possible to over-ride some of the deficiencies of a collection by using species averages for germination and estimates of moisture content. As purity tests are non-destructive, they are not an issue. Problems with seed registration limit some users from collecting or purchasing seed as they are restricted to registered seed. Increased clarity in requirements for and methods of seed registration would facilitate more extensive planting of this endangered species.

Table 11. Seed collection criteria for registration in BC (Chief Forester's Standards (Gov. of BC 2010).

a)	Seeds must be collected from at least 10 trees
b)	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
c)	Maximum elevation range between the highest and lowest elevation range of collection area is 250 metres
d)	Seed moisture content must be greater than 4% and less than or equal to 9.9 % .
e)	The lot must be at least 97% pure seed by weight.

Under FRPA, the standards for seed collection in BC are intended to meet free to grow stand objectives. Although not required for restoration, the principles would achieve gene resource collection objectives as well. In some case where putatively resistant material is being tested or used, planting single family or lots of less than 10 parents, may be acceptable provided the identities of the seedlings are maintained, recorded, and mapped in the field. The requirement that the collection be made within the same natural stand seed planning zone and biogeoclimatic zone, is not as important for whitebark pine as being within a radius of less than 8 km (or even smaller, defined stands), and have a maximum elevation range between the highest and lowest point of collection of 250 metres. Whitebark pine presents a novel case where species recovery priorities must be prioritized over existing seed policy if they form a barrier to recovery. It may be possible to work within the constraints of the current system, and attempts should be made to do so, but this system must be malleable enough to recognize that it may be impeding the recovery of the species.

2.4 Seedling Production

Whitebark pine seed collection and seedling production capabilities have advanced greatly in the past several years. Prior to 2007, few BC nurseries grew whitebark pine seedlings. Since 2007, six nurseries in

BC, five private and one government[4], have grown significant quantities of whitebark pine seedlings. These were used in either blister rust screening projects, provenance trials, field trials, or operational restoration work. Seedling culture methodologies have improved dramatically over time, and quality will likely continue to improve with increasing pressure to meet growing production demands.

2.4.1 Seed Processing, Stratification, and Germination

Following a drying period, seeds are extracted by hand (Figure 10). The cones are highly resinous and do not open fully when dried and are thus inappropriate for automated seed extraction. After the seeds are extracted, sanitation is required using either hydrogen peroxide or bleach to prevent mold growth (Table 12).

Stratification is one of the cultural stumbling-blocks to nursery production. It is both time-consuming and expensive. The MFLNRO Tree Seed Centre offers stratification services mainly for commercial tree species in BC, particularly lodgepole pine due to the most recent mountain pine beetle epidemic. The Tree Seed Centre has not offered stratification services for whitebark pine due to workloads, staff shortages, and absence of operational experience with the species. The Centre hopes to be able to include whitebark pine stratification in their work plans over the next couple of years. In general however, stratification to date has been done by private parties or government research personnel due to the time and cost constraints, limited experience, and the potential liability of damaging or destroying expensive seed.

Figure 10. Whitebark pine cone showing exposed seeds.

Stratification involves both a warm phase to facilitate embryo maturation and a cold phase to break dormancy. The duration of each of these phases has been broadly tested and may vary between regions and seedlots (Table 12).

Table 12. Summary of stratification and germination methods employed at select facilities.

Source	Sanitation	Soak (hrs)	Warm Stratification	Cold Stratification	Germination	Nicking/ Sanding
Lindsay Robb – Alberta Tree Improvement and Seed Centre	None	48	12 weeks (20°C)	16 weeks (2°C)	25°C in clean sand	Not required with warm period
Vicky Berger – Kalamalka Forestry	3% H_2O_2 as	48	28 days (20°C)	120 days (2°C)	Peat/ vermiculite	Nicked after cold

[4] Tipi Mountain Native Plants, Kimberley; Woodmere Nursery, Smithers; Skimikin, Tappen; Splitrock Nursery, Lillooet; Landing Nursery, Vernon; Kalamalka, Vernon

Centre	needed					stratification
Dave Kolotelo – Surrey Tree Seed Centre	3% H_2O_2 as needed	48	28 days (20°C)	14 weeks (2°C)	Kimpak, 28 day evaluation period	Nicking after cold stratification
Burr et al. 2001	None	48	28 days (20°C)	60 days (2°C)	On Kimpak germination papers - 20°C night/22°C day with 12 hour photoperiod	Nicking after cold stratification
Dorena	1% H_2O_2 as needed	48[1]	30 days (10°C)	90 days (1-2°C)[2]	28 day evaluation period[3]	After cold stratification, seed are sanded by hand using small motorized machines with 110-grit sandpaper
Coeur d'Alene	1% H_2O_2 as needed	Periodic rinses	30 days	90 days	24 hours at 28°C	Drum scarifier after cold stratification period

[1] 24- hour soak in 1% H_2O_2; rinse; 24- hour soak in H_2O. Seed are in mesh bags.
[2] We have also gone as long as 120 days in cold stratification for germination trials. This year (2015), the seed will be in cold stratification for up to 110 days.
[3] All scarified seed are placed on moistened blotter paper in 4"x4" (10.16 x 10.16 cm) clear plastic boxes. The boxes are placed in a germinator maintained at 16 °C night/18 °C day (61/64°F) with a 12-hour photoperiod. Germinated seed (radicle protrudes from the seed coat by at least 2 mm and is curved) are transplanted into Ray Leach Supercell Containers (164 cm^3).

Once stratification has been completed, seed is sown into cells or placed into a germinator. To facilitate germination, some advocate nicking of seedcoats prior to sowing, while others deem this unnecessary (Table 12). Unlike other smaller, conifer seeds that may be mechanically sown, whitebark pine seeds must be sown manually due to their large size, value, and because some may germinate prior to sowing. When more than one seed germinates in a cavity it is usually hand-transplanted to another cell. Overall, the germination process is complex and has been tested extensively with the development of a number of separate protocols (Table 12).

2.4.2 Seedling Culture

Containerized seedling production for forestry began in 1961 with the Walter's bullets, and in 1969 the first stryoblock containers were manufactured and tested. Since that time stryoblock containers have almost been exclusively used for seedling production in BC (Van Eerden 2002). In Western Canada in 2002 over 400 million seedlings were grown, the majority in styroblocks. In 2014, over 260 million seedlings were grown for reforestation in BC, almost entirely by private forest nurseries. British Columbia is the world leader in container production and culture, and nurseries adapt quickly to requests to grow new species of trees and other plants. In the US, the Ray Leach tubes are used which have some advantages, but also disadvantages when it comes to large scale production.

In general terms, whitebark pine seedlings are grown as a two year old crop. They are usually sown in April-May in a heated greenhouse until germination is complete then remain there without heat until the following year. After bud-set in the following year, they are probably best planted in the summer (J. Kusisto, Skimikin Nursery, pers. comm.). In BC all have been grown in the Beaver Plastics styroblocks, whereas in the US, the Ray Leach tubes are used (Table 13). The Ray Leach tubes are almost double the length which is good for species with a tap root and being used as a 2-0, but can be more difficult and costly to plant in shallow rocky soils common to whitebark pine habitat. The Ray Leach tubes are much easier to amalgamate cells when there are empty cavities. The cell density in Ray Leach tubes is also much higher, which can make seedlings more susceptible to diseases such as Botrytis, and may make it difficult for blister rust spores to infect seedlings during inoculation. The styroblocks are less costly and easier to plant, but may not last as long and there is concern about extraction of plugs after 2 years due to roots growing into the container. However, they are the industry standard in BC and the technology is well-developed to handle these obstacles.

Figure 11. One-year old seedlings grown in 412A Styroblocks and their root growth.

Although Ray Leach tubes have the advantage of being 'reconfigurable,' if losses are high or germination is poor, they are outside the norm of most seedling production facilities in BC. As it is desired to increase whitebark pine seedling production to levels necessary to contribute to species' recovery; production should fit with existing methodologies where possible including: growth medium, fertilizing regimes, watering and seedling extraction. Several growers have already demonstrated good seedling production using procedures developed for mainstream species (e.g. Randy Armitage, MFLRNO; Dave Enns, Landing Nursery; Joe Wong, Woodmere Nursery; Jim Kusisto, Skimikin Nursery).

Table 13. Comparison of Beaver Plastic's 412A and Ray Leach SC 10 growing containers.

Container	Diameter (cm)	Length (cm)	Volume (ml)	Cells/Block	Cells/m^2	Cost/cell
Stryro - 412 A	4.3	11.7	125	77	364	$0.05
Ray Leach -SC 10	3.8	21	164	98	528	$0.12

Using 100,000 seedlings per year as a benchmark requirement, an annual availability of 2,000 cones will be necessary (Table 14). At present this is nonexistent, thus limitations to seed availability must be overcome to meet these needs.

Table 14. Cone and seed requirement summary to produce 100,000 seedlings.

Seeds/ Cone	Seeds/g	Avg. % Germination	Sowing Factor	Over sow	Seedlings/Kg seed	Cones for 100,000 Seeds[1]	Cones for 100,000 Seedlings[2]
50	8	50	2	1.3	3077	2000	5200

50	8	50	3	1.3	2051	2000	7800

[1]Cones required for 100,000 seeds = 100,000 ÷ avg. no seeds/cone
[2]Cones required for 100,000 seedlings = 100,000 seedlings x sowing factor x over sow ÷ Avg. No. Seeds/Cone.

2.4.3 Seedling Deployment and Needs

Seedling deployment for rust screening or restoration purposes to date has been inadequate compared to what the species needs will be for recovery. At present, seedling planting has been conducted in the South Chilcotin, East Kootenay, West Kootenay, McBride, Smithers, Whistler, and Manning Park regions; with an total number of seedlings planted estimated at 25,000.

A number of companies including Canfor, Teck, Forests For Tomorrow Contractors (FFT), and BCTS have expressed a willingness to plant seedlings if they were available. At present most nurseries produce seedlings based on confirmed orders, however if some grew a small amount of whitebark pine based on speculation, it is probable that there would be adequate demand for those seedlings to have them planted. Although deployment of whitebark pine is limited, there is reluctance to embark on a program of widespread planting due to seedling availability, non-merchantable status, and unavailable rust resistant stock; it must be emphasized that even under widespread deployment, the impact to timber supply would be negligible due to the marginal sites on which whitebark would typically be planted and their limited extent within the timber harvest landbase. But with dwindling resources, and with increasing competition for timber, there may be more conflicts in the future.

Although whitebark pine is not a merchantable species, it is suitable for planting in several biogeoclimatic zones and site series that have been identified by the tree species selection tool produced by the provincial government to guide reforestation (BC Government 2015) (Table 15, Figure 12). This identifies where whitebark pine may be appropriate for planting or where it may contribute to stocking where it regenerates naturally (Table 15). While no forest companies have planted whitebark pine seedlings, it is probable that whitebark stock will be included in future seedling requests as companies are pressured to meet biodiversity and species at risk requirements of their certification regimes.

Table 15. Summary of BEC subzones and site series approved for whitebark pine stocking by the provincial government (Government of BC 2014a)[1]

BGC Subzone	Primary	Preferred	Secondary	Acceptable	Tertiary
ESSFdc2				03	03
ESSFdk					02, 04
ESSFdv					01, 02, 03, 04, 05, 06
ESSFmk	02,03	02,03			
ESSFmw					02, 03
ESSFwc1					02
ESSFwc1					02
ESSFwc4					02
ESSFwm					02
ESSFxv1	02, 04, 05	02,03, 04, 05	01,03	01	06, 07
ESSFxv2		02	02, 03, 04, 05	01, 03, 04, 05	01, 06

[1]These represent only a subset of the subzones and site series that may be suitable for reforestation with whitebark pine (see

Table 16)

Comparing the species' range in Figure 12 with the subzones where planting is potentially appropriate (Government of BC 2014a), additional subzones may be added to the reference guide to include portions of the range where planting whitebark pine is not approved. Identifying all areas where planting may be conducted will aid in determining the potential number of seedlings required each year.

Table 16. Activities (collection, restoration, monitoring) to date by BEC subzone.

Subzone	Acceptable species	Restoration	Seed collection	Number of Monitoring Plots	Confirmed occurrence	Inventory range occurrence
BAFAun			Y	1	Y	Y
BAFAunp					Y	Y
CMAun						Y
CMAunp			Y	1	Y	Y
ESSFdc1					Y	Y
ESSFdc2	Y	Y		1	Y	Y
ESSFdcp			Y		Y	Y
ESSFdcw			Y	1	Y	Y
ESSFdk1	Y	Y	Y	5	Y	Y
ESSFdk2	Y	Y	Y	15	Y	Y
ESSFdkp			Y	2	Y	Y
ESSFdkw			Y	16	Y	Y
ESSFdm					Y	Y
ESSFdmp						Y
ESSFdmw			Y	1	Y	Y
ESSFdv1	Y	Y	Y		Y	Y
ESSFdv2	Y	Y	Y		Y	Y
ESSFdvp			Y	1	Y	Y
ESSFdvw			Y		Y	Y
ESSFmc			Y		Y	Y
ESSFmcp			Y			Y
ESSFmk	Y	Y	Y		Y	Y
ESSFmkp						Y
ESSFmm1			Y	3	Y	Y
ESSFmm2					Y	Y
ESSFmmp			Y	3	Y	Y
ESSFmv1						Y
ESSFmv3			Y	1	Y	Y
ESSFmvp			Y	5	Y	Y
ESSFmw	Y	Y	Y		Y	Y
ESSFmw1					Y	Y
ESSFmw2					Y	Y
ESSFmwp					Y	Y
ESSFmww					Y	Y
ESSFvc					Y	Y
ESSFvcp				2	Y	Y
ESSFwc1	Y	Y			Y	Y

Subzone	Acceptable species	Restoration	Seed collection	Number of Monitoring Plots	Confirmed occurrence	Inventory range occurrence
ESSFwc2					Y	Y
ESSFwc4	Y	Y	Y		Y	Y
ESSFwc6					Y	Y
ESSFwcp			Y	2	Y	Y
ESSFwcw				5	Y	Y
ESSFwk1					Y	Y
ESSFwk2						Y
ESSFwm	Y	Y		10	Y	Y
ESSFwmp				1	Y	Y
ESSFwmw					Y	Y
ESSFwv						Y
ESSFxc1				1	Y	Y
ESSFxc2			Y		Y	Y
ESSFxc3			Y		Y	Y
ESSFxcp			Y		Y	Y
ESSFxcw			Y		Y	Y
ESSFxv1	Y	Y	Y		Y	Y
ESSFxv2	Y	Y			Y	Y
ESSFxvp			Y		Y	Y
ESSFxvw					Y	Y
IMAun					Y	Y
IMAunp			Y	1	Y	Y
MHmm2			Y		Y	Y
MHmmp						Y
MSdc1					Y	Y
MSdc2					Y	Y
MSdc3					Y	Y
MSdk1			Y		Y	Y
MSdk2				1	Y	Y
MSdm1			Y		Y	Y
MSdm2					Y	Y
MSdv					Y	Y
MSmw2					Y	Y
MSxk3			Y		Y	Y
MSxv					Y	Y
SBSmc2			Y		Y	Y

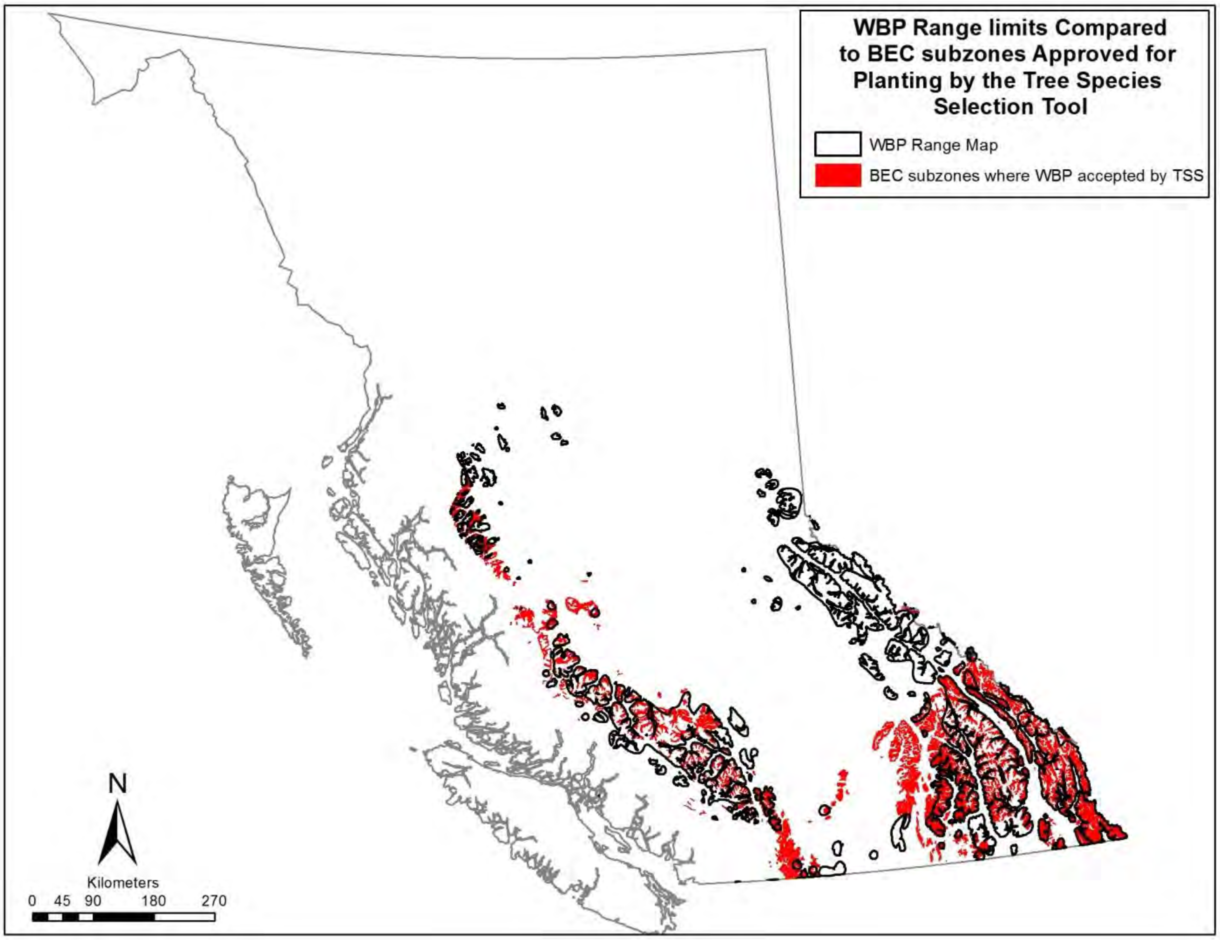

Figure 12. Biogeoclimatic subzones where whitebark pine is an acceptable planting species compared to the current species range.

Due to some of the previously mentioned uncertainties, there is little data available on the number of seedlings required annually in the province. BC Timber Sales manages approximately 20% of the AAC in BC. BCTS estimates that the annual needs would not exceed 10,000 seedlings per year. As a rough calculation, using the above mentioned ratio, the total annual seedling requirement for whitebark pine would only be 50,000. This does not include other uses by BC Parks, Parks Canada, mines, pipelines, communication installations on ridge tops, ski hills, and back country lodges. Applying these other uses and considering the political pressure which should be mounting regarding deployment of seedlings, we estimate the annual use to be 100,000 seedlings. A review of the Reporting Silviculture Updates and Land status Tracking System (RESULTS) database between 1995 and 2004 of the Site Series presented identified an average of 346 ha per year declared as free-growing with a whitebark pine component; if we backtrack this status several years, we can assume this corresponds to the average area harvest each year with a whitebark component (though whitebark is often missed or ignored so the real number is likely greater). If we consider that a commonly accepted density for whitebark pine planting is 400 stems/ha (M. Jenkins pers. comm.), as many as 138,400 seedlings could be planted per year in these openings. This number is considered a maximum and a high target for planning. This supports that 100,000 is a realistic target as it also includes sites outside of the timber harvesting landbase.

