Whitebark Pine Planting in East Kootenay Wildfire Areas

Prepared for: Fish and Wildlife Compensation Program

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Executive Summary

Whitebark pine (*Pinus albicaulis*) is a keystone species of high elevation ecosystems whose ecological role is diminishing due to declining populations caused by white pine blister rust, mountain pine beetle, changes to species composition due to changes in fire regimes, and global climate change. This population decline is so acute that whitebark pine has been listed as Endangered on Schedule 1 of the Federal Species at Risk Act (SARA). This project aligns with the Fish and Wildlife Compensation Program Upland and Dryland Action Plan Species of Interest Chapter, Species-Based action type: COLUPD.SOI.SB.27.01 Whitebark Pine Restoration Efforts – P2. The secondary action this project aligns with is COLUPD.ECO.HB.15.01 Identify, maintain and restore old-growth ecosystems – P1; also in the Upland and Dryland Action Plan from the Ecosystem Chapter and Habitat-based Action Type.

In 2021 we planted seedlings, collected cones, removed competition, conducted surveys, and conducted outreach. We planted 27,430 putatively rust resistant whitebark pine seedlings and 280 limber pine seedlings at 8 sites over 52.19 ha. In the Kootenay Pass we planted 1500 seedlings, at Hourglass Lakes we planted 1250 seedlings, at Blackfoot we planted 1500 seedlings, at Hollebeke we planted 2500 whitebark pine seedlings and 280 limber pine seedlings, at Hugh Allen we planted 4680 seedlings, at Spillimacheen we planted 3600 seedlings, at Whitetail we planted 1500 seedlings, and at White Grouse we planted 5500 seedlings. We collected cones from putatively resistant parents at 10 sites, which resulted in a yield of 4,241 cones for an estimate of 212,050 seeds. Competition was removed from around whitebark pine regeneration over 2 ha along a powerline corridor on Mount Puddingburn (VOR tower). We surveyed seedling survival at Hourglass Lakes and found high survival rates with 8/9 transects having survival in excess of 80%. Three 100 Tree surveys were conducted to rapidly assess rust levels; identified rust levels were: Kimberley (65%), Doctor Creek (58%), and Bobbie Burns (35%). Outreach was conducted with ski hill staff at Panorama and Kicking Horse, Panorama assisted in hosting a whitebark pine workshop and staff at Kicking Horse have initiated whitebark pine inventories of the ski hill.

Recommendation included: build relationships with groups that can facilitate access to whitebark pine habitat such as forest licensees, ski areas, and others with backcountry tenures; continue to monitor whitebark pine planting to determine if survival or growth is influenced by site, planting in clusters, or use of fertilizer; continue planting previously identified areas; continue with competition removal and trial areas that will not require ongoing maintenance; monitor cone crops to ensure that collections are made when large crops are present; re-initiate outreach programs with youth and naturalist clubs; and raise awareness about the positive actions ski areas. Key Best Practices include: allow microsite density to dictate seedling planting strategy, if suitable microsites are common, deploying single seedlings is appropriate, in areas where suitable microsites are uncommon it may be more desirable to plant multiples at suitable sites. During competition removal, retain some preferred or accepted species and track progress through pre and post treatment plots to ensure the treatment is well documented and the case for deploying this treatment on more productive forest lands is developed and strengthened.

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Introduction

Whitebark Pine (*Pinus albicaulis*) is a keystone species that plays significant ecological roles in subalpine ecosystems. It is under threat and listed as endangered under the federal Species at Risk Act (SARA) due to the negative effects of white pine blister rust (*Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*), changing fire regimes, and global climate change (COSEWIC 2010, Environment and Climate Change Canada (ECCC) 2017). Whitebark pine occurs throughout southern BC with its northernmost limits at Mount Blanchet and Kakwa Provincial Parks and occurs south to the Canada-US border, beyond which it extends south to northern California; it is absent from Vancouver Island.

As a keystone species, whitebark pine plays important ecological roles including moderating snowmelt (Farnes 1990), stabilizing soils, pioneering harsh sites, and providing an important food source for many wildlife species including the Clark's nutcracker (*Nucifraga columbiana*), red squirrel (*Tamiasciurus hudsonicus*), and grizzly bear (*Ursus arctos*) (Tomback and Kendall 2001).

The most ecologically significant relationship is between whitebark pine and the Clark's nutcracker. The two maintain a mutualistic relationship whereby the pine offers seeds as an essential food source and the nutcracker deposits uneaten seeds away from the parent tree; forgotten seeds may result in the colonization of new sites. A single nutcracker may cache up to 98,000 seeds per year for retrieval in late winter and early spring (Hutchins and Lanner 1982) and travel up to 32 km to cache seeds (Lorenz et al., 2011). This seed caching behavior results in the trees occurring on sites best suited to seed recovery due to low snow cover such as sites on southern aspects and ridgetops with direct wind and sun exposure. The presence of whitebark pine within stands ranges from a dominant to minor component, typically contingent on the competition level presented by other tree species related to the site's ecological characteristics.

Whitebark pine declines in the Rocky Mountains have been occurring at a rate of 1.5-3.5% per annum (COSEWIC 2010). This is largely due to rust impacts, with several large decline events attributed to the mountain pine beetle epidemic. Fire is also important in governing whitebark pine forests. Whitebark pine are more capable of surviving fires than their competition due to their thick bark, thin crowns, and deep roots. Changing fire regimes including fire suppression and fire exclusion have allowed other species to out-compete whitebark pine (Keane 2001). Further to these losses, many trees are ecologically compromised due to high competition levels resulting in trees being outcompeted by more shade tolerant species. This results in poor growth by whitebark pine and ultimately reduced cone production. Although direct human impacts via logging are rated as low, whitebark pine are incidentally cut during timber harvest, further contributing to the overall decline; conversely, resulting open areas following harvest may result in suitable conditions for whitebark pine recruitment.

To address the threats to whitebark pine, the Federal Recovery Strategy [draft] describes pathways to recovery in the Recovery Planning Table (ECCC 2017). As described in the table, this project addressed the following threats through the following actions:

- White pine blister rust: Planting putatively resistant seedlings and maintaining a range of age-class across the landscape by reducing competition around naturally occurring

whitebark pine. Support breeding and production programs to screen and propagate rust-resistant seedlings

- Fire: Planting seedlings in post-burn environments.
- Local or cumulative impacts of other threats: Applying best practices to mitigate losses to timber harvest.

This project was a collaborative effort involving several funders including the Columbia Basin Trust Ecosystem Enhancement Program (CBT-EEP), Fish and Wildlife Compensation Program (FWCP), American Forests, Natural Resources Canada Two-Billion Trees (2BT), BC Ministry of Transport, Teck Coal, and the Aboriginal Fund for Species at Risk (AFSAR).

Goals and Objectives

The project goals were to:

1) Restore whitebark pine by planting seedlings over wildfire impacted areas;

2) Conduct targeted cone collections;

3) Enhance natural regeneration of whitebark pine by removing competition from around naturally regenerating whitebark pine in open stands;

4) Survey whitebark pine planting success and stand health; and

) Conduct whitebark pine related outreach with community groups;

Linkages to Action Plans

This project most closely aligns with the Fish and Wildlife Compensation Program Upland and Dryland Action Plan Species of Interest Chapter, Species-Based action type: COLUPD.SOI.SB.27.01 Whitebark Pine Restoration Efforts – P2. The secondary action this project aligns with is COLUPD.ECO.HB.15.01 Identify, maintain and restore old-growth ecosystems – P1; also in the Upland and Dryland Action Plan from the Ecosystem Chapter and Habitat-based Action Type.

Study Area

The work for this project was completed at a range of sites throughout the region ranging from the Valemount Region south along the Columbia to Golden and south from here in the Purcell Mountains to Kootenay Pass in the west and the Upper Flathead divide in the Rocky Mountains. The locations of each task within the region are detailed in each section and the project appendices.

Methods

Planting

Planting was conducted using best practices to improve stock survival. Sites were selected by pre-surveying burned habitats for the pre-burn presence of whitebark pine as evidenced by burned or live whitebark pine remaining on site. This was achieved by hiking to sites or aerial reconnaissance via helicopter in previous years. Once a site was selected, planters were instructed to use the following techniques while planting:

- Do not plant in mixed species plantings
- Plant in areas with low understory competition
- Where appropriate, remove competing trees species to improve the microsite for whitebark pine, only trees <2 m tall will be removed
- Avoid frost pockets
- Avoid planting next to dead trees that may fall and uproot seedlings
- Plant at low densities to encourage open crowns in mature trees (5 m spacing)
- Plant in mineral soil as this will allow for better 'closure' around the seedling, this may require excavating the organic layer using shovels to reach mineral soil
- Plant in soils deep enough to allow for seedling roots to be vertical in the soil profile
- Plant to protect seedlings from both snow creep and excessive insolation by planting next to upslope and shade providing barriers where appropriate

Seedlings were putatively resistant seedlings produced from cones collected from healthy parent trees. Seedlings were generally planted as singles (one seedling per hole); however, planters were permitted to plant up to 25% of seedlings as doubles or triples. In discussions with representatives from Parks Canada, Waterton Lakes plants as singles but has experimented with planting as doubles and triples (G. Algers Pers. Comm.). Jasper exclusively plants seedlings as triples (S. Hazenberg Pers. Comm.).

We mapped each area using GPS once planting was completed. These map areas were used to determine planting area, planted seedling density, and to support future monitoring work of deploying plots within the known planted areas.

At the Hourglass and Blackfoot sites a small subset of trees were fertilized and monitoring transects established to measure any response. Planting monitoring transects were also established at the Hugh Allen and Splillimacheen sites as well.

Cone Collections

Cones were collected using the methods described in Moody and Pigott (2021). To collect seed, cones must be protected from predators early in the growing season, and cages and cones removed at the end of the growing season.

In June or July, stands were assessed for rust levels through ocular evaluation to characterize the healthiest trees for a given stand. Once a tree or trees had been selected, they were climbed typically using ropes and harnesses and cones placed over groups of cones. The cages were then hand crimped closed to prevent squirrels from entering the cages and to ensure the cages were securely affixed to the tree.

In mid-late September, trees were revisited and cones and cages removed. Cones were dried for six-weeks and seed removed by hand. Seed was then air separated and then sent to nurseries for production or to the Surrey Tree Seed Centre for storage.

Competition Removal

Competition was removed from along a distribution powerline right-of-way servicing the VOR tower on Mount Puddingburn. A narrow area that had been clear cut for the power line and was regenerating with whitebark pine along with a number of competing species. Following correspondence with the parties managing the powerline (NAVCanada) a management approach to retain whitebark pine on site was approved; all non-whitebark pine trees were removed using hand tools and the treatment area was mapped.

Surveys

Two survey types were conducted: remeasurement of 2020 planting and 100-Tree Surveys for blister rust levels. For the planting surveys, in 2020 a subset of seedlings were planted in groupings of singles, doubles, and triples at one meter intervals along a 30 m transect (e.g. triples resulted in 90 seedlings over 30 m). In 2021 we remeasured these to identify planting success and determine if any method of planting was superior.

For the 100-Tree Surveys, as per their name, 100 trees in a stand are assessed for the presence of blister rust and the number of rust cankers on each tree counted to determine the stand level infection rate and the intensity of infection based on the number of cankers per tree. For these surveys a larger reproductive cohort is typically sampled to characterize the cohort of trees from which cones will be collected. The trees in these surveys are not tagged or mapped allowing for a rapid assessment of stand health.

