Whitebark Pine Restoration in St'at'imc Traditional Territory

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Executive Summary

Whitebark pine (*Pinus albicaulis*) is a blue-listed species in British Columbia and listed as endangered under the Species at Risk Act (SARA) due to the impacts of: white pine blister rust, mountain pine beetle, fire suppression, and global climate change.

This project aligns with the Species Based Actions of the Upland and Dryland Ecosystem Chapter of the Bridge Seton Watershed Plan: 'BRG.UAD.SB.38.01: Build upon previously-funded Whitebark Pine work-P1.'

The objective of this project was to survey previous planting sites to gauge seedling establishment and to restore whitebark pine sites through planting. Surveyed densities identified survival rates of 55% and 74%; with measured densities of 225 and 221 stems/ha from the planted densities of 405 and 300. The survival rates are within expected rates. Although these survival rates are acceptable, suggestions to improve survival or increase stocking density were made including improving stock production to produce more robust seedlings and increasing planting densities at sites with easy access. A seedling production consultant hired by Splitrock Nursery in 2016 should result in the production of more robust whitebark pine seedlings in the future. All seedlings planted were from putatively resistant parents; given the moderate rust infection levels in the region, planting putatively resistant seedlings is likely to have high survival rates until seedlings with confirmed resistance are available.

Planting was conducted in five distinct units at three sites: Big Dog Mountain, Yalakom Provincial Park, and Blustry Mountain. A total of 3,248 seedlings were planted over 6.87 ha. This included planting in monitoring transect on Blustry Mountain. Each planting site required approximately a one-hour hike to access with each planter able to pack about 350 seedlings to site. This access constraint highlights some of the issues posed in increasing planting densities as suggested from the surveys as a large limitation is still present due to access issues.

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1. Introduction

The Whitebark Pine (*Pinus albicaulis*) is one of five "stone pines" worldwide, and the only species found in North America, that are co-evolved mutualists whereby cones contain energy-rich seeds that remain closed during maturation and require the services of animals for seed dispersal. In this case, the Clark's Nutcracker (*Nucifraga Columbiana)*, a member of the crow and jay family, fulfills that role.

Whitebark pine (*Pinus albicaulis*) is a blue-listed species in British Columbia and listed as Endangered under the Species at Risk Act (SARA) (BCDC, 2002; Environment and Climate Change Canada, 2017). These listings are largely due to four main agents:

1) **White Pine Blister Rust**
   White pine blister rust is caused by the fungus *Cronartium ribicola,* which was accidentally introduced to British Columbia in 1910 from Europe (Pigott, 2012). The fungus requires alternate hosts from the *Ribes* (currant and gooseberry), *Pedicularis* (lousewort), or *Castilleja* (Paintbrush) genera. Fungal spores are released from the alternate hosts and land on the needles of the tree (COSEWIC, 2010). The fungus enters through the stomata on the needles of the pine tree and travel down the branch to the main stem where it girdles and eventually kills the tree (Pigott, 2012).

2) **Mountain Pine Beetle**
   Mountain pine beetle (*Dendroctonus ponderosae*) can kill and reproduce in whitebark pine. Trees already weakened by white pine blister rust are more susceptible to mountain pine beetle attack (Alberta Whitebark and Limber Pine Recovery Team, 2014).

3) **Fire Suppression**
   Whitebark pine is a poor competitor. Under natural fire regimes, low intensity fires would burn through stands, removing the understory, which would allow whitebark pine to thrive (COSEWIC, 2010). As well, Clark's nutcracker uses burned sites for seed caching, allowing for rapid regeneration of whitebark pine. Years of fire suppression have allowed shade tolerant species to dominate whitebark pine habitats, limiting whitebark's ability to establish and survive on sites.

4) **Climate Change**

   Increasing global temperatures will require whitebark pine to migrate to areas of suitable climate and adapt to changed climatic conditions or be extirpated (COSEWIC, 2010). Warming temperatures are expected to increase competition as lower elevation species migrate upslope which will increase tree stress, potentially making it more susceptible to blister rust and mountain pine beetle attack.