2.5 Collecting Seed and Producing Whitebark Pine Seedlings Recommendations

- Have MFLNRO track seed and seedling requests to better quantify demand;
- Encourage the MFLNRO to publish clear “guidelines” on seed use and transfer;
- Conduct annual cone crop reconnaissance and assessments;
- Collect seed for in situ conservation and restoration projects as soon as good crops occur. If mast crops do occur, collect a five year supply based on 100,000 seedlings required each year (total 500,000);
- Coordinate training sessions in each region on whitebark pine cone and seed handling techniques, and the identification of white pine blister rust;
- Draft clear guidelines on parent tree selection standards, and collection protocols. Communicate with all potential field personnel selecting for rust screening;
- Set targets for parent tree selection in each of the five areas discussed;
- In collaboration with Tree Improvement staff, develop a plan for seed orchard establishment and deployment based on interim seed zones;
- Encourage establishment of clonebanks for parent tree selections being screened for white pine blister rust;
- In collaboration with Tree Improvement Branch staff, develop and recommend interim seed planning zones and seed transfer guidelines;
- Facilitate workshops, and provide extension at suitable venues to encourage the use of these guidelines;
- Establish a register of stands across the range for *in situ* gene conservation, protection, and cone collection;
- Identify potential seedling production facilities considering regional need assuming that it is not feasible to screen every seedling;
- Promote consistent stratification and seedling culture methods;
- Promote wider use of whitebark pine seedling within the forest sector; and
- Promote wider use of whitebark pine seedlings by other industries to reach the annual production target of 100,000 seedlings.
- Establishment of a seed collection fund

3 White Pine Blister Rust in BC

Quantifying the provincial incidence of blister rust infection on whitebark pine is essential for prioritizing seed collection, for screening, and for prioritizing regions for future restoration (Figure 13). In BC, data on blister rust has been collected as part of individual research, seed collection or restoration programs; while long-term monitoring plots have been established mainly by government.

3.1 Long-Term Blister Rust Monitoring in BC

The foundation for estimating provincial blister rust trends comes from long term monitoring of rust infection rates. The disadvantage of using temporary plots to determine provincial rust incidence rates is differing health assessment methodology as all survey objectives do not necessarily focus on health evaluation. Temporary plots also only quantify rust for a single time period. The advantage of long-term blister rust monitoring installations is their ability to track changes in rust infection over time in one stand, increasing the certainty in health history and therefore increasing understanding of rust trends over time. The reality in BC is that there have been relatively few long term monitoring plots installed to cover the large and ecologically diverse habitats of whitebark pine (Figure 14, Table 17).

Figure 13. A health transect ready for re-measurement

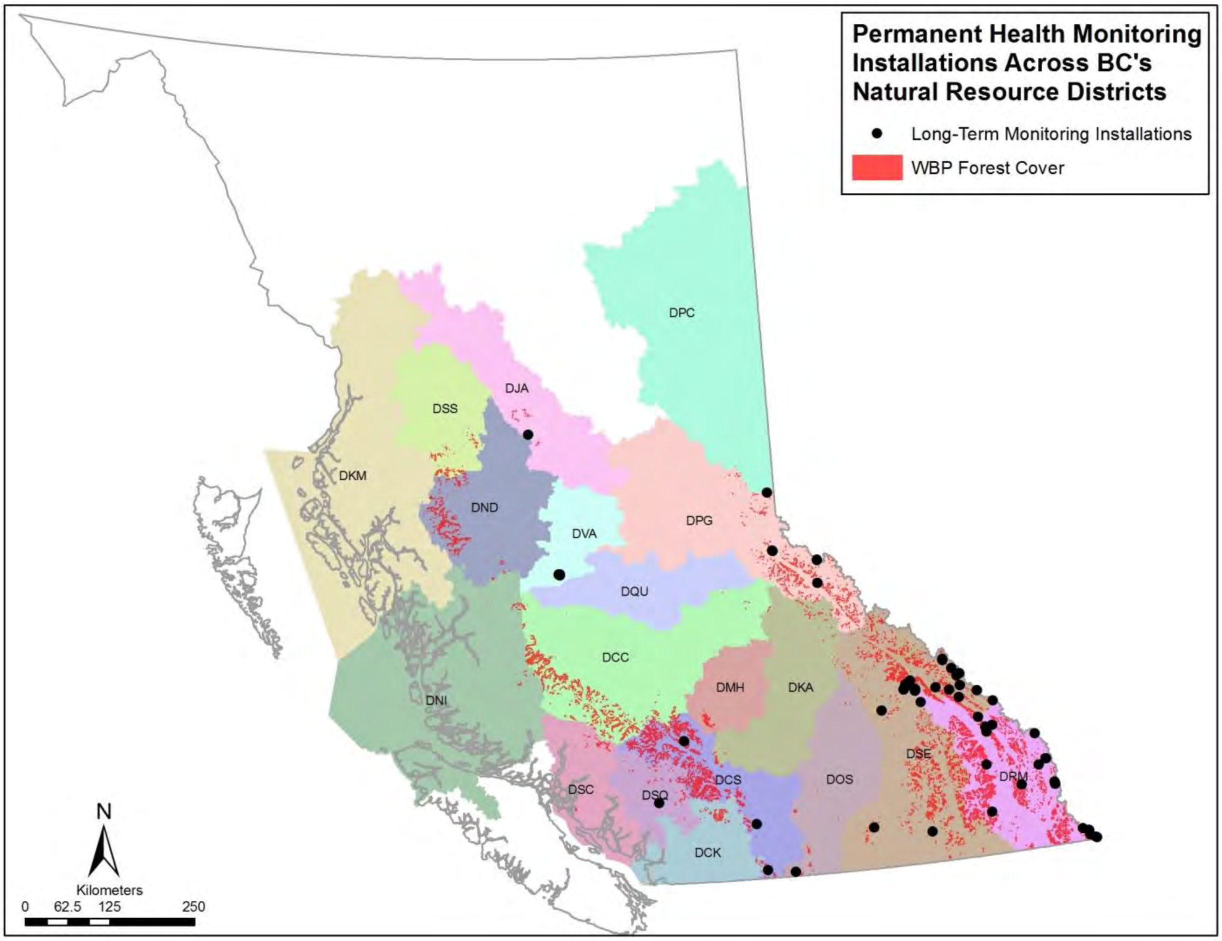

Figure 14. Location of provincial health monitoring plots installed by National Parks, FLNRO and industry (see Table 17 for Natural Resource District codes).

We compiled a total of 83 long term blister rust monitoring plots and transects within the province (Table 17, Figure 14). Of these, 67 were established by National Parks, 11 were established by the provincial government and 5 by industry. Elevation ranged from 1020 – 2350m for the sites established to date. Plots followed either the WPEF protocol (Tomback et al. 2005) or FLNRO protocol first developed by S. Zeglen. Plot sizes varied from 0.14 – 0.25ha, with an average size of 0.08ha.

Monitoring plots are not distributed evenly throughout the range of whitebark pine in the province, with most located in the SE. The ESSFdk (dk1 & dkw) in particular, is over-represented in the monitoring network in comparison to the proportion of the range contained within this BEC subzone (

Table 16). The same over-representation occurs when the monitoring network is examined by Seed Planning Zone (SPZ) or Natural Resource District; there is a disproportionate number of monitoring sites in the East Kootenay (EK) SPZ. The reason for this high density of plots is not ecological or strategic, but a result of the majority of plots having been installed in or directly adjacent to the National Parks of SE BC by the Parks Canada monitoring program. These tie into a much larger set of plots in Alberta that were installed in 2003-04, and have mostly been re-measured 3 times by 2014 (see Smith et al. 2013 for second assessment results).

Table 17. Number of monitoring plots by Natural Resource District in relation to the relative abundance of whitebark [1]. Blue highlighting indicates a large disconnect between the amount of whitebark pine in the district compared to the number of monitoring plots established.

Natural Resource District	Code	# of Monitoring plots	Ranked relative abundance of WBP[1]	# of monitoring plots/ relative abundance of WBP[2]
100 Mile House	DMH	**0**	**4**	**0**
Cariboo-Chilcotin	DCC	**0**	**160**	**0**
Cascades	DCS	**3**	**471**	**0.01**
Chilliwack	DCK	**0**	**5**	**0**
Coast Mountains	DKM	**0**	**1**	**0**
Fort St. James	DJA	**1**	**4**	**0.25**
Nadina Natural	DND	**0**	**126**	**0**
North Island - Central Coast (Mainland)	DNI	**0**	**4**	**0**
Okanagan Shuswap	DOS	**1**	**3**	**0.33**
Peace	DPC	**0**	**1**	**0**
Prince George	DPG	**7**	**72**	**0.1**
Quesnel	DQU	**0**	**1**	**0**
Rocky Mountain	DRM	**26**	**903**	**0.03**
Sea to Sky	DSQ	**1**	**7**	**0.14**
Selkirk	DSE	**39**	**337**	**0.12**
Skeena Stikine	DSS	**0**	**5**	**0**
Sunshine Coast	DSC	**0**	**8**	**0**
Thompson Rivers	DKA	**0**	**11**	**0**
Vanderhoof	DVA	**5**	**1**	**0**

[1]Ranking is based on the basal Area (total m^2/ha) for whitebark pine in each natural resource district divided by the minimum BA of whitebark pine in any district. This indicates a relative abundance of whitebark pine amongst the districts. i.e. a value of 4 indicates 4 times as much whitebark pine basal area as a value of 1.

[2] A higher value indicates more monitoring plots relative to the amount of whitebark pine in the district compared to a lower value.

While increasing the number of long-term blister rust monitoring plots is important, it is not a prerequisite for seed collection and restoration activities. However, if more plots were established across the province, we would have a greater ability to track blister rust infection dynamics in whitebark pine over time, helping prioritize collection and restoration activities. The lack of good data on rust incidence levels can impede recovery through increased uncertainty in where and how to use limited resources, as well as lacking a benchmark for evaluating conservation outcomes in the future (i.e. increasing or decreasing threat). When planning ground work, whether for blister rust screening or the deployment of rust-screened seedlings, information on the location, size and health of whitebark pine populations is essential for higher level planning and prioritization. This kind of information is not available for all regions of the province (Clason 2013).

Table 18. Number of blister rust monitoring plots by SPZ

SPZ Code	SPZ Name	# of monitoring plots
BB	Big Bar	0
BLK	Bulkley	0
BSH	Bush	13
CHL	Chilcotin	5
CP	Central Plateau	1
CT	Cariboo Transition	0
EK	East Kootenay	41
MGR	McGregor	0
HH	Hudson Hope	1
MIC	Mica	9
MRB	Mt Robson	6
NCH	Nechako	0
NST	Nass Skeena Transition	0
QL	Quesnel Lakes	0
SA	Shuswap Adams	0
SM	Submaritme	2
TOA	Thompson Okanagan Arid	2
TOD	Thompson Okanagan Dry	1
WK	West Kootenay	2

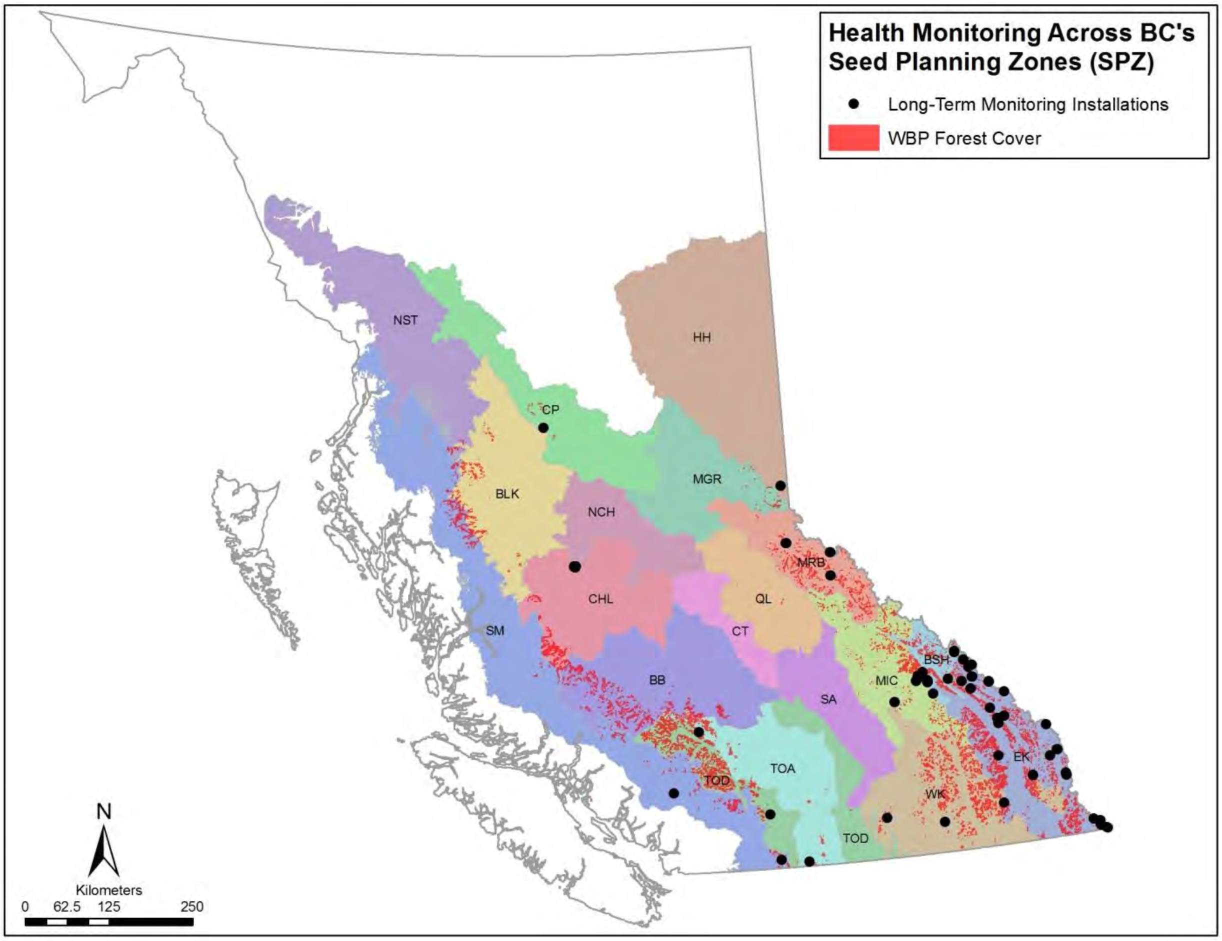

Figure 15. Location of health monitoring installations in BC by Seed Planning Zones (SPZ).

Understanding rust incidence over time also requires consistent health monitoring protocols that maximize information on stand health and minimize time and resources required for installation and re-measurement. For instance, the Whitebark Pine Ecosystem Foundation (WPEF) has developed protocols followed by the Parks Canada (Tomback et al., 2005 and see Appendix 2 – Health Survey Methods for datasheets). These transects are relatively quick to install and focus on collecting only the data necessary to evaluate whitebark pine stand health. If these protocols are followed, and trees permanently marked, even stands surveyed for blister rust during a cone collection can be added to the monitoring network and re-measured over time. <u>Regardless of monitoring protocol used, adequate training in blister rust identification is required</u>.

3.2 Blister Rust Infection Rates in BC

White pine blister rust was first introduced into BC in 1910 (Mielke, 1943), but has since spread province-wide (Campbell and Antos, 2000; Zeglen 2002, Haeussler et al., 2009). Given the gaps in long-term monitoring plots across the province, temporary plots that describe infection rates can be used to help quantify provincial rust incidence. While any data on infection rates is useful in evaluating the status of rust across the province, summarizing data from multiple sources with different data collection methods can be a challenge. For instance, variation in the factors used to calculate infection rates may result in inaccurate comparisons of blister rust incidence across the province over time. Following a standard protocol for health assessment would go a long way to improving the consistency in data collected between surveyors.

We collated a total of 573 temporary and permanent (long-term monitoring – most recent measurements) plots to summarize rust incidence in BC to date (Figure 17). Four hundred twenty four of these plots came from MFLNRO, 67 from Parks Canada, 61 from individual researchers and consultants, and 5 from industry. These plots span almost two decades, from 1995 to 2014 (Table 19), and cover more of the extent of whitebark pine in the province than the long-term monitoring plots alone.

Figure 16. Active stem canker

When summarized by Natural Resource District, mean rust infection rates (calculated as the proportion of live stems >1.3m in height with cankers) was lowest in the SW, and highest in the SE and NW portions of the range (Figure 17, Table 19). These mean % infection values were generated from different numbers of plots in each Natural Resource District, and for several, very few plots were available (Table 19). Even in districts with substantial sample sizes, variance is high (Table 19**Error! Reference source not found.**). Averaging infection rates at this scale resulted in no district exceeding 80% infection rate, however individual plots in many districts far exceeded this value.

While not a perfect descriptor, summarizing rust infection rates by Natural Resource District may be useful for practitioners and decision-makers within the different regions to identify (1) how much is known about blister rust in whitebark pine forests in the area, and (2) what actions might be required. Averaging blister rust infection rates for districts that span large time periods is also potentially problematic, however, it is still important to use the relatively little data that is available on blister rust in whitebark pine to help inform provincial priorities.

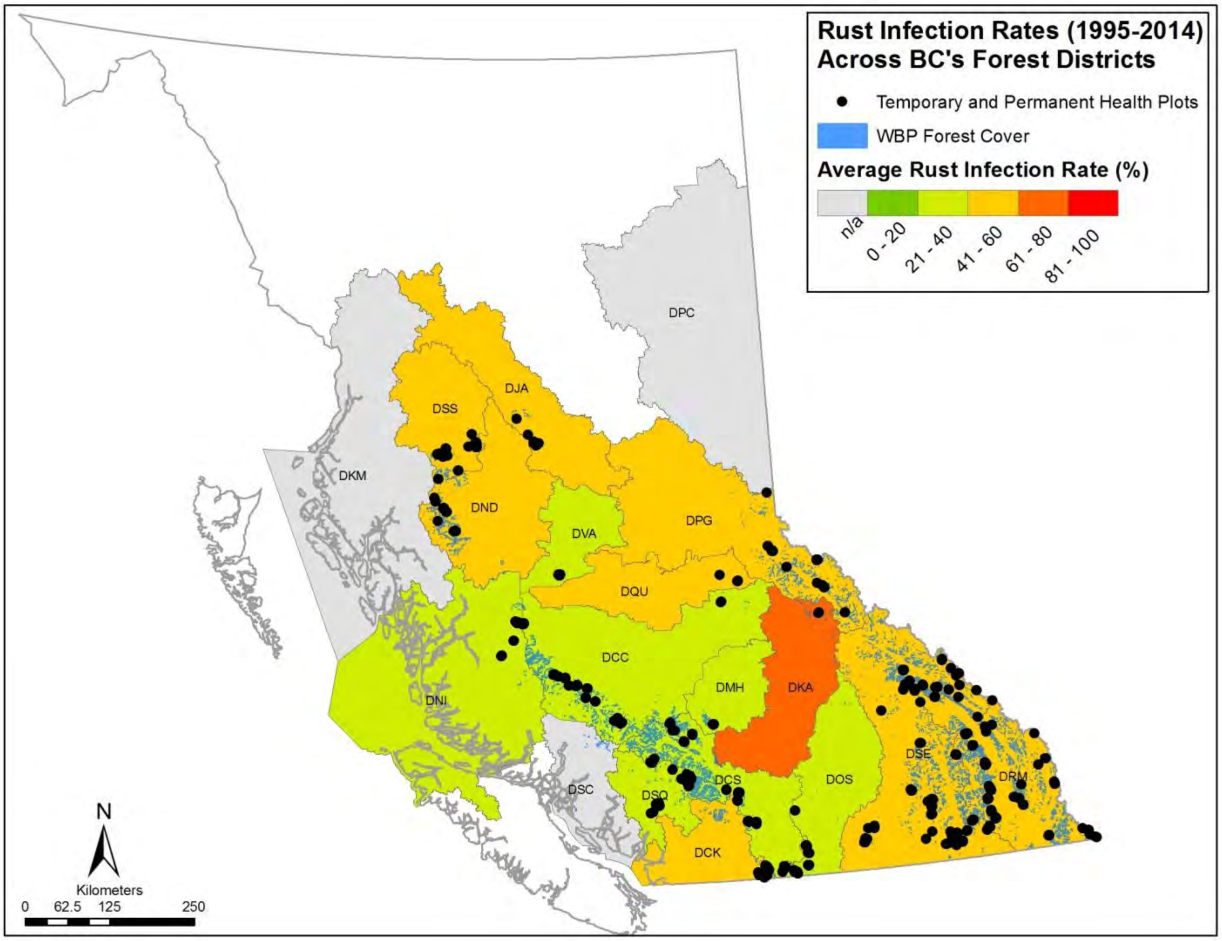

Figure 17. Average rust infection rates (%) by Natural Resource District from both temporary and the most recent measurement of permanent plot. See Table 19 for sample sizes and variance estimate.