Outreach

To conduct outreach during the COVID pandemic, we reached out to youth groups and ski areas and then developed a suitable mode of outreach. In 2021 all proposed outreach was field based.

Results

Planting

Planting was conducted at eight separate locations between August 30th and September 20th, 2021. The planting sites included: Hugh Allen, Whitetail, Spillimacheen, Blackfoot, Hourglass Lakes, White Grouse, Hollebeke, and Kootenay Pass (Figure 1). A total of 27430 whitebark pine seedlings and 280 limber pine seedlings were planted over 52.19 ha (Table 1, Appendix A). All planting was done in areas burned by wildfire over the last decade (Figure 2), with the exception of the Blackfoot site which was in a post-logging cutblock and Kootenay Pass, which was planted into an undisturbed open parkland site. Whitebark pine seedlings were grown by Sylvan Vale Nursery with limber pine seedlings produced by Nupqu Native Plants (formerly Tipi Mountain). Seedlings typically require a 22 month production period in the nursery, however a small number of seedlings (~10,000) were produced on a much shorter 15 month program this year (Figure 3).

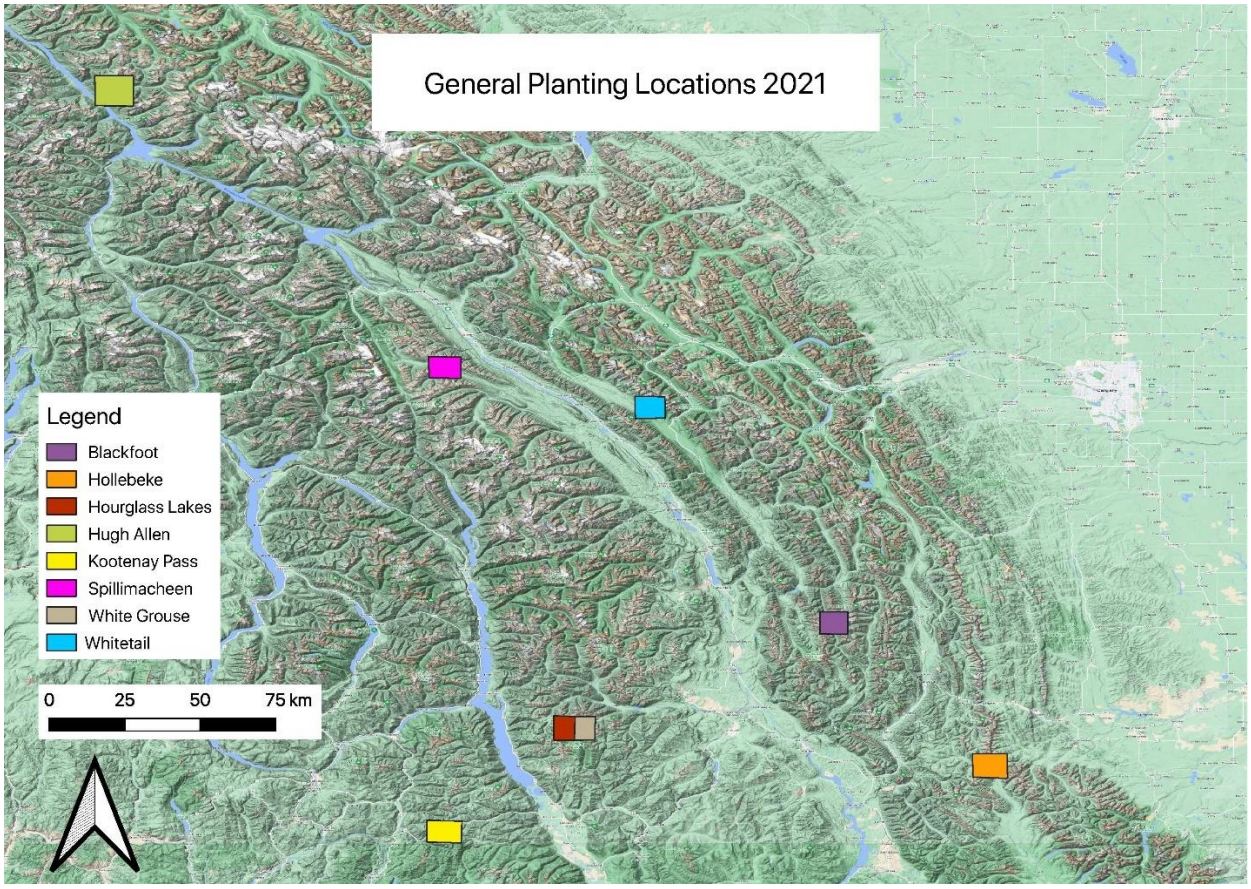

Figure 1. General locations of whitebark pine planting conducted in 2021.

Table 1. Summary of all sites planted in the Columbia Region in 2021.

Site	# of whitebark pine seedlings planted	# of limber pine seedlings planted	Area Planted (ha)	Planted density (seedlings/ha)
Hugh Allen (2 sites)	10080	0	18.01	559.7/ha
Whitetail	1500	0	3	500/ha
Spillimacheen	3600	0	8.92	403.6/ha
Blackfoot (3 sites)	1500	0	0.76	1973.7/ha
Hourglass Lakes	1250	0	0.57	2193/ha
White Grouse	5500	0	17.21	319.6/ha
Hollebeke	2500	280	2.17	1281.1/ha
Kootenay Pass	1500	0	1.55	967.7/ha
Total	**27430**	**280**	**52.19**	

Figure 2. Aerial photo of Spillimacheen planting area.

Figure 3. Photo of whitebark pine seedlings planted in 2021.

Access to Hourglass Lakes and Hugh Allen was via hiking (Figure 4); to Spillimacheen, Hollebeke, Whitegrouse, and Kootenay Pass was via helicopter (Figure 5); and Blackfoot and Whitetail was via direct vehicle accesss to the site. At the Kootenay Pass site, access and logistics were arranged by the Ministry of Transport and Infrastructure in collaboration with their avalanche control technicians (Figure 6). At the Whitetail site, additional brushing work was required to assist with planting whitebark pine as the area had a high density of fireweed.

Monitoring transects were established at the Hourglass, Spillimacheen, Hugh Allen, and Blackfoot sites to monitor seedling success. At the Hourglass and Blackfoot sites, a component of the seedlings were fertilized to test if this technique may assist with survival, establishment, and growth.

Figure 4. Hikers packing whitebark pine seedlings into the Hourglass region.

Figure 5. Preparing seedlings for a heli lift to the White Grouse Mountain area.

Figure 6. Planting landing site at Kootenay Pass, note avalanche control infrastructure in the background.

Cone Collections

Cones were collected at ten locations throughout the eastern portions of the Columbia (Figure 7, Appendix B). Cones were collected in conjunction with other project partners including industry partnerships. A total of 4,241 cones were collected for an estimated collection of 212,050 seeds (Table 2). These cones were collected in partnerships with other funders, thus approximately 70% of the seeds were dedicated to work in the Columbia basin with 30% directed to other projects. Approximately 100,000 seeds are in storage, with the remainder sent for seedling production at Sylvan Vale Nursery. Estimates indicate that 2.6 to 3.9 seeds are generally required to produce a single seedling (Moody and Pigott 2021); thus, this collection will result in between 54,370 and 81,560 seedlings.

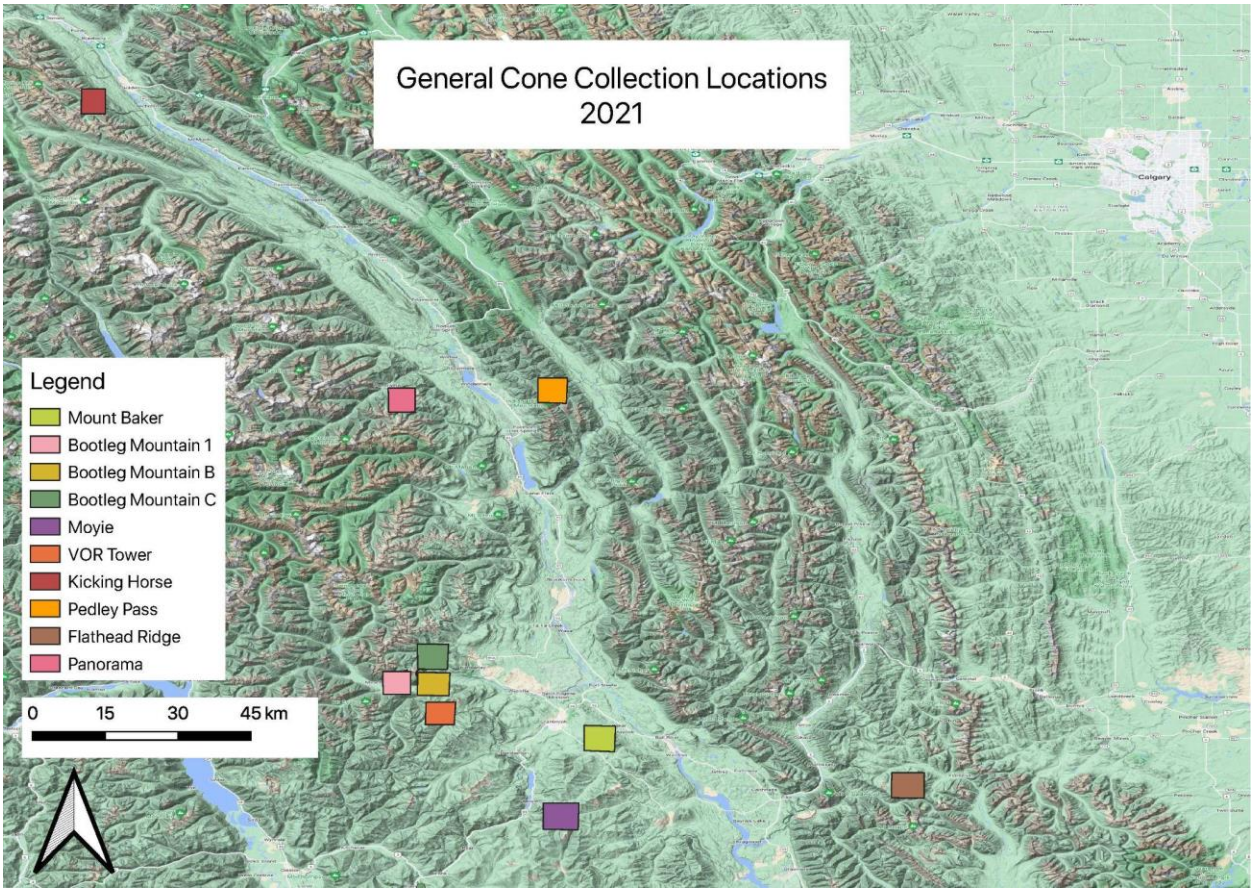

Figure 7. General locations of where whitebark pine cones were collected in 2021.

Table 2. Summary of cone collections at 10 sites across the Columbia basin.

