BEST MANAGEMENT PRACTICES FOR WHITEBARK PINE MANAGEMENT MINING AND MINERAL EXPLORATION

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ABSTRACT

Whitebark pine is a species of five needle pine that is found broaly at high elevations in BC roughly south of the Yellowhead Highway. Within BC the species is currently Blue Listed and in Canada is listed as Endangered indicating a substantial conservation concern, its primary threats are white pine blister rust, mountain pine beetle, fire suppression and climate change. Mining and other industrial activities have the potential to further damage the species through habitat loss yet with good planning may to provide benefits to the long-term survival of the species through the use of best management practices. Key means for the mining sector to create a net-benefit for whitebark pine include funding blister rust screening, seed collections, planting in reclamation and habitat offsetting.

Keywords: restoration, species at risk, net-positive impact, environmental assessment, reclamation, *Pinus albicaulis*

INTRODUCTION

Whitebark pine is a broadly distributed high elevation pine species that has high importance to wildlife, indigenous peoples, is of conservation concern, and its habitat frequently overlaps with mineral resources in British Columbia. Whitebark pine is a **foundation** and **keystone** species in high elevation ecosystems. Whitebark pine is listed as endangered under the Federal Species at Risk Act (SARA) due to four main agents: 1) the introduced white pine blister rust, 2) mountain pine beetle, 3) fire suppression, and 4) global climate change. A sizeable number of mines in BC are within whitebark pine Critical Habitat as described by the Federal Whitebark Recovery Plan (Environment and Climate Change Canada 2017). New mines in whitebark pine Critical Habitat are likely to have conditions within their Environmental Assessment Certificates requiring whitebark pine management and recovery activities. This higher-level paper is intended to promote discussion and conservation of whitebark pine, it is not intended to be a 'how to guide'.

Species Description

Whitebark pine (*Pinus albicaulis*) is a long-lived subalpine tree characterized by five-needle bundles and egg-shaped cones. The tree typically grows 5-20 metres (m) tall and may display an irregular crown with curved and twisted stems when open-grown, to a straighter growth form when growing among competitors (Ogilvie, 1990; Committee on the Status of Endangered Wildlife in Canada (COSEWIC), 2010; Alberta Whitebark and Limber Pine Recovery Team, 2014). The cones remain closed on the branches unless removed by animals, additionally, unlike most other conifers the seeds do not have wings and thus are dependant on animals for their dispersion. Whitebark pine may live more than 500 years, with initial cone production occurring around 30-50 years of age; however, sizable crops do not occur until 60-80 years of age (COSEWIC, 2010). The large seeds were an important source of food to First Nations throughout much of their range (Moerman 1998).

Distribution and Habitat

Whitebark pine occurs in very dry to moderately moist environments at or near treeline in the high-elevation forests of Canada and the USA (COSEWIC, 2010). The Canadian distribution accounts for approximately 56 percent of its global range, extending from the Canada-USA border north beyond Ft. St. James in the west and Jasper in the east (Figure 1). The low elevation limit of whitebark pine ranges from a low of 765 m near Morice Lake to a more common low of approximately 1700 m in the southern portions of its range.

Ecological Importance

Whitebark pine is a **foundation** and **keystone** species in high elevation ecosystems. The deep, spreading root system of the whitebark pine stabilizes slopes, reducing erosion and helping to regulate snowpack and runoff (Arno and Hoff, 1989; Farnes, 1990; COSEWIC, 2010). Other important ecosystem services include providing wildlife with habitat and a nutritious food source. Both birds and mammals forage on the seeds of the whitebark pine. The Clark’s nutcracker (*Nucifraga columbiana*) co-evolved