While blister rust data is important, so too is data on the other disturbances and stressors impacting whitebark pine. Mortality from mountain pine beetle (MPB), encroachment of competing conifers, or presence of other disturbance agents (*Ips*, *Pineus,* etc.) should all be documented to better understand the health of whitebark pine province-wide. It may be particularly important for prioritizing seed collection areas, to target sites with high risk of MPB mortality, especially if coinciding with high rates of blister rust in order to conserve potential rust-resistant seed.

Table 19. Average rust infection rates and sample sizes from permanent and temporary plots by Natural Resource District[1.]

Natural Resource District	Code	Mean ± SD Infection Rate (%)	Total Sample Size (N)
100 Mile House	DMH	**35 ± 10**	**N = 4**
Cariboo-Chilcotin	DCC	**23 ± 15**	**N = 41**
Cascades	DCS	**27 ± 18**	**N = 130**
Chilliwack	DCK	**57 ± 17**	**N = 9**

Natural Resource District	Code	Mean ± SD Infection Rate (%)	Total Sample Size (N)
Coast Mountains	DKM	**n/a**	**N = 0**
Fort St. James	DJA	**52 ± 25**	**N = 17**
Nadina Natural	DND	**45 ± 18**	**N = 16**
North Island - Central Coast (Mainland)	DNI	**27 ± 16**	**N = 16**
Okanagan Shuswap	DOS	**30 ± 20**	**N = 29**
Peace	DPC	**n/a**	**N = 0**
Prince George	DPG	**50 ± 25**	**N = 28**
Quesnel	DQU	**43 ± 38**	**N = 5**
Rocky Mountain	DRM	**57 ± 21**	**N = 94**
Sea to Sky	DSQ	**31 ± 16**	**N = 16**
Selkirk	DSE	**49 ± 19**	**N = 131**
Skeena Stikine	DSS	**45 ± 28**	**N = 24**
Sunshine Coast	DSC	**n/a**	**N = 0**
Thompson Rivers	DKA	**74 ± 28**	**N = 2**
Vanderhoof	DVA	**28 ± 14**	**N = 11**

[1]Data sources: S.Zeglen, M.Murray, Parks Canada, E.Campbell (incomplete), A.Clason, S.Haeussler, A.Leslie (missing other data sources: F. Iredale, S. Haeussler, E.Campbell, B.Wilson).

Overlaying the location of current seed collections and health plots and average blister rust infection rates by Natural Resource District indicates a high number of collections from relatively healthy areas, such as the south Chilcotin. Future collections should then be targeted towards areas of higher rust incidence. The regional rust incidence values reported here may be used to identify at a broad scale which districts may contain stands with higher rust infection. However, it is stand level rust infection rates that are more important in determining whether there has been adequate exposure to blister rust in the stand. This stand-level information is what suggests whether canker-free trees may be putatively resistant, as opposed to simply having never been exposed to rust.

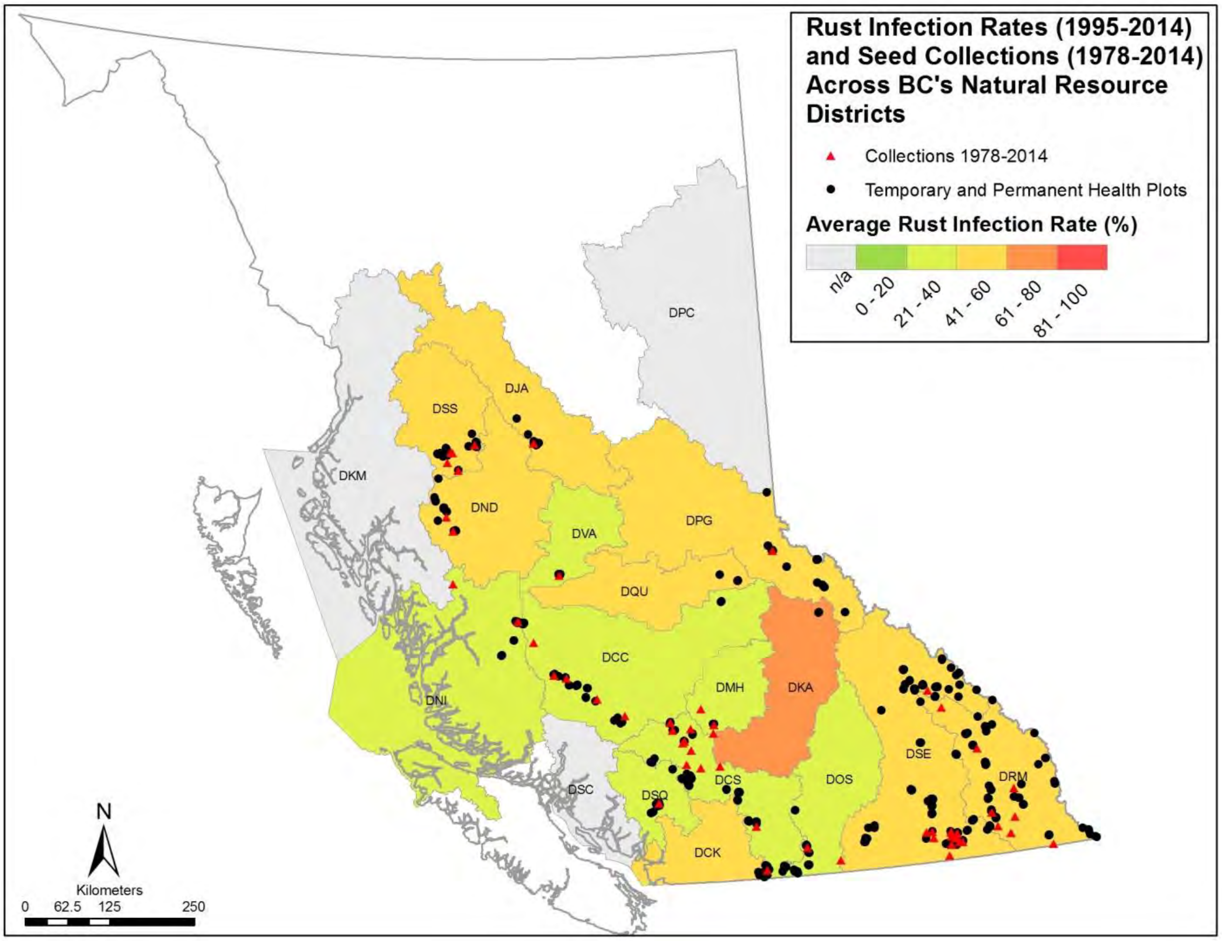

Figure 18. Blister rust infection rates (%) across Natural Resource Districts in relation to the location of temporary or permanent health plots and seed collections to date.

3.3 Blister Rust Monitoring and Collection Prioritization Recommendations:

- New health monitoring plots/transects are needed, particularly in specified SPZ's and Natural Resource Districts (Table 20). Potential sites have been identified in Table 21 and Figure 19.
- All sites where collections have been made in the past should be assessed, as well as new potential collection sites (see Table 7).

Table 20. Recommended priorities for installing blister rust monitoring plots

Priority	SPZ	Natural Resource Districts
1	Big Bar	Cariboo-Chilcotin
2	Chilcotin	Cariboo-Chilcotin, North Island (mainland only)
3	Bulkley	Nadina, Skeena Stikine
4	MacGregor	Prince George
5	Central Plateau	Fort St. James
6	Quesnel Lakes	Quesnel, Prince George, Cariboo-Chilcotin
7	Thompson Okanagon-Arid	Cascades, Okanagan
8	Thompson Okanagon-Dry	Cascades
9	Mt. Robson	Prince George

Table 21. Potential sites to establish blister rust monitoring transects.

Location	Latitude	Longitude	Elevation (m)	Seed Planning Zones	BEC Subzone/ Variant	Access
July Creek (Coquihalla)	49.689140	-121. 079389	1583	TOD	ESSFmw1	Good road, almost 2 wheel drive, off the Coquihalla. Some large mature trees, heavy mortality. Very low elev.
Stoyama Peak (Cabin Lk)	49.974984	-121.217405	1858	TOD	ESSFmwp/mww	4x4. Mixed ages, mature to krum. Access from Merritt-Spences Bridge Rd.
Cathedral Park	49.062904	-120.196430	2056	TOA	ESSFxc1	Long walk, or pay $60 for shuttle. Scattered throughout area. Good food.
Black Dome	51.341175	-122.482723	1969	BB	ESSFxvp	Loads of trees, all age classes. 2 wheel drive. Need mine permission (Black Dome Mine; Sona Resources).
Mt Seven	51.274326	-116.876618	1980	BSH	ESSFdk2	Most of area access by 2 wheel drive some 4x4. Many mature trees, some 30 – 50 yrs.
Potato Range-Tatlayoko Lk	51.512862	-124.326288	1929	BB	MSdc2/ESSFxvp/ESSFxv1	Large areas of many age classes. Walk or horse is better.
Sunshine Mt near Bralorne	50.753968	-122.790282	1500	TOD	ESSFdx1	Condition uncertain,4x4 and walk.
Ptarmigan Mountain	52.039806	-119.256363	1970	SA/MIC	ESSFwcw	4x4 Drive and fair walk.
Telkwa Mtns (Hunter Basin)	54.535	-127.172	1502	BLK	ESSFmc, mcp	Helicopter (road washed out).
Mt. Sweeney	53.732	-127.255	1431	BLK	ESSFmc	4x4 drive to.
Dunster	53.102956	-119.843524	1450	MRB	ESSFmm1	2wd and hike (good trail).
Ghost Lake/Ishpa Mtn	52.969444	-120.950829	1649	QL	ESSFwc3, wcw, wcp	2wd, hike (no trail).
Mt.Sidney Williams/ForFar Ck. area	54.904628	-125.319052	1511	CP	ESSFmv3, mvp	Helicopter.
Tulameen Mtn	49.388	-121.118	?	TOD/SM	ESSFmwp?	?
Northern Chilcotin	?	?	?	BB	?	No sites identified to date.
MacGregor	?	?	?	MGR	?	No sites identified to date.

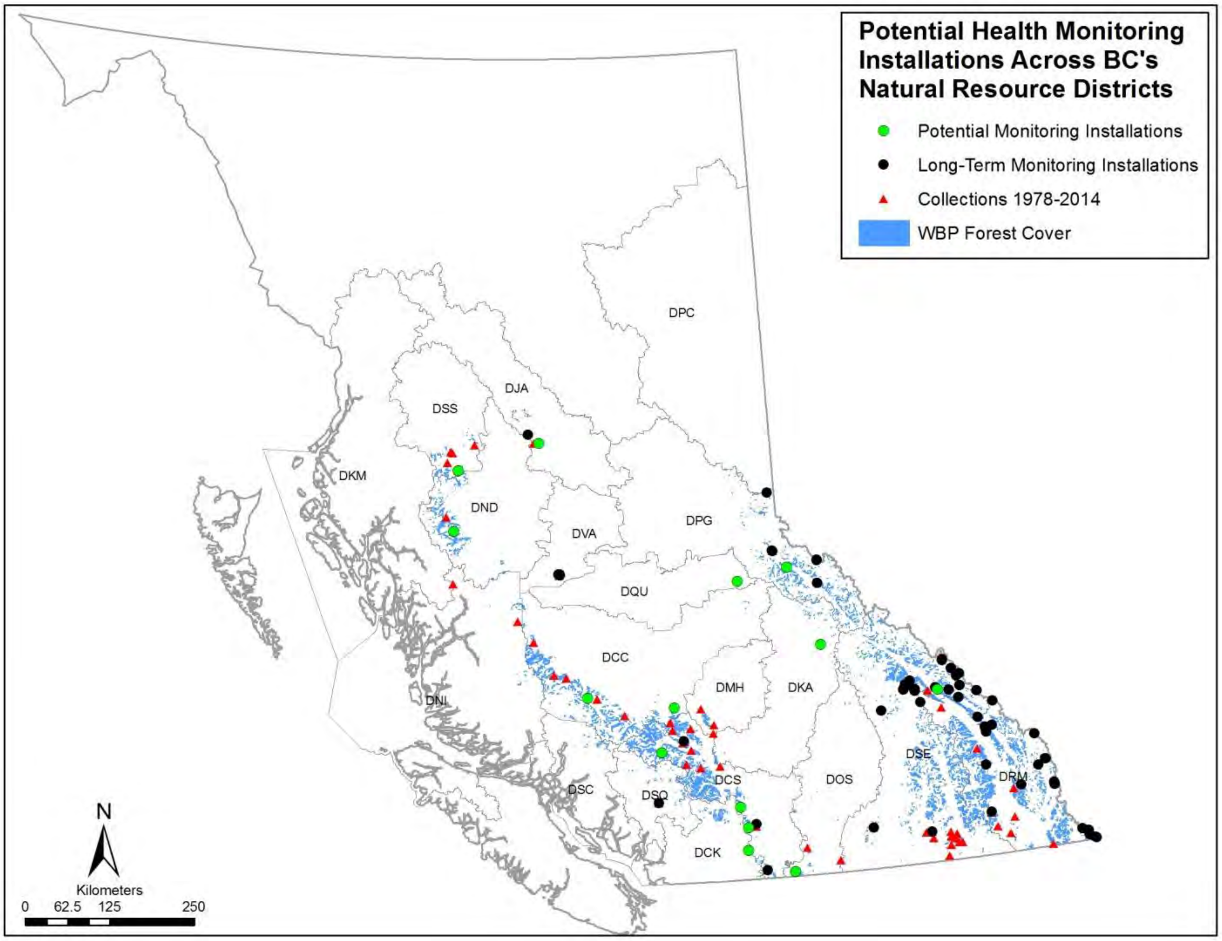

Figure 19. Potential sites to install new long-term health monitoring plots in BC (green circles or red triangles).

- Seed collections could be targeted to areas of relatively high rust incidence and low number of collections, such as the following SPZ or Natural Resource Districts:

Table 22. Recommended priorities for future collection areas based on rust infection rates.

	SPZ	Forest Districts
1	Mt. Robson/Mica	Prince George
2	Central Plateau	Fort St. James
3	Bush/Mica	West Kootenay
4	Bulkley	Nadina
5	Bulkley/Sub-maritime/Nass-Skeena Transition	Skeena Stikine/Nadina
6	East Kootenay	Rocky Mountain
7	West Kootenay	Selkirk
8	McGregor	Prince George
9	Quesnel Lakes	Quesnel/Cariboo-Chilcotin

- Develop new, or recommend standards for health monitoring plots, both temporary and permanent.
- Better document <u>all threats</u> to whitebark pine (Mountain Pine Beetle, competition, etc.)
- Adequately train surveyors in blister rust identification
- Either develop a Canadian database or make use of the U.S. database housing blister rust monitoring data

4 Testing Seedlings for Blister Rust Resistance

4.1 Rust Screening Methods

Once candidate parent trees have been selected and seed collected, screening for white pine blister rust can occur. The screening process is complex and requires sound biological and environmental protocols throughout. The basis for the process is widely collected seed as described in above sections. Screening can be accomplished using three general methods: i) Intensive nursery based screening; ii) Seedlings grown near *Ribes* beds; and iii) Field based screening. Each of these approaches varies in terms of costs, rigour, and time to achieve results.

4.1.1 Intensive Nursery-based Screening

For intensive screening, seedlings are grown in the nursery for two-years, inoculated with spores from infected *Ribes* leaves in an inoculation chamber under highly controlled conditions, and then assessed at various intervals for infection by white pine blister rust (Figure 20). The level of assessment for infection depends on the degree of applied research being conducted in conjunction with the screening program. The seedlings are usually transplanted to either large containers or to the field for long term monitoring. The advantage of this approach is the highly controlled inoculation; the disadvantage of this program is the high costs per tree.

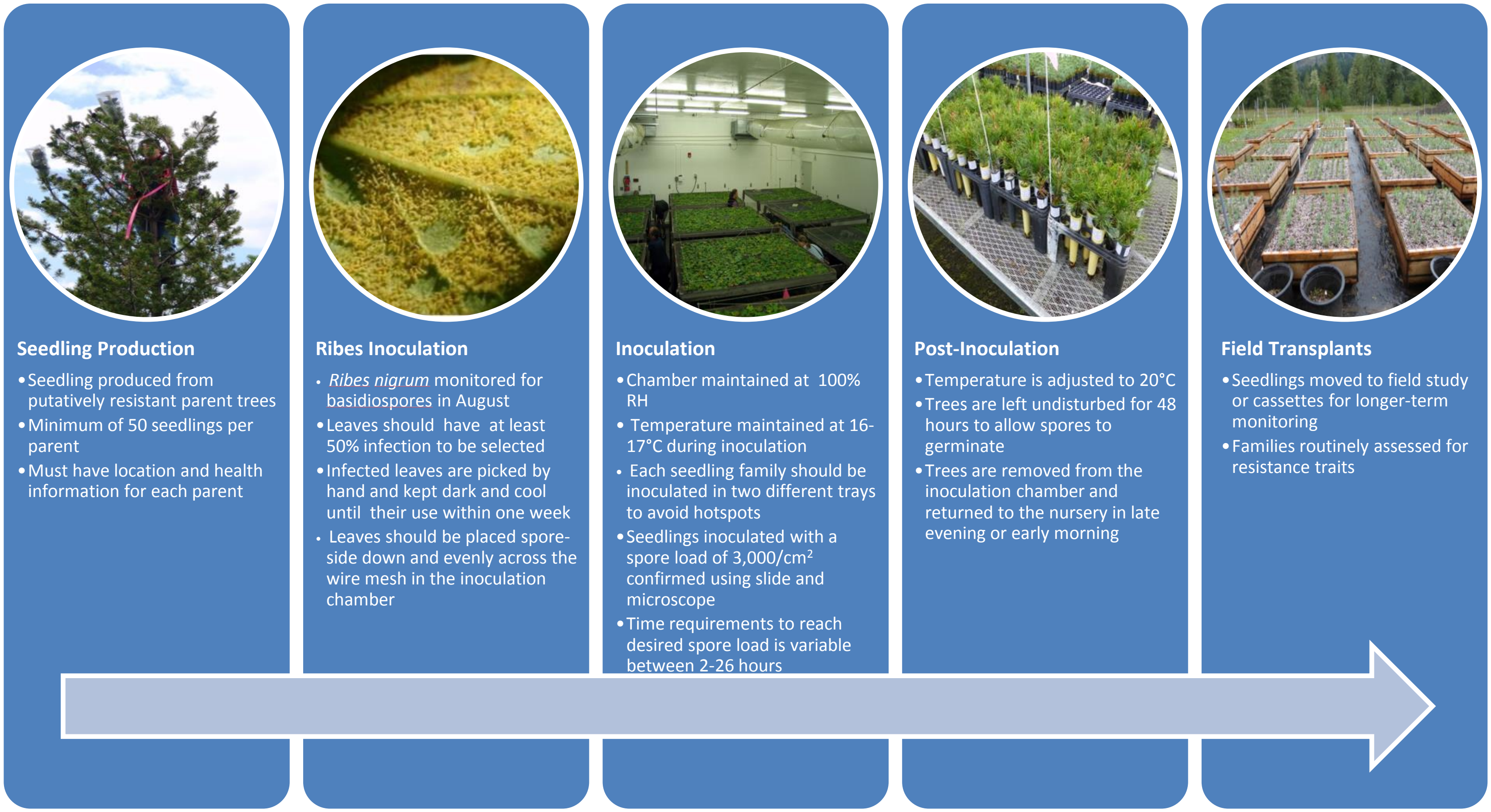

Figure 20. Summary of intensive screening method to identify white pine blister rust resistance.

4.1.2 *Ribes* Bed Screening

For *Ribes* bed screening, seedlings are placed beneath a hedge of *Ribes* plants in nursery beds for two weeks in late summer (Figure 21). Assessment will follow in the autumn of that year and will continue annually in the nursery. Surviving seedlings will be planted in a holding area for further monitoring, and possible seed production. The advantage of this option is the low tech approach and relatively low costs; the disadvantage of this option is the lack of control regarding inoculation levels often resulting in excessive or incomplete infections.

Figure 21. Summary of *Ribes* bed method to identify white pine blister rust resistance.

4.1.3 Field-based Screening

Field-based screening relies on natural inoculant loads to infect planted seedlings (Figure 22). Like other methods, two-year old seedlings are produced from traceable parent trees and monitored over time for health; the main difference is these seedlings are planted in the field and monitored for natural infections. The advantages of this method are the low cost per family and the exposure to real-world spore loads. The disadvantage of this method is the lack of control regarding inoculation, the potentially long time-lag to gain results, high monitoring costs, and a high level of variability regarding causes of mortality.

