Whitebark Pine Planting in East Kootenay Wildfire Areas

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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 fifth year of a five-year 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. To recover whitebark pine we conducted health surveys to identify the healthiest trees for cone collections, collected cones, planted putatively rust resistant seedlings, which may have resistance to white pine blister rust; removed competition from around naturally regenerating whitebark pine seedlings and saplings, and conducted outreach. We conducted five 100-Tree Surveys and established two permanent health transects; in the 100-Tree surveys rust infections ranged from 35% to 91%, in the permanent transects infection ranged from 58% healthy at Mount Bradford to a low of 3% healthy at Kisoo Pass. Cones were collected from 119 trees at eight sites with 10.5 kg of seed going into seedling production and 7.6 kg going into storage; nine collection trees were selected for white pine blister rust resistance screening. A total of 10,080 seedlings were planted at Mount McKirdy over 23.1 ha, 4,280 seedlings were planted at Castle Mountain over 13.5 ha, and 760 seedlings were planted at Doctor Creek over 1.45 ha. Surveys conducted at plantings from 2020 and 2021 indicated that survival and stocking of planted sites was generally high and within target stocking levels. Competition was removed from around whitebark pine over 2.04 ha with 1.4 ha of habitat improved near Sorcerer Lodge and 0.63 ha cleared near the VOR Tower on Mount Puddingburn. Surveys were conducted to identify future competition removal sites at Lavina Lookout and Bobbie Burns area. Outreach was conducted with the Simpcw First Nation and Valemount Community Forest employees; both groups participated further in cone collections and seedling planting. The primary recommendations from 2022 work included: 1) continue collecting cones in areas of high rust; 2) continue working with health monitoring and remeasurement team; 3) capitalize on periods of high cone production; 4) establish permanent monitoring plots in planting areas; 5) survey competition removal sites for rust hazards and supplemental planting needs; and 6) expand outreach as there is a clear appetite for this type of offering. Five-year project successes included expanding the ecological range of planting sites, identifying new cone collection sites, working to identify different site objectives to facilitate thinning to support whitebark pine, conducting outreach to a range of groups, and building partnerships with a range of stakeholders.

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Introduction

Whitebark Pine (*Pinus albicaulis*) is a five-needled pine that plays keystone ecological roles in subalpine ecosystems. It is listed as endangered under the federal Species at Risk Act (SARA) due to the negative effects of the introduced fungus 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 2017).

As a keystone species, whitebark pine is an important food source for many wildlife species, namely the Clark's nutcracker (*Nucifraga columbiana*), red squirrel (*Tamiasciurus hudsonicus*) and grizzly bear (*Ursus arctos*) (Tomback and Kendall 2001). Whitebark pine and Clark's nutcracker 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 grow into new trees resulting in the colonization of new sites.

In the fall, red squirrels hoard whitebark pine cones into middens to feed on over winter. Middens are vulnerable to predation by opportunistic species such as grizzly bears. In many areas, grizzly bears regularly feed on whitebark pine cones during their pre-denning hyperphagic phase (Mattson et al., 1992; Mattson and Reinhart, 1997; Gunther et al. 2004). Grizzly bears have also been observed stripping branches from trees to access cones.

The decline of whitebark pine has resulted in disruptions to the important ecological processes it supports. These declines have resulted in whitebark pine being listed as Endangered by Environment and Climate Change Canada (ECCC) under SARA (Environment and Climate Change Canada, 2017). To address the threats to whitebark pine, the federal Recovery Strategy [draft] describes pathways to recovery in the Recovery Planning Table (Environment and Climate Change Canada, 2017). As described in the table, this project addressed the threat of rust and fire through planting of putatively resistant seedlings and planting seedlings in post-burn environments.

Goals and Objectives

This is year-five of a five-year project. The objectives for this year were to:

a) Plant seedlings grown from seed collected from putatively resistant parents (parent trees displaying some level of resistance to rust in the field but not confirmed through testing);

b) Remove competition from around naturally occurring whitebark pine saplings to support the natural recruitment in areas of high natural density co-occurring with high densities of competing species;

c) Collect seed from populations with very high rust levels to select the healthy, likely genetically superior, parent trees; and

d) Conduct outreach with the public, government decision makers, and local licensees considering whitebark pine management in their operations.

Linkages to Action Plans

This project most closely aligns with the Upland and Dryland Chapter of the Columbia Action Plan; within this chapter the project aligns with species-of interest, namely the priority action of Species Based Actions OLUPD.SOI.SB.27.01 Whitebark Pine restoration efforts-P2: Integrate Whitebark Pine restoration initiatives following SARA Recovery Strategy into habitat restoration work. May include research and habitat enhancements for Clark's Nutcracker (indicator species) – Improve Priority Whitebark Pine Habitat.

Methods

The primary recovery activities undertaken were health surveys, cone collections, planting, competition removal, and outreach.

Health Surveys

Health surveys are primarily conducted in the context of cone collections as highly rust infected stands are surveyed to identify the healthiest trees in the stand to serve as candidates for cone collections. Two types of health surveys were implemented: 1) permanent transects and 2) 100-tree surveys.

Permanent transects were established by laying out a 50 m x 10 m belt transect with start and end points permanently monumented to facilitate future re-sampling. Within the belt transect all whitebark pine taller than 1.4 m were tagged, measured at DBH, and blister rust and mountain pine beetle impacts recorded where relevant. Trees within the transects will be re-sampled at 5-year intervals to identify any rust or beetle related health trends. Cones can be collected from the healthiest trees in the transect and trees that remain healthy over time should have cones regularly collected and submitted to the provincial screening program.

The alternate 100-Tree Surveys are rapid means to assess whitebark pine health without the additional time of establishing the plot and tagging all trees. For these surveys 100 trees of reproductive size are surveys for the number of rust cankers present, to expedite surveys rust levels are recorded categorically to determine the both the infection level (% of stand infected) and infection intensity (number of infections per tree). From this survey the healthiest cohort in the stand can be identified and cones collected from these trees. The 100-Tree survey is often established in areas where whitebark pine is diffuse and not likely to capture a significant sample in the permanent transect layout.

Cone Collections

Cone Collections were conducted by selecting the healthiest trees in stands with relatively high levels of blister rust as these trees are the most likely to contain blister rust resistant genes. Cones were collected in accordance with common techniques for cone collection; wire cages were put on the selected trees in August 2022 to protect the cones from predation by rodents and the Clark's nutcracker, and crews returned in October 2022 to collect the mature cones. At the time of caging, trees were tagged and GPS locations recorded. Cones were stored in breathable sacks and kept separate by parent tree to facilitate any rust screening or parent tree tracking in the future. Seed was extracted by hand and sent to nurseries for propagation or to the Surrey Tree Seed Centre for storage. Whitebark pine cones were collected from Kicking Horse Mountain Resort, Mount 7, Mount Peter, Mount Stevens, Panorama Mountain Resort, McBride Peak, Swift Mountain, and VOR Tower.

Seedling Planting

Seedling planting sites were identified at Castle Mountain, Doctor Creek and Mt. McKirdy. To select planting sites, walkthroughs were completed to determine the level of whitebark pine

regeneration and the suitability of the site for whitebark pine planting as evidenced by fire killed whitebark pine remaining on site. Field surveys also ensured that high-density natural regeneration had not already been established on site. Each site was surveyed for hazards such as danger trees, steep slopes, and potential wildlife related issues such as bear sign. Planters were instructed to report and avoid any hazards encountered.

Planting was done at a target density of 500 stems/ha. During planting, planters were instructed to plant seedlings as singles, and adhere to the following guidelines:

- Ensure soil closed well around the roots of the seedling, this was accomplished by avoiding organic soils and closing mineral soils around the roots using the shovel blade or by hand.
- Ensure seedlings were planted deep enough to eliminate the risk of frost heaving, this was accomplished by ensuring the root collar was planted just below the level of the native soils and the root collar never extended above this level; further seedlings were always planted deep enough that roots extended straight down.
- Select protected microsites; this included avoiding cool air drainage sites and protecting from snow creep and excessive insolation by planting in the shelter of rocks, stumps, or other protective features. On many sites this required protecting seedlings on both upslope and downslope sides.

Planting Monitoring

As a follow-up to planting, surveys were conducted to evaluate planting success at previous planting locations including:

- Kianuko Provincial Park – fixed radius plots of 2020 planting
- Hourglass Lakes – Planting transects established in 2020
- Hugh Allen – Planting transects established in 2021 and fixed radius plots
- Spillimacheen – Planting transect established in 2021

The fixed radius plots were 11.28m radius (400m^2), we used this large plot size due to the wide spacing of whitebark pine planting. Permanent transects were established where access facilitated remeasurement and were generally 30m in length with seedlings planted at one meter intervals along the transect line.

Competition Removal

Competition removal was conducted to improve the growing conditions of smaller whitebark pine and to ensure the longevity of mature trees by removing fuels and shade tolerant trees growing in the understory. In 2022 we surveyed two sites to plan for competition removal in 2023-24 and removed competition at another site.

Competition removal was conducted in the areas adjacent to Sorcerer Lodge including the Ventigo drainage and Perfect Valley. At this site individual whitebark pine were located and

competition removed where it impeded growth or created a potential ladder fuel risk. At each location, the treatment tree protected by competition removal was mapped. Any cut debris was removed from around the tree to limit fire hazard and to eliminate potential insect outbreaks on the dead and decaying wood.

Surveys were done at Lavina Lookout and the Bobbie Burns area by establishing fixed radius plots and sampling the species composition in regenerating stands to determine competition removal need. These plots were used to apply for permits to remove competition in 2023.

Outreach

Throughout the range of whitebark pine there exists numerous gaps in expertise to deliver appropriate recovery project. In 2022 we conducted outreach with potential partners in the region including the Valemount Community Forest who have both whitebark pine and restoration opportunities within their tenure and the Simpcw First Nation who is collaborating on whitebark pine work in the region, has a multi-year whitebark pine project, and whose traditional territory extends into the Columbia Basin.

Outreach was conducted in a field based environment to review species identification, white pine blister rust identification, and recovery techniques. Training was conducted at McBride Peak and at Swift Mountain above Valemount.

Results

Health Surveys

A permanent health transect was established at Mount Bradford and Kisoo Pass; and five 100-tree surveys implemented throughout the region. At Mount Bradford 101 trees were sampled with 58% healthy, 32% infected by rust, and 10% dead; nine trees were dead due to rust (Table 1). At Kisoo Pass 27 trees were sampled with 3% healthy, 63% infected by rust, and 23% dead; two trees were dead due to mountain pine beetle, one tree due to rust, and four dead trees had both rust infections and mountain pine beetle attack (Table 1).

Table 1. Summary of permanent health transects.