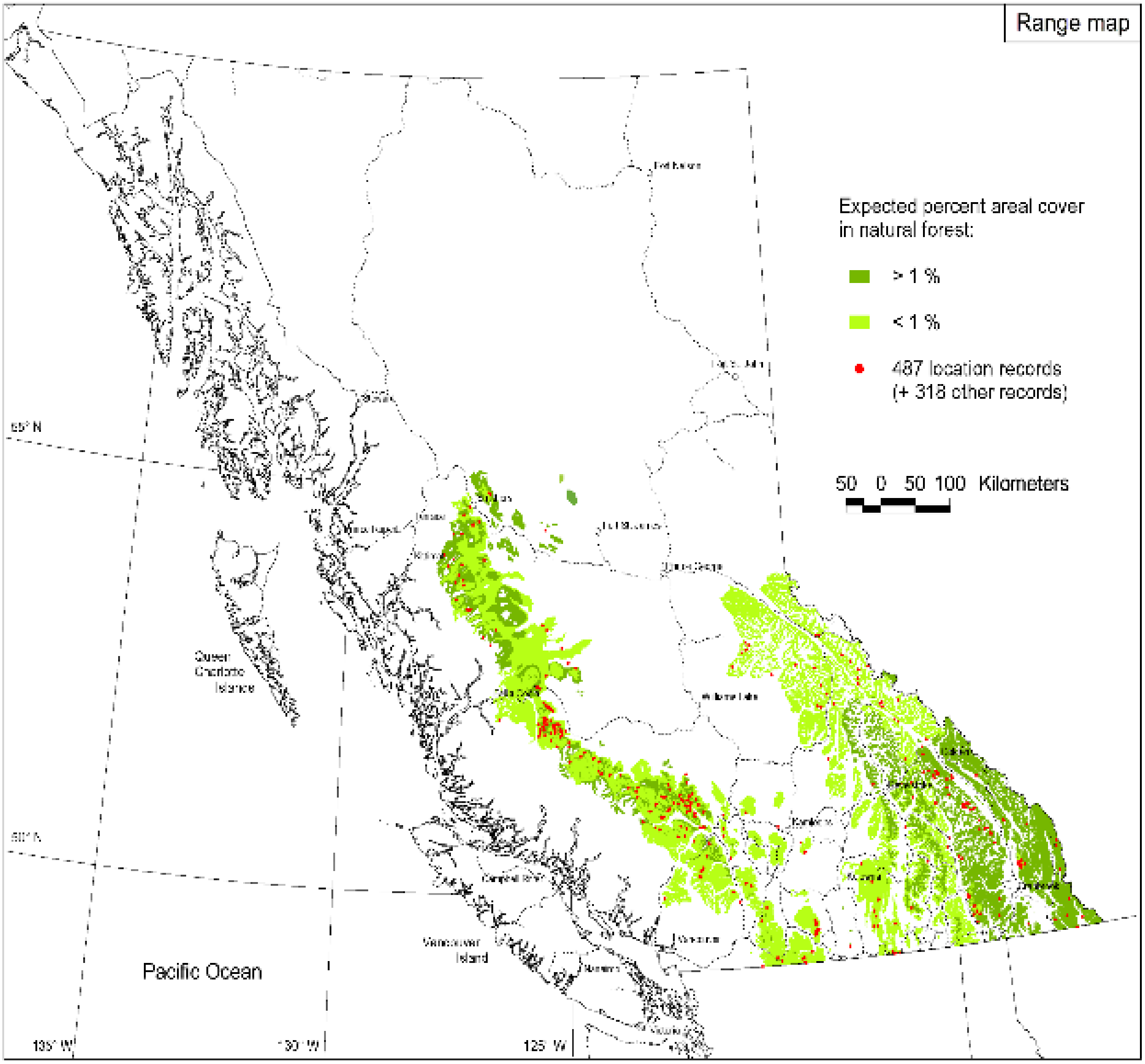

Figure 1. Canadian Range of Whitebark Pine.

with the whitebark pine and is the species only effective seed disperser (Lanner, 1990; Tomback, 1982a, 1982b; Lorenz et al. 2008; COSEWIC, 2010). Clark's nutcrackers extract the seeds, store them in a special throat pouch, then cache them in many different locations. Seeds may be cached up to 32 kilometres (km) away and a Clark's nutcracker may remember up to 16,000 cache locations. Forgotten or uneaten cached seeds may later germinate to produce new whitebark pine seedlings (Lorenz et al., 2011; Pigott et al., 2015a), and it is through this critical process that a whitebark pine is regenerated and dispersed.