Site	# of trees caged	# of cones collected	Estimated Seed yield (Based on 50 seeds/cone)
Mount Baker	10	169	8450
Bootleg Mountain 1	10	221	11050
Bootleg Mountain B	18	501	25050
Bootleg Mountain C*	8	148	7400
Moyie	53	1642	82100
VOR Tower*	11	412	20600
Kicking Horse*	10	116	5800
Pedley Pass*	9	105	5250
Flathead Ridge	15	656	32800
Panorama	15	271	13550
Total	159	4241	212050

Competition Removal

Competition was removed from around whitebark pine regeneration along a distribution powerline servicing the VOR tower on Mount Puddingburn (Figure 8). In addition to whitebark pine, all subalpine larch were retained on site as well. Pre and post cutting photos show how the stand composition was changed through cutting; most competing trees were taller than the whitebark pine, resulting in better light conditions for most trees in the corridor (Figure 9). Surveys of pre and post treatment stand composition surveys were not taken to characterize the transition of the stand from mixed species to a whitebark-larch stand.

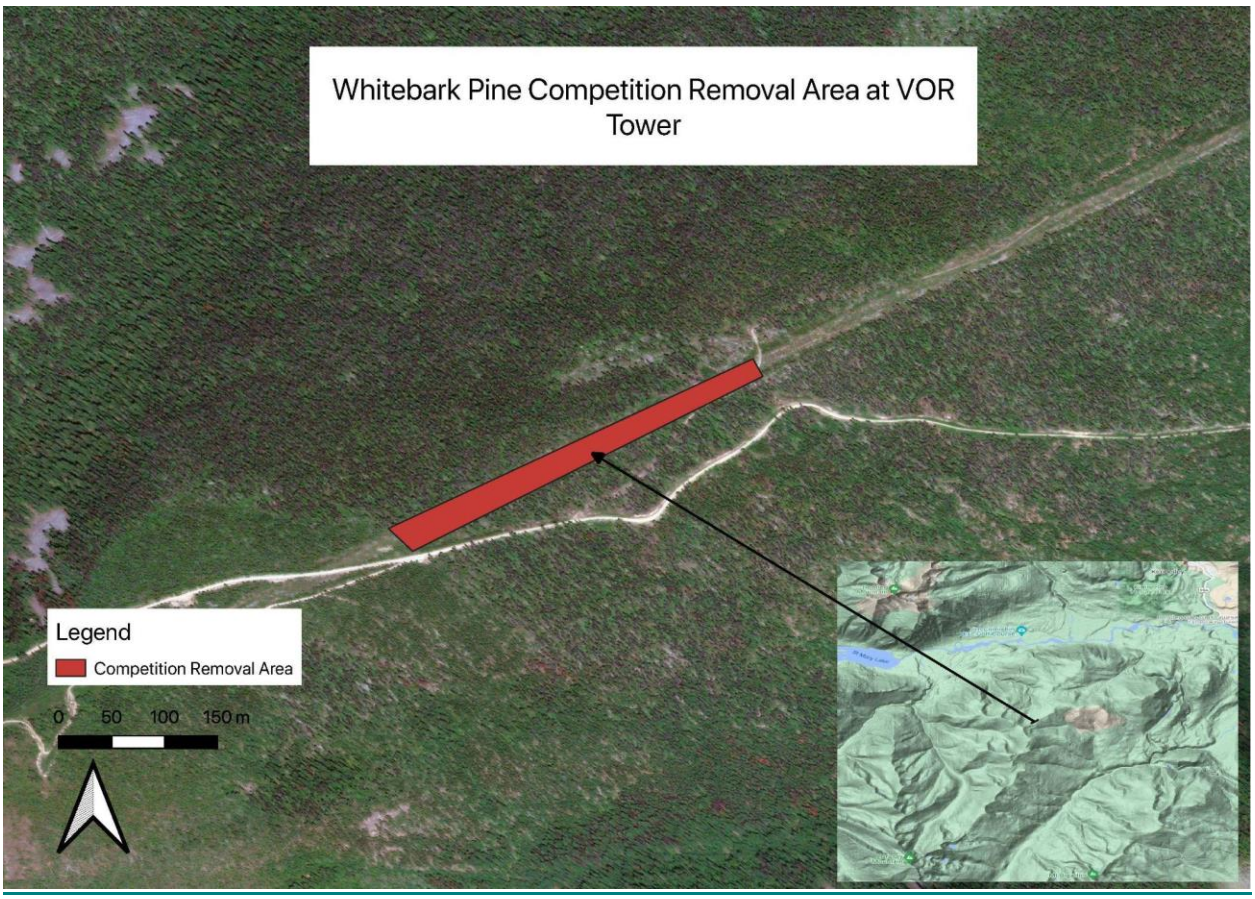

Figure 8. Competition removal area along VOR powerline corridor on Mount Puddingburn; a total of 2.01 ha were treated.

Figure 9. Pre and post cutting photo, note the subalpine fir in the centre of the photo was removed to create better growing conditions for whitebark pine.

Surveys

Two survey types were conducted in 2021; a remeasurement of 2021 planting at Hourglass Lakes, and 100-Tree Surveys to quantify health at Kimberley ski hill, Doctor Creek, and near the Bobbie Burns Lodge (Figure 10).

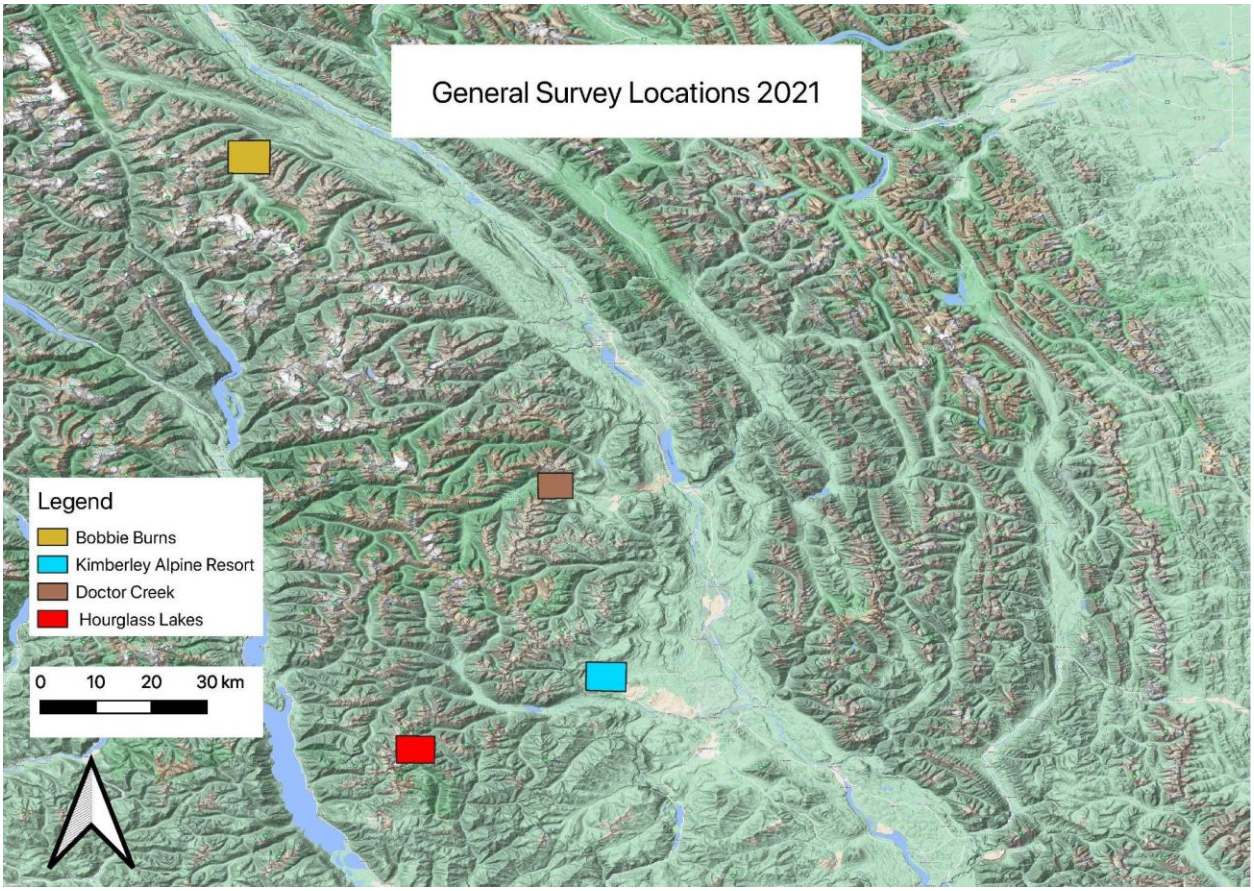

Figure 10. General locations where whitebark pine health surveys were conducted in 2021.

Seedlings planted in 2021 at Hourglass Lakes were planted in plantings of single, double, and triple plantings three sites, low elevation cool, level, and high elevation warm. On August 12th 2021, seedling survival was surveyed here with all sites showing good survival rates; the highest survival was observed at the high elevation warm site for all planting arrangements and site level survival (Table 3). The low elevation cool site showed marginally lower survival than other sites. At the planting site level, all sites showed good survival, with single level having the lowest survival at 76.7%, when considered at the planting site level all site types exceeded 90% survival (Table 4). For this metric all seedlings at a planting site must have died to reduce survival levels, for example to lose a site in the triple plantings all three seedlings must die and effectively lose the restoration site.

Table 3. Survival summary of all seedlings in each planting arrangement at all sites; note site level is all seedlings pooled.

Site	Singles	Doubles	Triples	Site
Low Elevation Cool	100%	83.3%	85.6%	87.2%
Level	76.7%	85%	94.4%	88.3%
High Elevation Warm	100%	88.3%	90%	91.1%

Table 4. Survival summary of all seedling locations in each planting arrangement and at all sites; to lose a site, all seedlings at it must die.

Site	Singles	Doubles	Triples	Site
Low Elevation Cool	100%	93%	97%	97%
Level	76.7%	97%	97%	90%
High Elevation Warm	100%	93%	100%	98%

The three 100-Tree surveys were conducted in late August at Kimberley, Doctor Creek, and Bobbie Burns. For each of these sites a random meander approach to tally the health status of the first 100 trees encountered was conducted. The highest infection level was found at Kimberley (65%/4 cankers per tree); the lowest level was observed at the Bobbie Burns site (35%/2 cankers per tree) which was also characterized as a younger stand than the other two sites (Table 5).

Table 5. Summary of rust infection levels observed at three sites as determined by 100 Tree Surveys.

Site	Percent Infected (Incl. dead)	Percent Dead	Mean number of rust cankers per tree	Stand Descriptor
Kimberley	65%	11%	4	Mature open stand
Doctor Creek	58%	12%	3	Mature open stand
Bobbie Burns	35%	6%	2	Juvenile open stand

Outreach

Outreach was greatly limited in 2021 due to the COVID pandemic limiting public events; and where events were possible, garnering enough participation to make events worthwhile. The primary outreach was conducted with Kicking Horse and Panorama ski areas during cone collections. Panorama has long supported whitebark pine work but Kicking Horse has had less exposure to recovery work. At Panorama we conducted a workshop to train industry personnel about proper whitebark pine inventory and assessment protocols. This workshop was implemented by the Whitebark Pine Ecosystem Foundation of Canada and was not directly funded through this project; however, the relationship we have forged with Panorama over many years through seed collections and surveys funded by FWCP made this venue a perfect fit for this workship. At Kicking Horse, staff accompanied the cone collection crew and gained knowledge on assessment of trees and cone collection methods. Staff at this ski resort are now using iNaturalist to document whitebark pine locations on the hill to develop a better inventory of the site.