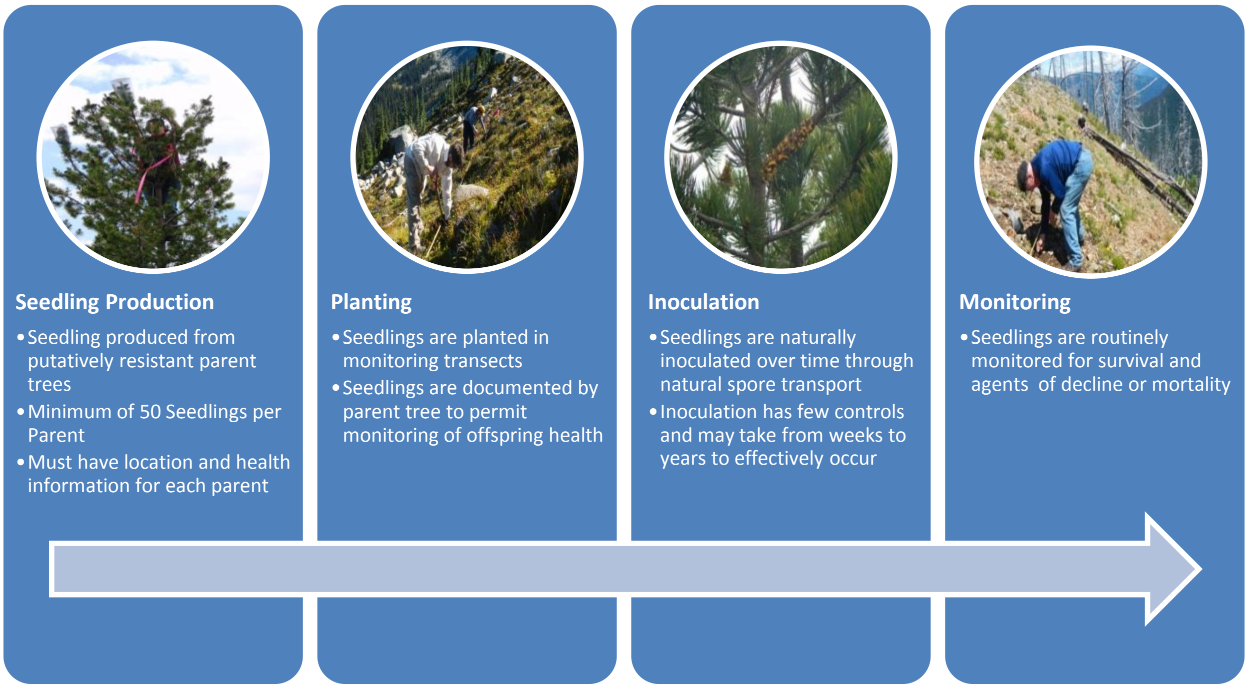

Figure 22. Summary of field based method to identify white pine blister rust resistance.

4.2 Status of White Pine Blister Rust Screening in BC

4.2.1 Intensive Nursery-based Screening

Screening for white pine blister rust using BC parent trees has occurred at three different facilities and plans are afoot to continue screening over the coming years (Table 23). Screening thus far has occurred at the following facilities:

1. *Idaho Panhandle National Forests (IPNF) Coeur d'Alene Nursery:*

- Six seedlots from Northwest BC were sent for testing in 2014, no results to-date. Five of these seedlots were collected by the Bulkley Valley Research Centre and one was collected by New Gold.

2. *Dorena Genetic Resource Centre:*

- Twenty seedlots collected from the Kootenay Region in 2012 provided for screening; 10 of these have displayed some resistance (all West Kootenay collections);
- Three more seedlots tested in 2014; and
- Five seedlots collected from the Chilcotin Region in 2007 were tested and showed little to no resistance.

3. *Kalamalka:*

- Forty seedlots collected from the Kootenay region were screened in 2013 and 2014; many of these seedlots were concurrently being screened at Dorena.

4.2.2 Ribes Bed Screening

- No screening for rust resistance has been conducted using this approach; however, this method was applied to western white pine trials with mixed results including over-inoculation.

4.2.3 Field Based Screening

- In 2014, 41 families were planted at three locations in the Kootenay-Columbia Region. Many of these were a part of the families inoculated at Kalamalka as a part of the intensive screening project.
- There is a major field based screening project being developed by the MFLNRO - Whitebark pine Provenance Screening for Blister Rust Resistance, (C. Cartwright, N. Ukrainetz, and M. Murray). The plan is a hybrid between *Ribes* bed and field screening approaches, which includes controlled inoculation of seedlings following the protocols established by Rich Hunt (Canadian Forest Service, retired) for screening western white pine seedlings in an infected *Ribes* bed. Seedlings will then be moved to a nursery for care and monitoring. Nursery assessments will include spot counts on needles, canker development, and mortality. Surviving seedlings will be outplanted in a holding area for further monitoring and will be available for research and possible seed production. The target number of provenances for screening is 100 with approximately 10 families per provenance (total of 1000 families screened). Based on

experience with screening western white pine, approximately 5000 seedlings can be screened per year, and it is anticipated it will take 6-years to complete. Under current budgetary constraints, only 500 families are being screened (C. Cartwright). The cost estimate is $360 per family once seed has been collected (C. Cartwright pers. comm.).

Table 23. Current plans for screening of BC whitebark pine parents. These are the currently known number of parents to be screened between 2013 and 2021, contingent on continued funding through the Forest Genetics Council of BC (C.Cartwright, N. Ukrainetz, and M. Murray).

Inoculation Year	Proponent	Number of Families		
		Intensive Nursery-based Screening	Ribes Bed Screening	Field-based Screening
2013	M. Murray	10		
2014	M. Murray	30		40
2015	C. Cartwright		250	250
2016	M. Murray	40		
2016	C. Cartwright			
2017	M. Murray	40		
2017	C. Cartwright		250	250
2018	M. Murray	40		
2019	C. Cartwright			
2020	C. Cartwright			
2021	C. Cartwright			
Total		**160**	**500**	**540**

4.3 Rust Screening Facility Options for BC

Prior to embarking on the development of a screening program for BC, it is important to consider infrastructure needs, capacity requirements, and redundancy should such programs already be in place in other jurisdictions. Consideration of existing facilities in the U.S. is important prior to embarking on facility development in BC.

Five main options for developing a rust screening facility in BC were identified:

1. A new stand-alone facility;

2. A combined facility developed in conjunction with an existing government research centre;

3. A combined multi-approach facility;

4. Explore collaboration options for a joint Canadian facility with Alberta; and

5. Do not build a facility in BC, rather utilize existing U.S. facilities.

4.3.1 OPTION 1: Stand Alone Facility

A stand-alone facility will be the most expensive of the three rust screening facility options. It requires a great deal of capital up front, and hiring staff solely for the purpose of screening and/or whitebark pine recovery work.

Infrastructure

The infrastructure considered when developing the facility budget included:

- a greenhouse to grow the stock for two years
- an inoculation chamber, room, or possibly greenhouse where ideal conditions can be provided for the successful inoculation of the two year old seedlings
- raised or movable beds where the seedlings can transferred to and monitored for five or more years after transplanting
- office space with washroom and basic laboratory capabilities
- equipment required for moving plant and soil materials
- miscellaneous nursery supplies

Existing facilities may only require a renovation or upgrade to meet these needs. Regardless, controlled conditions conducive to seedling production and blister rust screening are a must.

The summary costs for both infrastructure and personnel are described below. For a full break-down and description of costs, refer to Appendix 3 – Capital and Operational Cost Estimates for a Stand-Alone Facility.

4.3.2 OPTION 2: Combined Facility

An alternative to building a stand-alone facility is to develop a rust screening program in partnership with an existing operation, such as a forest research centre, nursery, seed orchard complex, or university. There could be many willing partners provided there was a source of funds for operational costs, staff, and some capital for improvements or upgrades to their existing facilities. The preferred candidates to be considered should have some, or all of the following attributes:

- a vested interest in, or experience with whitebark pine
- nursery facilities and a competent grower
- professional and technical staff familiar with white pine blister rust
- access to experienced nursery labour
- opportunities for nursery screening or out-planting
- location in an area central to whitebark pine range and activities

Currently, whitebark pine screening for white pine blister rust and seedling production is being conducted or planned in two locations in the south-central BC: at the Kalamalka Research Station, and the Skimikin Seed Orchard and Skimikin Nursery sites. The advantage of a partnership with an existing facility would be low capital costs and access to an existing labour pool. Union labour contracts could be an issue at some sites restricting flexibility. Means of funding both professional and technical staff could also be a concern, unless contractors were allowed to provide professional/technical services.

The summary costs for both infrastructure and personnel are described below. For a full break-down and description of costs, refer to Appendix 3.

4.3.2.1 Kalamalka Research Station

The MFLNRO Kalamalka Research Station and Seed Orchards is located three kilometres south of Vernon along Highway 97 in the grassland phase of the Interior Douglas fir BEC Zone. The property sits between the city and Kalamalka Lake, at an elevation between 450 and 475 metres elevation. The stations and orchards cover approximately 29 ha with about 12 ha of seed orchards and the remaining reserved for research plantations. Mild dry winters and hot dry summers characterise the Vernon area. The dry summer weather is ideal for stimulating conifer flower production – an essential factor in tree improvement research and seed production (Table 24). The station is the centre for the Interior tree improvement and genetic conservation programs with active research programs being conducted for interior spruce, lodgepole pine, interior Douglas fir, western white pine, and western larch. Staff would provide technical expertise and services in propagation, seed handling, and tree breeding, as well as maintaining a gene archive for the Interior. They have several greenhouses for producing stock for research trials. They have been growing whitebark pine seedlings and artificially inoculating the seedlings with white pine blister rust since 2012. They have raised beds on site that were used previously for other projects.

4.3.2.2 Skimikin Seed Orchard

Skimikin Seed Orchard is located approximately 14 km northwest of Salmon Arm near to the community of Tappen. It is home to the oldest MFLNRO interior spruce orchards in the province, but has western white pine and lodgepole pine as well. There have been over 30 research trials established for progeny testing, seed source screening trials, and a *Ribes* garden established for nursery screening western white pine for blister rust. It is much cooler, wetter and has fewer hours of sunshine per year, with a much more moderate climate than Kalamalka (Table 24). They have an office, implement sheds, and cone sheds for post-collection storage prior to shipping to the Tree Seed Centre for processing.

Table 24. Summary of growing conditions at Kalamalka and Skimikin sites.

Location	Daily Mean Temperature (^{o}C)	Precipitation (mm)	Snow (cm)	Rainfall (mm)	Total Hours Sunshine
Kalamalka	12.8 C	425.6	93.3	333.3	2026.6
Skimikin	7.4 C	653.0	184.2	468.9	1802.3

4.3.2.3 Skimikin Nursery

Skimikin Nursery is a private commercial tree seedling nursery that was formerly owned by the Ministry of Forests. They grow up to 12 million seedlings per year, almost entirely in styroblocks. In 2014 they prepared and grew approximately 34,000 one-year old whitebark pine seedlings for Tree Improvement Branch to be used in nursery screening trials and provenance field experiments. The nursery complex has a large office and numerous auxiliary buildings which could potentially be used as an inoculation chamber to inoculate and screen for white pine blister rust. They have a substantial amount of nursery equipment including tractors, fork-lifts, and seedling production related equipment. Both the permanent and temporary staff have many years of nursery production experience.

4.3.2.4 Combined Facility Costs

As mentioned previously, there are many technical advantages to establishing a blister rust screening facility in conjunction with an existing facility, particularly where there has already been work with whitebark pine. One significant consideration is cost. In the case of the three previously mentioned sites, most if not all of the infrastructure is in place, negating the need for most of the capital investments. Trained casual or auxiliary staff is available, and accounting staff as well. In both cases however, the scientific and technical staff are already over-committed to existing projects. A full-time FTE for both a scientist, and a technician is likely not required for a screening program, but external investment to staff a project could provide more relief to the their existing program. Accurately calculating costs would require extensive consultation with potential partners, but for discussion purposes we have suggested the following potential costs. The summary costs for both infrastructure and personnel are described in Table 26. For a full break-down and description of costs, refer to Appendix 3.

4.3.2.5 Other Possible Options in BC

There are many other potential partners, or facilities that have been considered to have merit for the development of a rust screening facility. All had facilities or staff with experience in nursery operations, propagation, tree breeding, or have been involved with various aspects of whitebark pine activities. These include; Woodmere Nursery, (Smithers), Prince George Tree Improvement Centre (Red Rock), Cowichan Lake Research Centre, (Lake Cowichan), Landing Nursery (Vernon), Pacific Regeneration Technologies (Vernon, Armstrong, and various other locations.), Split Rock Nursery (Lillooet), Tipi Mt. Nursery (Cranbrook), Selkirk College (Castlegar), Thompson River University, (Kamloops) UNBC (Prince George), and UBC (Vancouver and Okanagan). These options were considered and discussed, but not evaluated in detail as they did not meet as many of the attributes described in Table 25 as the two examined. These facilities, may play a role in piecing together the multi-facility option described in Option 3, thus should not be fully disregarded.

4.3.3 OPTION 3: Multi-Facility

Because the process of screening involves several distinct steps, it may be possible to utilize the resources of more than one facility. For example whitebark pine stock could be grown in one facility, inoculated in another, and outplanted at a third. A multi-facility approach may facilitate additional funding such as collaborating with First Nations or accessing geographically restricted funds for certain components of the process; however, it is bound to require a higher level of coordination.

4.3.4 OPTION 4: Collaboration with Alberta.

Alberta Environment and Sustainable Resource Development (ESRD) recently hired a forest genetics specialist to work on gene conservation, whitebark, and limber pine. Jodie Krakowski had previously worked for the MFLNRO in BC in several positions with gene conservation, and whitebark pine research. Although having only been there a couple of months, she has a sense that there is an indication of "general support," for rust screening. Alberta has made several hundred seed collections from both whitebark and limber pine, but unfortunately there is little or no information about the health of the parent trees. The plan is to begin new collections in 2015 and 2016. This will involve training staff, and providing instruction on cone collection, and data collection. Provided there is a crop in 2015 and collections are made, seedlings would be grown for two years and a pilot screening conducted in 2017 or 2018. This is dependent on approval and funding which is currently unsecured. The Alberta Tree Improvement and Seed Centre (ATISC) is located at Smoky Lake east of Edmonton. At this site are both the government operations, and a private commercial forest nursery and seed processing facility. Jodie is of the opinion that although there are some issues to work around, they are solvable. There will be ample space for nursery production, and screening activities after 2015. As in BC, staffing could be an issue. Most of the work is done with staff, and few auxiliaries. Staff resources are currently limited, but if screening is approved, that could be alleviated. Jodie expressed the opinion that screening Alberta parents in BC is an option, if we have a facility and costs that could be presented as a business case option. Her next best option is to do the screening at ATISC. If BC indicated they would or could be partners, it would be an incentive to make it establish a screening facility in Alberta.

4.3.5 OPTION 5: Utilize Existing U.S. Facilities

If it is decided to forego the development of a rust screening facility in BC, existing facilities in the U.S. may be utilized for rust screening services. This would involve contracting the screening to one of the facilities in US, either the Dorena Genetic Resource Centre in Oregon, or the IPNF Coeur d'Alene Nursery in Idaho. There are several advantages to this; they already have the facilities in place, they have experienced staff, and they have the capacity to screen the amount of material we need for BC. The cost per seedlot (as of Nov. 2014) would be approximately $1250 USD per seedlot. Based on that cost, 500 seedlots would cost $625,000. This cost is likely less than it would cost to establish a rust screening program for whitebark pine; however there are a number of other aspects to consider. Establishing a white pine blister rust screening program for whitebark pine could have other spin-offs for limber pine, western white pine, or other plant conservation initiatives.

4.3.5.1 Dorena Genetic Resource Centre

The Dorena Tree Improvement Centre was established in 1966 as the headquarters for the White Pine Blister Rust Resistance Program. Their mandate is to ensure biodiversity through restoring and sustaining white pines in ecosystems by developing blister rust disease-resistant western white pine, sugar pine, and whitebark pine.

For whitebark pine, seeds are stratified in before mid-November, then sown in 10 cu. Inch Ray Leach tubes in late March or early April and grown in a greenhouse for two seasons. Two seeds per cavity are sown, and when there is more than one germinant per cavity they are transplanted to other cells. The seedlings are inoculated in September of the second growing season. The inoculation is accomplished by exposing the seedlings in their tubes, to white pine blister rust by placing infected Ribes leaves on screens elevated over the seedlings. The inoculation "chamber" is a modified implement shed which has fine misting nozzles to increase the humidity and improve the conditions for inoculation (Figure 23). They remain in the chamber for one week.

After inoculation the seedlings are transplanted into 4' x 3' plywood-side containers on plastic pallets to facilitate handling. Sixty seedlings per family are distributed in a randomized complete block design with

6 blocks and 10 row plots. The seedlings are assessed after inoculation and annually for 5 years. They have the capacity to screen well over 100 families annually on a contractual basis. The cost for a full rust screening is approximately $1250 USD per seedlot.

Figure 23. Seedlings being inoculated under Ribes leaves at Dorena Tree Improvement Centre.

4.3.5.2 IPNF Coeur d'Alene Nursery

The IPNF Coeur d'Alene Nursery was established in 1960 on 222 acres. The mission for the nursery is to: i) Provide quality seedlings for publicly-owned lands; ii) Develop the best possible methods for producing quality seedlings; and iii) Work with cooperative forestry to demonstrate successful tree growing practices and share new technology.

With respect to whitebark pine production and screening, the nursery is capable of full phase seedling production and screening, with potential for additional physiological and genetic testing. Seedlings are propagated in Ray Leach tubes using either a single or double seed sowing protocol; the tubes facilitate re-organization if germination is poor.

If seedlings are destined for screening, seedlings are inoculated in a controlled humidity inoculation chamber. During this process, microscope slides placed among the seedlings are used to measure whether sufficient spore rain has occurred prior to removing seedling from inoculation. After inoculation, seedlings are monitored for several years, eventually planted in beds to monitor for up to five years (Figure 24).

Figure 24. Inoculated seedlings being monitored in nursery beds at IPNF Couer de'Alene Nursery.

4.3.6 Technical Support Considerations (Full Time Equivalents (FTE))

We have estimated operational costs with one FTE – scientist, and one FTE –technician. The costs used were based on approximate, current MFLNRO rates (scientist = $100,000, technician $64,000). These costs were used because currently there are limited resources to manage a program in BC. At the Kalamalka Research Centre where the only screening in BC is currently underway, the staffing level will be reduced by at least 25% through attrition in the next two years. At this point it is questionable if they will be replaced, despite a demanding workload. It is unlikely that current staff will be replaced as they retired from service, creating a potential skills shortage. External funding could alleviate this problem, but there are difficulties accepting such funding. In government it is problematic terminating staff after short-term projects are complete (5-6 years). The other impediment could be with conflicts arising with existing unionized personnel. Both of these issues provide good arguments for conducting screening at a non-governmental facility.

The other aspects of a whitebark pine recovery program to be considered, albeit related to the screening facility, are "off site." A well-coordinated program requires the following:

- Coordination of parent tree selection
- Scion and seed collection and propagation for screening and seed orchards
- Field assessment of whitebark pine stands for crops and health
- Extension for operational seed collections and deployment
- Cone and seed processing
- Seed preparation
- Establishment of field trials
- Maintenance of data
- Contract administration

Many of these tasks are currently being undertaken by existing professional/technical staff, but again at least two will retire in the next few years, and others are only able to devote a certain amount of their time to whitebark pine.

One professional/technical person to coordinate an improvement program for whitebark pine would likely be able to manage all of the aforementioned activities, provided there were additional resources to guide, or consult with on technical aspects of the program. In particular, these would include pathologists, geneticists, and forest practitioners. These resources are available in BC, AB and areas where there are whitebark pine recovery programs in the US. A coordinator could operate under government, the direction of a Society, stewardship committee (comprised of stake-holders), or under contract with the MFLNRO. This model has been used with the MFLNRO for programs such as the Coastal western white pine and sitka spruce programs. The BC Cranberry Growers Association uses a similar model where a part-time manger is employed to facilitate all aspects of their research program. There are well-suited candidates available that could be considered for such a position, and would likely be interested in short term contracts. In similar situations, the coordinators cost were between $21, 000 - $30,000 per year.

4.3.7 Facility Selection Summary

The development of the technology, and expertise in BC could also be applied to limber pine, and possibly to advance the coastal and interior western white pine programs. The methodologies may also be applied for other diseases such as *Dothistroma*. One scientist FTE, and one technical FTE to screen whitebark pine alone are likely not required or justifiable for whitebark pine alone, but could provide additional resources for programs already suffering from lack of personnel through attrition, and down-sizing. Table 25 shows the pros and cons of all five options for a rust screening facility.