Location	Healthy	Sick	Dead	Cause of Death
Bradford	58% (59)	32% (32)	10% (10	R-9, U-1+
Kisoo	3.3% (1)	63.3% (19)	23.3% (7)	R-1. B-2, R/B-4. U-1

The 100-Tree surveys ranged from a low of 35% at Certainty Mine to 91% at Quartz Creek (Table 2). Quartz Creek also had the greatest number of cankers per infected tree at 30.

Table 2. Health Summary of 100-tree surveys conducted in 2022.

Location	Trees with Rust	Total Trees	Average number of Cankers per Tree	% Infection
Certainty Mine	35	102	2	35%
Mount Sproat	33	68	3	49%
Silvercup Ridge	85	138	6	62%
Quartz Creek	104	114	30	91%
Lavina Lookout	44	109	5	40%

Cone Collections

Whitebark pine cones were collected from Kicking Horse Mountain Resort, Mount 7, Mount Peter, Mount Stevens, Panorama Mountain Resort, McBride Peak, Swift Mountain, and VOR Tower (Appendix A). Cones were collected from 119 trees with a total 3,557 cones collected across the eight sites. (Table 3). Two of the sites, Swift and Mount Peter, were collected from for the first time. The discovery of both of these new sites is unique in that the Swift site was discovered while conducting outreach and training in the Valemount area and the Mount Peter site is unique in that it was discovered by a group of backcountry skiers who passed on the information regarding the site. The 10,523 g of seed in production should result in between 30-40,000 seedlings for planting in 2024. Seed from three trees at each of Mount Peter, Mount Stevens, and Swift Mountain were accepted into the provincial rust screening program.

Table 3. Summary of cone collections and seed fate in 2022.

Site	Number of Trees	Total Cones	Seed in Storage (g)	Seed in Production (g)	Trees in Screening
Kicking Horse	14	660	1724	1731	0
Mount Seven	17	551	1438	1768	0
Mount Peter	22	415	869	1504	3
Mount Stevens	15	295	0	1450	3
Panorama	26	869	3064	1050	0
Swift Mountain	10	527	494	1343	3
McBride Peak	10	205	0	1477	0
VOR Tower	5	35		200	0
Totals	**119**	**3557**	**7589**	**10523**	**9**

Planting

Planting was conducted at three separate locations, Castle Mountain, Mount McKirdy, and Doctor Creek. The Castle Mountain planting site was planted on September 17-18, 2022 with 4280 seedlings planted over 13.5 hectares, resulting in a planted density of 317 seedlings/ha (Figure 1). The site was spread over a broad range of elevation, soil types, and levels of natural regeneration and was ultimately separated into 3 sections- a warm main ridge, a cooler aspect, and a rocky area (Figure 2). All three sections were planted and monitoring transects established in each area (Table 4).

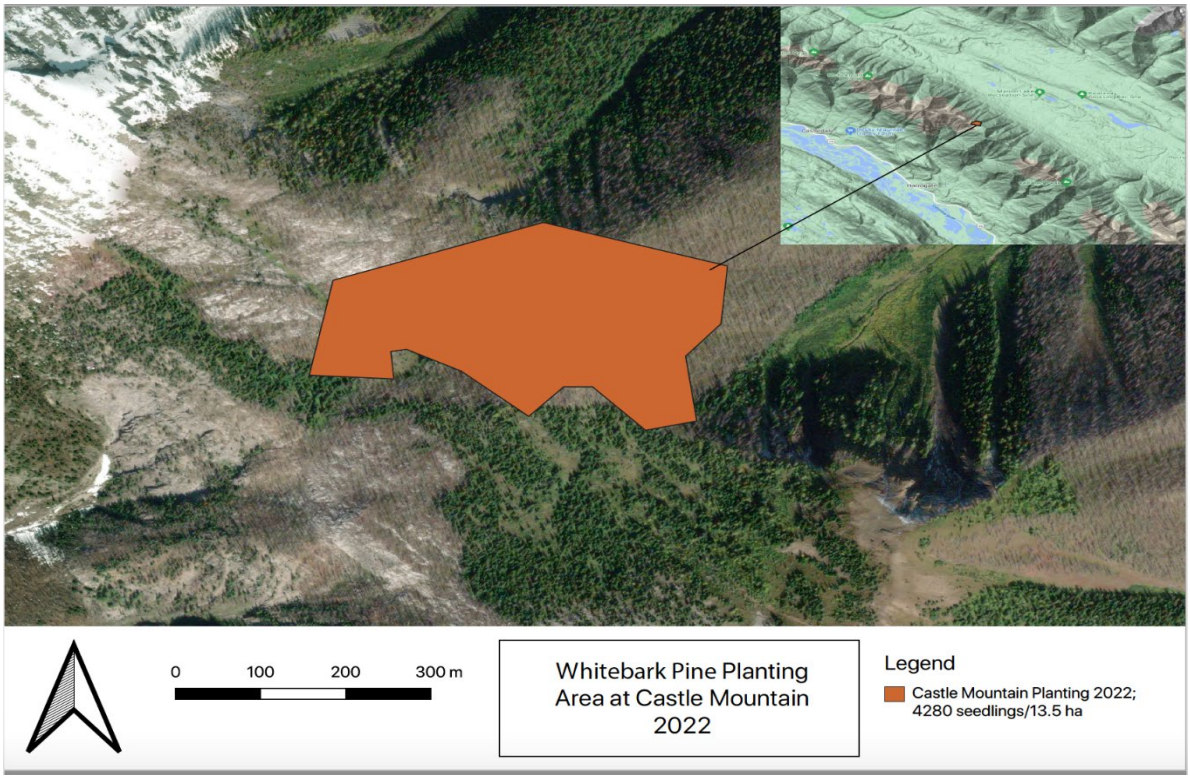


Figure 1. Planting area on Castle Mountain south of Golden.

Figure 2. Burned whitebark pine at Castle Mountain planting area, not rock in foreground was common in some sections of the planting area.

At Mt. McKirdy, 10,080 seedlings were planted on September 14-15, 2022 over 23.1 hectares for a planted density of 436 seedlings per hectare (Figure 3); permanent monitoring transects were established here as well to facilitate future monitoring (Table 4).

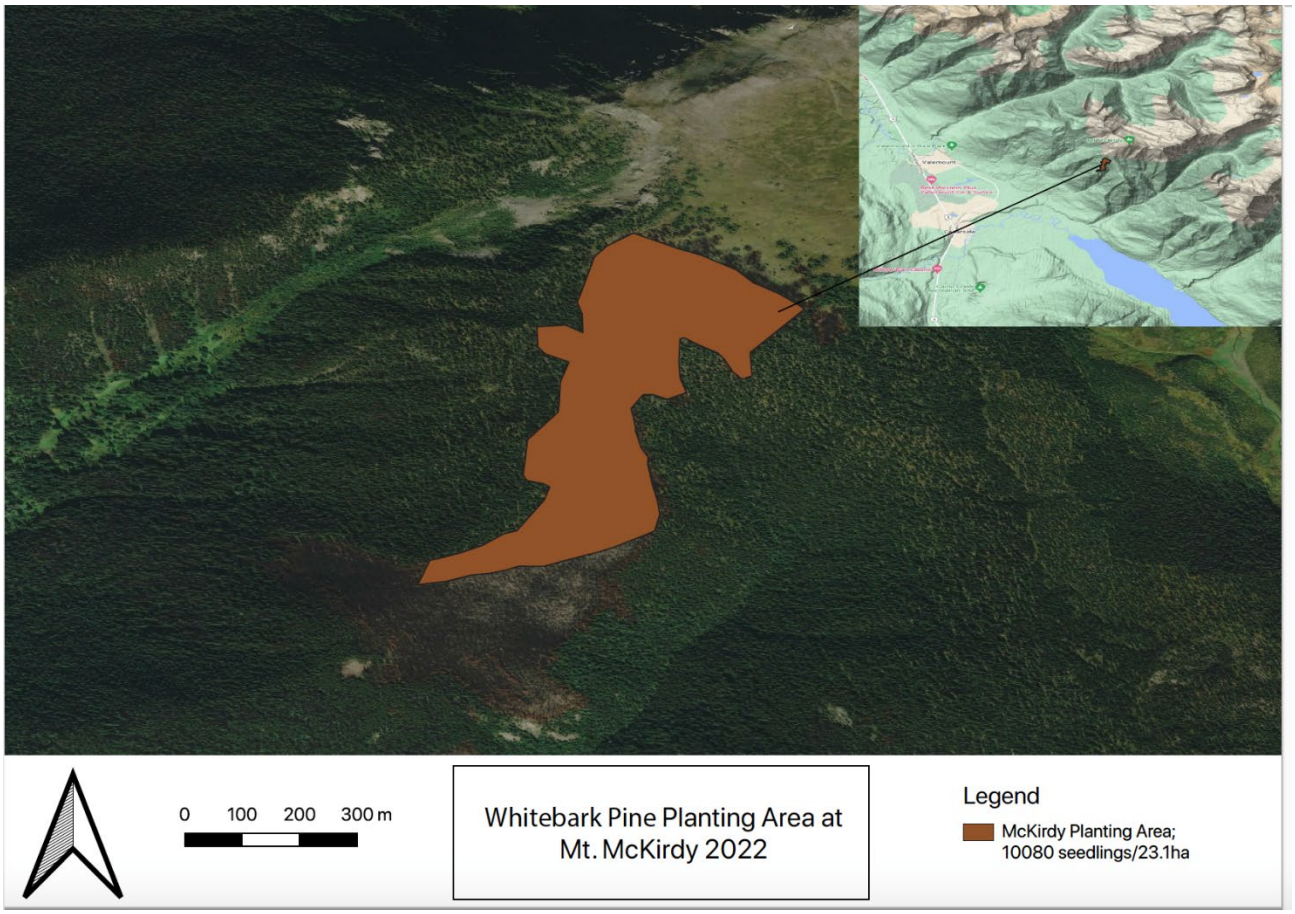


Figure 3. Planting area at Mount McKirdy near Valemount.

The Doctor Creek burn, about 35km west of Canal Flats, was planted on September 16th, 2022; 760 seedlings were planted over 1.45 hectares for a planted density of 524 seedlings per hectare (Figure 4 and Figure 5).. The site contained many dead standing trees that provided microsites for seedlings and the soil was mineral with little organic matter. The number of seedlings planted was limited because of restricted access. The planting crew was able to drive up partway but ultimately had to bag up and hike in the last few kilometers. A heli site was located here to facilitate expanded planting in 2023. Monitoring transects were established as at other sites (Table 4).

Figure 4. Burned whitebark pine stand in Doctor Creek burn.