In addition to foraging birds, red squirrels (*Tamiasciurus hudsonicus*) harvest the whitebark pine cones and store them in underground middens; black bears (*Ursus americanus*) and grizzly bears (*Ursus arctos*) may raid these stores as an easy source of pre-denning food. Whitebark pine seeds are highly nutritious, containing about 52% fat, 21% carbohydrates and 21% protein, which make them a highly valuable food source for these animals (Pigott, 2012).

Threats and Conservation Status

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

Figure 2. White pine blister rust.

White pine blister rust is the primary cause of declining whitebark pine populations (COSEWIC, 2010) (Figure 2). Native to Europe, it was introduced to British Columbia in 1910 and attacks all 5-needle (white pines), including western white pine and limber pine. The fungus enters the needles and travels down the branch to the main stem where it girdles and eventually kills the tree (Pigott, 2012). Throughout this process, cone production may be greatly reduced as branches individually succumb to the rust, prior to full tree mortality. Since its introduction, the disease has spread throughout the entire range of the three 5-needle pine species in British Columbia and caused wide-spread mortality. Further evidence suggests that whitebark pine, stressed by rust infection, is increasingly susceptible to attack from mountain pine beetle (Arno, 1986; Six and Adams, 2007; Bockino and Tinker, 2012; Alberta Whitebark and Limber Pine Recovery Team, 2014).

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

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

Climate change is gradually changing the distribution and availability of whitebark pine habitat. Whitebark pine are likely to be pushed higher in elevation, but on many sites, it already occupies the highest ground or higher elevation sites have poorly developed soils and provide poor habitat for whitebark pine. Climate change is also affecting the distribution of competing species, allowing subalpine fir, alpine larch and spruce to better survive and compete at higher elevations (Bentz et al., 2010; Logan and Powell, 2001). While new habitat may become available at the northern limit of the species range, occupying this habitat will rely on seed dispersal by Clark's nutcrackers, which require suitable nutcracker habitat and the availability of critical alternate nutcracker food sources.

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

ESTABLISHING BASELINES

Given the broad distribution of whitebark pine and the severe threat posed by whitebark pine blister rust, the primary threat to the species is not habitat loss. However, mining operations are frequently located within Critical Habitat of whitebark pine, and as such there is a need to incorporate planning for the species in the post-disturbance landscape. Though there may be opportunities for the avoidance of whitebark habitat in mining operations, it could be argued that the best opportunities to offset the impacts of mining are the identification of disease resistant trees and the planting of that genetic stock in the post-disturbance landscape. The following sections briefly outline some of the key steps required to create a whitebark pine conservation program for mine operations.

Ecosystem Mapping

Ecosystem mapping may involve either Predictive Ecosystem Mapping (PEM) or Terrestrial Ecosystem Mapping (TEM), both these mapping techniques are valuable for the identification of potential habitat. Vegetation Resource Inventory (VRI) mapping is also a valuable tool but is often too coarse. Large landscape-scale projects may be less likely to capture sufficiently-detailed whitebark pine information, whereas mapping at smaller scales, say for example that of a mine development, is more likely to capture whitebark pine information at a more detailed level. PEM is often conducted using models which may not differentiate whitebark vs. non-whitebark ecosystems, whereas TEM projects are undertaken using detailed air-photo interpretation and a level of ground-truthing. Given the Endangered status of whitebark pine, it is critical for mappers to familiarize themselves with whitebark pine ecosystems to ensure they are being mapped to an acceptable standard. This should occur at both the office and field levels.

Appropriate Identification of Critical Habitat

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

White Pine Blister Rust Identification

Field workers conducting baseline surveys should be able to identify bluster rust at various life stages and be able to identify the post-infection impacts on live and dead trees. Understanding this disease is critical for effective whitebark pine management and recovery.