The other criterion for selecting a facility is costs. In Table 26 we have tried to estimate the cost per family for screening based on our current best available knowledge for all five options. In options 1, 2, and 3 , we have shown costs that; reflect current MFLNRO rates for one professional and one technical person for one year (1); and a contract professional/technical person supplemented with labour help (2) (See also “FTE’s). We have used 80 families per year as a target to estimate cost per family, and screening a total of 480 families over a six year period .The capital costs (in light blue) have been amortized over the six year period. It is quite clear that contracting out the responsibilities to a competent coordinator, operating at an existing facility in BC is the most viable and cost-efficient option. The choice of that location is open for discussion and negotiation with the operators of those facilities. It should also be considered here that some of the cases presented are to screen whitebark pine only, yet working with other species that require screening, such as western white pine or limber pine in the same facility to increase efficiencies and make the proposed cases even more viable.

Table 25 – Pros and cons of the four current nurseries (“Combined facilities”) available for screening work.

	Option 1	Option 2		Option 3*	Option 4	Option 5	
Faciltity Attributes	**Stand alone facility**	**Kalamalka Research Station**	**Skimikin Nursery**	**Multi-facility- Can capitalize on best available resources ***	**Alberta**	**US Research Facility – Dorena Tree Improvement Centre**	**Coeur d’Alene Nursery**
Staffing – Professional	Must be hired.	Geneticists, breeders, and d orchard managers	Nursery manger	Yes	Geneticist, Seed technologist.	Nursery manager	Nursery manager
Technical Support	Must be hired.	Experienced production growers, and propagator.	Experienced production growers, and propagator.	Yes	Some, but limited resources.	Experienced production growers, and propagator.	Experienced production growers, and propagator.
Auxillary Labour	Must be hired	Experienced unionized labor. Limitations on flexibility.	Experienced labor	Yes	Commercial nursery adjacent- possible.	Experienced labor	Experienced labor
Experience with whitebark pine	Qualified personnel must be hired.	Yes	Yes	Yes	None	Yes	Yes
Experience with Inoculation.		2 years.	None	Possible	None	Many years. Assessor has 20 years	Many years.
Greenhouses	None.	Yes, but could require more space	Yes	Yes	Yes	Yes	Yes
Inoculation Chambers	None.	Need some work to increase capacity.	Area available, but needs work to facilitate.	Needs to be built or existing structure modified	None	Yes	Yes
Raised beds	None	Some available, could require more.	Would need to be developed.	Yes.	None. Must be built.	Used movable pallets	In ground
Nursery beds	None	Limited	Yes	Yes.	Possible.	Limited	Yes
Clonebank capabilities	None	Yes	Available here and at adjacent seed orchard	Yes.	Possible.	Yes	Yes
Ribes gardens	None	Off-site (Skimikin Seed Orchard)	Yes	Yes	None	Yes	Yes
Location-climate	Site to be determined.	Dry	Moderate - Cool	Depends on exact location.	Cold winters. Similar to Prince George for both average max and min temps.	Moderate –Cool	Dry
Location-general	Site to be determined.	Central to Pa range. Good services available	Central to Pa range. Good services available	Depends on exact location.	116 km NE of Edmonton. 967 km from Vernon.	USA. Could be plant transfer issues	USA. Could be plant transfer issues

* Option 3 – Multi-Facility. This option has the advantage to make use of available resources from more than one facility. (Grow seedlings at one location, inoculate at another, and outplant at another). However there can be logistical difficulties that require much more coordination

Table 26. Cost comparisons of whitebark pine screening options (Based on screening 80 families per year).

	Option 1	Option 2		Option 3	Option 4	Option 5	
Faciltity Attributes	**Stand-Alone Facility**	**Kalamalka Research Station**	**Skimikin Nursery**	**Multi-facility- Can capitalize on best available resources ***	**Alberta Costs for 1 year pilot study-33 families**	**US Research Facility – Dorena Tree Improvement Centre**	**Coeur d'Alene Nursery**
(1) Permanent Staff						$1250 USD per seedlot ($1586 CDN) March 10/15	$1250 USD per seedlot ($1586 CDN) March 10/15
Staffing – Professional	100,000	100,000	100,000	100,000	Estimate: 58 FTE days @$328 = $19,024**		
" Technical	64,000	64,000	64,000	64,000			
Auxiliary Labour	6,000	6,000	6,000	6,000			
Total (1)	**170,000**	**170,000**	**170,000**	**170,000**	**19,024**		
(2) Coordinator	**40,000**	**40,000**	**40,000**	**40,000**	-		
Labour (technicians)	6,000	6000	6,000	6,000	-		
Consultants	-	-	-	-	7,000		
Total (2)	**46,000**	**46,000**	**46,000**	**46,000**	**7,000**		
<u>Capital Costs</u>							
Greenhouse	47,200	47,200	47,200	-	-		
Inoculation chamber	71,300	10,000	10,000	10,000	12,700		
Office	33,910	-	-	-	-		
Raised beds	12,625	On site.	12, 625	-	-		
Nursery beds	-	-	-	-	-		
Tractors and equipment	20,000	-	-	-	-		
Miscellaneous	5,000	5000	5000	5000	-		
Site	?	-	-	-	-		
Total	**190,035**	**62,200**	**74,825**	**15,000**	**12,700**		
Cost/Yr. (6 yrs.)	**31,672**	**10,367**	**12,470**	**2500**	**2116.67**		
<u>Operating Costs</u>							
Utilities /Rent	7,000	1,000	4,000	1,000	-		
Supplies	4,328	1,000	1,000	1,000	-		
Contract Services	1,533	1,533	1,533	1,533	-		
Total	**12,861**	**3,533**	**6,533**	**3,533**	-		
Total cost /year –(1)	**372,896**	**183,900**	**189,003**	**176,033**	**38,724**		
Total cost /year- (2)	**90,533**	**59,900**	**65,003**	**52,033**	-		
Cost per family- (1)	**$2,682**	**$2,299**	**$2,362**	**$2,200**	-		
Cost per family- (2)	**$1,132**	**$748**	**$812**	**$650**	**$1173**	**$1586**	**$1586**

* **Option 3** – Multi-Facility. This option has the advantage to make use of available resources from more than one facility. (Grow seedlings at one location, inoculate at another, and outplant at another). However there can be logistic difficulties that require much more coordination.

** FTE's based on median value of $100,000 Professional, $64,000 Technician at 250 days per year prorated to 58 days.

5 Funding Options

The funding options presented below range from single to multi-year programs; most will address project-based needs and not facility establishment. Securing long-term, reliable funding is necessary to support the long-term production and screening of seedlings, and ultimately the recovery of the species.

A number of wildlife species utilize whitebark pine (Table 27). Additional funding may be available through those species identified as Species at Risk or Identified Wildlife through the establishment of Wildlife Habitat Areas where whitebark pine could be specifically managed to provide habitat elements necessary for the survival and management of those species.

Table 27. Summary of wildlife species that utilize whitebark pine. Species in bold are listed (under Sec 13 of the *Government Actions Regulation*)as Species at Risk or Identified Wildlife.

Mammals	Birds	
Grizzly Bear	**Williamson's Sapsucker**	Mountain Chickadee
Black Bear	Hairy Woodpecker	Pine Grosbeak
Chipmunks	**White-headed Woodpecker**	Cassin's Finch
Golden-Mantled Squirrel	Stellar's Jay	Red Crossbill
Douglas Squirrel	Raven	Clark's Nutcracker
Red Squirrel	Red-breasted Nuthatch	White-breasted Nuthatch
Deer Mouse		
Southern Red-backed Vole		

Funding options to support the recovery of whitebark pine as outlined in this plan are often short-term; thus it is probable that a continual source of fundraising and proposal writing will be required to sustain recovery. Overcoming short-term funding is essential to maximize the chances of success for facility establishment and species recovery. Under this premise, one primary objective must be the identification and securing of long-term funding to serve as the primary backing for the program, with this in place all other short-term funds may aid in supplementing and building the program. As the requirements to conduct successful rust screening are many, we need not wait for a long-term funder to initiate work. Seed must be collected across the range to meet the screening needs, expertise must be developed to ensure a skilled labour force, and a concerned public must be made aware of the situation to ensure that funds will continue to be directed at this important project.

5.1 Unified Funding

The funding opportunities described below cover a wide range of project types with a range of objectives and deliverables. Although each funding source will be used to deliver a specific project, a unified funding approach should be developed such that common goals are being met and where possible contributions are being made to enable the establishment of a blister rust screening facility (Table 28). Several examples of unified recovery planning and funding can be found in BC, such as with Garry Oak recovery and the recovery of the Nechako White Sturgeon. With respect to garnering sturgeon support, Cory Williamson, head of the new facility in Vanderhoof provided several key messages to achieving the objective of establishing a blister rust screening facility in BC including:

- Identify and engage key stakeholders including industry, First Nations, Naturalists, and others;
- Create champions in government throughout the range of whitebark pine;
- Prioritize facility phases – what can we operate with and what is the ideal scenario;
- Develop a 'shovel ready' plan such that when funds become available they can be put to use, some funders may be shy of plans that are in concept only;
- It is actually advantageous that some industries are operating in whitebark pine habitat as they will feel an obligation to contribute;
- Develop a marketing plan, presentation, and brochure; and
- Always promote the idea.

5.2 Provincial Government Funding

Habitat Conservation Trust Fund (HCTF) – The HCTF is funded through the sale of angling, hunting, and trapping licenses. To be eligible for this stream of funding linkages with wildlife are always given preference. The greatest opportunity with this funding stream would be collaborating with grizzly bear biologists on field based trials. Funding Duration: Short Term.

BC Hydro Fish and Wildlife Compensation Program (FWCP) – BC Hydro offers two funding programs within the range of whitebark pine, these include the Columbia-FWCP and the Coastal-FWCP. The mission for this program is to compensate for impacts to fish, wildlife, and their habitats affected by BC Hydro developments. Funding Duration: Short Term.

Land Based Investment Strategy – The BC MFLNRO delivers the Land Based Investment Strategy (LBI), which provides major investments to improve the quality of forest and range lands. Within this program, several funding envelopes may be suited to whitebark pine recovery including: Inventory, Forests for Tomorrow, Forest Health, Tree Improvement, Ecosystem Restoration, Species at Risk and Wildlife. For many of these funding envelopes, whitebark pine will be a secondary thought, however with increase lobbying of decision makers it is possible that whitebark pine may be elevated to a higher priority. At present accessing the LBI is through priorities and investment planning conducted internally thus it is important to continue promoting whitebark pine recovery with government officials.

5.3 Federal Government Funding:

Aboriginal Funds for Species at Risk (AFSAR) – AFSAR is an Environment Canada directed funding source which is used for First Nations to assist with the implementation of the Species at Risk Act (SARA). Projects within this program must be held by First Nation Governments, businesses, or other official boards. Work is to be conducted within the respective Nation's Traditional Territory, thus most work will likely be field based. The applicability of this funding to blister rust screening is most likely through seed collections, payment for production and screening, planting, and development of more intensive seed production areas. First Nations with Traditional Territories linked to the location of the screening facility may have some eligibility for direct employment. Funding Duration: Up to three-years.

Habitat Stewardship Program for Species at Risk (HSP) – The HSP program encourages land and resource use practices that maintain the habitat necessary for survival and recovery for species at risk. To maximize use of limited resources, HSP is a targeted program, with new funding priorities set every few years. Whitebark pine and whitebark pine habitat is not a priority for this program at present; however, as funding priorities change, it will become a priority and it may be worthy of large proposal writing campaigns in those years. Funding Duration: Up to three-years.

Industrial Research Assistance Partnership (IRAP) – IRAP is a Federal funding program dedicated to assist businesses with innovation development. To be eligible for this funding the following conditions must be met: (1) a private for profit Canadian incorporated business, and (2) have the objective to grow and generate profit through the commercialization of innovative technologies and (3) be willing to build a trusting relationship with IRAP. IRAP has funded other programs linked with nurseries and natural resources. IRAP may provide multi-year funding in excess of $50,000 per year. The key to securing these funds is to develop or work with a for-profit business and develop a research program that will directly link with bringing whitebark pine to a larger market. As well there must be:

- Technical uncertainty associated with the R&D to be done that requires experimenting with innovative solutions to the technical problems.
- The company must have a business infrastructure that can undertake the required R&D and undertake the required commercialization activities to benefit from the results of the R&D, or have a plan to build that business.
- There must be a market opportunity that supports the growth of the business and ROI in terms of Benefits to Canada, commensurate with the size of the IRAP investment.
- Assuming some private partnership exists, a rust screening facility would likely benefit from this form of funding to research screening and/or production methods which may assist in making this a profitable venture.

5.4 Industry and Policy Options

Mitigation offsets (Financial) – Financial offsets are payments from industry when other mitigation approaches are not possible or do not sufficiently address the issue. Determining the amount of payment required is a complex process and has not previously been calculated for whitebark pine or whitebark pine habitat. To determine the value the same unit of measure should be used for the impact and the offset (hectares of land or number of trees). Payments are calculated based on the cost of implementing a proposed offset measure and not on ecological services (Government of BC 2014b). The duration of the offset is equivalent to the duration of the impact; payments will cover all costs for the duration of the offset. There is a high level of uncertainty regarding whitebark pine mitigation due to the potential loss of restored seedlings being infected by rust, the loss and accounting for the biodiversity role linked to wildlife use, and an inability to effectively replace the whitebark pine ecosystem; due to this uncertainty, companies should be pressed to use a multiplier to mitigate above their impact level. To generate a financial offset, it is anticipated that most companies will conduct some onsite restoration, but to reach their full permit obligations some additional work in the form of offsets either offsite or financial should be emphasized.

To maximize the offset potential, whitebark pine and species which utilize it as a food source should be identified as valued ecosystem components. This would facilitate mitigation work linked to both the tree health and the ecological role to be considered when determining mitigation requirements (www.eao.gov.bc.ca/pdf/EAO_Valued_Components_Guideline_2013_09_09.pdf).

Corporate Partnerships - A corporate partnership is likely the most stable and long-term funding method, which will also include facility and personnel investments. These types of partnerships may be essential in establishing a new stand-alone facility or making major renovations at an existing facility. Without a stable partnership, any other funding secured may be inefficient to screen seedlings on what amounts to a shoestring budget. It is paramount that some form of large fund be operating in the background (or foreground) to ensure that screening promises made to other funders may be conducted in a rigorous and efficient manner.

Whitebark Pine Trust –The funds collected from industry offsets and industry partnerships may be used to fund a whitebark pine trust, which would aid in improving and streamlining funding opportunities for whitebark pine recovery. This Trust could be used for three main purposes: (1) Support rust screening facility creation and operation; (2) Support a seed collection fund for years where large mast cone crops are identified (See Seed Collection Fund); and (3) To provide matching and/or seed funds for select projects as is often required.

5.5 Market Options

Seed and Seedling Sales – Seedling sales may at least partially address some of the facility costs. Several companies including Canfor, Teck, and Forest For Tomorrow Contractors have expressed a willingness to purchase seedlings if they were available. If one or more identified industrial players display potential to purchase large quantities of seedlings, it may be prudent to enter into facility improvement and development agreements with such groups.

Additional Funding:

Regional and Non-Profit Funds – There are a number of other funding sources that operate at a regional scale or solely require the engagement of a non-profit society. These include funders such as:

- Columbia Basin Trust,
- TD Friends of the Environment

Table 28. Summary of select funding options based on rust screening activities.

Funding Source	Seed Collection	Seedling Production	Rust Screening	Seedling Planting	Seed Orchard Creation	Facility Construction	Facility Maintenance	Staff Wages	Directed Research
Habitat Conservation Trust Fund	X	X	X	X	X				
BC Hydro Fish and Wildlife Compensation Program	X	X	X	X	X				
Aboriginal Funds for Species at Risk	X	X	X	X	X				
Habitat Stewardship Program	X	X	X	X	X				
Industrial Research Assistance Partnership		X	X						X
Industrial Offsets	X	X	X	X	X				
Corporate Partnership	X	X	X	X	X	X	X	X	X
Seed and Seedling Sales	X	X	X					X	

5.6 Funding Recommendations

Funding options to facilitate whitebark pine recovery are presently largely disjointed into a number of smaller funding options, which makes a cohesive approach difficult as each funder has its own set of goals and objectives. Steps may be taken to provide a more unified approach to ensure funds contribute to rust screening thereby increasing the likelihood of establishing a blister rust screening facility in BC. Recommendations to this extent include:

- Appointing a whitebark pine coordinator to oversee and develop letters of support for proposal submissions to ensure proposals address existing recovery strategies or contribute to the creation of a rust screening facility;
- Marketing to the whitebark pine community to ensure that proposals include some form of funds to the establishment of a rust screening facility, this may include for-fee screening, seed contributions, or proposal add-ons to provide direct facility funding;
- Work with industry to identify avenues of offsetting or corporate partnerships;
- Encourage industry to maximize offsetting and corporate partnership returns;
- Develop a business and marketing plan for the creation of a rust screening facility to promote to industry partners;
- Bring facility to a shovel ready state to ensure an ability to react once funding is secured;
- Identify technology gaps and market opportunities to qualify for multi-year IRAP funding;
- Prioritize phases of facility construction in the event that only partial funding is available;
- Identify levels of government where whitebark pine champions need to be developed considering the layers and jurisdiction of varying roles; and
- Identify or create champions throughout government to increase level of awareness.
- Encourage the development of Ecosystem Based Management with whitebark pine as a keystone species with spin-off benefits to other species at risk and ecosystem functions.
- Funding and resource acquisition. Seek funding for all whitebark pine recovery efforts both within and outside government agencies
- Develop relationships with First Nations communities where whitebark pine or the species of importance that rely on the associated ecosystem benefits of whitebark pine, are recognised.

6 Legislation and Practices to Protect Whitebark Pine

This section regarding potential legislation and practices to protect whitebark pine addresses legal avenues to increase the level of whitebark pine protection. Given the 'results-based' approach being employed in BC, many formal documents including policies, guidelines, strategies, etc. are not legal documents. Rather they are highly suggestive ways of meeting legal requirements, and may form components of legal agreements such as Forest Stewardship Plans and Permits.

6.1 Federal Level

There are several Federal level documents regarding the protection of species at risk in Canada including:

1. The Species at Risk Act
2. Canada-British Columbia Agreement on Species at Risk; and
3. The National Accord for the Protection of Species at Risk

6.1.1 Species at Risk Act (SARA)

The Federal Species at Risk Act (SARA) was designed to prevent native species from becoming extinct or extirpated. SARA provides a legal framework for developing recovery strategies, developing action plans, and for identifying critical habitat in order to aid in species recovery. Although the act has strong language regarding the protection of individuals and their habitat, the application of these sections to non-Federal lands is insubstantial:

32. (1) No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species.

> (2) No person shall possess, collect, buy, sell or trade an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species, or any part or derivative of such an individual.
>
> (3) For the purposes of subsection (2), any animal, plant or thing that is represented to be an individual, or a part or derivative of an individual, of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species is deemed, in the absence of evidence to the contrary, to be such an individual or a part or derivative of such an individual.

33. No person shall damage or destroy the residence of one or more individuals of a wildlife species that is listed as an endangered species or a threatened species, or that is listed as an extirpated species if a recovery strategy has recommended the reintroduction of the species into the wild in Canada.

34. (1) With respect to individuals of a listed wildlife species that is not an aquatic species or a species of birds that are migratory birds protected by the Migratory Birds Convention Act, 1994, sections 32 and 33 do not apply in lands in a province that are not federal lands unless an order is made under subsection (2) to provide that they apply.

(2) <u>The Governor in Council may, on the recommendation of the Minister, by order, provide that sections 32 and 33, or either of them, apply in lands in a province that are not federal lands with</u>

respect to individuals of a listed wildlife species that is not an aquatic species or a species of birds that are migratory birds protected by the Migratory Birds Convention Act, 1994.

(3) The Minister must recommend that the order be made if the Minister is of the opinion that the laws of the province do not effectively protect the species or the residences of its individuals.

(4) Before recommending that the Governor in Council make an order under subsection (2), the Minister must consult

> (a) the appropriate provincial minister; and
>
> (b) if the species is found in an area in respect of which a wildlife management board is authorized by a land claims agreement to perform functions in respect of wildlife species, the wildlife management board.

Key to SARA is that under 34(1), sections 32 and 33 related to killing and destruction of habitat, may not apply to non-federal lands. However, under 34(3), if the laws of the province do not effectively protect the species at risk, an order may be made to apply to non-federal lands 34 (2 & 3). Considering that 56% of the species' range is in Canada with 76% of this occurring in BC (COSEWIC 2010), there is an onus on the province to act in the interest of species recovery, which to-date has not occurred.