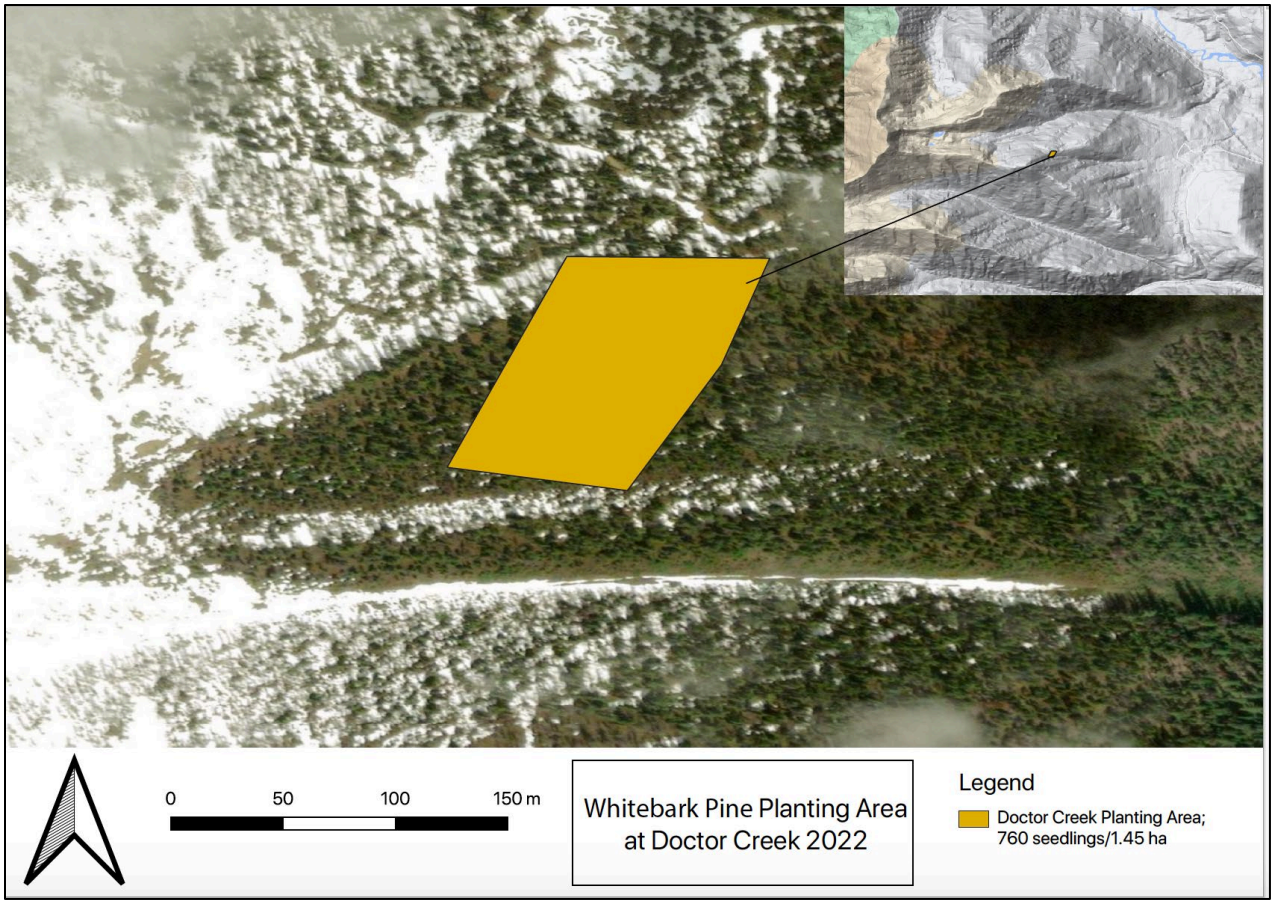


Figure 5. Whitebark Pine planting in Doctor Creek burn near Canal Flats.

Planting Monitoring

Permanent monitoring transects were established at all planting sites to aid in tracking the success of planted seedlings on site (Table 4). These transects are 30 m in length and have 30 seedlings planted every metre beginning at the 0.5 m mark.

Table 4. Summary of transect start-end coordinates for planting monitoring.

Site	Latitude	Longitude
Castle Mountain transect A start	51.02821	-116.40868
Castle Mountain transect A end	51.02799	-116.40850
Castle Mountain transect B start	51.02983	-116.40965
Castle Mountain transect B end	51.02979	-116.40926
Castle Mountain transect C start	51.02815	-116.41325
Castle Mountain transect C end	51.02806	-116.41372
Doctor Creek transect A start	50.12240	-116.13428
Doctor Creek transect A end	50.12205	-116.13435
Mt. McKirdy transect A start	52.826599	-119.151961
Mt. McKirdy transect A end	-	-
Mt McKirdy transect B start	52.832546	-119.149041
Mt McKirdy transect B end	-	-

Planting monitoring from work conducted in 2020 and 2021 was completed at four sites: Hourglass, Kianuko, Hugh Allen, and Spillimacheen.

At the Hourglass Lakes site trials were established on cool, level, and warm aspects with seedlings planted as singles, doubles, or triples. Overall two-year survival was 83% across all sites with the high elevation warm site having the greatest survival at 89% (Table 5). Planting in groups of three seedlings had the highest overall survival but only a single point higher than planting as singles (Table 5).

Table 5. Summary of planting survival at the Hourglass Lakes planting trial established in 2020.

Site	Singles	Doubles	Triples	Site
Low Elevation Cool	87%	77%	87%	84%
Level	67%	77%	87%	77%
High Elevation Warm	100%	83%	84%	89%
Totals	85%	79%	86%	83%

At Kianuko Provincial Park, five plots were established to monitor seedling survival from 2020. Five 11.28m fixed radius plots were established, two of these plots (2 and 4) had extensive grizzly bear excavation for glacier lily bulbs. The mean sampled density was 325 stems/ha (+/- 213) across the five plots (Table 6).

Table 6. Summary of planting survival density at Kianuko Provincial Park planted in 2020.

Plot	Count	Stems/ha
1	19	475
2	8	200
3	15	375
4	1	25
5	22	550
Mean Density Stems/ha (St. Deviation)		325 (+/-213)

At Hugh Allen near Valemount, two planting transects established in 2021 were re-sampled with survival rates of 100% and 97%, plot one had all 30 seedlings survive and plot two had 29 of 30 seedlings survive. Surveys were also conducted outside of the transects to determine stocking for the planted area with a five plot mean of 430 (+/-97) stems/ha; which given the width of one standard deviation, is within the planting target of 500/ha (Table 7).

Table 7. Summary of planting survival density in the Hugh Allen Burn planted in 2021.

Plot	Count	Stems/ha
1	17	425
2	20	500
3	17	425
4	11	275
5	21	525
Mean Density Stems/ha (St. Deviation)		430 (+/-97)

At the Spillimacheen planting site south of Golden, two monitoring transects were measured with survival levels of 88% and 100% for a site level survival of 94% (Table 8). Attempts were also made to establish a series of fixed radius plots around the site; however, heavy thunderstorms on the day resulted in the crew being evacuated by helicopter and the plots were not completed.

Table 8. Summary of planting survival at the Spillimacheen planting site.

Transect Number	Live Seedlings	Dead Seedlings	Percent Survival
1	22	3	88%
2	30	0	100%
Mean Survival			94%

Competition Removal

Competition was removed over a total of 2.04 ha at two locations. Competition was removed at the Perfect Valley and Ventigo Valley regions around Sorcerer Lodge located just north of Glacier National Park in the Rogers Pass area (Figure 6) and near the VOR Tower on Mount Puddingburn (Figure 7). At the Sorcerer Lodge site competition was removed over 1.41 ha; at the VOR Tower sites, a total of 0.63 ha was cleared along the powerline corridor servicing the VOR Tower. At Sorcerer competition was removed from around an estimated 50 trees with an estimated 300m^2 radius cleared around each tree. During clearing, healthy whitebark pine were located and competition growing in the understory was removed to prevent the more shade-tolerant competition from growing up into the canopy and to reduce the level of ladder fuels around each tree in the event of wildfire.

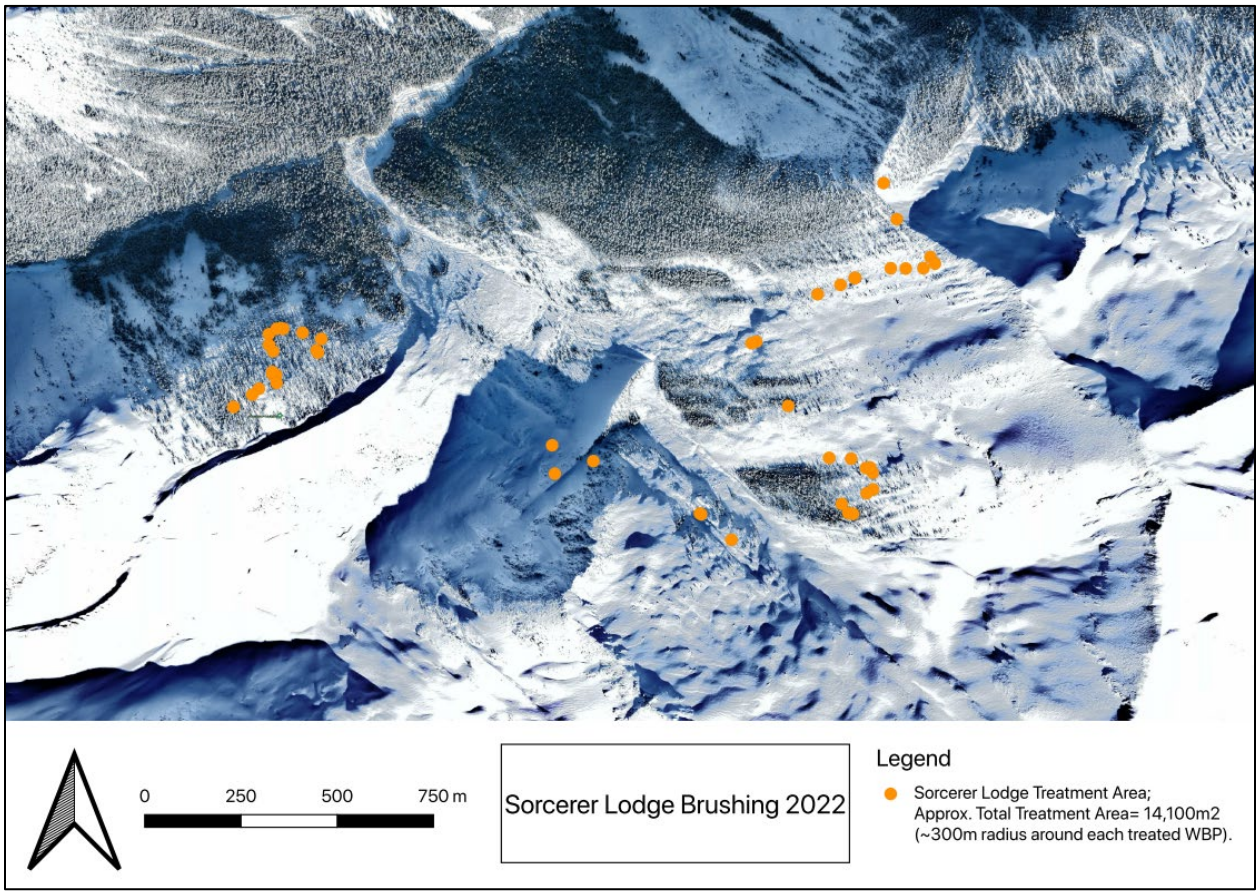


Figure 6. Locations of whitebark pine trees that had competition removed in the Sorcerer Lodge region.