The losses of Whitebark Pine are not only detrimental due to its intrinsic value but also have ecosystem scale effects as it plays a role as a keystone species. Even more, it is considered a foundation species due to its occurrence in high elevations where it helps in regulating snow melt and thus plays a role in watershed stability. It provides important ecosystem services by establishing in disturbed sites following forest fires (Arno 2001), capturing soil moisture to facilitate the establishment of other species

(Tomback and Kendall 2001), and by providing food for wildlife species in high elevation sites (Iredale, 2016; Tomback and Kendall 2001).

To effectively restore whitebark pine, a multi-pronged approach is required to address the multiple threats it faces. These approaches may include: screening select seedlings for rust resistance, protecting against mountain pine beetle, prescribed burning for habitat creation, thinning out more competitive conifers and experimenting with assisted migration to move whitebark to suitable habitats in response to climate change. Given the vastness of the range occupied by whitebark pine, delivering effective restoration will require a combination of paid work, volunteer efforts, and reliance on the Clark's Nutcracker to effectively disperse desirable genes throughout the range.

1.1. Goals and Objectives

This project aligned with the Species Based Actions of the Upland and Dryland Ecosystem Chapter of the Bridge Seton Watershed Plan: BRG.UAD.SB.38.01: Build upon previously-funded Whitebark Pine work-P1. This included multiple recovery-based goals including: 1) re-establish whitebark pine in wildfire areas; 2) assist in identifying blister rust resistant stock; and 3) improve public knowledge of whitebark pine.

The approaches to addressing these goals included:

1) Planting 1,500 whitebark pine seedlings over 4 ha on Big Dog Mountain, Yalakom Provincial Park, and Blustry Mountain.

2) To determine the efficacy of planting; two past plantings were surveyed at Mt. Mclean and Porcupine Ridge to determine seedling survival and early establishment density.

3) We continued to conduct outreach in the region to increase the level of support, increase the size of the labour pool, and improve our knowledge of local high value whitebark pine stands.

2. Methods

The methods and approach employed to implement the goals and meet the objectives of this project included:

a) Planting: The planting sites on Big Dog Mountain and Yalakom Provincial Park were pre-selected based on the former presence of whitebark pine and the extensive fire caused mortality in the region. The Blustry Mountain site was pre-selected in previous years as well due to high blister rust mortality in the region. The planted seedlings were from seed collected from putatively rust resistant parents, that is wild parents demonstrating some level of resistance but not proven in screening tests. Planting was done by a combination of paid and volunteer planters. Planters were instructed to plant seedlings at 400 stems/ha and were educated on proper planting techniques. When planting was completed, the boundary of each planting site was mapped using GPS.

b) Monitoring: Plantings from 2016 (Porcupine Ridge) and 2017 (Mount Mclean) were monitored in 2018 to determine survival of seedlings after 1 and 2 years. After this short duration most mortality will likely be due to site or seedling factors and not white pine blister rust. These surveys are important as they will help to guide future planting practices; ie – if seedling mortality is high on a

certain microsite we will advise planters to avoid these sites in future years. Monitoring was done by establishing fixed radius plots of 11.28m at 100m intervals throughout the planted areas. In each plot, all seedlings from all species were tallied to determine the surviving density to compare with the planted density at each site.

c) Outreach: Previous outreach has primarily focused on naturalists and other potential volunteer pools. To elevate whitebark pine within the professional fields, outreach was conducted with government foresters and planners. This primarily included planning discussions and ensuring data reporting with appropriate officials from BC Ministry of Forests, Lands, and Natural Resource Operations, and BC Parks officials.

3. Study Area

The work conducted in 2018 was within the Bridge River Watershed with the exception of planting at Blustry, which was on the east side of the Fraser River in the Clear Mountain Range between Lytton and Lillooet (Figure 1). The other worksites were at Big Dog Mountain and Yalakom Provincial Park, both of which occur within the Yalakom drainage, which flows into the Bridge River northwest of Lillooet.