Discussion, Recommendations and Best Practices

Planting whitebark pine seedlings is always a logistical challenge in terms of seedling production. The production of a cohort of seedlings for this project over 15-months as opposed to the usual 22-month period may have proved a new technique to improve seedling availability and allow project managers to pivot when faced with issues or opportunities. Seedlings are usually started in November for planting in September roughly 2-years later; seed stratification requires 6-months, thus seeds germinate in April of the first growing season. These seedlings spend two full growing seasons in the nursery. In the first year of growth seeds tend to germinate with very little additional growth until the 2nd year of production, yet the current production schedule requires growers invest labour into tending to these germinants despite little to no growth. Under the methods trialed here, seedlings were started in July and given their long stratification, germinated in December; then seedlings then sat essentially dormant until outdoor conditions permitted additional growth early in the spring. Thus, under this regime the first year of seedling growth was truncated to several weeks. The nursery that used this method is based on Vancouver Island where conditions for suitable spring production occur much earlier than at other sites and it is unlikely that this approach would work elsewhere without artificial heat and lighting.

Accessing whitebark pine sites has always been logistically difficult, typically via long hikes or costly helicopters. As whitebark pine has gained prominence access has improved as forest tenure holders now reach out when good access to whitebark pine is identified as occurred with both the Blackfoot (Canfor) and Whitetail (Louisiana Pacific) sites. Both Panorama and Kicking Horse provided access up their ski runs including vehicle and gondola access. Helicopter access has long been the most expensive means of access, however, the Ministry of Transport has provided free helicopter access to Kootenay Pass for two years, and we have a surplus of restoration sites identified thus extensive aerial surveys are not required and flights can be more direct to sites.

All planting sites for 2021 had dead whitebark pine and pockets of live standing trees scattered throughout (Figure 3). These trees stood as strong indicators that the site can support whitebark pine populations. These dead trees may provide for better seedling survival by providing protection as described above but may also be a liability if they fall and uproot or crush seedlings. Many trees had already fallen and standing trees were tested for stability and were deemed to more likely be a benefit by moderating the site by providing shade and limiting snow creep than a liability to the seedlings. The presence of whitebark pine on-site may indicate that some population of mycorrhizae may remain within the soil to support seedling growth; Cripps and Grimme (2011) found that mycorrhizae populations declined following fire but colonization was facilitated by proximity to a nearby inoculum source.

The monitoring planting monitoring transects measured here revealed good regeneration at all sites and all planting types. This was only the first year of monitoring and trends may appear in future years Cripps et al. (2018) recommend monitoring at years 2 and 5-following planting to capture the most significant decline and the period after decline has stabilized. There was no clear advantage to planting as singles vs clusters of doubles or triples, comparable to findings of Cripps et al. (2018). There is motivation to plant whitebark pine in clusters to mimic multi-seed caches of Clark's nutcracker, though it is unclear if any survival gains are present. Where suitable microsites are limited, multi seedling plantings may be desirable to ensure that suitable microsites are occupied.

The rust infection levels observed at Kimberley, Doctor, and Spillimacheen were comparable to other studies of infections in the region (Smith et al. 2008); though most studies focused on the Rocky Mountains with few surveys done of populations in the Purcell Mountains. The low rust level observed at the Bobbie Burns site was likely an artifact of tree age as this stand was younger and had smaller trees than the other survey locations; stand age may matter as young infected trees are rapidly removed from the population due to rust infections when compared to larger trees that may tolerate rust infections better as they have more biomass to lose to infection before lethal infection levels are reached; likewise older whitebark pine have been exposed to rust spores for a longer period of time and larger whitebark pine form a greater target area to intercept the rust spores.

Removing competition from along an additional section of VOR tower powerline was an extension of work initiated in 2020. This two-hectare section maintained to encourage whitebark pine growth may serve as a pilot project to demonstrate the use of areas under utility lines where tree vertical growth is limited but outward growth to support lateral branches is encouraged. The retained whitebark pine will need to be pruned to maintain shorter stature while encouraging the production of cone crops. In this case since there were not forestry objectives for the site, rather limiting vertical growth of vegetation was the objective, no survey plots were established to describe the pre and post treatment species composition of the stand. In the future, it is recommended that pre and post treatments plots always be established during thinning, not simply to document restoration gains but also to convey to forest managers that on some sites thinning to support whitebark pine will not unduly impact the density of merchantable species and meeting multiple objectives within the more productive forest lands is likely feasible.

The cone collections were successful in their diversity (geographic) and total seed yield, particularly in light of the very large recent seed yield in 2018. Moody and Pigott (2021) estimated that 2.6 – 3.9 seeds are required to produce a single seedling thus, this collection will likely yield between 54,000 and 81,000 seedlings. Considering that 27,000 seedlings were planted for this project this collection may only provide 2-3 years of seedling production to support recovery work, underscoring the need for increased seed collections of the development of a breeding program. This need is especially notable given that planting programs are planned to expand and increase over the next decade.

Though limited, the outreach with ski areas was effective given the workshop put on at Panorama and the small increase in recorded tree points at Kicking Horse. Fortunately ski areas operate in a highly communicative industry and hopefully we can expand this outreach to other ski areas within the Columbia Basin. Given the apparent downturn in the COVID pandemic, it is hoped that previously planned outreach with youth and naturalist groups may be reinitiated in 2022.

Recommendations based on project outcomes include:

- Build relationships with groups that can facilitate access to whitebark pine habitat such as forest licensees, ski areas, and others with backcountry tenures;
- Continue to monitor whitebark pine planting to determine if survival or growth is influenced by site, planting in clusters, or use of fertilizer;
- Continue planting previously identified areas;
- Continue with competition removal and trial areas that will not require ongoing maintenance;

- Establish pre and post treatment plots where competition removal is at the site or stand level;
- Monitor cone crops to ensure that collections are made when large crops are present;
- Re-initiate outreach programs with youth and naturalist clubs; and
- Raise awareness about the positive actions of Panorama Mountain Resort and Kicking Horse to encourage other ski areas to develop comparable signage and whitebark pine recovery programs.

Based on the results of this project, Best Practices for in-field restoration include:

- Planting may be done using either singles or multiple seedlings at each planting location. Where suitable plantable microsites are common planting singles is recommended as planting density will be high and survival likely, where suitable microsites are uncommon (spaced at greater than 7m) planting multiple seedling in these microsites is recommended to ensure that even given some seedling mortality, the site is likely to have at least a single seedling survive to occupy the site.
- During competition removal, attempt to retain well-spaced merchantable species where they do not impact the retention of whitebark pine and establish pre and post monitoring plots at a recommended sampling of one 400m^2 plot per hectare. If thinning to support whitebark pine can be shown to not unduly impact the required stocking of merchantable (preferred or accepted) tree densities, thinning may be a more broadly accepted restoration method on more productive forest lands.

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- Teck Coal
- Two Billion Trees
- American Forests

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- BC Ministry of Transportation and Infrastructure
- Panorama Mountain Resort
- Kicking Horse Mountain Resort

Figure 11. Hollebeke Mountain planting area.

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Appendix A – Seedling Planting Sites

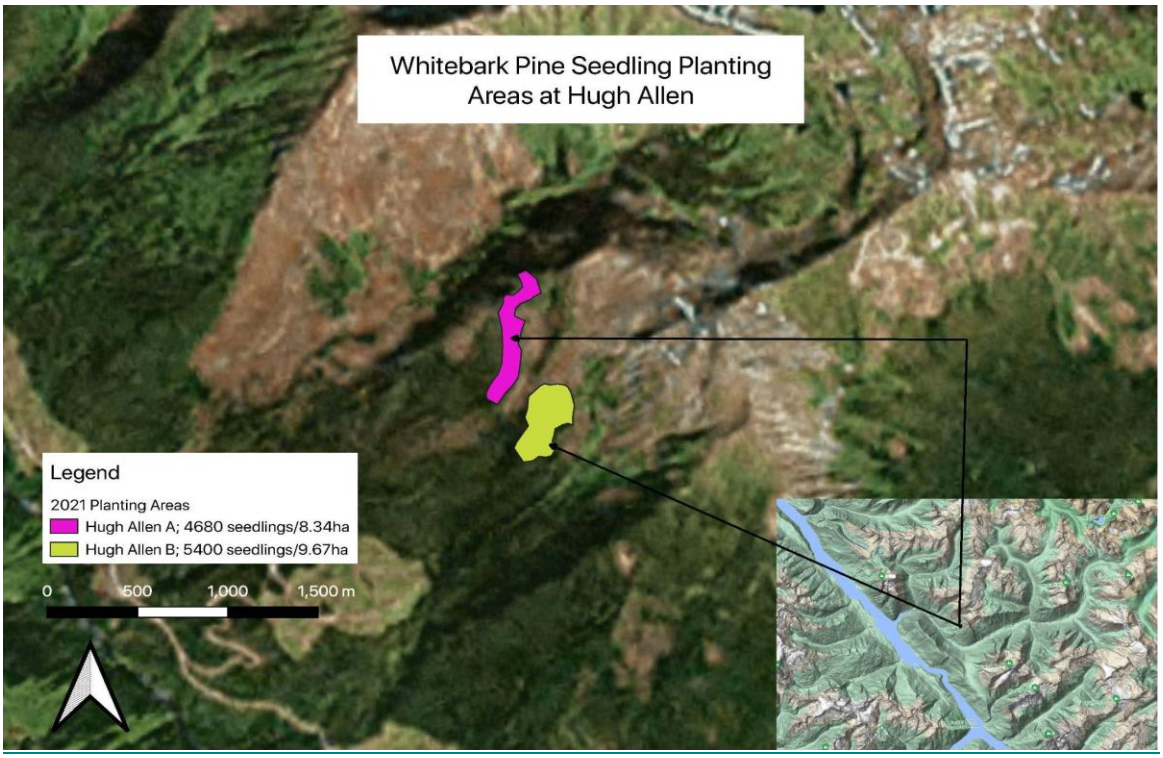

Figure 12. Whitebark pine seedling planting locations at the Hugh Allen burn site.