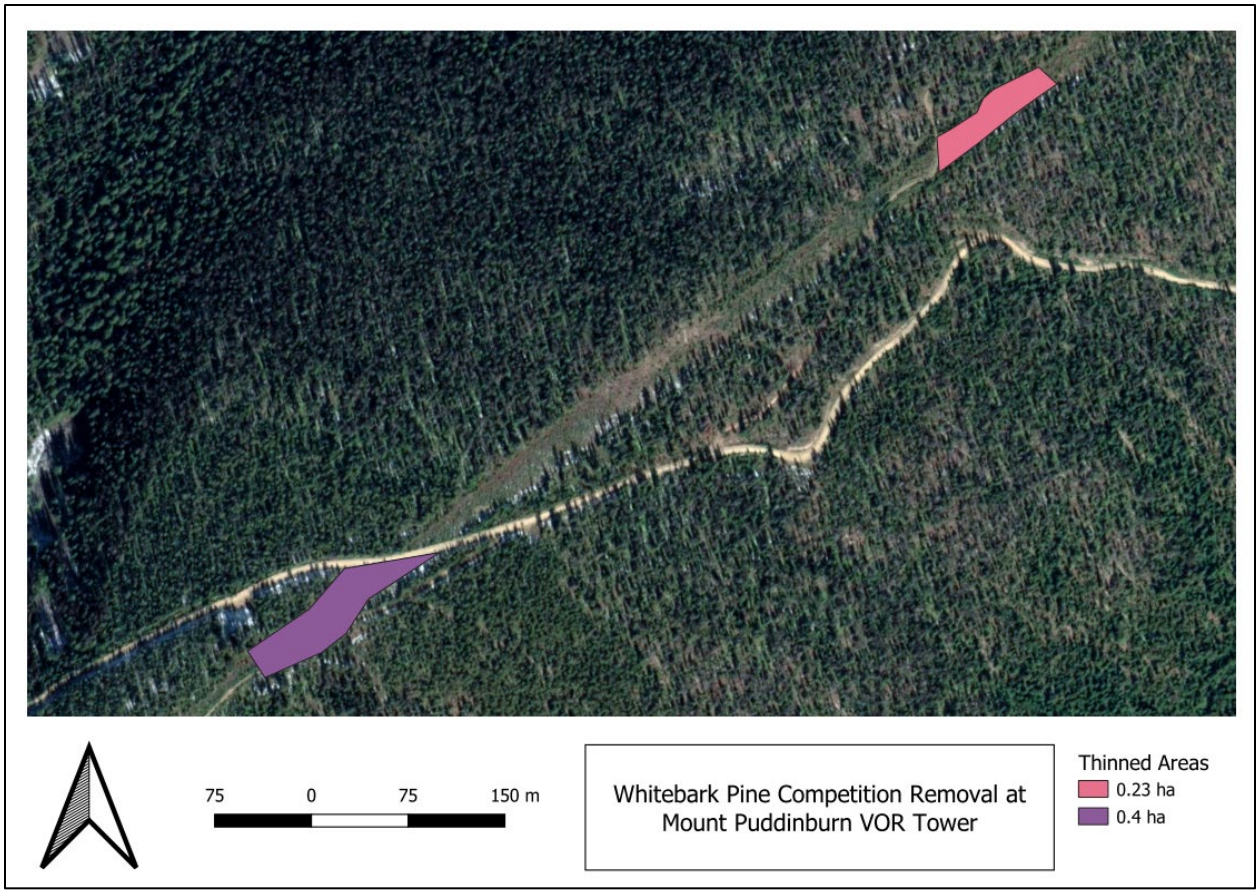


Figure 7. Thinned area near the VOR Tower on Mount Puddingburn; the area between these two areas was thinned in 2021.

Plots were also established at the Lavina Lookout and in the Bobbie Burns region to determine the competition removal needs. At the Lavina site whitebark pine was the tallest species but had height competition from lodgepole pine and from the high density of subalpine fir growing up in the understory which will eventually compete with whitebark pine and limit regeneration opportunities (Figure 8); at the Bobbie Burns site, whitebark pine generally occurred at the same densities as subalpine fir (Figure 9).

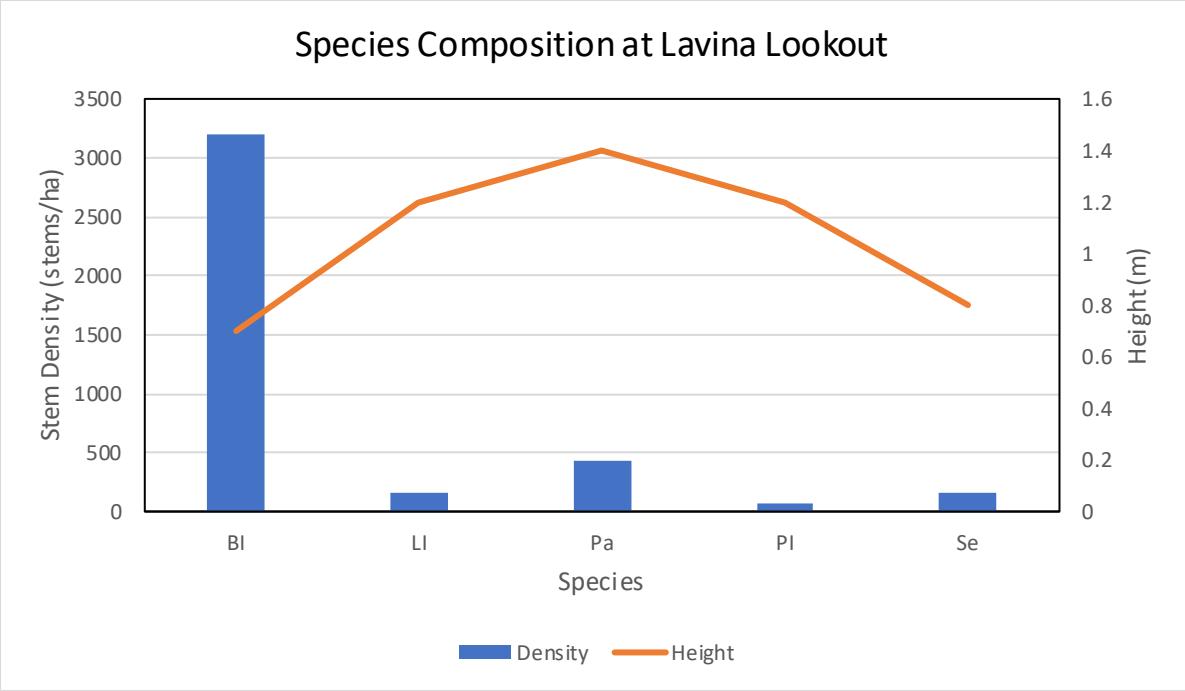


Figure 8. Summary of species composition at Lavina Lookout; Bl- subalpine fir, Ll – subalpine larch, Pa – whitebark pine, Pl – lodgepole pine, and Se -Engelmann spruce.

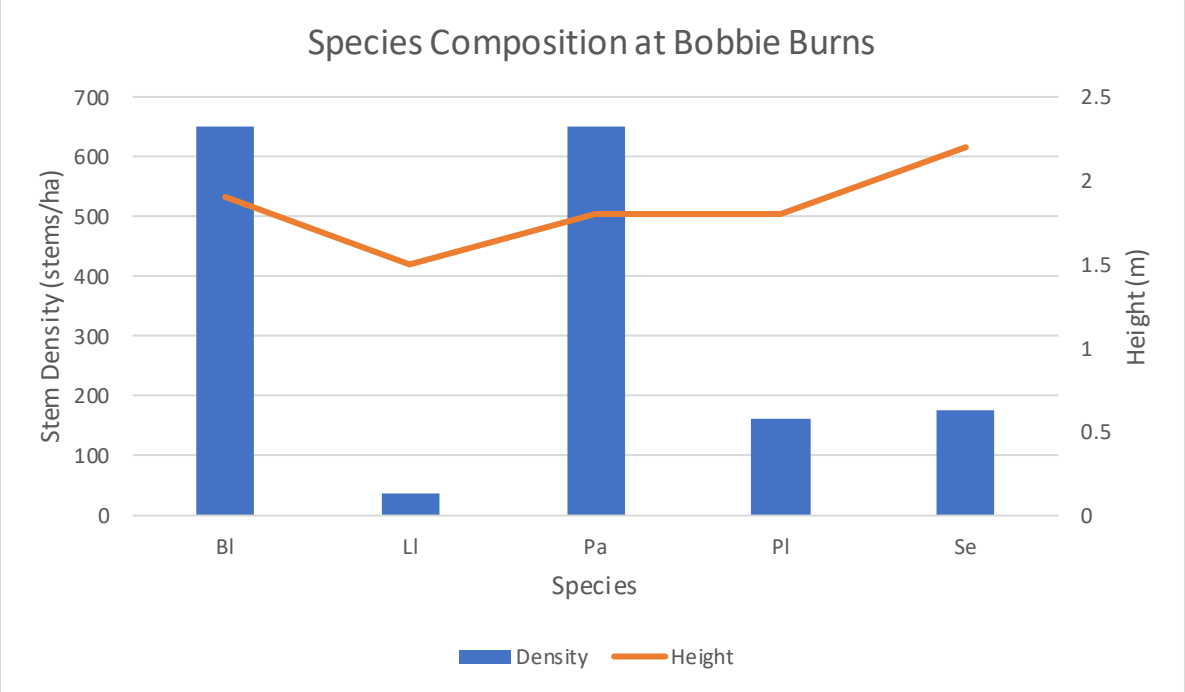


Figure 9. Summary of species composition at Lavina Lookout; Bl- subalpine fir, Ll – subalpine larch, Pa – whitebark pine, Pl – lodgepole pine, and Se -Engelmann spruce.

Outreach

We conducted outreach at McBride Peak and Swift Mountain near Valemount. These events were attended by members of the Simpcw First Nation and the Valemount Community Forest (Figure 10). Training included sampling and identification of blister rust, setting up monitoring transects, cone collections, restoration site identifcation, and reporting. The first day was attended by Simpcw community members only and the second day near Valemount also had employees of the community forest in attendance; seven participants attended the first day and nine participants attended the second day. These groups are likely to continue implementing whitebark pine recovery in the future. The local newspaper in Valemount featured an article about the work in the region thanks to participants reaching out [www.therockymountaingoat.com/2022/11/local-tree-planters-help-rescue-whitebark-pine/] and several interested locals hiked in to the site to observe the planting that was written about.