6.1.2 Canada-British Columbia Agreement on Species at Risk

This agreement provides an understanding between the federal and provincial governments and does not provide any real levels of protection. As stated in Section 4.0 (4.1) of this agreement, the purpose is to create an administrative framework within which the Parties can cooperatively exercise their respective powers and duties to ensure a coordinated and focused approach to the delivery of species at risk protection and recovery through legislation, policies, and operational procedures in British Columbia. It does so by:

- Setting out the respective roles and responsibilities of the Parties with respect to species at risk protection and recovery in British Columbia;
- Establishing the coordinating mechanisms needed to consult on key decisions, establish joint priorities, share information and design coordinated programs of work; and
- Providing opportunities to jointly develop species at risk policies where appropriate.

6.1.3 The National Accord for the Protection of Species at Risk

The National Accord for the Protection of Species at Risk (The Accord) was developed as a national approach for the protection of species at risk; with the state goal to "prevent species in Canada from becoming extinct as a consequence of human activities." The accord provides no direct actions; rather it provides a level of understanding between the provinces and the federal government. The key component of the accord identifies that the provinces (including BC) will "establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada," which BC has not explicitly addressed, though may have indirectly partially addressed through the series of regulations reviewed in this section.

6.2 Provincial Level

At the provincial level, there are few dedicated regulations which are automatically triggered once a species becomes listed under the Federal Species at Risk Act or added to provincial red or blue lists; rather, managers and decision makers must be educated about the plight of whitebark pine and 'persuaded' to include whitebark pine management as conditions of permits and management plans. The greatest gain to elevating the level of whitebark pine management, and hopefully recovery, will be through the education of managers and decision makers. Although educating decision makers on the plight and recovery tools for whitebark pine may suffice, an approach that describes existing legislation and regulations may aid in empowering decision makers and ultimately yield better results in the form of durable decisions. The regulations described here are linked to direct legislation and regulation in the forestry and mining sectors.

6.2.1 Forestry

6.2.1.1 Forest and Range Practices Act (FRPA)

The *Forest and Range Practices Act* contains several sections that may be applicable to the conservation and recovery of whitebark pine habitat including forest operations-based decisions to designating a species as endangered under FRPA. These include:

1) Requirements of a forest stewardship plan

A Forest Stewardship Plan (FSP) is a landscape level plan detailing planned forest development over a 5-year period. Plans must be submitted to government for approval and serve to keep the FSP holder accountable to agreed-upon expectations reflecting the values of numerous stakeholders. Contents of the plan may include both legally binding and non-legal obligations.

Section 5 of FRPA details the requirements of a stewardship plan, including 1(b) intended results or strategies in relation to (i) objectives set by government, and ii) other objectives that are established under this Act and that pertain to all or part of the area subject to the plan. The key to ensuring whitebark pine is included in plans, is to ensure that it is identified in government objectives; potential modes for inclusion include:

Objectives set by government may pertain to

> 8(2)(a) objectives for a wildlife habitat area established under the regulations, or
>
> (b) objectives set by government.

With respect to whitebark pine, the government may set objectives in relation to:

> 149 (1)(b) visual quality,
>
> (c) timber,
>
> (d) forage and associated plant communities,
>
> (g) wildlife,
>
> (h) biodiversity, and
>
> (j) resource features.

When evaluating a forest stewardship plan; Section 9 – Proportional Objectives may be important for widespread species recovery. In this section, the minister may establish targets between the holders of stewardship plans to share the responsibility in meeting objectives set by the government. Where whitebark pine is identified as an objective, it should be communicated to all tenure holders.

In addition to the requirements of a forest stewardship plan, other sections of FRPA may also apply to whitebark pine recovery including:

Gene resources

As conserving whitebark pine genetics forms a significant component of species' recovery, particularly in trees demonstrating genetic resistance to blister rust, conserving specific genetic lines may be of particular significance; Section 158 of FRPA may enable particular actions related to this:

> **158** The Lieutenant Governor in Council may make regulations respecting seed and tree gene resources including but not limited to regulations respecting the collection, processing, storage, registration, transportation, purchase, sale, selection, conservation and use of seed and tree gene resources.

Forest health emergency

Section 27 of FRPA pertains to forest health emergency legislation; the language in the act pertains primarily to limiting the spread of disease through timber harvest, however it also contains ambiguous language such as 'to carry out measures'

> **27** **(1)** If the Lieutenant Governor in Council considers that a forest health emergency exists in an area of Crown land or private land, he or she may designate the area by regulation as a forest health emergency management area.
>
> (2) The minister may order
>
> (a) the holder of an agreement under the Forest Act that authorizes timber harvesting in the emergency management area, or
>
> (b) the timber sales manager
>
> to carry out measures in the emergency management area, limited in the case of the holder, to the area of the holders agreement, to prevent, contain or limit the spread of forest health factors.
>
> *The above legislation is usually regarding the spread of disease or insects and harvesting the area to limit such spread; in areas hard hit by white pine blister rust, the reverse may be true and measures taken to protect healthy plus trees. It is not known if this approach is palatable, but may be an avenue to explore further.*

Silvicultural Systems

The Lieutenant Governor in Council may make regulations respecting (157) (1) silvicultural systems and silviculture treatments. Under (2) of this section, decisions may also be made regarding a) clearcutting, b) silviculture treatments, c) rehabilitation, d) free growing requirements, and e) exemptions from free growing. Under this section there are a number of tools at the disposal of the forest sector that may be used to facilitate recovery, including:

A) Timber harvest - timber harvest to create regeneration sites by mimicking mixed severity fire is desirable, this restoration approach is comparable to what has occurred in the Rocky Mountain Trench for grasslands restoration;

B) Modified Stocking - Inclusion of stocking standard guidance within the Chief Forester's Stocking Standards Guidelines for BC, including changes to stocking requirements to encourage recruitment of whitebark pine. Silviculture practices to facilitate berry production for bears have been implemented in Coastal BC (Government of BC 2001); similar practices could be developed for whitebark pine and encouraged throughout its range to facilitate broad ecosystem based management of benefit to a range of other species; and

C) Surveys - Further, many foresters indicate that whitebark pine is often noted during surveys but treated as a 'ghost tree' so it doesn't show in silviculture/inventory labels or contribute to stocking/free growing requirements. Since improving our knowledge regarding recruitment and regeneration is a key component of assessing species' recovery, it is crucial that whitebark pine become an acceptable species and included in silviculture surveys.

6.2.1.2 Old Growth Management

Old growth management areas (OGMAs) were developed to retain old forest values and conserve biodiversity or rare features across the landscape. OGMAs may be created by area or by percent of the land base within forest stewardship plans. The age of forest required for inclusion within an OGMA is determined by the Natural Disturbance Type and biogeoclimatic Zone, thus would only apply to older whitebark pine forests. As whitebark pine rarely forms components of forest stewardship plans, it is unlikely to occur within OGMAs. As inclusion of areas into OGMAs puts limitations on timber harvest, forest companies would likely prefer to place whitebark pine in OGMAs; however, considerations should be made for what potentially rarer stands or attributes are not being conserved on the land base due to whitebark occupying the OGMA area.

6.2.2 Forestry Practices

Although whitebark pine 'generally' occurs in high elevation non-productive forests, it may still occur within portions of the timber harvesting landbase. Within the day-to-day operations of forestry and forest management, a number of small adjustments to common practices may aid in facilitating and promoting the recovery and management of whitebark pine.

6.2.2.1 Vegetation Resources Inventory (VRI)

Vegetation Resources Inventory (VRI) is the primary forest inventory database used by the province of BC to guide forest management decisions. Unfortunately the data is often lacking for whitebark pine and is highly variable depending on the technician who classified specific forest stands. Although errors in the data are often explained by the primary purpose of the inventory being merchantable species management; VRI is the best available data to identify whitebark pine sites and is frequently used in conservation planning.

As VRI is continually being updated, it is crucial that technicians and interpreters are aware of whitebark pine and consider it during inventory. VRI mapping of whitebark pine in the Lillooet area produced a map where whitebark pine polygons did not follow ecological boundaries, rather they followed mapsheet boundaries (Figure 25). This discrepancy highlights that one mapper was likely aware of whitebark pine while another was not; underscoring the need for better awareness of whitebark pine when conducting inventory mapping.

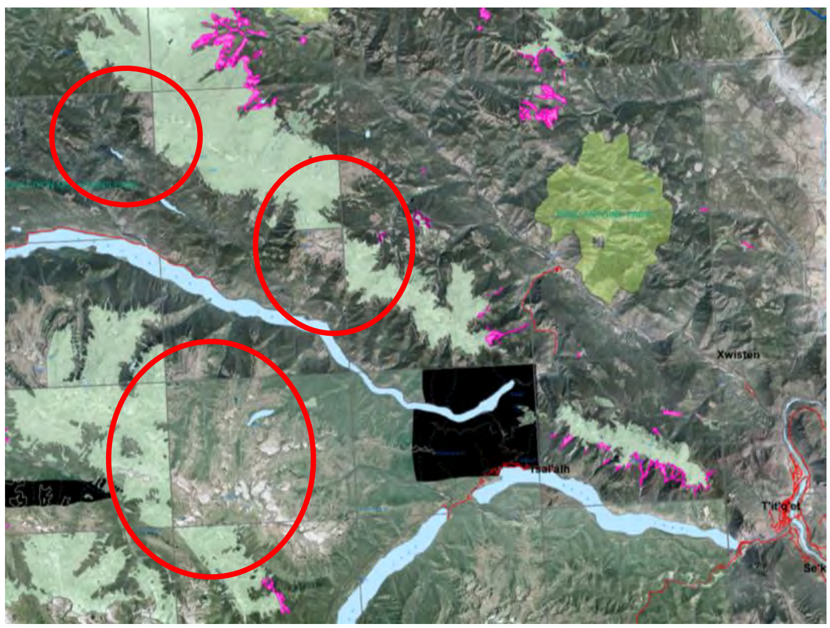

Figure 25. VRI map showing whitebark pine polygons in mint-green, note hard edges where map sheets intersect.

6.2.2.2 Timber Cruising

During timber cruising whitebark pine is often recorded as generic "pine" or as lodgepole pine. In several cases further investigation revealed that technicians assumed there was no code for whitebark pine in the cruise compilation program or that given the poor form, getting the species correct was secondary when documenting a tree with no merchantable value. Conversations with the makers of the primary cruise compilation software (Cruisecomp) revealed that there is a code for whitebark pine entry and that it is not being used due to a lack of awareness. Although cruising is simply a sample point of a given forest and is not an overall inventory, these small point samples are very useful in developing an overall inventory given the state of the current whitebark pine inventory.

6.2.2.3 Harvesting

Under appropriate planning timber harvest may be used for whitebark restoration. Many licensees have indicated that all stands with a whitebark pine component will be placed in non-harvesting reserves; although such a management strategy is well intentioned, it may do little for species recovery. Stands where whitebark pine is suppressed, dead, or declining, may benefit from well-planned timber harvest with the objective of retaining healthy trees and maximizing recruitment opportunities. Stands where whitebark pine is a leading species will likely not benefit from timber harvest. Identifying stands where whitebark pine is a leading species will require ground truthing by forestry technicians as current inventory methods poorly document whitebark pine presence on the landbase.

6.2.2.4 Reforestation

Reforestation using whitebark pine stock following timber harvest or natural disturbance has only rarely been conducted in BC and only in small restoration plantings often in wildfire areas. Existing stocking standards identify some subzones where whitebark pine use may be appropriate as discussed in Table 15**Error! Reference source not found.**. Stocking standards are guidelines only and do not carry legal weight; however, they may be incorporated into Forest Stewardship Plans (FSP's), which are legal documents. Many forest company representatives have expressed a willingness to plant whitebark pine seedling to meet biodiversity needs. Unfortunately the present availability of whitebark pine seedlings is generally by custom production only.

Reforestation using whitebark pine should also be promoted in wildfire areas under the Forests for Tomorrow (FFT) program. Within FFT, wildfire areas are reforested where there is a suitable business or biodiversity case to do so, and in many cases fires have burned into whitebark pine habitat killing many mature trees in the process. These sites pose ideal restoration opportunities as they have been returned to early seral conditions well suited to whitebark pine regeneration. Unfortunately on some sites in the East Kootenay region, crop species were planted into whitebark pine habitat at higher than typical elevations to account for climate change (O. Thomae, 2012 Pers. Comm.). Through the crop tree lens this approach is logical; however, it may increase the level of competition to whitebark pine on these sites and accelerate the threat posed by climate change. Reforestation under the FFT program needs to recognise the threats facing, and needs of, whitebark pine to increase the number of seedlings planted and limit the threats associated with planting programs.

6.2.3 Government Actions Regulation (GAR)

The Government Actions Regulation (GAR) may be used to create ministerial orders for various natural features and values that may be impacted by forest and range practises that may require special management. GAR is a regulation under FRPA and forms part of the legal framework inherent in the application of FRPA. Before a GAR order may be issued, a series of consultations and reviews must be undertaken as per GAR Section 3).

GAR Section 13 addresses species at risk and may apply to whitebark pine:

"Species at risk, regionally important wildlife and ungulate species
13 (1) The minister responsible for the Wildlife Act by order may establish one or more categories identifying species of wildlife as species at risk if satisfied that the species are endangered, threatened, or vulnerable.

(2) The minister responsible for the Wildlife Act by order may establish one or more categories identifying species of wildlife as regionally important wildlife if satisfied that the species:
a) Are important to a region of British Columbia
b) Rely on habitat that requires special management that is not otherwise provided for in this regulation or another enactment, and
c) May be adversely impacted by forest practices or range practices."

Within GAR there are requirements for land use decisions for features that require special management. There is a sequence of GAR tests that must be applied before a GAR order may be issued. These tests include:

- Test 1: Is special management required?
- Test 2: Is the proposed action consistent with established objectives?
- Test 3: Would the proposed action unduly reduce the supply of timber from BC's forests?
- Test 4: Do public benefits from the action outweigh any material adverse impact on delivered wood costs and any undue constraint on the ability of a forest or range agreement holder to exercise their rights under the agreement?

If the above tests are satisfied, a rationale document may be prepared and a notice of order released. An example of a review of these four tests for Mountain Caribou is included here: (http://www.env.gov.bc.ca/wld/documents/uwr/u-4-013_GAR_rat.pdf)and a link to GAR implementation is included here: (https://www.for.gov.bc.ca/ftp/hth/external/!publish/Web/frpa-admin/frpa-implementation/gar-guide.pdf). Once a species is designated through a GAR Order, management policies may be developed under the Identified Wildlife Management Strategy.

6.2.4 Identified Wildlife Management Strategy

FRPA and its regulations provide tools for managing species listed as at-risk under GAR. The Identified Wildlife Management Strategy (IWMS) is an initiative to provide policy direction for the protection of species and habitat impacted by forest and range activities. GAR provides some level of legal protection, while the IWMS provides policy direction to guide the implementation of GAR but provides no additional legal protection. Within the IWMS, whitebark pine fits primarily within the 'Species at Risk' category as it is negatively impacted by forest management and it is listed as endangered by COSEWIC. "The list of Identified Wildlife will be updated annually and will reflect changes in COSEWIC and Species at Risk Act listings," (Government of BC 2004); however the most recent update to the FRPA SAR list was in 2006, bringing the total number of species at risk listed under FRPA to 85. For a minister to add new species to the list of species at risk under FRPA, he or she must be "satisfied that the species is endangered, threatened or vulnerable." To be managed under the IWMS, a GAR order (as above) must be created and then an IWMS will be developed to provide guidance for developing objectives and operational plans, some of which may become legal objectives. Once included in the IWMS, accounts and measures are developed to guide management decisions. These accounts and measures are to provide management guidance to planning committees or to guide management in the absence of higher level plans; accounts and measures are not mandatory nor do they form legal requirements. Thus, although the IWMS provides no legal protection, it may be used to provide consistent guidance and management protocols to ensure a uniform approach during recovery activities. A designated IWMS species may then be managed through other GAR legal tools such as Wildlife Habitat Areas.

6.2.5 Mining and Mineral Exploration

Mining and mineral exploration is governed and regulated by a number of acts, policies, regulations, and protocols from both the federal and provincial governments. Within the industry, mining companies are members of a number of national and international associations, many of which promote sustainability with language regarding the protection and recovery of endangered species associated with industrial project work.

Figure 26. Abandoned mine in whitebark pine habitat at Perkins Peak in the Chilcotin.

6.2.5.1 Mines Act

The Mines Act is legislation that applies to all mines throughout the mining life cycle; exploration, development, construction, production, closure, reclamation and abandonment. Most major mining operations require a permit to establish and operate a mine. The Health, Safety and Reclamation Code details requirements for obtaining a permit, and contain operational standards and provisions related to health, safety, and reclamation. Permits are applied for and granted under the Mines Act, and state regulations, requirements, and recommendations specific to the site.

As part of the permit application process, proponents must submit a plan describing not only the proposed work, but also the approach to protecting natural resources present and the reclamation of the land post-mining (10.1). <u>If specific efforts for the mitigation of potential effects to endangered species are specified in environmental assessment submissions, and are written into permits, then they would become required conditions of the awarded permit, and the company would be obligated to meet those specified efforts or risk being in non-compliance with their permit</u>. It is possible, given the increasing focus on environmental sustainability, that specific goals regarding the intention to include endangered plant species in reclamation work be written into permits, especially for species that have a high likelihood to survive in the post-mining conditions developed.

6.2.5.2 Health, Safety and Reclamation Code for Mines in British Columbia (2008)

The Health, Safety and Reclamation Code for Mines in British Columbia (HSRC) provides standards for health, safety and reclamation as relating to mining operations. It is continuously reviewed to stay current with changing mining practices, technology, and safety concerns.

Information and provisions relating to reclamation are very general. Proponents of proposed coal and mineral mines, major modifications to existing mines, and major exploration and development must document the present use and condition of land and watercourses (Section 10.1.4(2)), including: vegetation (i), wildlife (j), and land capability and present land uses (k).

In addition to baseline information, a Plan for Environmental Protection of land and watercourses during construction and operation (Section 10.1.4(4)) must be submitted. This is to include information on the management of metal leaching and acid rock drainage (4a), erosion control (4b), and describing how environmental monitoring work would demonstrate that the project is meeting requirements; an annual report (4ci), how they will meet reclamation standards outlined in the HSRC (4cii), and how the environmental protection of land and watercourses are being maintained (4ciii)). A Reclamation Plan is also required (Section 10.1.4(6 and 7)), describing the operational reclamation plan for the next five years, as well as a final reclamation plan for closure.

Reclamation standards are listed (pages 10-15 to 10-19), however they are very general. The main standards are that:

- Land and watercourses will be restored;
- Land is re-vegetated to self-sustaining state with appropriate plant species.

The end land use to reclaim to is to be approved by the chief inspector, and should consider the previous condition and potential uses (10.7.4). There is a standard regarding land capability (10.7.5), which states that the average land capability of land to be reclaimed should not be less than what existed prior to mining. However, there is an exception to this standard, and this can be disregarded if “the land capability is not consistent with the approved end land use”. The standard specific to re-vegetation (10.7.7) is also extremely vague, stating that “land shall be revegetated to a self-sustaining state using appropriate plant species”.

All of the standards for reclamation in the HSRC are vague, and allow the proponent to interpret them as they choose. There is no requirement to consider endangered species, or manage for them in any way.

6.2.5.3 BC Environmental Assessment Act & BC Environmental Assessment Office

Administered by the BC Ministry of Environment and coordinated by the BC Environmental Assessment Office (EAO), the Act requires an environmental assessment be conducted on reviewable projects prior to being built, and a certificate must be awarded in order for the project to begin. The Canadian Environmental Assessment Act is a similar process for projects requiring federal approval.

The Act is the legislation requiring that an assessment be carried out on reviewable projects. How an assessment is carried out is directed by the EAO, as the review process is not specified in the Act. The purpose of an environmental assessment is to provide a mechanism to identify and evaluate the potential social, health, environmental, heritage and economic effects of a project in BC, and to provide a process for the consideration of input from the public, First Nations, local stakeholders, and government.

For each project deemed reviewable, the scope, procedures and methods of the assessment is established by an EAO project lead, and an order under the Act is provided to the proponent to communicate this. The order describes elements of the project that will be assessed, and the effects to be considered in the assessment. Subsequently, an Application Information Requirements (AIR) document is developed by the EAO, which provides greater detail for the proponent in terms of issues that need to be addressed, and the information is required for the final application (baseline studies, how to assess cumulative effects, etc.). <u>The information that proponents are required to address is entirely dependent upon the EAO.</u> Precedence has been set by projects that have gone through the assessment process and have been granted certificates. However, onus rests with the EAO in terms of providing guidelines for project studies, effects to be considered, and impacts to be addressed, and these should evolve over time as new issues, such as whitebark pine, come to light.