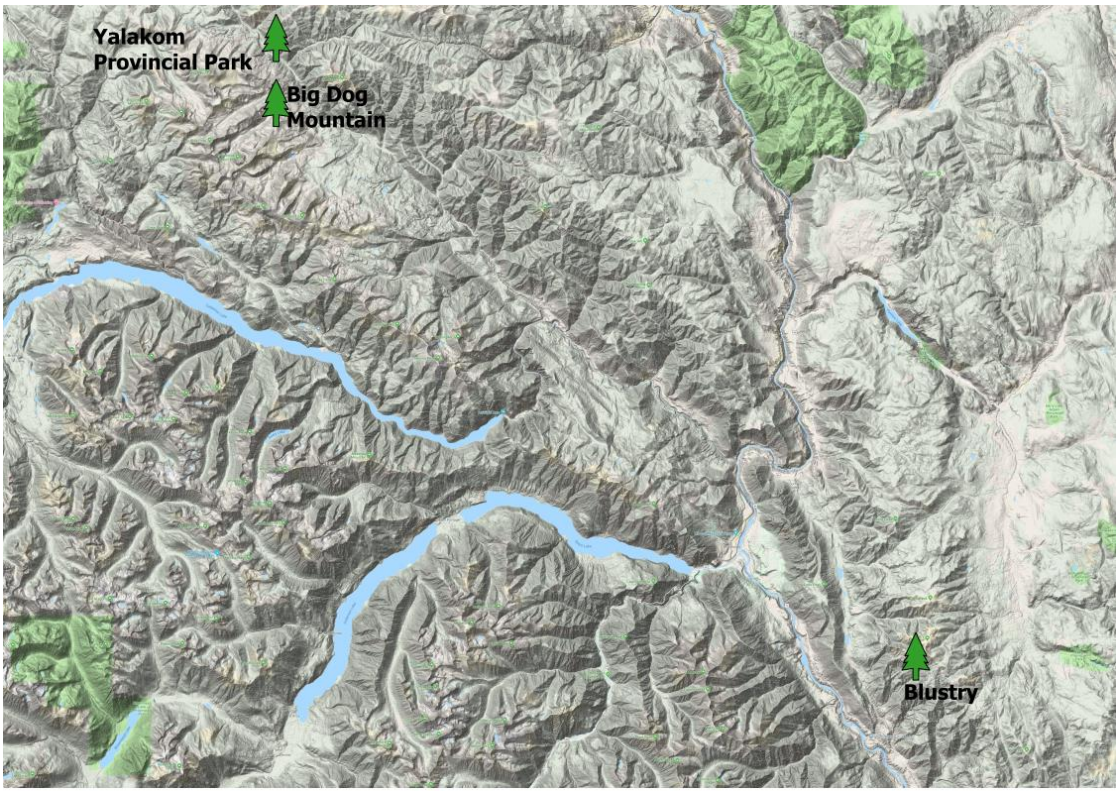

Figure 1. Locations of Whitebark Pine planting in 2018 in the Lillooet Region.

3. Results

a) Planting

Planting was conducted at Big Dog Mountain, Yalakom Provincial Park, and Blustry Mountain (Figure 1, Appendix A). The latter two sites were planted in collaboration with BC Parks and the Forest Enhancement Society. A total of 3,248 seedlings were planted over 6.87 h; for an overall planted density of 473 seedlings/ha (Table 1). At Blustry, 180 of the seedlings were planted in trial format with 30 seedlings from 6 parent trees planted along monitoring transects.

Table 1. Summary of planting areas and densities from the Lillooet Region in 2018.