Figure 10. Outreach and training on Swift Mountain near Valemount.

Discussion

Health Surveys

The health surveys implemented for this project highlighted the variability of whitebark pine health in the Columbia region of BC. The Quartz Creek and Kisoo surveys indicated that any healthy trees in the region may have some resistance to blister rust as only 9% and 3% respectively were identified as healthy. Specific plus trees should be confirmed in these regions and monitored for cone production and targeted cone collections for submission to rust screening programs.

The permanent transects were submitted to the provincial monitoring team managed by Parks Canada; these transects will now be measured at 5-year intervals. Thus far we have not identified dense enough stands of whitebark pine in the Columbia region between Valemount-Golden-Revelstoke to establish permanent health transects, this will be a future objective of recovery planning in the region.

Cone Collections

Cone collections were undertaken primarily due to the presence of a large cone crop in 2022; based on the crop from 2021 we did not anticipate such a large crop in 2022 but were able to mobilize resources and capitalize on the large crop that was identified. Large crops were identified incidental to other work such as outreach in the Valemount-McBride area and conducting health surveys. This cone collection scenario underscores the need to be able to pivot to collections during years of high production as these may be followed by years of little to no cone production which can greatly delay restoration work.

The nine parent trees submitted to rust screening will be grown through 2023 and screened in 2024 with results not known until 2027. This seed contribution represents about 15% of the screening seedlings for 2024. In discussions with other agencies (BC Parks, Parks Canada, Alberta Recovery Team), the submissions to the program in 2023 are likely to be much lower as seed crops are not anticipated; thus, if cone crops materialize in the region a high proportion of submitted seed may be accepted to the screening program. As occurred in 2022, any early season field work should also serve as a cone survey to identify the production level on the landscape or specifically in the healthiest cohort of trees.

Planting

Planting was conducted at three sites covering a vast geographic area each with monitoring transects established. These transects should be re-measured in years one, three, five, and onwards. Although planting is the primary means of restoration, there remain challenges such as efficient planting approaches (helicopters are costly) and ensuring high levels of survival. The high survival levels across all plantings is a testament to the seedling quality and selection of appropriate sites. Whitebark pine occurs across a broad ecological amplitude and when considering events such as the heat dome of 2021 and potential future stressors, it may be prudent to plant in 'safer' and ecologically lower stress sites to ensure these high survival rates are maintained.

Planting Monitoring

The monitoring plots and transects showed that whitebark pine survival was quite high in the first several years following planting and this monitoring approach should be continued. Given the ease of measuring these transects with a relatively high sample size (~30 seedlings), establishing a series of transects at time of planting across the planting area is likely more efficient than the fixed radius approach currently paired with the transects. Based on current planting densities of approximately 500 seedlings/ha, a sample plot of 400m^2 should have 20 seedlings in it; however, locating these seedlings can be challenging given the small seedling size, cryptic nature of the seedlings when compared to existing vegetation, and when there is mortality in young seedlings it is difficult to know if the plot area was underplanted or a seedling has died and decayed. Along a planting transect seedlings occur at known intervals and repeated sampling will aid in better determining cause of morality, namely was rust or site related factors responsible. Establishing up to five permanent transects throughout the planting area at time of planting will likely result in more effective and efficient monitoring of planting success.

Competition Removal

Competition removal can be both a highly impactful and challenging management approach. It may be impactful in that many of the seedlings/saplings that are being supported through competition removal are well established and not as vulnerable as seedlings planted at the same site. In many instance the sites may have represented a regeneration sink with high whitebark stocking but low odds of recruitment to large size classed due to competition levels, competition removal removes this potential competition induced sink. Even when whitebark pine is the tallest tree in the stand such as at the Lavina survey area, the high density of subalpine fir is troubling as it is shade tolerant and can effectively spread laterally; thus, even where whitebark pine appears successful, a prudent approach is to remove competition while it is still small and easy to manage to ensure recruitment of whitebark pine to reproductive sizes.

Competition removal can be challenging in instances such as encountered this year near Sorcerer Lodge where trees were diffuse on the landscape and workers had to located well-spaced individual trees and work out from each one; conducting this work in higher stocked stands is a more efficient approach as clearing around one tree often grades into the next and treatments can be more easily measured by area treated as opposed to individual trees treated.

Another challenge of competition removal may be that the newly opened stands will allow greater interception of rust spores by the remaining whitebark pine trees. Thinning moves the tree out of the competition threat category into the blister rust threat category; given that in the pre-thinned state trees faced a dire and certain threat due to excessive competition, shifting this threat to rust may result in a restoration gain if trees have resistance or are able to escape infection, resulting in a restoration gain.

At both Lavina and Bobbie Burns the primary species for removal will be subalpine fir which is highly competitive as it is shade tolerant and can spread via layering, virtually smothering smaller trees. Other tree species will also be removed where they directly compete with whitebark pine but the cutting of these species will be limited; in general subalpine larch (Ll) is not cut during our treatments as like whitebark pine it is not an overwhelming competitor. Given the high density of whitebark pine at Bobbie

Burns, the only treatment will be competition removal to support the established trees whereas at Lavina it is likely that some supplemental planting may conducted to bolster the population.

Outreach

The outreach conducted was to both interested individuals and to Professionals and technicians delivering whitebark pine recovery projects. Given the vast range of whitebark pine and the high levels of rust observed in our survey work, it is clear that extensive outreach is required to build the expertise needed to recover whitebark pine across its range. It is probable the topics covered in the outreach should be re-visited with participants over time to ensure the knowledge uptake remains. That individuals took it upon themselves to visit the restoration site underscores the interest in this species and recovery personnel should take note and find ways to empower the public in aiding with recovery.

2022 Recommendations

Based on the fieldwork undertaken in 2022, the following recommendations were developed:

- Conduct future cone collections in the Quartz Creek and Kisoo regions where rust levels were very high, increasing the likelihood of locating rust resistant parent trees;
- Submit transect data to Parks Canada to be incorporated into their rust monitoring program, which extends across the range of whitebark pine in Canada;
- Establish additional health transect/surveys in the Kinbasket region;
- There is only enough seed for one-year of planting in storage, cone collections should be prioritized when large cone crops are present or when rust resistant trees are producing a cone crop;
- Establish five permanent 30 m transects across each planting area to be sampled in years 1, 3, and 5;
- Plant seedlings as singles as grouping seedlings reduces the area treated and did not lead to greater survival;
- Avoid areas of high grizzly bear excavation, survey sites for glacier lilies or spring beauty prior to planting;
- Competition removal should be monitored to determine if supplemental planting is required to fully stock the site;
- Competition removal sites should be monitored to determine if rust levels increase;
- There is an appetite among both the public and practitioners to aid in whitebark pine recovery, outreach offerings should be expanded to ensure participants are properly trained.

Multi-Year Project Achievements

This was the fifth year of a five-year project, In the first four years of this project, we achieved the following objectives:

In year-one of this project we collected seed from over 350. This seed is being grown into seedlings and will be deployed in years 3 – 5 of the project. This was originally a 3-year project with all seed and seedling to be planted in year-three; however, the seed yield was so high that the project was expanded to five years.

In year-two of the project, Aboriginal Funds for Species at Risk (AFSAR) funded work to identify planting locations across the province, primarily in recent wildfire areas.

In year-three of the project we planted 6,000 seedlings at Kianuko Provincial Park, Hourglass Lake, and Kootenay Pass. We removed competition from around seedlings at Bootleg Mountain, Mount Puddingburn, and pre-surveyed competition removal at the Mount Bradford site. We surveyed five cutblocks in the region and worked with licensees and BC MFLNRO to better integrate whitebark pine management with the forest sector. Extensive outreach was conducted with youth in Kimberley who started and grew whitebark pine seedlings for planting; unfortunately, COVID limited the completion of this outreach where students were going to plant the seedlings they started.

In year-four of this project we planted 28,350 seedlings at eight locations in the Columbia Basin. This included adding fertilizer at several sites and brushing to improve the 'plantability' of some sites. Planting occurred from the Valemount region south to Kimberley region. We removed competition from around whitebark pine saplings over nearly 2 ha in collaboration with NAV Canada in an agreement that will see whitebark pine retained and pruned under a powerline as opposed to cutting the trees.

Project Successes

Overall whitebark pine recovery work generally has a high level of success, namely:

- Planting: Planting on all site types showed excellent survival over several years, this result will allow for a broader selection of sites for future planting. In the past planting typically occurred on warmer sites similar to those used by the Clark's nutcracker for seed caching; low numbers of whitebark pine occur on cooler wetter sites but these were typically avoided for planting as competition levels were generally greater and assumed to be a limiting factor. The success of planting on cooler sites supports increasingly including these sites in planting prescriptions where competition is moderate, drought is a concern, or as events such as heat domes become more frequent.
- Cone Collections: Adding new sites to the cone collection list was a great success as cones are not produced at all sites each year; for example, at the VOR tower only 35 cones were collected in 2022 whereas over 400 cones were collected at Mount Peter, which is in the same mountain range but 100 km to the north. Increasing the number of suitable cone collections sites allows for a greater likelihood of some cones being collected each year as opposed to years of complete failures due to limited collection options. Further, that the two new collection sites utilized in 2022 were identified largely due to outreach results and keen members of the public bringing them to our attention speaks greatly to the integration outreach can have with recovery initiatives.
- Competition Removal: Competition removal has largely been the domain of prescribed fire specialists and its role in overall whitebark recovery somewhat downplayed as implementing these treatments was generally restricted to the National Parks. Surveys of cutblocks during the midpoint of this project identified that timber harvest areas housed a high density of whitebark pine seedlings and were likely serving as a whitebark pine regeneration sink as these seedlings had a low probability of growing to maturity as these sites are managed to favour merchantable species. Fortunately, when these sites were presented to forest managers, ideas on co-management of sites were developed to allow for reduced stocking of merchantable species to favour whitebark pine and in some cases where future timber production was not the primary

objective and biodiversity objectives were favoured, treat the site to make it whitebrk pine leading. At the outset of this project, thinning cutblocks to favour whitebark pine was unimaginable, but now it is being proposed for several sites for implementation in 2023-24.

- Outreach: Outreach was very well received by community members and professionals alike, there is often some reservations on the uptake of outreach as whitebark pine is typically out of the scope of forest management and the public is more easily swayed to wildlife over plant species; however, its plight, habitat, and ecological importance all make it resonate with the public.
- Partnerships: Over the duration of the project, a number of partnerships were formed including working with ski areas and tenure holders, lodges, guide outfitters, First Nations, and industry groups. Many of these partnerships would not have formed if there was not a need to engage with local users during project implementation. These partnerships included sharing of local knowledge, providing accommodation, providing helicopter time, and direct field assistance. These partnerships will continue beyond the scope of this project and will be instrumental in furthering whitebark pine recovery in the future.