6.2.5.4 Canadian Environmental Assessment Act & Canadian Environmental Assessment Agency

There are specific circumstances under which a proposed project would trigger a federal environmental assessment under the Canadian Environmental Assessment Act (Government of Canada 2012). These are listed in Schedule (Sections 2 to 4) Physical Activities, and include projects that would be constructed in a wildlife area or migratory bird sanctuary, as well as the development of certain new or expansion of existing facilities (power generating, dams or dykes, oil sands mine, offshore development, liquefied natural gas, petroleum, or rare earth element, coal, or metal mine, etc.) of specific production capabilities or size.

A project description is submitted to the Canadian Environmental Assessment Agency, and the Agency conducts a screening of the project. Several factors are considered during this process (Section 10.a), including “(ii) the possibility that the carrying out of the designated project may cause adverse environmental effects”. The term “adverse environmental effects” is not defined in the Act, and no other information is provided. Once the screening process has been completed, the Agency will decide if the project requires an environmental assessment.

One of the purposes of the Act (Section 4.1) is "(***a***) to protect the components of the environment that are within the legislative authority of Parliament from significant adverse environmental effects caused by a designated project." Although "significant adverse environmental effects" is not defined and may be interpreted differently by various proponents, the purpose statement is clear regarding components of the environment that are within legislative authority of Parliament. Section 5 lists the Environmental Effects to be considered under a federal assessment, and include:

> (***a***) a change that may be caused to the following components of the environment that are within the legislative authority of Parliament:
>
> > (i) fish and fish habitat as defined in subsection 2(1) of the Fisheries Act,
> >
> > (ii) aquatic species as defined in subsection 2(1) of the Species at Risk Act,
> >
> > (iii) migratory birds as defined in subsection 2(1) of the Migratory Birds Convention Act, 1994, and
> >
> > (iv) any other component of the environment that is set out in Schedule 2

It is unclear as to why only aquatic species listed under the Species at Risk Act should be considered during a federal assessment, and not terrestrial species as well, as they would arguably fall under the legislative authority mentioned in Section 4.1a of the purposes of the Act. Unfortunately, at this time Schedule 2 is blank on the government website, and its contents could not be acquired.

Projects must take into account several factors outlined in Section 19, including the environmental effects of the project and any cumulative effects that are likely to result from the project (a), the significance of those effects (b), public comments (c), and technically/economically feasible mitigation efforts that would address any significant adverse environmental effects.

As with the BC Environmental Assessment Act and BC Environmental Assessment Office, there is open-ended language which leaves room for interpretation in the Canadian Environmental Assessment Act and Agency. Precedence has been set by previous projects, and expectations exist for the assessment of endangered species within project areas and potential effects from the proposed project. However the vague language that exists can lead to a lack of consistency regarding level of effort.

6.2.5.5 The Mining Association of Canada (MAC)

The Mining Association of Canada (MAC) is an organization that represents the mining industry in Canada. The Association works to promote the Canadian mining industry both nationally and internationally, works with government on mining policies, and engages with the public and other stakeholders. Voting membership is comprised of companies involved in mineral exploration, mining, smelting, refining and semi-fabrication.

Towards Sustainable Mining (TSM) is a set of tools and indicators developed by MAC to support socially, economically, and environmentally responsible mining. All MAC members must participate in TSM. In 2011, the Mining Association of BC (MABC) became the first provincial association to adopt TSM, and its members must participate as well. Assessments are done at the site level, and members annually report their performance against a set of guiding principles, using 23 indicators. Results for each site are externally validated every three years.

Biodiversity Conservation Management is one of the TSM protocols, with the aim to promote environmental responsibility, and minimizing operational impacts on the environment and biodiversity. The performance indicators for the Biodiversity Conservation Management protocol are geared towards high-level planning:

1. Corporate biodiversity conservation commitment, accountability and communications
2. Facility-level biodiversity conservation planning and implementation
3. Biodiversity conservation reporting

The site would be assessed on whether a formal commitment to manage biodiversity has been made, if action plans have been developed and are being implemented, and whether there are reporting systems to communicate findings and inform decision-making. Wording regarding biodiversity components in the assessment criteria and supporting guidelines for each performance indicator is vague, and is limited to broad terms such as 'significant biodiversity aspects'. However, definitions for many terms are supplied in Appendix 1: Frequently Asked Questions. For example, 'significant biodiversity aspects' are defined as:

> …significant issues that have been identified by the site for specific management <u>to meet regulatory requirements</u>, to avoid or mitigate potential impacts on biodiversity or to address community or other stakeholder concerns. Examples include endangered and threatened species, protected areas, critical habitats (e.g. for wildlife, fish or endangered plants) or valued ecosystem components (e.g. wetlands), or ecosystem services (provision of clean water).

This Appendix helps mitigate the ambiguity and confusion that accompanies vague, high-level language used in many regulatory documents, where practitioners are left to decide what they mean without the benefit of a standardized approach. Although the TSM program is geared towards high-level planning at this time, there is adequate guidance specified in the Biodiversity Conservation Management framework and protocol documents to support the development of meaningful biodiversity management at the site level, including guiding sites to assess and mitigate potential effects on endangered species.

Another area of TSM that may support endangered species work is Mine Closure, which was added in 2008. At this time, a framework has been developed which encourages companies to engage with communities, and identify important values to incorporate into reclamation objectives.

6.2.5.6 International Council of Mining and Metals (ICMM)

The International Council of Mining and Metals (ICMM) is a member organization established in 2001 to drive social, economic, and environmental progress in the global mining and metals industry. It is comprised of 21 mining and metals companies, and 35 national and regional mining associations, and global commodity associations. The Mining Association of Canada is a member of ICMM. Members are required to publicly commit to improving their sustainability performance, and annually report on their progress.

Members are committed to the 10 principles for sustainable development outlined by ICMM. Principle 6 is to "Seek continual improvement of our environmental performance", and includes the requirement to "assess the positive and negative, the direct and indirect, and the cumulative environmental impacts of new projects – from exploration through closure". Principle 7 is to "Contribute to conservation of biodiversity and integrated approaches to land use planning".

ICMM has produced many documents to help members of the mining industry and governments improve their environmental best management practices, including "Mining and Biodiversity Good Practice Guidance" (ICMM 2010), "Mining and Biodiversity: A collection of case studies – 2010 edition" (2010), and "Integrating Mining and Biodiversity Conservation: Case Studies from around the world" (IUCN 2004). When assessing biodiversity elements, endangered species are always discussed as important elements to consider.

6.2.6 Oil and Gas

The oil and gas commission has created an Environmental Protection and Management Guide (BC OGC 2013) to aid in understanding and implementing the Environmental Protection and Management Regulation (EPMR). With respect to Species at Risk, applicants are to provide a mitigation strategy to detail what measures will be taken to mitigate potential impacts to high priority species. High priority species are identified as those under Section 29 of the EPMR including: a) species at risk, b) regionally important wildlife, and c) ungulate winter range. This order links directly with that created under the Government Actions Regulation (GAR), thus working within the GAR framework is likely to have the greatest impact within forestry and oil and gas development.

6.2.7 Mitigation Procedures

To address environmental mitigation in BC, the province has released several documents to support mitigation planning including: Procedures for Mitigating Impacts on Environmental Values (Government of BC 2014b) and Policy for Mitigating Impacts on Environmental Values (Government of BC 2014c). Neither of these documents carry legal authority rather they support existing legislation and aim to bring consistency to the manner in which environmental values are identified, applied to impact assessments, and mitigation hierarchy applied to these values.

The basic premise of the mitigation policy and procedures is to establish a framework or hierarchy that will form the basis for industry and decision makers to follow. The procedures identify four potential mitigation streams including: 1) No mitigation measures needed; 2) Environmental Values are present and Best Management Practices (BMP) or other guidance documents are present; 3) Environmental Values are present, there are no BMP's, no review by provincial technical staff is needed, but there is a need for oversight by Qualified Professionals; and 4) Environmental Values are present, there are no BMP's, and there is a need for review by provincial technical staff because of high risk to environmental values or because it is a reviewable project. Whitebark pine generally fits in either category 3 or 4 depending on the project, region, and level of impact. To identify environmental values, a series of sources may be consulted including: natural resource policy and legislation, cumulative effects studies, First Nations, and technical experts.

Once an area has been identified to have whitebark pine (high environmental value), the planned development should be compared with the distribution and needs of whitebark pine, and the mitigation hierarchy applied, including consideration of the following principles:

1) Avoidance: This principle involves avoiding impacts to whitebark pine within project footprints. Though highly effective for other environmental values, for whitebark pine this approach should consider the health of the trees being avoided and how the avoidance approach will preclude the implementation of other steps such as restoration and off-setting, which may have greater species recovery benefits.

2) Minimization: Minimizing impact to whitebark pine during development is difficult to implement as generally trees are either impacted or they are not. Some modes of minimization may include limiting cutting of trees to infected trees only, retaining trees on site for as long as possible to facilitate nutcracker use and pollination or off-site trees, and transplanting healthy seedlings and saplings if feasible.

3) Restoration On-site: Restoration simply attempts to make up for what was lost due to impacts on ecological systems (Government of BC 2014b). In general, simply re-planting whitebark pine seedlings on-site at a date in the future is not satisfactory restoration when the starting point may have been a mature cone-producing stand. Whitebark pine restoration on-site involves a complex array of health and ecological attributes to consider including trade-offs between a potentially sick forest at present to a healthy forest in the future and between an ecologically functioning forest with many existing wildlife and ecosystem linkages (even in infected forests) to replacing such characteristics through restoration in a century or more. Balancing the health gains with the time-lag in ecological functioning is important to consider when developing restoration requirements and when considering when off-setting is required.

4) Offsetting: Offsetting may consist of off-site restoration or offsetting payments to deliver the best conservation outcome for the impact. Offsets should be based on ecological equivalency to determine the type and scale of offset required. The same unit of measurement should be used for both impact and the offset (like for like and assed based on area, number of trees etc.). The amount of offsetting will increase with the amount of uncertainty, in this case survival of seedlings; thus the offset:impact ratio should be high.

When considering offset payment approaches, calculations are based on the full cost to carry out the offset, not the value of the ecological services; although this may undervalue cost, it simplifies the costing calculations. For large projects or cumulative effects with numerous contributors, a governance model to ensure effective conservation delivery is recommended.

When identifying the best offset mode (off-site of payments), the measure which will deliver the best conservation outcome in the shorted timeframe is preferred. Although restoration off-site may deliver more of a like for like model; species recovery in a timely manner is relying on blister rust screening to implemented and scaled to meet the needs of the species, thus offset payments to support such a program should be pursued where possible.

Whitebark pine requires proactive approaches to species recovery. Although the mitigation hierarchy is designed in order of declining conservation values and increasing complexity (it is generally better and simpler to avoid impacts than it is to restore or offset); this approach may not serve whitebark pine recovery well. Conservation wise it would be far better to impact a diseased stand of whitebark pine and be required to offset through contributions to blister rust screening programs than it would be to simply avoid such stands. Identifying the proper mitigation pathways will require stand evaluations by skilled workers to ensure conservation gains are maximized.

6.2.8 Professional Reliance

As British Columbia does not provide clear legal guidance for appropriate management of species at risk, the Association of BC Forest Professionals and the College of Applied Biology have created a guidance document for managing species at risk in BC (ABCFP/CAB 2009). This guidance document provides some guidelines but also acknowledges the inconsistencies in legislation: “Although most provinces have specific stand-alone legislation to protect species at risk, BC does not. Here an often-confusing array of agencies, legislation, regulation, and policy guides the conservation of species at risk, their habitats and ecosystems at risk. Government guidance is incomplete, so BC resource professionals can have a strong influence on sustaining the province’s native species at risk over the long term.”

This guidance document identifies several expectations of resource professionals working in areas where impacts to species at risk are likely, including: i) be reasonably informed of species at risk in the area affected by their advice; ii) be reasonably informed of the requirements to conserve such species; iii) consult with other professionals if information about such species is required; iv) assess the risk to species at risk from the proposed activities, v) be informed of the legal requirements surrounding the stewardship of species at risk; vi) advise alternatives that align with legal requirements when designing mitigation approaches; and vii) propose that professional associations advocate for changes to laws or policies that conflict with sound stewardship of the particular species.

This document provides some general expectations of resource professionals and it is probable that in many cases professionals are not meeting the expectations of their respective organizations when it comes to whitebark pine recovery. Very few professionals act in the interest of whitebark pine and while this may be due to the will of business interests, item vii) above indicates that there should be a greater level of discussion around how professionals can best manage whitebark pine as opposed to the general inaction at present.

6.2.9 Legislation and Practices Recommendations

Many regulatory descriptions listed above have some latitude for decision makers to develop requirements, which from the perspective of whitebark pine identifies a need for the education of decision makers to ensure decision makers are not making misguided judgements. Consider the approach taken by many forest companies to simply place stands with whitebark pine in reserve so as not to cause any direct mortality; while this approach is commendable, in some cases it may not maximize contributions to species recovery. If some of these stands were open to cutting with a requirement to contribute to rust screening actions, then species recovery would certainly be addressed with these actions if the payments were significant enough. Whitebark pine requires proactive recovery actions; thus potential impacts which may facilitate this proactive approach should be carefully considered when applying conservation policy.

Recommendations regarding the above legislation and regulation include:

- Familiarize policy makers with Section 34(2)(3) of the Species at Risk Act to underscore that the Act may apply if whitebark pine is not adequately protected in BC;
- Improve awareness around the National Accord for Species at Risk, particularly that BC is not providing effective protection at this time;
- Prior to pursuing blanket legislation to protect whitebark pine, determine what level of protection is most desirable under the existing policies – Identified Wildlife, creation of Wildlife Habitat Areas, or other approaches;
- Evaluate whitebark pine against the four tests in the GAR Species at Risk process to evaluate if whitebark may be elevated to a species at risk status under FRPA;
- Educate foresters about the needs of whitebark pine and how it may be incorporated into forest stewardship plans;
- Educate foresters on the need for improved inventory to include whitebark pine in VRI, cruising, and silviculture surveys;
- Educate mining company representatives about whitebark pine and how it fits within their third party certifications;
- Improve the awareness of whitebark pine to ensure it is captured in all management plans and permit reviews, including Timber Supply Reviews;
- Develop clear and acceptable best management practices, and mitigation procedures; and
- Develop a clear direction for rust screening to aid in uptake of offset payments.
- Through the WPEFC, and in consultation with all stakeholders, draft “Best Management Practices” guides for those stakeholders, including; parks, forest companies, mining companies, wind power companies, recreation operators, and telecommunication companies

7 Conclusions and Recommendations

7.1 Linking with Higher Level Plans

Recovery planning for whitebark pine is presently underway in several jurisdictions, recently produced plans and documents include:

- Alberta Whitebark Pine Recovery Plan 2013-2108 (Alberta Whitebark and Limber Pine Recovery Team 2014);
- A Range-Wide Restoration Strategy for Whitebark Pine (*Pinus albicaulis*) (USDA, Keane et al. 2012);
- Genetic Conservation Strategy for Whitebark Pine in British Columbia (GCTAC and FGC 2009);
- A Tactical Plan for the Recovery of Whitebark Pine in the Omineca Region (Clason 2013); and
- Recovery Strategy for Whitebark Pine (*Pinus albicaulis*) in Canada (*In Draft*) (Environment Canada 2015).

This document forms more of an action plan, than a recovery plan for BC; however as an action plan, it must link directly with higher level plans. No higher level plans have formally been developed for BC and the federal strategy is presently in draft. In the absence of such a document, the Tactical Plan for the Recovery of Whitebark Pine in the Omineca Region (Clason 2013) was used as a guidance document to link with actions in this document.

Table 29. Summary of actions recommended in the tactical plan for the recovery of whitebark pine in the Omineca Region addressed in this document.

Action	How Addressed in this Document
Quantify the accuracy of the VRI	VRI errors were identified as an issue with existing forest management practices, recommendations were made to improve awareness of whitebark pine when conducting forest inventories.
Remote sensing whitebark pine locations	Not addressed
Increase ground plots to verify locations	Recommendation to improve sampling of whitebark pine in silviculture and cruise plots will aid in meeting this action, though won’t completely address it as whitebark pine typically occurs outside of the timber harvesting landbase.
Forest structure inventory	Recommendation to improve sampling of whitebark pine in silviculture and cruise plots will aid in meeting this action, though won’t completely address it as whitebark pine typically occurs outside of the timber harvesting landbase.
Survey blister rust	Recommendations made to improve distribution of rust monitoring transects on the landbase.
Survey MPB mortality	Not addressed

Action	How Addressed in this Document
Planting rust resistant seedlings	Tasks identified to produce rust resistant whitebark pine seedlings and to deploy on landscape. Numerous aspects of this task are discussed.
Pruning	Not addressed
Forest clearing and/or thinning	Addressed with respect to educating foresters and including whitebark pine in forest stewardship plans. Whitebark pine benefits from proactive management and appropriate forestry actions may aid both whitebark pine recovery and ecosystem based services.
Seed collection area	Actions discussed to identify and establish selected stands, seed production areas, and seed orchards.
Use Verbenone or carbaryl on trees identified as potentially rust resistant	Used as a potential method to protect parent trees identified as putatively resistant to whitebark pine.
Manage Clark's nutcracker food sources	Not addressed
Monitor Clark's nutcracker population trends	Not addressed
Revise BEC land management handbooks	Outreach with foresters and decision makers will target 'tools of the trade' including planning documents such as land management handbooks.
Revise BC "Tree species selection tool"	Discussion on whitebark pine's use and acceptance in forestry is discussed including site series where it may be deployed and where it should be considered. Includes getting included in forest stewardship plans and making seedlings available to industry.
Evaluate policy options for minimizing and mitigating industrial impacts	Policy section explores options for protecting whitebark pine in a range of scenarios including forestry, mining, and other industrial operations requiring permit submissions.

7.2 Recovery Coordination

Each of the sections within this document provides detailed background and recommendations on various steps to facilitate the recovery of whitebark pine. However, ensuring oversight and coordination is a key element to ensure that activities are appropriate and contributing to overall recovery goals. Recovery of whitebark pine across its Canadian range will also require cooperation and guidance to achieve local recovery goals in the context of overall species recovery. To facilitate this, it is suggested that a recovery team be developed to oversee recovery actions. The team will need to include representatives from stakeholder groups, expertise to address the array of threats, and operate at both a provincial and regional scale. The Whitebark Pine Ecosystem Foundation of Canada already serves the interests of whitebark pine coordination and outreach in BC, but is not mandated to oversee recovery; members from this group could form the basis of a recovery team.

Several boards within BC were examined to gain insight into recovery team format and structure, including the Garry Oak Ecosystems Recovery Team (GOERT), Invasive Species Council of BC (ISCBC), and the Coastal Douglas-fir and Associated Ecosystems Conservation Partnership (CDFCP). Each of these groups consists of boards and structures appropriate to the specific needs of the group. All boards have representation from different stakeholder groups. For instance, ISCBC has dedicated positions identified for stakeholders, while the other boards appear to simply have diverse boards.

To develop a whitebark pine recovery team that covers the breadth of the problem, several factors beyond recovery planning should be considered including business structure (non-profit or other), staffing, and what role the team will play (oversight, coordination, implementation, etc.). Regardless of business structure, an informed board with direct linkages to regional representation and Recovery Implementation Groups should be considered. A potential team structure may consist of:

- Provincial Recovery Team

  The role of the provincial recovery team would be to provide higher level guidance, strategic planning, and identification of relevant funding opportunities for project implementation. Recovery team composition could consist of land managers and decision makers tasked with high level planning. The team should consist of representatives from the provincial government, federal government, First Nations, industry, and science community. As whitebark pine faces an array of issues, the recovery team should have expertise in pathology, entomology, fire, climate change, and policy if possible. Specifically, potential team members may be drawn from:

    - Environment Canada
    - BC Conservation Data Centre
    - Ministry of Forests, Lands and Natural Resource Operations
    - BC Parks
    - First Nations Representative
    - Forest Industry Representation
    - BC Wildfire Management Branch
    - BC Mining Representation
    - BC Forest Industry Representation
    - Parks Canada
    - Consultant
    - Academia

- Recovery Implementation Groups

Recovery Implementation Groups (RIGs) should be designed to implement and monitor the main recovery actions. These groups may manage higher level actions such as rust screening activities and aid in coordinating regional activities such as planting and seed collections. The RIGs will ensure some level of consistency for a given action. For example, the RIG for seed collections will ensure that all collections are done to a given standard and are consistent across the province. As whitebark pine faces an array of issues, it is important to partition activities into appropriate RIGs with appropriate expertise. RIGs should be guided by the recovery team and may operate at a range of scales depending on the extent of recovery action being implemented.