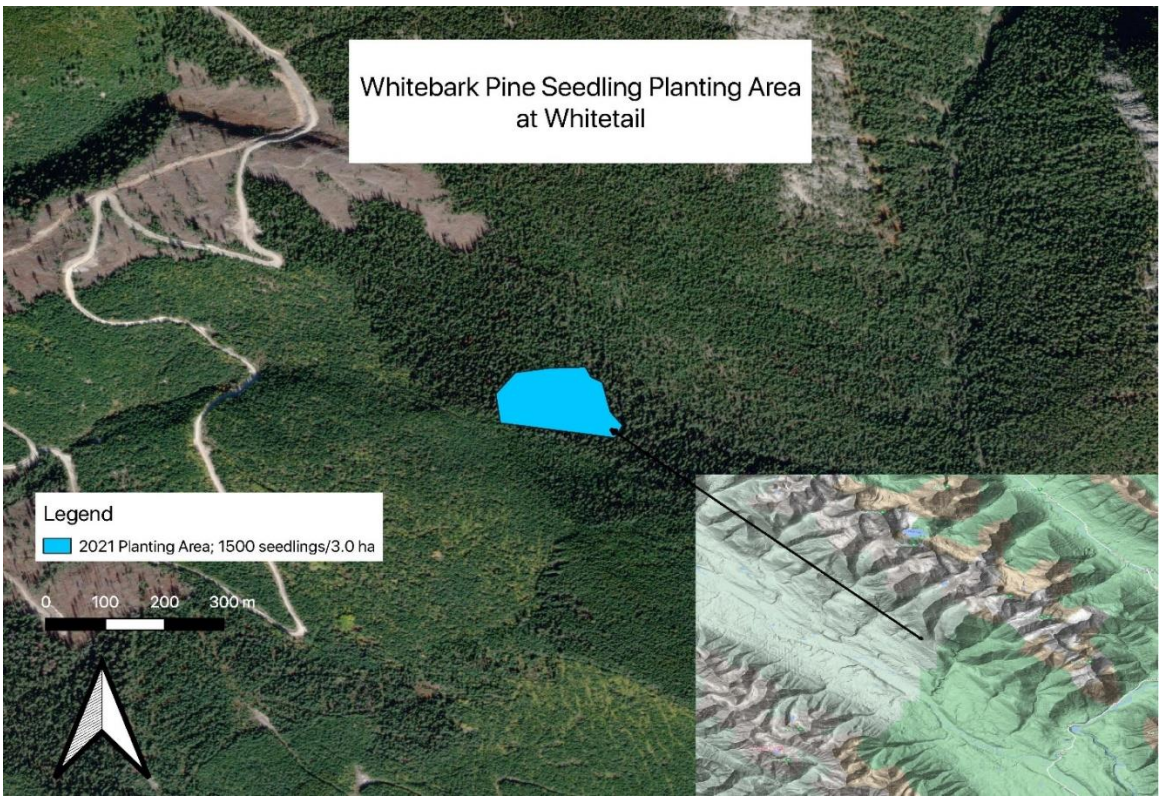

Figure 13. Whitebark pine seedling planting locations at the Whitetail site, 1500 seedlings were planted over 3.0 ha; note burned area from 2018 is not shown on photo.

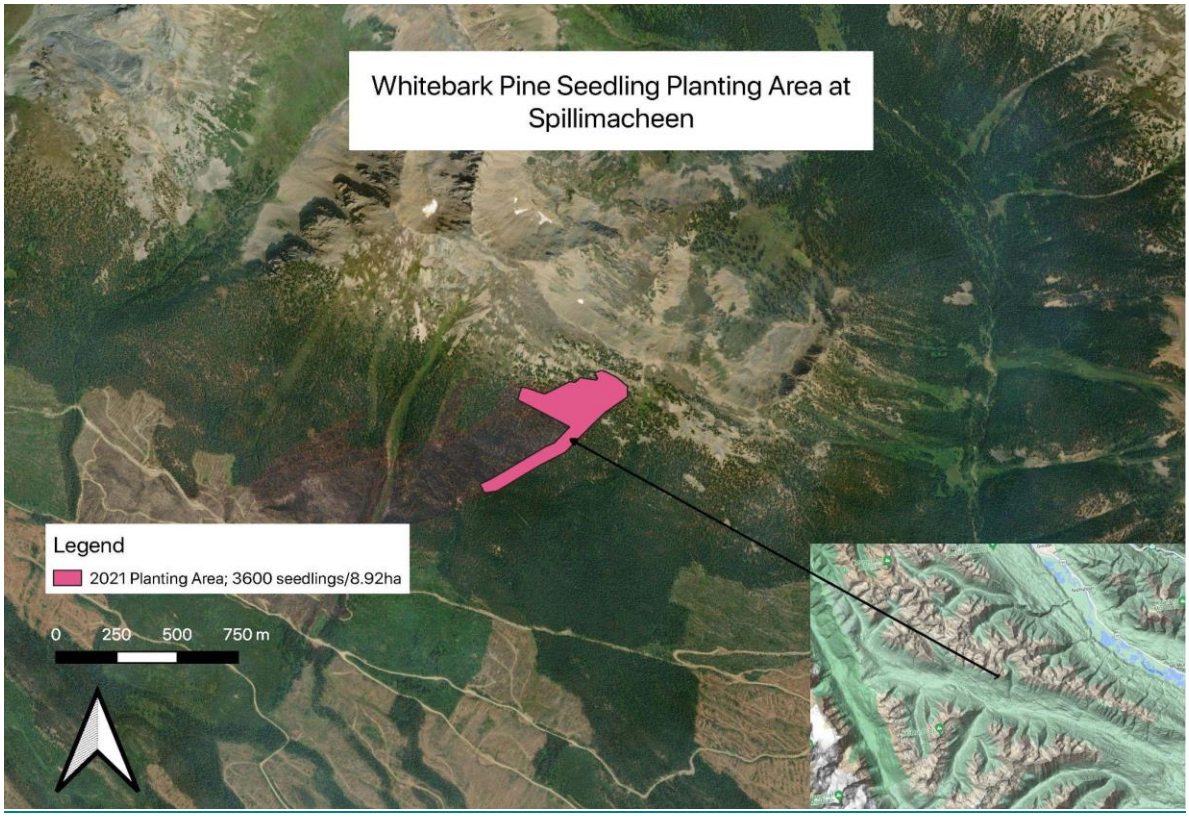

Figure 14. Planting location at the Splillimacheen burn; 3600 seedlings were planted over 8.92 ha.

Figure 15. Planting at Blackfoot; note three separate areas were planted.

Figure 16. Planting area at Hourglass Lakes; 1250 seedlings were planted over 0.57 hectares.

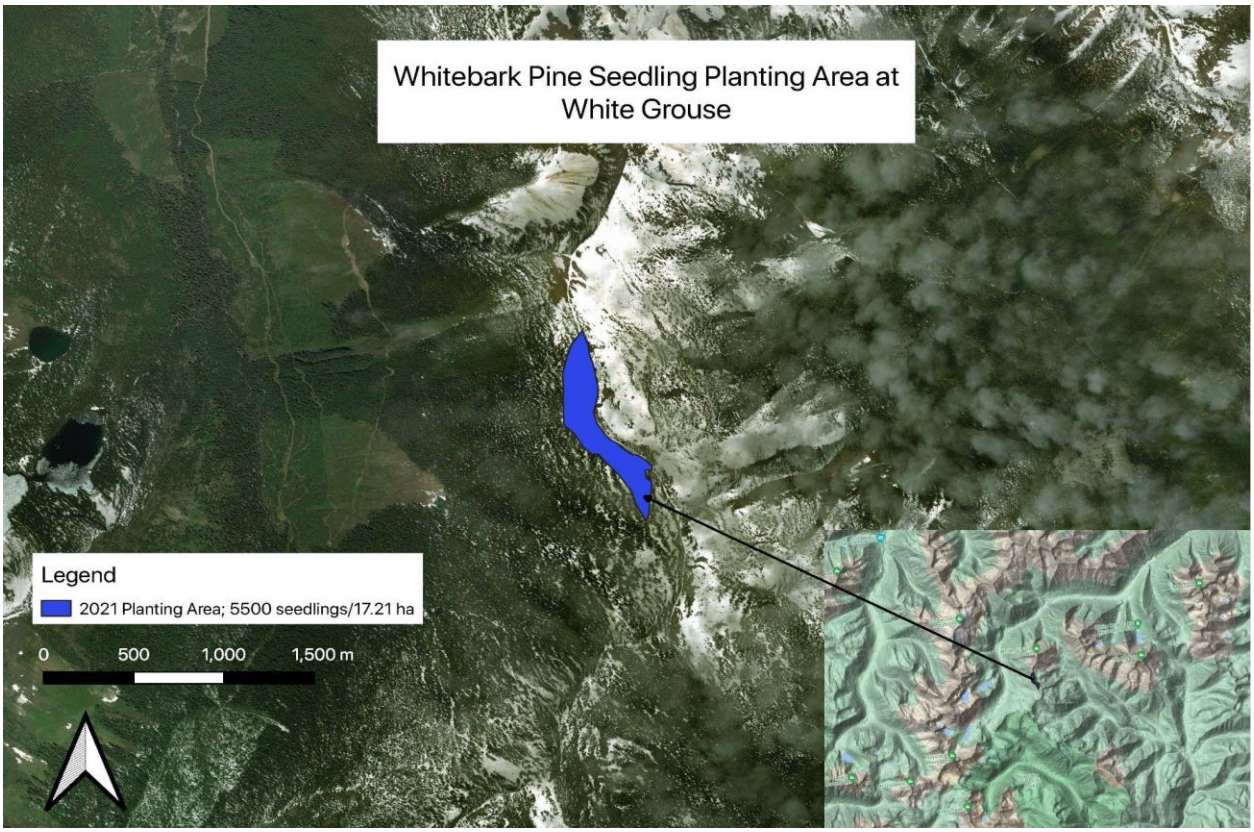

Figure 17. Planting area at White Grouse Mountain; 5500 seedlings were planted over 17.21 ha.

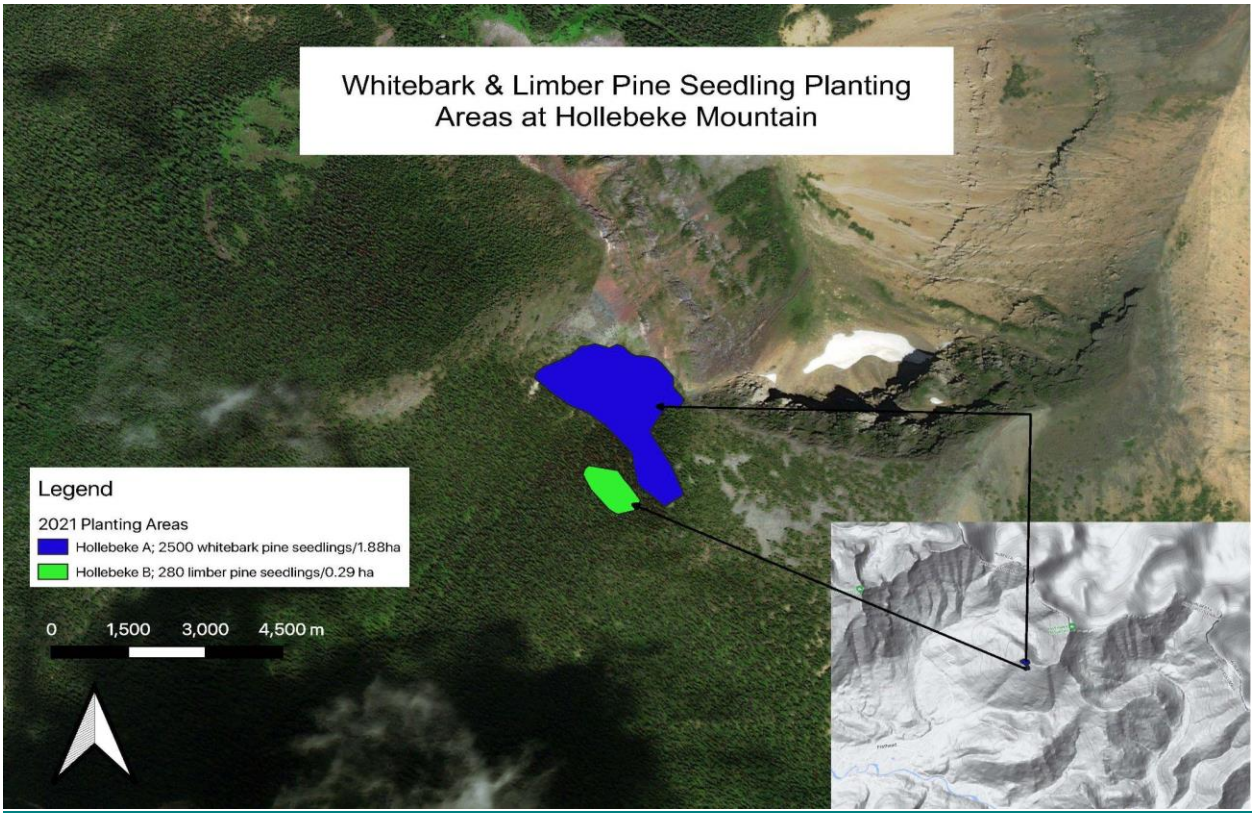

Figure 18. Planting areas at Hollebeke Mountain; 2500 whitebark pine seedlings were planted over 1.88 ha; 280 limber pine seedlings were planted over 0.29 hectares.