Project Challenges

Despite the successes of the project, implementing this project over multiple year highlighted several challenges (above and beyond the obvious pandemic years). These challenges included:

- Drought: In 2021 and excessive heat event occurred in BC with record high temperatures observed across much of BC. During whitebark pine planting in fall 2021 it was observed that soils were still extremely dry due to the spring conditions and there were concerns for the survival of these seedlings. This weather event motivated the establishment of planting trials on a range of sites including cooler 'climate safe' sites (see planting in success section). Though this drought did not result in any notable losses of whitebark pine seedlings, challenge may arise if these weather events become more common.
- Ski Tenures: In many areas of the project, namely in the Purcell and Selkirk Mountains, it was identified that numerous backcountry, heli, and cat ski tenures were present. These user groups favour skiing in burned stands, the very habitat type in which we are trying to restore whitebark pine. While these tenures present challenges for project implementation they also presented opportunities for success (see partnerships in success section). The challenges in these areas included: i) tree planting – these area ideal areas for planting but naturally these tenure holders do not want trees growing into their terrain; ii) added bureaucracy – prior to restoring sites, it is important that proper permits are obtained, which include all tenure holders, as tree planting can directly impact ski terrain, the review by the ski industry may be more thorough than other tenure holders; and iii) many tenure holders actively glade their ski runs to reduce tree cover, including the removal of whitebark pine. In areas that have been gladed in the last decade, many runs are 'wide open' but planting seedlings presents a challenge as noted above; the ideal scenario is for advanced whitebark pine regeneration to be present and restoration undertaken to remove other species to open runs and retain any whitebark pine present on the slope.
- Bear Impacts: Whitebark pine occurs in prime bear habitat and we encountered challenges with bears during both planting and seed collection. In one instance a grizzly bear excavated a planting area to feed on glacier lilies, prompting a need to ensure summer surveys of planting areas are conducted to ensure the location of these sites is identified prior to planting these

risky sites. Bears have also interrupted our cone collections at three separate locations by actively removing cone cages and feeding on the encaged cones. To address this challenge, cones should be collected as soon as possible in the fall, as the feeding was generally observed in the latter half of September. Where this feeding occurred, there were numerous uncaged cones remaining on the trees and it was assumed that the bears were likely using the cages as an indicator for cone locations.

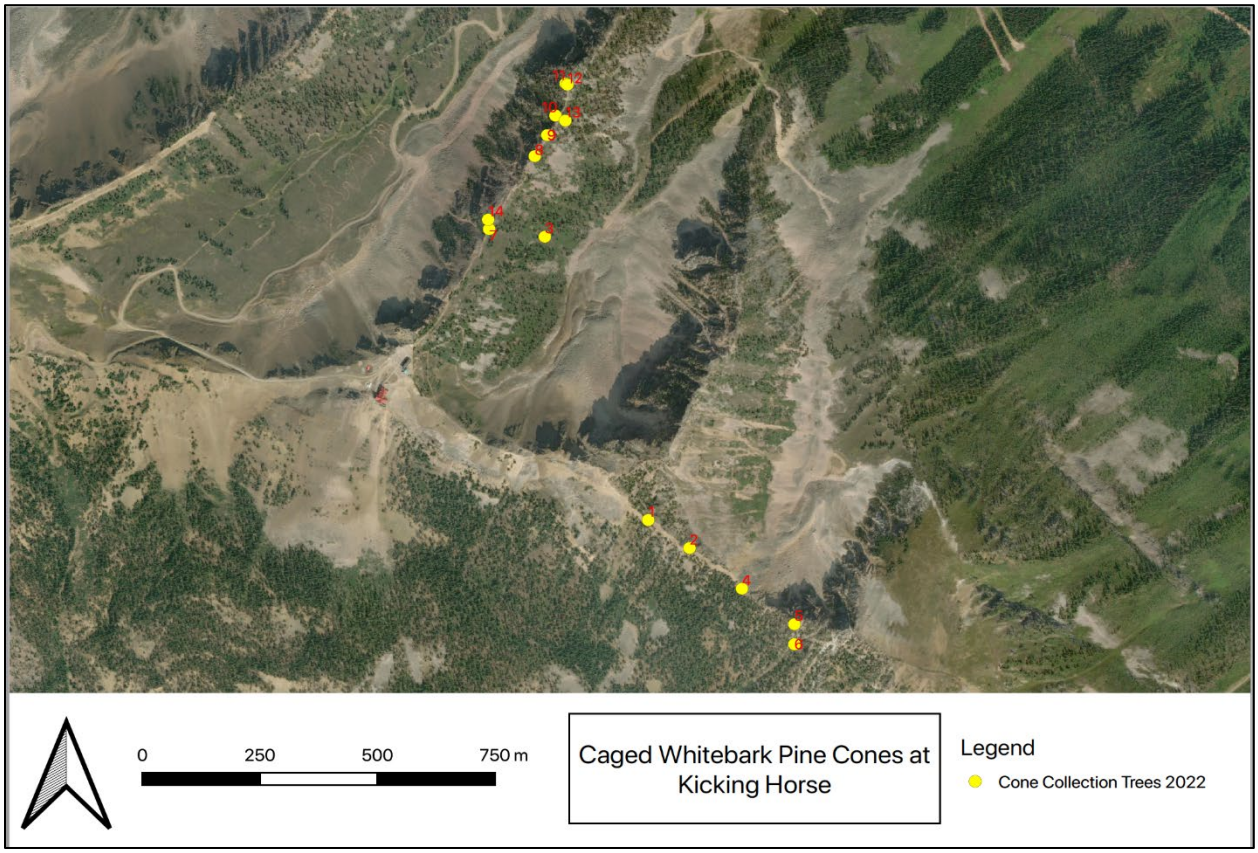
- Whitebark Pine Seedlings: Whitebark pine seedlings are a relatively new crop for most nurseries, with most nurseries having less than a decade of experience in their production. Whitebark pine presents a novel challenge to nurseries as it has a long stratification period (6 months), has seeds too large to utilize existing mechanized methods, takes two-years to produce a plantable seedling, and has comparatively low nursery success ranging from 40 to 60% of seeds growing into a plantable seedling. These nursery factors make planting planning challenging as the number of seedlings produced from a number of given seeds can vary greatly; planning must be conducted over a longer time frame including starting seedlings under one funding cycle with finishing and planting occurring under another funding cycle; and seedling cost can vary greatly as nurseries want compensation for their labour not just for seedlings produced. For example, two seedlots of 10,000 seeds will cost the same, one that yields 4,000 seedlings costs more per seedling than one that yields 6,000 seedlings; seedling cost is the typical budgeting and planning tool used in planting, thus these variations in seedling cost must be considered during planting planning.

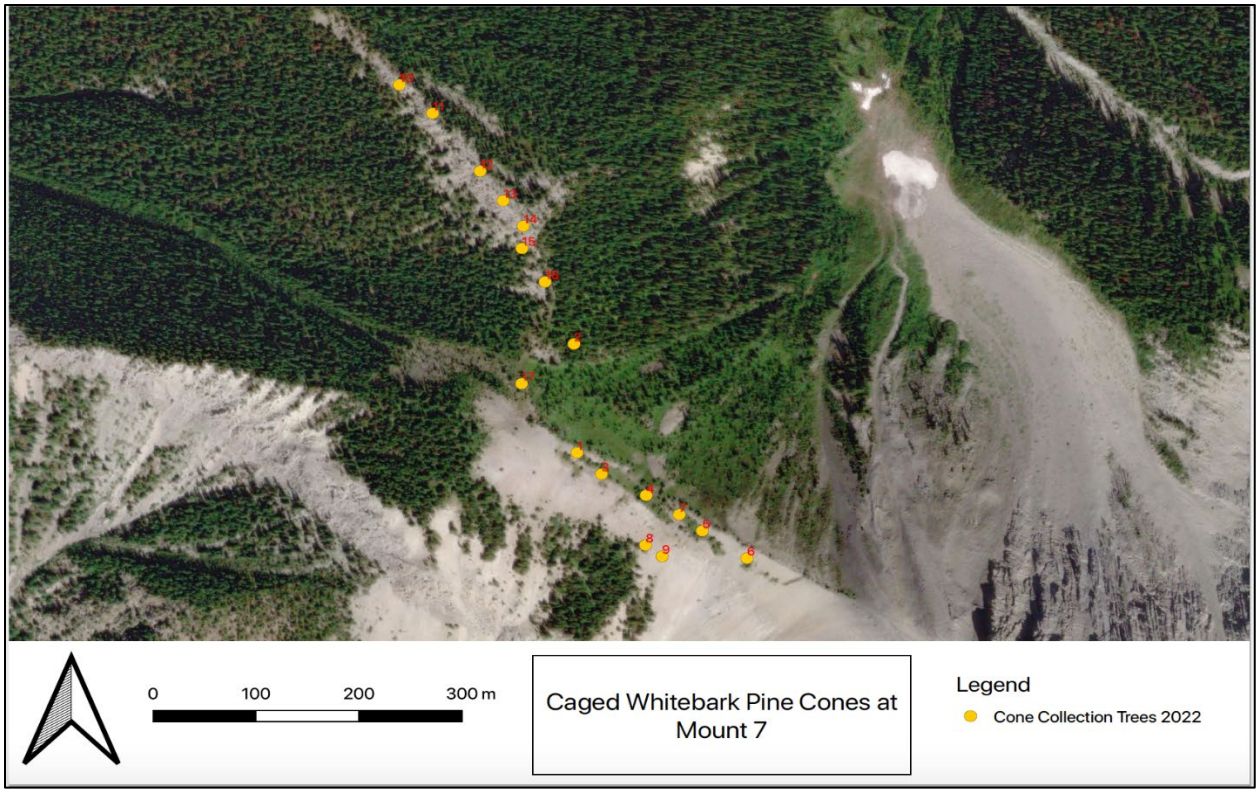
Next Steps

Whitebark pine continues to need active restoration across its range, including within the Columbia basin, where whitebark pine decline shows no signs of slowing. Groups including government, First Nations, industry, and non-profits all continue to work on recovery and there has been an increase in restoration actions. Related to the work described in this report, the next steps for whitebark pine recovery in the region include:

- Host regular stakeholder meetings to identify restoration needs, identify constraints, and identify opportunities.
- Conduct large cone collections to ensure a surplus of seed and submit seed to the provincial rust screening team.
- Recommend cones be collected as close to September 15 as possible to limit bear predation.
- Seek long-term funding to provide a continual and reliable seedling supply.
- Identify competition removal sites in cutblocks that have been removed from timber supply due to recreation or biodiversity management needs.
- Identify and plant sites that are climatically safe (mesic sites), bear safe (avoid glacier lily or spring beauty), and skier safe (ensure tenure holders review plans).
- Continue monitoring whitebark pine treatments.
- Continue outreach with all groups to aid in the identification of new sites, build a core of volunteers to assist in recovery, and build awareness around the importance of this keystone species.
- Train technicians and volunteers to aid in recovery, whitebark pine covers a vast area and to effectively restore it we need to improve the number of skilled individuals working on recovery.