- Regional Recovery Representatives

Each region or district with whitebark pine should have a representative to inform the recovery team of local recovery actions. Regional representatives should also be tasked with conducting local outreach linked with promoting whitebark pine recovery.

7.3 Recommendations

Most of the recommendations below default to a government lead to implement at present. However, it should be underscored that if a recovery team or coordinator is put in place to act on behalf of whitebark pine recovery, the following would be more appropriate leads:

Recommendation	Partners
Collecting and Producing Whitebark Pine Seed	
Track seed and seedling requests, and deployment.	BC MFLNRO[5]
Develop clear guidelines on seed use and transfer	BC MFLNRO- Tree Improvement Branch/Forest Genetics Group, WPEFC, and Consultants
Conduct annual cone crop assessments	Consultants, First Nations, Naturalists, MFLNRO, BVRC[6]
Collect cones as mast crops materialize	Consultants, First Nations, Naturalists, MFLNRO, BVRC
Conduct comprehensive workshops on cone collection and protocols	Consultants, WPEFC[7]
Develop a seed collection fund to rapidly respond to mast cone crops	BCTS[8]
Develop guidelines on parent tree selection and set targets	Consultants, MFLNRO- Forest Genetics Group, WPEFC
Develop a seed orchard development plan	Consultants, MFLNRO Forest Genetics Group.
Develop clone banks using rust resistant parents	Consultants, MFLNRO-Forest

[5] BC Ministry of Forests, Lands, and Natural Resource Operations
[6] Bulkley Valley Research Centre
[7] Whitebark Pine Ecosystem Foundation of Canada
[8] BC Timber Sales

Recommendation	Partners
	Genetics Group
Establish a register of stands for in situ gene conservation	MFLNRO- Tree Improvement Branch, WPEFC, Consultants.
Seedling Production	
Identify and promote recognized seedling production facilities (not screening), throughout the range of whitebark pine	Consultants, MFLNRO
Promote consistent stratification and seedling culturing methods	Consultants, MFLNRO- TSC[9]
Promote the use of whitebark pine seedlings within forest management	MFLNRO, WPEFC
Promote a wider use of whitebark pine seedlings in other industries such as mine reclamation and ski area management to meet the production target of 100,000 seedlings per year.	WPEFC
White Pine Blister Rust in BC	
Establish blister rust monitoring plots in Forest Districts identified.	MFLNRO, WPEFC, BVRC, Industry
Use rust trends to guide seed collections by collecting from areas of high rust infection.	MFLNRO, WPEFC, BVRC, Industry
Incorporate rust monitoring transects into cone collections to consistently describe stand health.	MFLNRO, WPEFC, Consultants
Develop and recommend standards for health monitoring plots such as design and data collection.	MFLNRO, WPEFC
Conduct a health monitoring workshop to train technicians and ensure consistency in plot establishment.	WPEFC, Parks Canada
Promote the inclusion of blister rust transects in industry mitigation work to provide project baselines and contribute to the overall rust infection knowledge base in a consistent manner.	MFLNRO, WPEFC, Consultants, Environmental Assessment Office, MoE[10]
Develop a central database or promote the use of HI5Db (USDA) to house all rust monitoring data	WPEF, USDA[11], Parks Canada, Environment Canada
Testing Seedlings for Blister Rust Resistance	
Review the options for rust screening and select a direction for the facility from the options presented.	MFLNRO
Funding Options	
Appointing a whitebark pine coordinator	MFLNRO, WPEFC
Marketing the concept and needs of a rust screening facility to the whitebark pine community to include within related proposals	MFLNRO, WPEFC
Working with industry to identify and maximize avenues of offsetting and corporate partnerships	MFLNRO, WPEFC, MoE
Identify technology and market gaps to qualify for IRAP funding	MFLNRO, WPEFC ,Whitebark Coordinator, or staff at selected

[9] Tree Seed Centre
[10] Ministry of Environment
[11] US Department of Agriculture Forest Service

Recommendation	Partners
	screening location
Develop a business and marketing plan to present to potential industry partners	MFLNRO, WPEFC, Whitebark coordinator
Bring facility to a 'shovel ready' state to ensure an ability to react once funding is secured	MFLNRO, WPEFC, Whitebark coordinator
Prioritize construction phases in the event that only partial funding is available	MFLNRO, WPEFC, Whitebark coordinator
Identify where whitebark pine champions need to be developed	MFLNRO, WPEFC, Whitebark coordinator
Legislation and Practices to Protect Whitebark Pine	
Familiarize policy makers with Section 34(2)(3) of the Species at Risk Act to underscore that the Act may apply if whitebark pine is not adequately protected in BC	WPEFC, Environment Canada
Improve awareness around the National Accord for Species at Risk, particularly that BC is not providing effective protection at this time	WPEFC, Environment Canada
Prior to pursuing blanket legislation to protect whitebark pine, determine what level of protection is most desirable under the existing policies – Identified Wildlife, creation of Wildlife Habitat Areas, or other approaches	WPEFC, MFLNRO, MoE
Evaluate whitebark pine against the four tests in the GAR Species at Risk process to evaluate if whitebark may be elevated to a species at risk status under FRPA	MoE
Educate foresters about the needs of whitebark pine and how it may be incorporated into forest stewardship plans	MFLNRO, WPEFC, ABCFP?
Educate foresters on the need for improved inventory to include whitebark pine in VRI, cruising, and silviculture surveys	MFLNRO, WPEFC
Educate mining company representatives about whitebark pine and how it fits within their third party certifications	MoE, WPEFC, MoEM[12]
Improve the awareness of whitebark pine to ensure it is captured in all management plans and permit reviews;	MoE, WPEFC, First Nations
Develop clear and acceptable best management practices, and mitigation procedures	MoE, MFLNRO, WPEFC, MoEM

[12] Ministry of Energy and Mines

7.4 Priority Actions

Some of the actions presented above are high priority and require immediate attention to facilitate recovery. For example, identifying rust resistant stock and deploying it throughout the landbase is a high priority. High priority actions identified in this report are presented here. In general these were placed as high priority for two reasons: 1) whitebark pine recovery requires it immediately, and 2) the action facilitates a sequence of other activities. **Priority actions are presented below, <u>in no particular order</u>**.

- Select a screening facility direction
  - The strategic direction for screening in BC hinges on the selection of a facility direction. This selection will guide future funding decisions and contributions from industry. Failing to achieve this priority will result in continued disjointed rust screening actions among players in the province.

- Produce a development strategy and marketing plan
  - The facility selected will not be developed overnight. A development strategy will be useful in prioritizing development stages and priorities. A marketing plan will aid in selling the idea and securing funds to support the creation of the facility.

- Maximize cone collections
  - Cone and seed collection is the basis of any recovery related to rust screening. Actions to maximize cone collections and resolve management barriers such as registration and collection protocols should be formally resolved.

- Develop a cone collection fund
  - Funding for cone collections is often allocated without any awareness of the size of the upcoming cone crop, with funds often allocated when there is no crop or not allocated when there is a very large mast crop. A cone fund would be used to facilitate rapid response collections in years of very large crops, which would allow the cone crops to dictate when to collect as opposed to successful funding proposals dictating cone collections.

- Resolve seedling deployment barriers
  - Seedling deployment faces a number of barriers linked to Forest Stewarship Plans, seed registration, acceptability within certain subzones and site series, transfer restrictions, and general availability. Resolving each of these barriers is relatively straightforward and is likely to only require a directive from relevant personnel. Resolving these barriers will result in a greater willingness of stakeholders to deploy whitebark pine seedlings.

- Develop and implement a significant outreach campaign.
  - Outreach is required to better inform foresters, First Nations, biologists, government decision makers, and the general public to aid in swaying public policy and better include whitebark pine in planning documents.

- Develop consistent mitigation options for negotiating with industry
    - Mitigation options presented to industry are generally 'one-off's' as there is no unified recovery direction. Although industrial impact must be assessed individually and mitigation options uniquely assigned, direction from higher level plans particularly with respect to the offsetting process would aid in industry based negotiations.

- Pursue GAR and Identified Wildlife listings or other legal or policy options
    - At present there is no legal protection for whitebark pine aside from what SARA offers on federal lands. Listing under a GAR order may provide some legal protection and will elevate the presence of whitebark pine among regulators, resulting in conservation and recovery actions forming conditions of industrial permits.

- Develop provincial recovery team
    - At present there is no real voice to advocate for whitebark pine in BC. Several BC government employees work on it "off the sides of their desks", and the Whitebark Pine Ecosystem Foundation of Canada works to promote whitebark conservation and recovery. However, there is no body with a mandate to promote whitebark pine recovery. Forming a recovery team may have been impeded to date as a result of whitebark pine is a tree, which defaults to the responsibility of foresters. However as a species-at-risk, others would view this as an issue of species-at-risk biologists and the MoE. Regardless, a team must be developed that can account for the broad range of issues facing whitebark pine from the four main threats to the economic, policy, and financial barriers that are limiting widespread recovery of this iconic species.

7.5 Conclusion

The conservation and recovery of whitebark pine is a complex process. Most are aware of the four main agents of decline requiring a diverse approach to recovery. However this document identified additional agents that although not primary agents of decline, do confound recovery efforts. While it is widely accepted that producing rust resistant stock is the primary pathway to recovery, it is implementing a well-coordinated program that not only produces resistant stock, but recognizes the complexity of securing a reliable seed source, resolving regulatory issues, securing stable funding, and managing a collection of diverse stakeholders that will be required to implement the successful recovery of whitebark pine forests in the mountains of British Columbia.

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9 List of Appendices:

Form 1: BC Seed Collection

WHITEBARK PINE RECORDS

SPECIES: ___________________ STAND NAME & NO: ____________________________

Biogeoclimatic Zone & Subzone: ________________Ecosystem Asoc:

Species Composition: _________________ Stand Density: Open___ Medium___ Dense___

Age & Distribution of Ages: ___________________ Even ___ Two aged ___ Multi-aged ___

Stand History: ____

Landform & Terrain: ____

Site/Stand Comments: ____

Level of Blister Rust: ____

Health Survey Type: ____

TREE NO.	LATITUDE	LONGITUDE	ELEV.	DBH (cm)	HT. (m)	Branch cankers	Stem cankers	COMMENTS

Form 2: USDA Rust Screening WBP Location and GPS Record

Status (X Appropriate Box(es).) CDA Nursery-Assigned I.D. Number _____

☐ Tree Selected
☐ Cones Collected

WHITEBARK PINE PLUS-TREE LOCATION & GPS RECORD

Cooperator Name: _____Cooperator Number:__|__|__|__|__|__
State: ______ USFS Seed Zone: _____
Legal: T ____ R ___ __ S __

GPS Data: Latitude: In Degrees (DD.dddddd) __.______ N (Geodetic Datum -WGS-84)
Longitude: In Degrees (DDD.dddddd) ___.______ W (Geodetic Datum -WGS-84)
Elevation _____ Feet above Mean Sea Level
Is GPS data corrected from an established base station? ☐ Yes ☐ No (Corrected data is preferred)
Base Station Name or why not corrected: _____
Convert Lat/Long to Universal Transverse Mercator (UTM) Coordinate System
Northing _____ meters Easting _____ meters

Located By: _____ Date: _____

STAND DESCRIPTION

Area Name: _____ **Stand Number**: _____
Habitat Type: # ___ Physiographic Site: ______ Aspect: __
Stand Age (Ave.): ___ yrs Stand Size: ___ acres
Composition: _____
Trees (live & dead) in stand infected with blister rust: ____% based on 100-tree survey
Average number of cankers per tree (live & dead) in stand: ____based on 100-tree survey
Mountain Pine Beetle attack: ____% based on 100-tree survey

Stand Description Remarks:

PLUS-TREE DATA

Tree ID: _____ Age @dbh: ___ years. Crown Class: ________
Diameter: ____ inches. Height: ___ feet. Growth Form: _____________
Cone bearing history: _____
Phenotype:

Blister Rust Cankers:
Tree has NO visible blister rust cankers ☐
Tree has blister rust cankers ☐ Record their status and location: Live(L) or Dead (D) __, __, __, __, __, on ____, ____, ____, ____, ____ bark (year bark infected) from branches originating from the stem ___, ___, ___,, ___,, ___, feet above the ground on the __, __, __, __, __ side of the trunk.

Remarks on cankers:

Mountain Pine Beetle attack: None ☐, Low ☐, Moderate ☐, High ☐. Estimated year of last attack ____

Remarks on MPB attack:

Plus Tree Remarks:

CDA Nursery-Assigned I.D. Number _____

WHITEBARK PINE PLUS-TREE LOCATION & GPS RECORD – Page 2

Stand Number: _____ **Tree ID**: _____

LOCATION INFORMATION

The location marker is on Road #_____ which goes from _____ to _____. The key starting point along this road is ______(bridge, junction, etc.).

From the key starting point go _____ miles ___ (up, down) the road towards _____ to the location marker which is on the ____ (up, down, left, right) side of the road on a _____ (e.g., 4' post, 12" Douglas-fir, etc.).

From the marker go ____ chains ___° to tree _____. From tree _____ go ____ chains ___° to tree _____. From tree _____ go ____ chains ___° to tree _____.

Type of Tags or Markers used:
Color of Paint used:

Attach a sketch map to help relocate the tree(s)--REQUIRED.

****

For Nursery Use Only

Lot number:	_____	Date received:	_____
Seed year:	_____	No. cones:	_____
Seeds/cone:	_____	Grams/100:	_____
Original seed:	_____	Storage location:	_____

****

Form 1: WPEF Blister Rust Survey and Monitoring Data Sheet (Tomback et al., 2006)

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 10o): _____
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)				

Blister Rust Survey and Monitoring Data Sheet – Page 2

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											
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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

Appendix 3 – Capital and Operational Cost Estimates for a Stand-Alone Facility

Capital Cost Estimates for a Stand Alone Facility		
1	**Greenhouse(s)**	
	Estimated annual operational needs of 100,000 seedlings will likely exceed any annual needs for plants to be screened. Commercial space and contract-growing is typical additional activity to screening	
	Structure (including heating system, ventilation, double poly, end walls, delivery, and taxes)	$ 25,000.00
	Erection (including cement footings)	$ 8000.00
	Electrical	$ 2,000.00
	Gas fitter	$ 1,000.00
	Fuel tank	$ 1,000.00
	Benches (used)	$ 2,000.00
	Irrigation supplies	$ 2,000.00
	Miscellaneous materials	$ 1,000.00
	Site preparation	$ 2,000.00
	Drainage (including trenching tile, geotech and gravel)	$ 1,200.00
	Gravel (for floor)	$ 1,000.00
	Permits	$ 1,000.00
	TOTAL	**$47,200.00**

2	**Inoculation Chamber**	
	There have been many different structures used for, or adapted for inoculation of seedlings with white pine blister rust. These include; implement sheds, greenhouses, walk-in coolers, and utility buildings or rooms. The primary needs are to be able to control the humidity and temperature during the inoculation period. At the Dorena Tree Improvement Centre, an implement shed has been adapted for use. In BC, a similar structure 24 x 36 could be used to inoculate several hundred families per year. The building can also serve as a header house when inoculations are not taking place.	
	24' x 36' Three-bay garage, 2x6" walls insulated, 3/8" plywood interior finish	$ 62,000.00
	Cement slab (24x36'x 6" = 16 cu yds. Plus forming and placing)	$ 3,200.00
	Pony wall (6")	$ 800.00
	Electrical (200 amp service to supply the chamber and office/lab	$ 2,500.00
	Outlets, plugs, fluorescent fixtures, baseboard forced air heaters	$ 2,000.00
	Water supply	$ 300.00
	Permits	$ 500.00
	TOTAL	**$ 71,300.00**

3	**Header House (combine with Inoculation Chamber)**	**0.00**
	Three bay garage could also be used as a header house	
4	**Office/Lab**	
	A stand-alone facility would require an office/ laboratory with a washroom facilities, and storage for equipment and supplies. The most cost-efficient building would be portable similar to those used in camps and construction sites. They are inexpensive, durable, and are set up quickly. They can often be purchased used at reasonable prices. Electrical and water connection are simple, and inexpensive as well. Sewer connection or septic system installation prices will vary depending on the location, and local regulations. Many have self-contained waste water holding tanks.	
	Portable (10 x'32')	$ 22,900.00
	Transportation and set-up	$ 1010.00
	Electrical connection	$ 1,000.00
	Waste disposal system	$ 8,500.00
	Permits	$ 500.00
	TOTAL	**$ 33,910.00**

5	**Raised beds (5 years screening 500 families)**	
	Beds are needed after inoculation to allow the seedlings to grow and undergo annual assessments for up to 5 years, for blister rust infections. Beds can be constructed out of wood, or concrete blocks on pallets. They contain approximately 12 cubic feet of soil. Only very basic irrigation equipment is required. Screening a total of 500 families at a rate of 100 families per year would require 25 pallets if 30 seedlings per family were screened or 50 pallets if 60 seedlings per family were screened each year.	
	a.) Cost for 5 years for screening using Dorena system (pallets)	
	Pallets (4x3' (plastic) with 12" high plywood sides, 25 @ $60 each, 30/family) x 5 years	$ 7,500.00
	Soil ($25 x 25 pallets –(12 cubic ft.) = $625 x 5 years	$ 3125.00
	Irrigation: $ 200/year x 5 years	$ 1000.00
	Groundcover: $ 200/year x 5 years	$ 1000.00
	b.) *Alternative*: Cost for fixed beds would be **$8000** , and includes the following;	
	Cedar (2x6', 500 fbm/year = 2500 fbm) = $3,000	
	Labour = 2,500	
	Soil ($25 x 25 pallets - 12 ft3) = 2,500	
	TOTAL	**$ 12,625.00**
6	**Nursery beds**	**$ 0.00**
	Nursery beds or arable land are useful for holding excess plant material, and also for clone banks to store grafted material from the selected parent trees. Site selection should take this into account.	
7	**Tractor**	**$ 20,000.00**
	A small tractor with a front-end loader, pallet forks, and a small trailer are needed to move materials around the site (Kuboto 22 HP B7500 or equivalent).	
8	**Miscellaneous**	**$ 5,000.00**
	Incidental items that need to be capitalized (over $1000)	
9	**Site**	**???**
	All of the above costs assume there is a site available for a rust screening facility. This could mean a rental or lease agreement with a government research facility, a private nursery, or possibly a Ministry or private seed orchard. Purchasing land with power, and an adequate water supply would increase the up-front capital cost many-fold.	

TOTAL CAPITAL COST STAND–ALONE FACILITY: $ 190,035.00

Operational Costs of a Stand-Alone Facility

1	**Staffing:**	
	Scientist	$ 100,000.00
	Technician	$ 64,000.00
	Auxiliaries	$ 6,000.00
	The costs shown for professional and technical staff are the current loaded costs for the MFLNRO. In the stand-alone model, we have shown the yearly cost for these categories. However, it is unlikely that year-round full-time positions are required.	
2	**Power:** Office, greenhouse and inoculation chamber	$ 2500.00
3	**Water:** Greenhouse, office and inoculation chamber	$ 2500.00
4	**Natural gas or propane:** Unit heaters for the greenhouse. Used only during the germination period. .	$ 1000.00
5	**Sewage and waste disposal:** Self-contained system that must be removed each year.	$ 1000.00
6	**Nursery supplies:** Soil media, fertilizers, pesticides, tools.	$ 1000.00
7	**Styroblocks:**	$ 1328.00
	412A styroblocks . There are 77 cavities per block. Each cavity is 4.3 cm dia. and 11.7 cm long, and contains 125 ml of soil. Leach tubes used in the US are 3.8 cm dia., 21 cm long and contain 164 ml of soil. The length of Leach tubes can be an impediment to planting. 2 blocks per family 77 cavities. In order to ensure adequate numbers for screening, two blocks (77 cavities/ block) x 166 families = 332 blocks @ 4.00	
8	**Contract to fill blocks**	$ 1,533.00
	Soil mixing and filling equipment lines are very expensive. Many private commercial nurseries will fill blocks. Price is approximately $.06 per cavity or $4.62 per bloc.	
9	**Equipment, general:** Miscellaneous facility supplies.	$ 1,000.00
10	**Office supplies:** Stationary supplies, paper towel, toilet paper, etc.	
		$ 1,000.00

TOTAL ANNUAL OPERATING COST STAND–ALONE FACILITY: $ 182,861.00