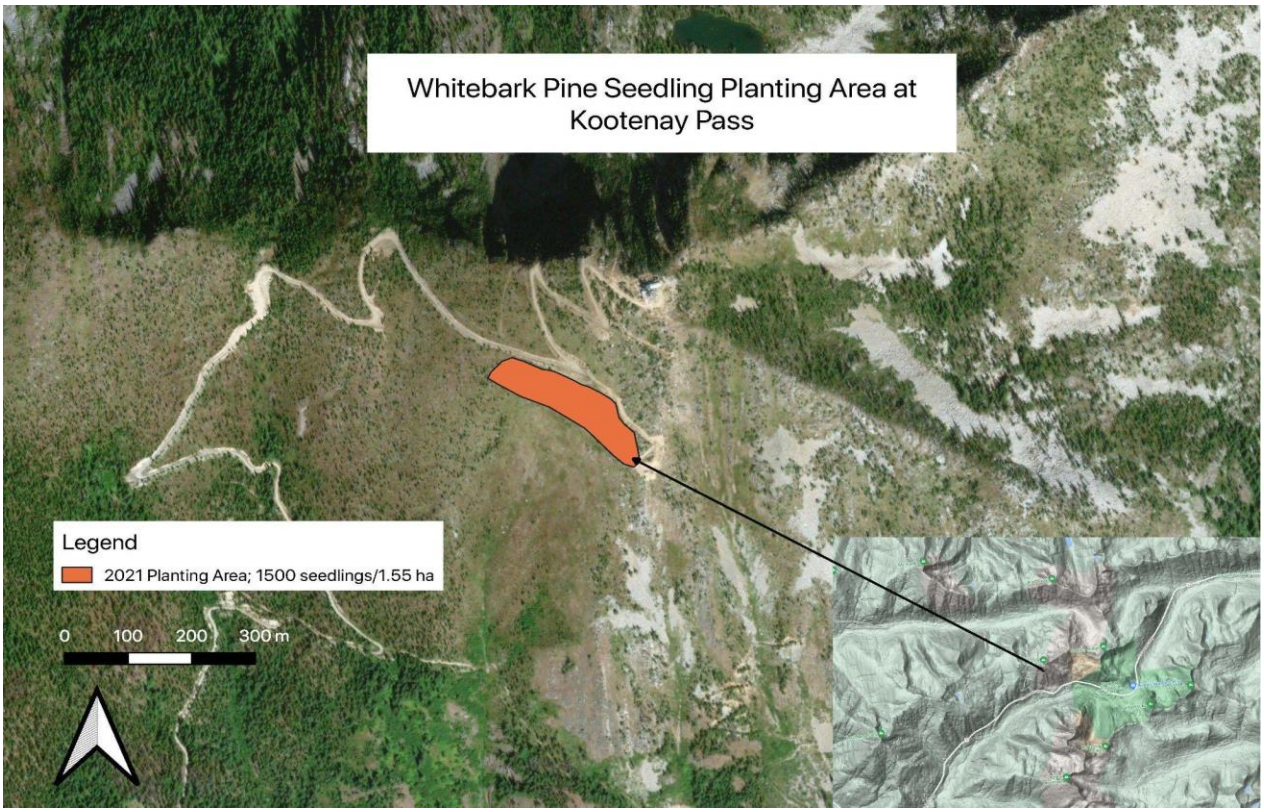

Figure 19. Planting area at Kootenay Pass; 1500 seedlings were planted over 1.55 hectares.

Appendix B – Cone Collection Sites

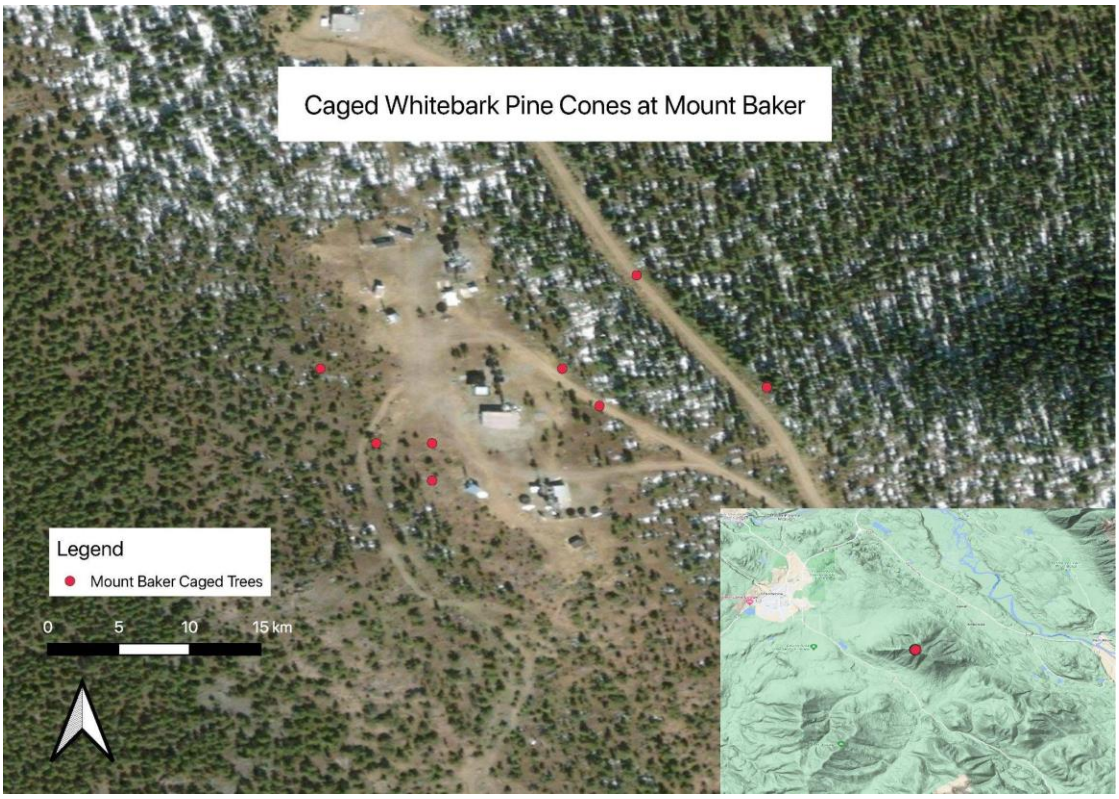

Figure 20. Whitebark pine cone collection trees at Mount Baker, 169 cones were caged from ten trees.

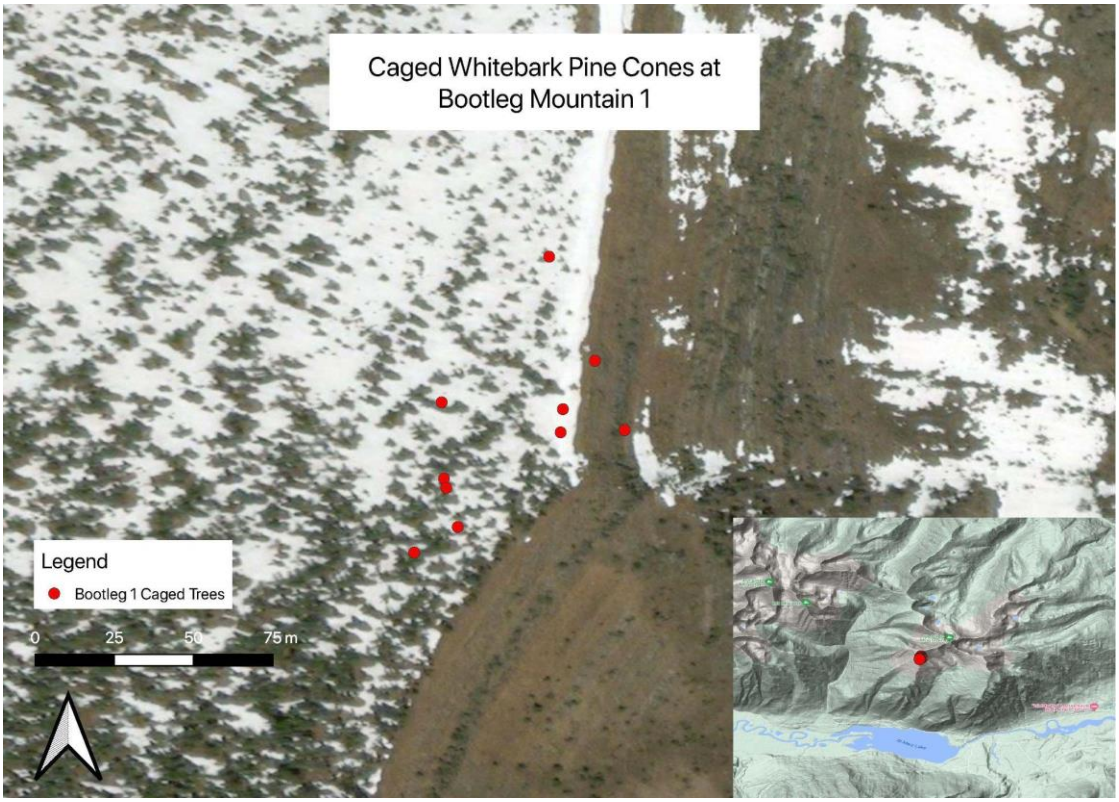

Figure 21. Whitebark pine cone collection trees at Bootleg Mountain 1; 221 cones were caged from ten trees.