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

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

Whitebark Pine Specific Surveys

Whitebark pine specific surveys are key for successful conservation as the surveys are designed to document whitebark pine presence and health, and can facilitate other management actions such as prioritizing cone collections, monitoring, and expectations of restoration success. To survey whitebark pine, the two specific survey procedures are the 100 Tree and Permanent Monitoring Transects.

100 Tree Surveys

The 100 Tree Survey is a means to rapidly assess and ascertain rust levels to aid in selection of plus trees, or trees suitable for cone collections. In general, this survey is intended to gain insights on the general condition of a stand to ensure cone collections reflect the healthiest stand cohort. There are several modifications of this protocol but in summary, 100 trees are visually surveyed and cone collections made from the healthiest cohort in the stand.

Permanent Monitoring Transects

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

- Aid in prioritizing trees for cone collections (healthiest trees in the most infected stands);

- Allow for early detection of pest increases;
- Develop realistic restoration success goals – without resistant stock can we expect restoration to be more successful than trends observed in local stands?
- Allow for targeted trend-based management; and
- Prioritize management actions where needed most (when transects are established across a broad landscape)

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

RESTORATION

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

Cone Collections

Whitebark pine cone collections are a critical step prior to initiating any program involving the removal of mature trees, planting, or blister rust screening. Whitebark pine seeds are highly preferred forage for Clark's nutcrackers and squirrels, who will target cones prior to seed maturity. To protect cones from this significant foraging risk, they must be caged by employing the protocols described in the following section.

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

- What is the volume of seeds or cones that you require to fulfill your needs?
- What is the existing seed availability?
- Can your needs be combined with the needs of other potential users?
- Does your restoration site fit within seed transfer distance of the collection stand?

Most people planning to collect whitebark pine seed for restoration, conservation, or research purposes, may already have a good idea where suitable stands are located. Roads to ski hills, mines, fire lookouts, and communication towers can provide good access to whitebark stands. When planning collections, reliable access must exist. Collections require two visits to each site, one to cage the cones, and one to retrieve the cones. Both visits require packing ladders, climbing gear, cages and other equipment.

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

Ideal candidate natural stands for collection should include:

- Sufficient area and density of mature trees,
- High blister rust infection levels in the stand (surviving trees are likely to be disease resistant),
- Trees that are safe to climb, and
- Good stand access.

Trees to collect from within the stands should in order of preference have:

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

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

Seedling Planting

Objectives for seedling planting include:

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

A key goal for whitebark pine recovery is to increase the number of seedlings planted in suitable habitats. Currently, this goal has been confounded by a lack of seedling availability and by regulatory barriers to deployment. Regulatory barriers are due to it not a being merchantable species, thus is rarely planted and often does not meet the standards of more broadly collected merchantable species that are well developed through forestry in BC.

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

Planting whitebark pine seedlings is one of the top whitebark pine recovery actions, whether following timber harvest, during mine reclamation, or other habitat restoration initiatives. Although planting rust-resistant stock is the most desirable approach, having this material widely available is over a decade away, and deploying the best available seedlings is recommended. At present, planting putatively-resistant stock is the preferred approach. Further, in some areas, trees may escape rust infection and provide critical ecological services to wildlife despite still being susceptible.

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

OFFSETTING

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

For example, in some cases making financial contributions to whitebark pine recovery programs may be the best means to mitigate impacts, as these funds can be directed at programs or projects with strong recovery value. In some cases, mitigating local impacts may have minimal recovery gains which can be increased by providing financial support to projects with greater gains.

CONCLUSIONS

As with other endangered species, the conservation of whitebark pine is complex, costly and an activity that often relies on the expertise of specialists. Planned activities should be compared against the Federal Recovery Strategy and accompanying documents to ensure consistency, especially for those projects that need to adhere to Federal or Provincial Environmental Assessment Conditions. Mine reclamation offers an excellent opportunity to create new or restore existing whitebark pine stands in the landscape and, with effective monitoring, offers an excellent opportunity to advance the practices of establishing such stands. Sharing reclamation results with forums such as the BC TRCR could be an effective means of developing collaboration through different mining companies as well as the regulatory agencies.

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