Appendix A: Cone Collection Maps

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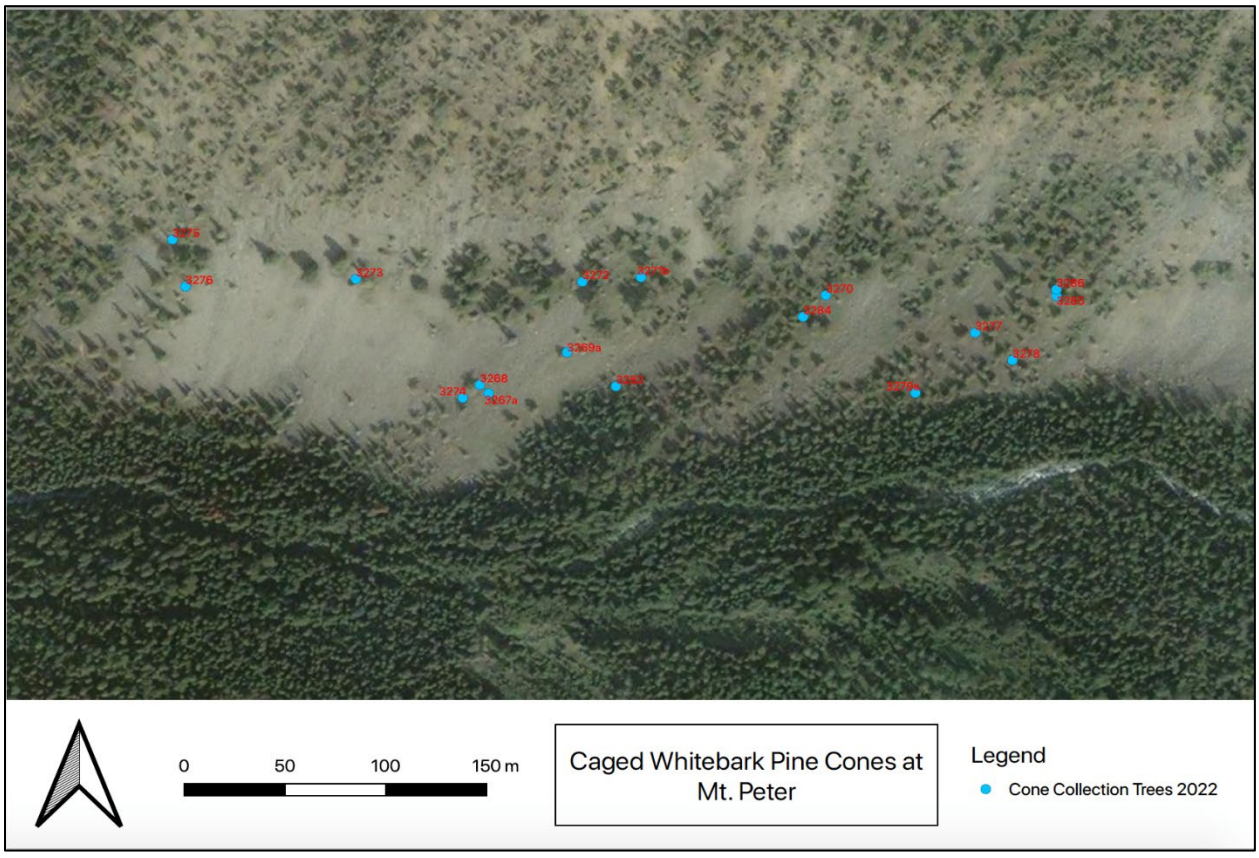
Caged Whitebark Pine Cones at Mount 7
Legend
Cone Collection Trees 2022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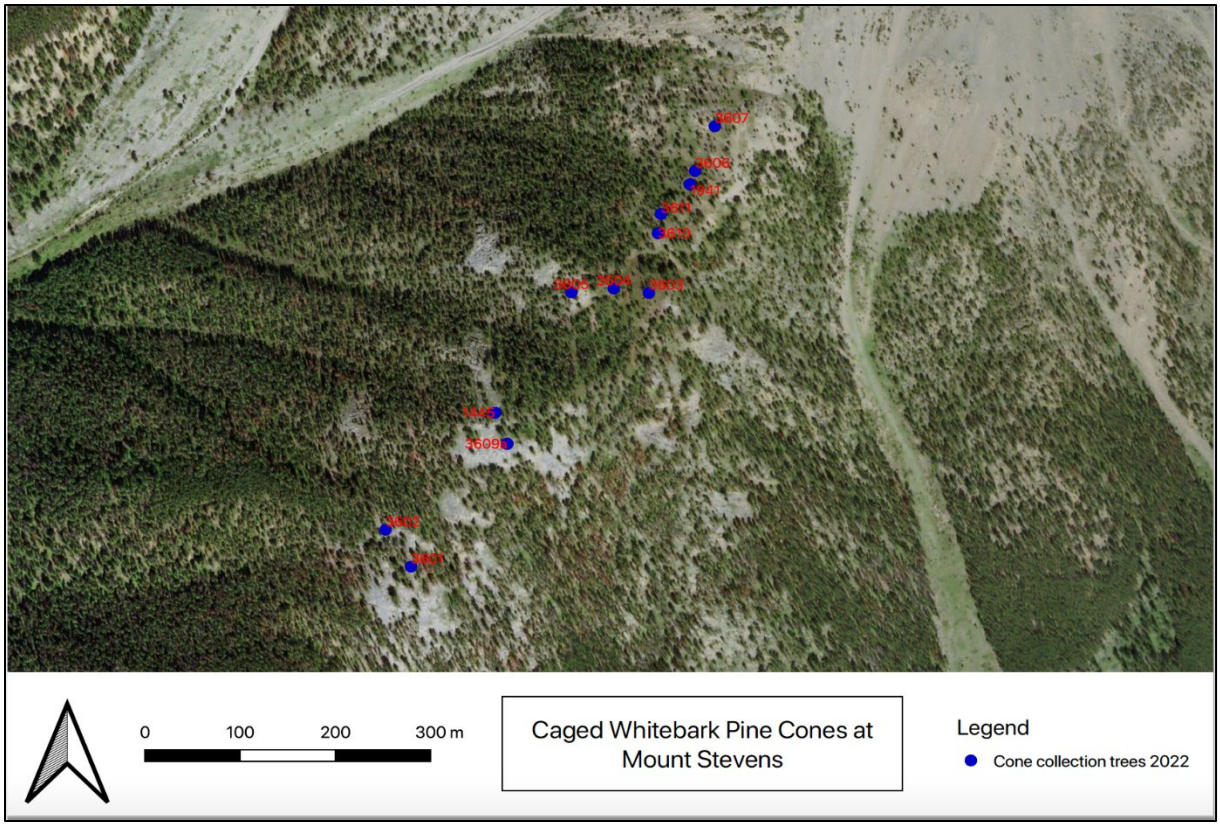
100
150 m
Caged Whitebark Pine Cones at Mt. Peter
Legend
Cone Collection Trees 2022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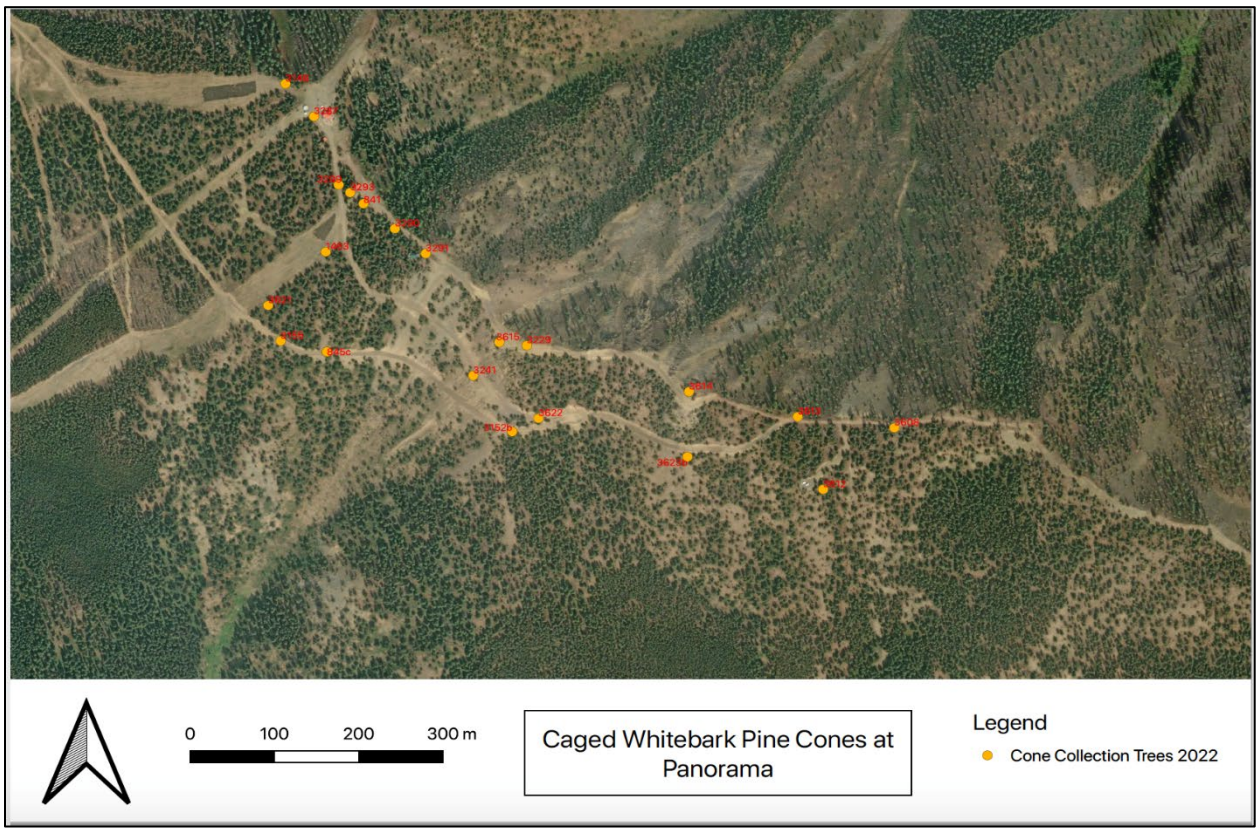
Legend
Cone collection trees 2022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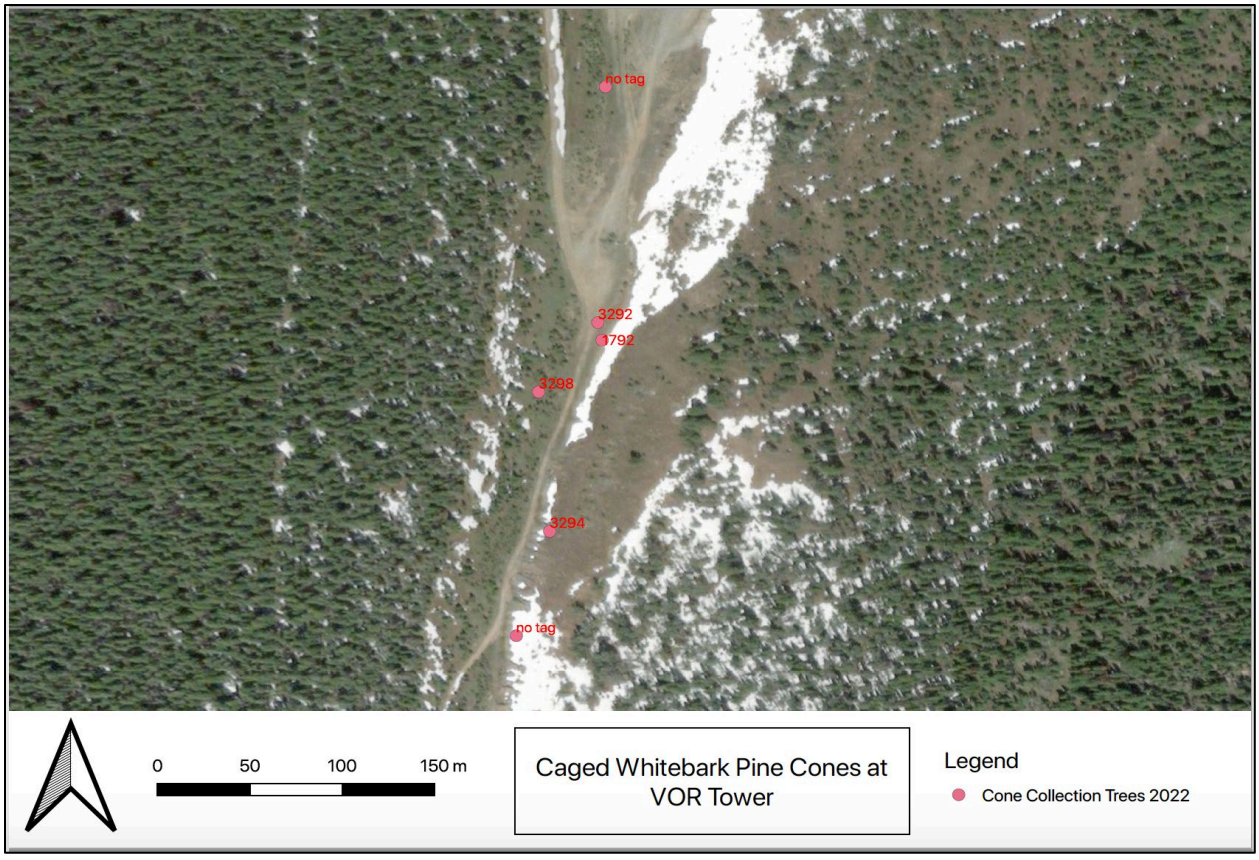
Caged Whitebark Pine Cones at Panorama
Legend