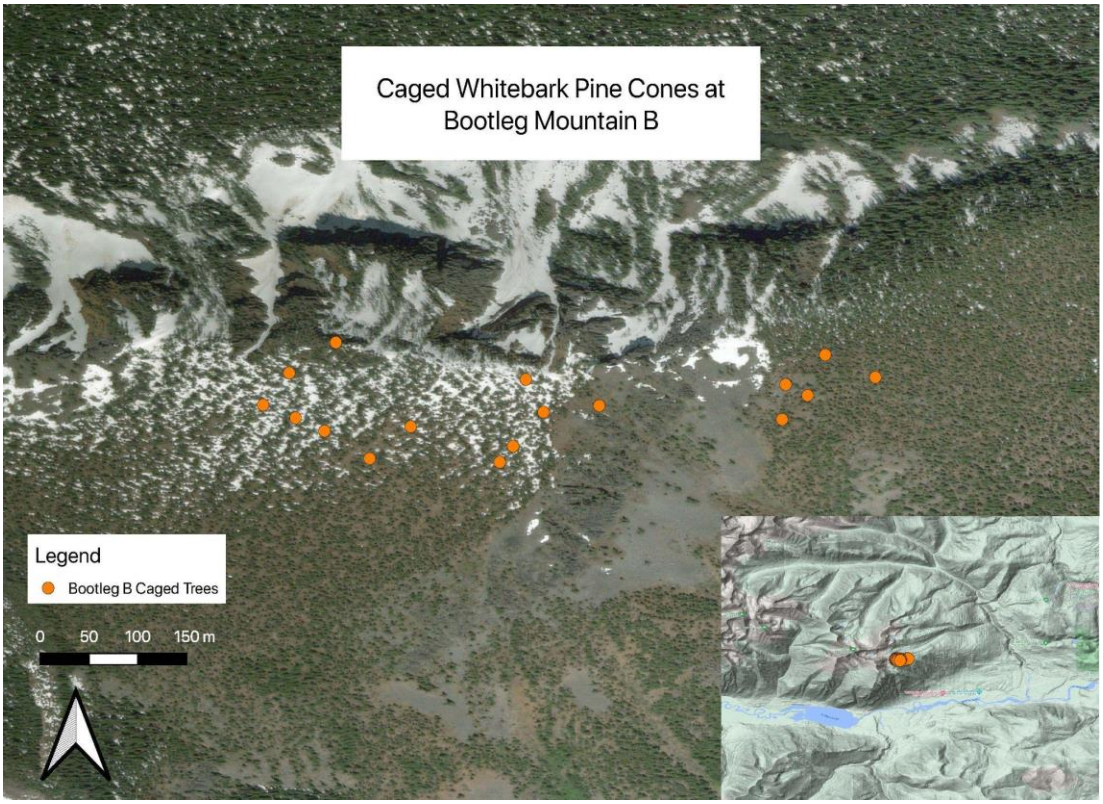

Figure 22. Whitebark pine cone collection trees at Bootleg B; 501 cones were caged from 18 trees.

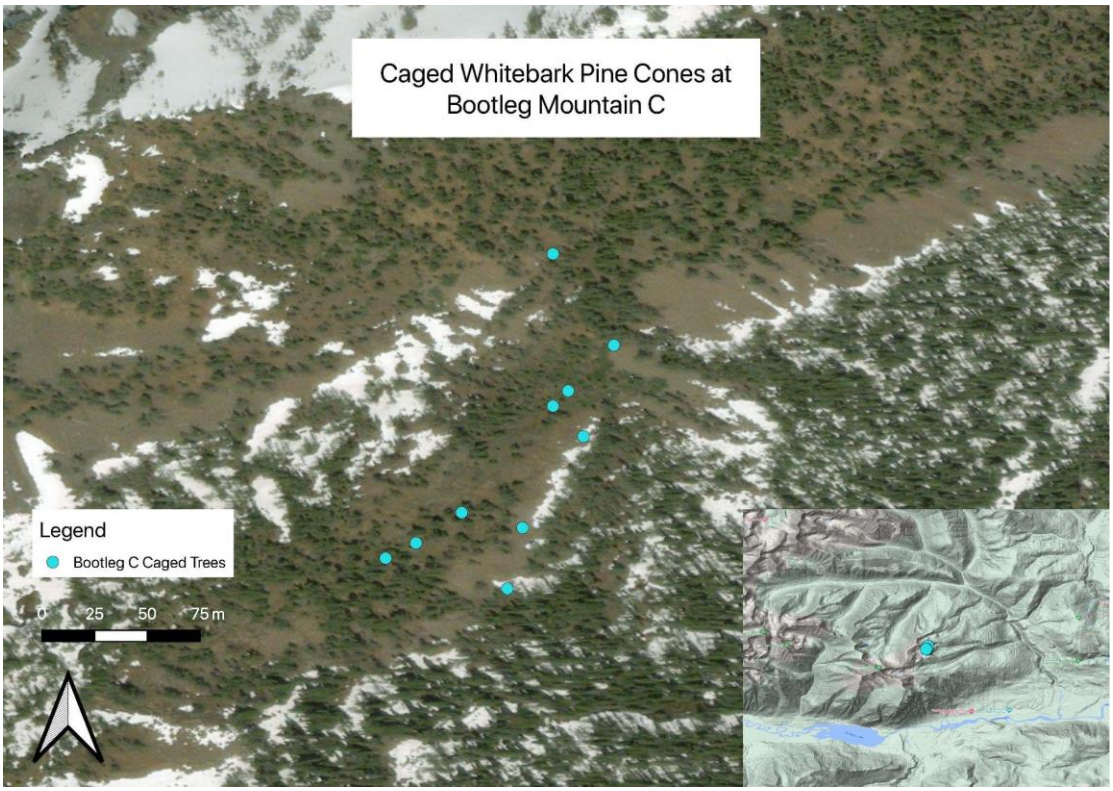

Figure 23. Whitebark pine cone collection trees at Bootleg C; 148 cones were caged from 8 trees.

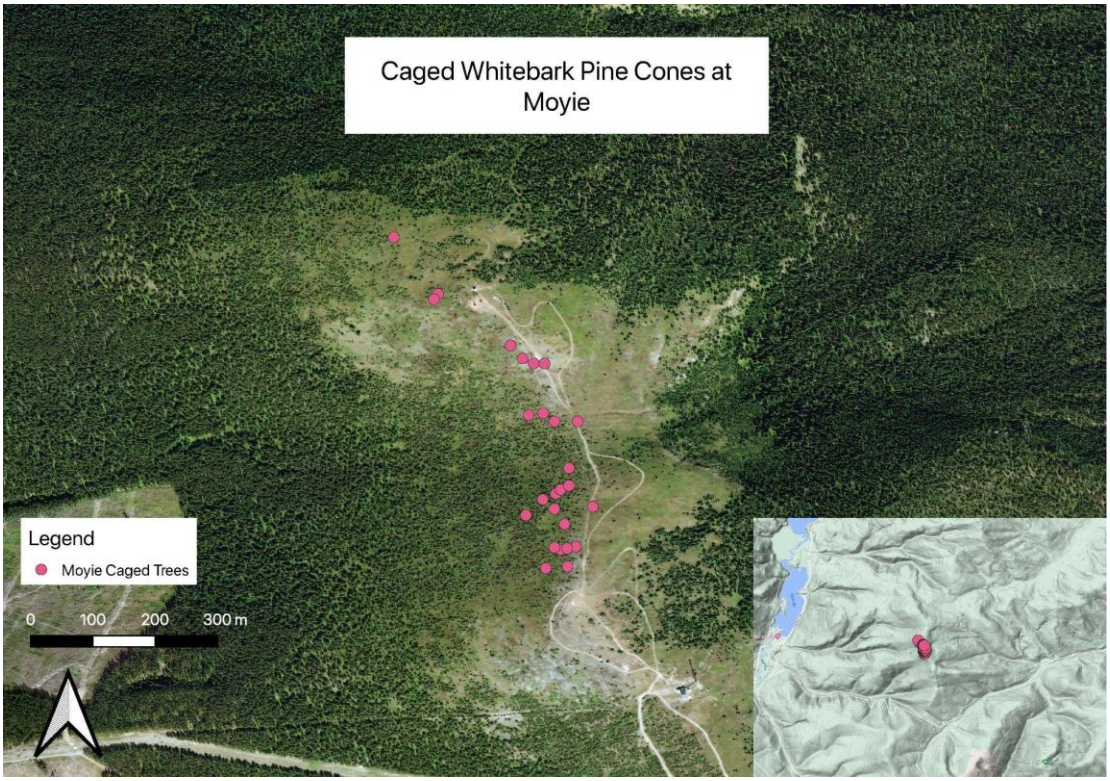

Figure 24. Whitebark pine cone collection trees at Moyie; 1642 cones were caged from 53 trees.

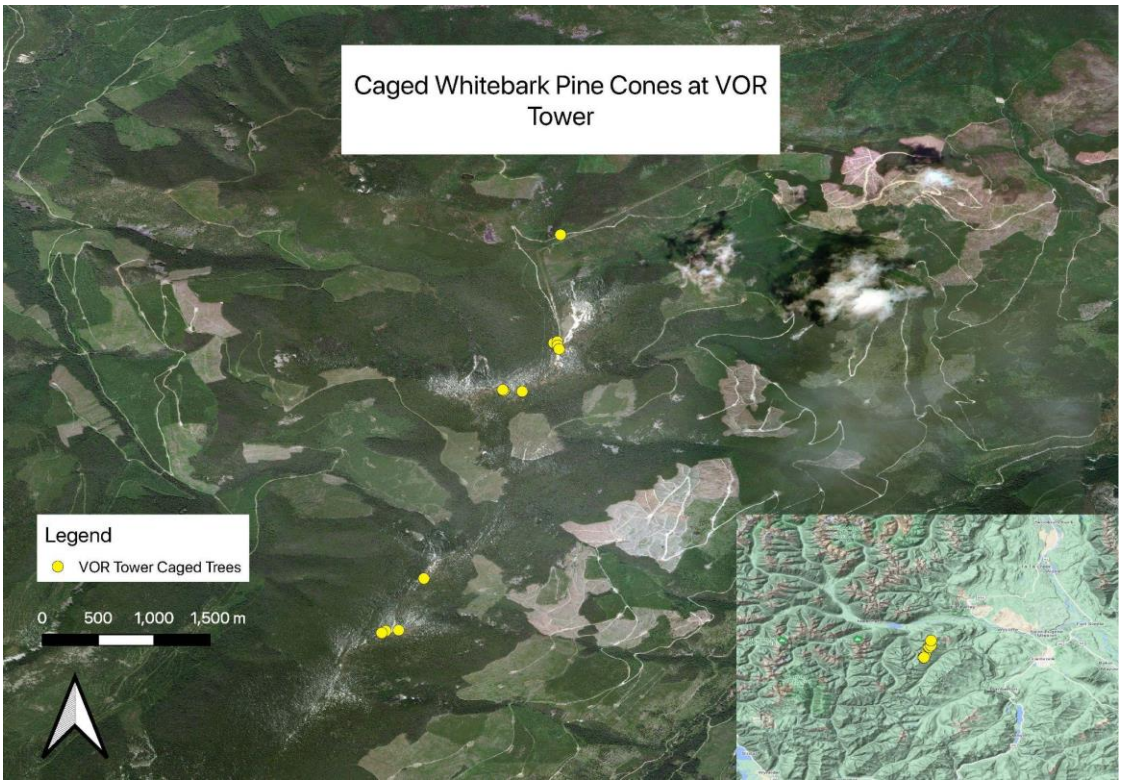

Figure 25. Whitebark pine cone collection trees at the VOR tower; 412 cones were caged from 11 trees.

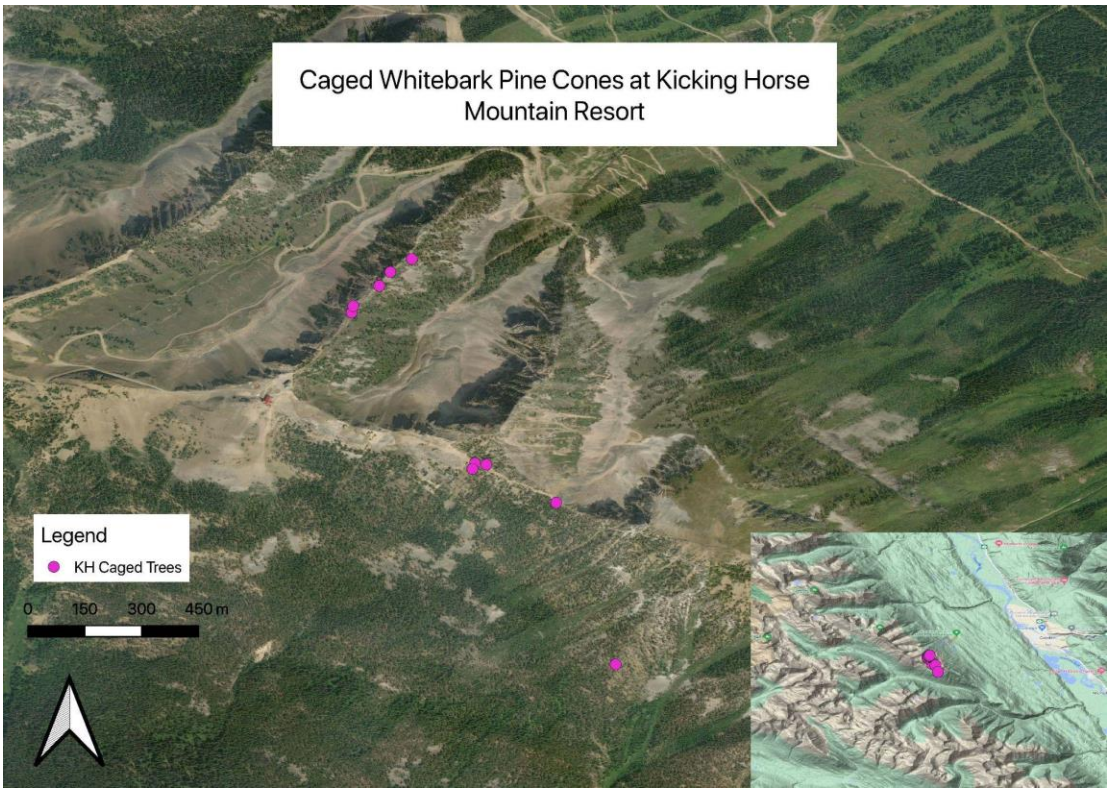

Figure 26. Whitebark pine cone collection trees at Kicking Horse; 116 cones were caged from 10 trees.

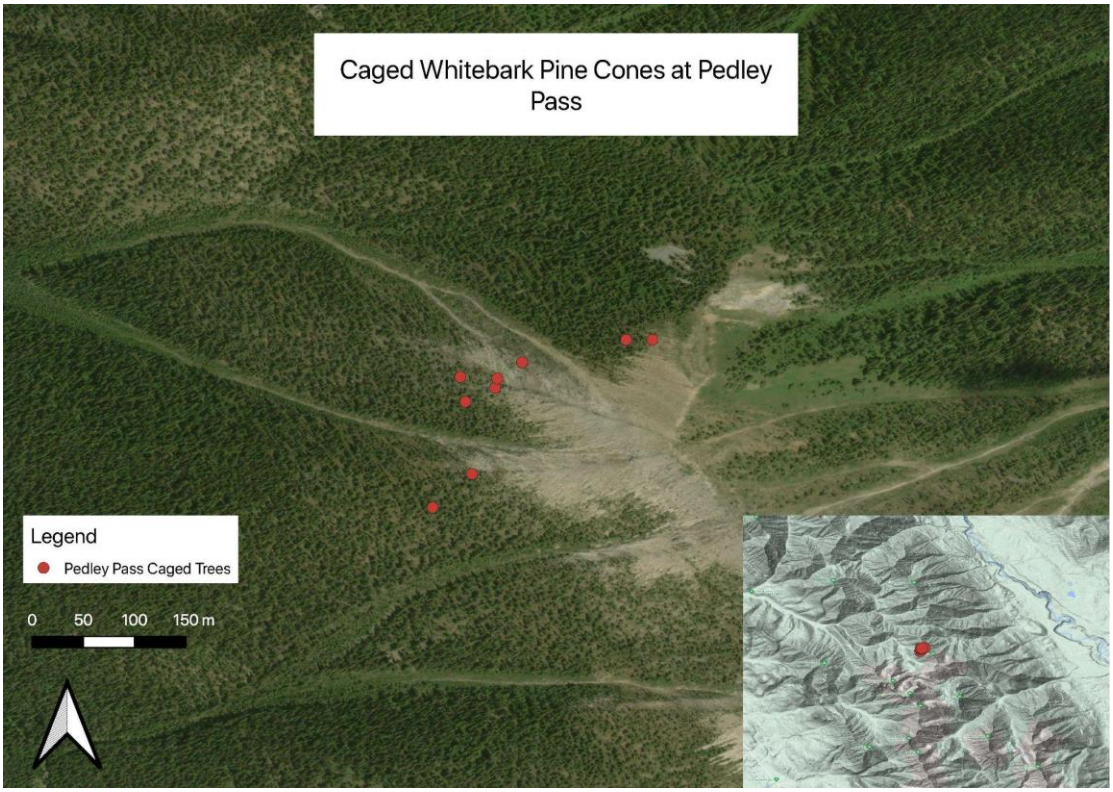

Figure 27. Whitebark pine cone collection trees at Pedley Pass; 105 cones were caged from 9 trees.

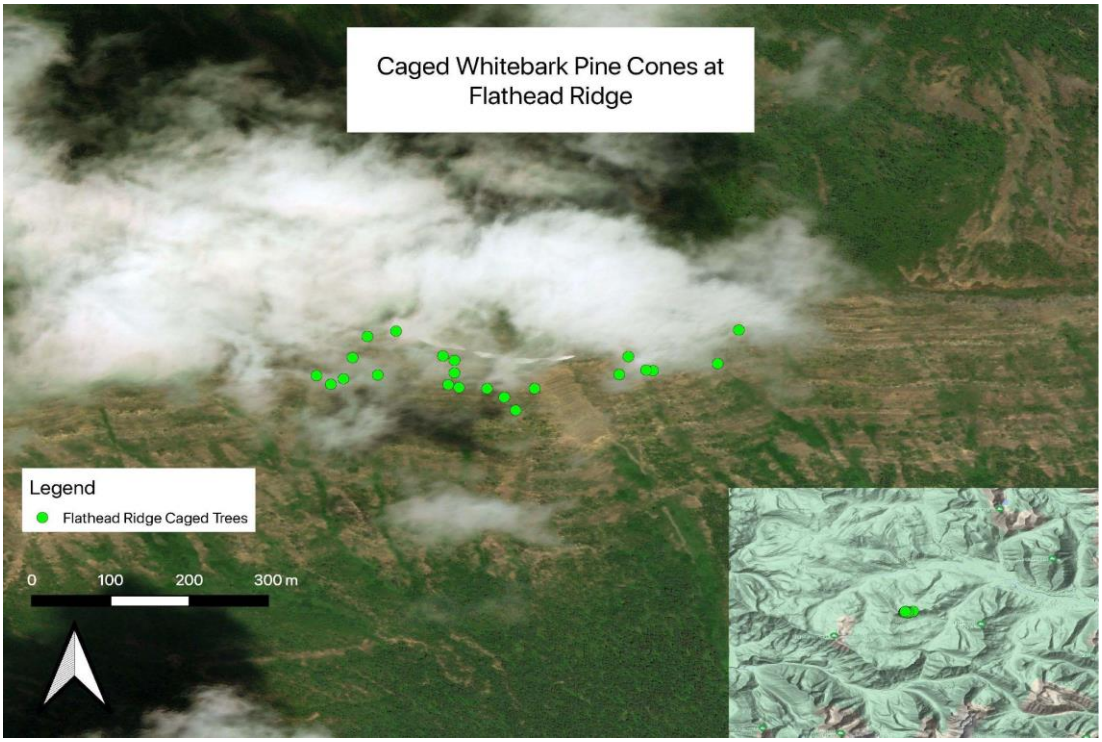

Figure 28. Whitebark pine cone collection trees at Flathead Ridge; 656 cones were caged from 22 trees.

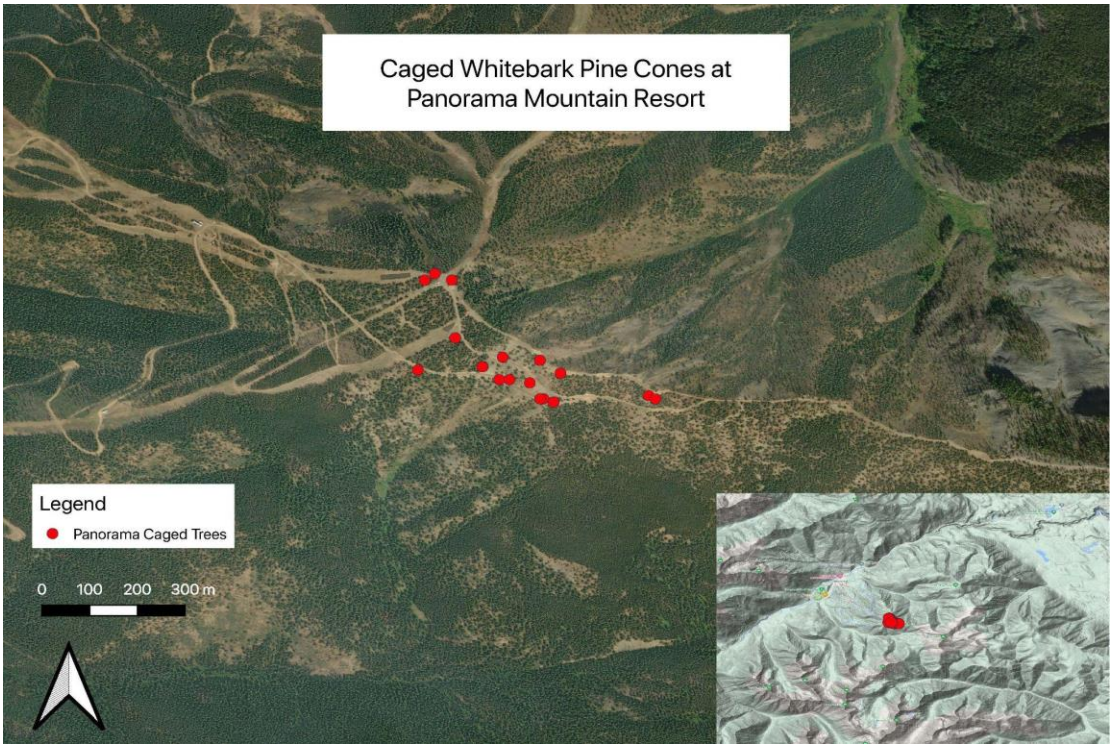

Figure 29. Whitebark pine cone collection trees at Panorama Mountain Resort; 271 cones were caged from 16 trees.