Cone Collection Trees 2022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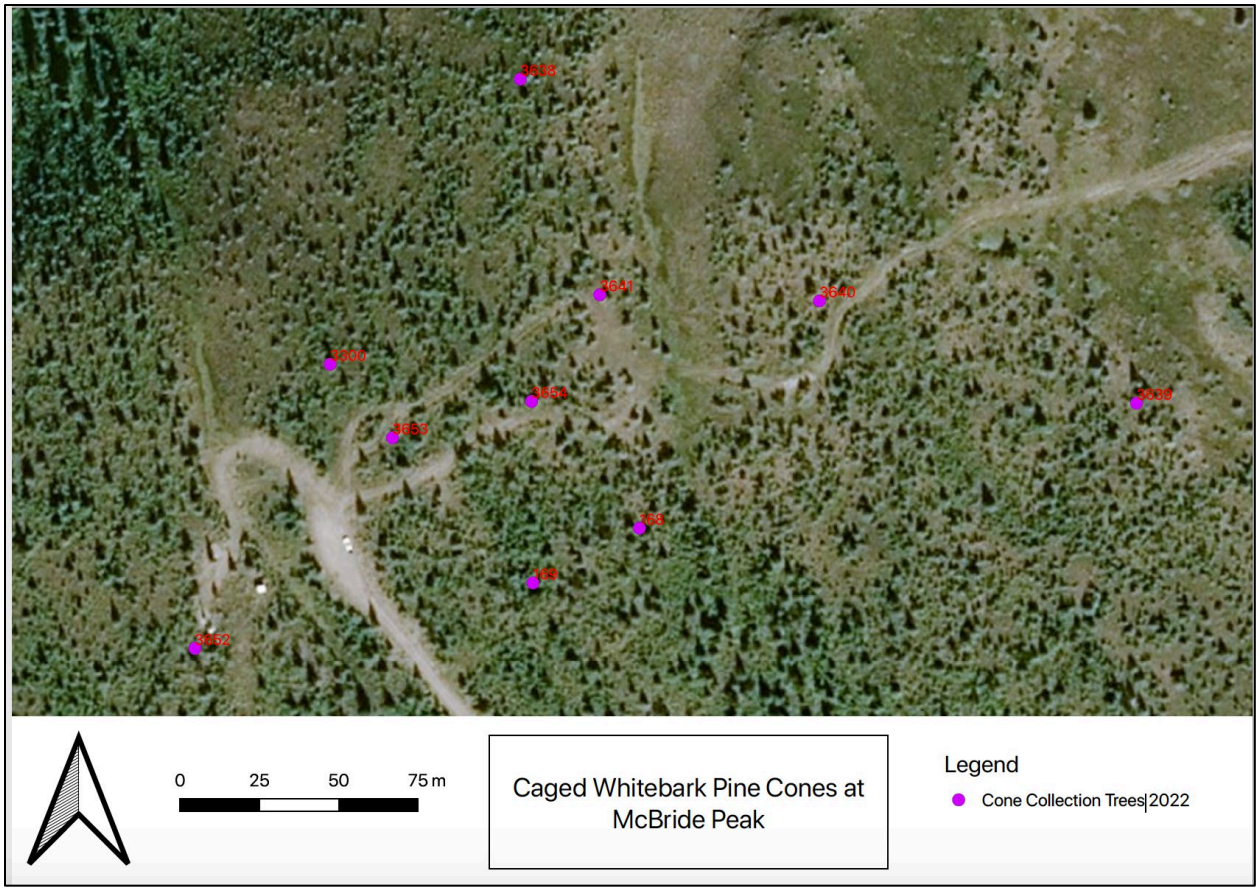
Caged Whitebark Pine Cones at VOR Tower
Legend
Cone Collection Trees 2022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3640
3650
3654
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3653
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3652
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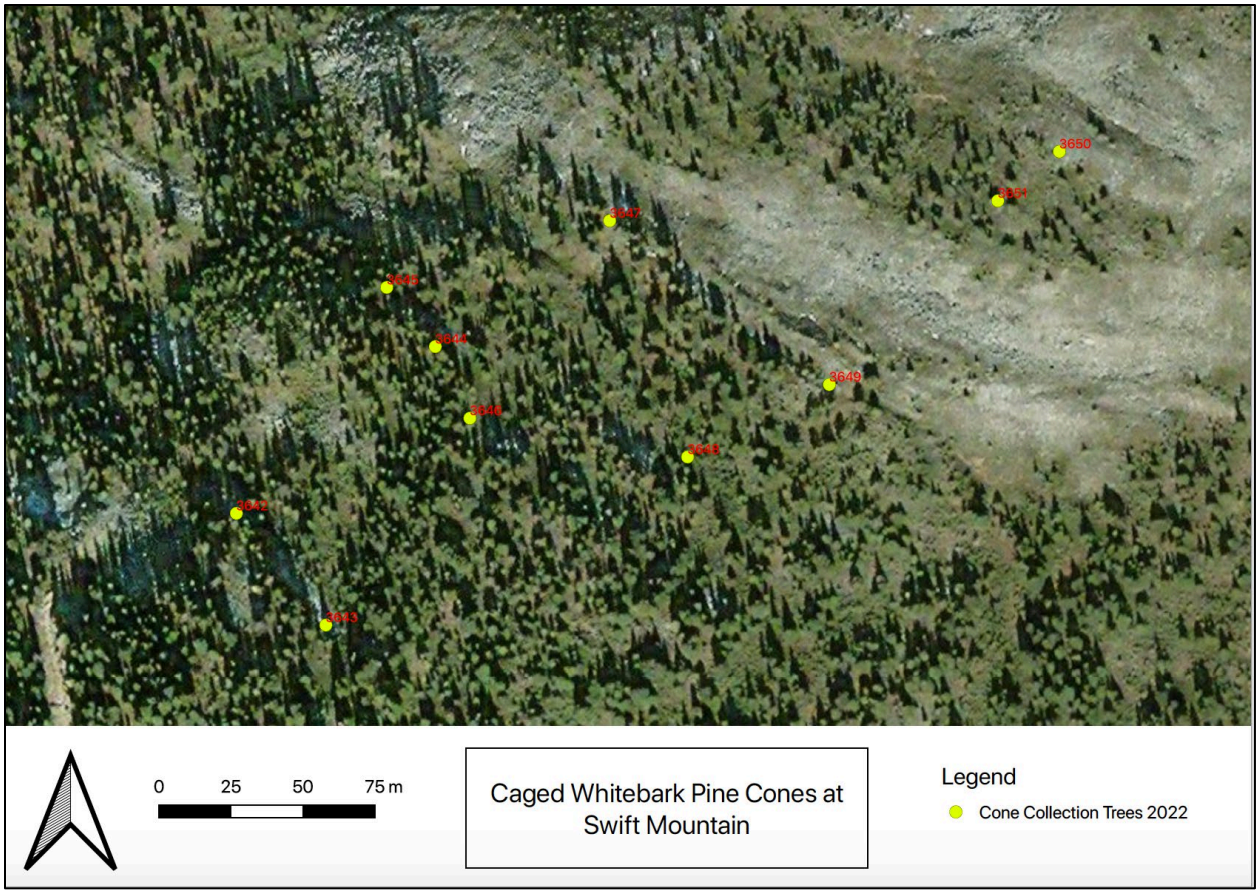
25
50
75 m
Caged Whitebark Pine Cones at McBride Peak
Legend
Cone Collection Trees 2022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0
25
50
75 m
Caged Whitebark Pine Cones at Swift Mountain
Legend
Cone Collection Trees 2022