Planting Site	Number of Seedlings	Area (ha)	Planted Density (seedling/ha)
Nine Mile Ridge (Yalakom PP)	1335	3.82	350
Lower Yalakom (Yalakom PP)	405	0.83	488
Big Dog	608	1.49	408
Blustry 1	500	0.49	1,020
Blustry 2	400	0.24	1,667
Totals	**3248**	**6.87**	**473**

b) Monitoring

Sampling plots were established at Mount Mclean and Porcupine Ridge to sample planting from 2017 and 2016 respectively. At Mount Mclean 5 plots were established and at Porcupine Ridge 6 plots were established, this was lower than the 10 planned for each site due to helicopter schedules limiting the time at site. At both sites the sampled density of whitebark pine was lower than the planted with Mount Mclean at 225 stems/ha (55% survival) and Porcupine Ridge 221 stems/ha (74% survival). At Mount Mclean whitebark pine was the leading species in the stand, whereas at Porcupine Ridge lodgepole pine was the leading species with more than double the density of whitebark pine. No white pine blister rust infections were observed on any of the seedlings.

Table 2. Summary of monitoring plots in planted areas from 2016 and 2017; Pa - Whitebark Pine, Pl - Lodgepole Pine, Se - Engelmann Spruce, and Bl - Subalpine Fir.

Location	Planting Year	Number of Plots (n)	Pa (stems/ha)	Pl (stems/ha)	Se (stems/ha)	Bl (stems/ha)	Planted Pa Density	Net difference (Pa)	% Surival
Mount Mclean	2017	5	225	105	10	10	405	-180	55%
Porcupine Ridge	2016	6	221	471	0	0	300	-79	74%

c) Outreach

Outreach was conducted with Andrew Snetsinger, RPF, Stewardship Officer for the Cascades Natural Resource District; this outreach was primarily focused on identifying methods to incorporated whitebark pine into provincial reporting programs (RESULTS) and to increase the level of acceptance for planting whitebark pine as it is not a merchantable species. Outreach was also conducted with Craig Bailey of BC Parks; this consisted of planning and providing input on prioritizing whitebark pine work within the Lillooet area Provincial Parks.

4. Discussion

The combination of planting and surveys of previous planting provided a good comparison and somewhat full circle study of this restoration approach. The planting generally achieved the desired densities of 400/ha, other than at Blustry where densities were much higher. At this site the terrain generally squeezed planters together due to rock outrcrops and in the monitoring transects seedling density equated to 10,000 seedlings per hectare.

The primary factors limiting planting was site access, as most sites required at least a one hour hike for access, with the exception of the lower Yalakom site which only required a 20 minute hike. These long hikes generally mean that planters are only able to plant what they can carry to site unless. At Nine-Mile Ridge a crew did a return hike to pack in additional seedlings but only because the planting area was very large and could accommodate additional seedlings.

The survival surveys showing survival rates of 55% and 74% are acceptable, however improved survival and establishment are always desired. The most comprehensive review of whitebark pine seedling planting estimated that survival of 50% can be expected for the first 3-5 years (McCaughey et al. 2009); our surveys were one and two-years post planting. Variables such as site variables were not tested as planting sites were deemed homogeneous and other broad scale factors such as drought may play a role but this could not be tested with design and survey implemented. At the time of planting a portion of the stock was deemed as poor quality. These challenges in seedling production were recognized, thus a seedling consultant was hired in 2016 to improve stock production. The seedlings planted in 2018 were more robust than seedlings produced previously; thus it may be considered that the seedling survival observed from past plantings may be expected to be the poorest in the recovery program. The sites planted this year should be sampled in 2-years to determine if survival has improved with the improvement in stock quality.

No seedling mortality was observed to be directly attributed to white pine blister rust infection. Although this is the desired outcome of the project, it must be underscored that the best available seedlings at present are ‘putatively resistant’ and not fully resistant to rust. Based on current seed collection and research in the region, the best available seedling display ‘putative resistance,’ some seed from the region is in testing thus suspected resistance may become available once testing is completed (Table 3). Whitebark pine has mechanisms to cope with rust infections as opposed to true resistance whereby the tree simply does not get infected by rust; this latter condition in known as major gene

resistance and has been observed in western white pine and limber pine, but not in whitebark pine. Due to this, we can expect all seedlings to get infected if a high spore load is present, coping with this infection is the key to survival. Planting putatively resistant seedlings in the Lillooet region is an appropriate approach at present as rust levels are generally low compared to other regions and these seedlings have undergone one level of screening (putative) at the time of parent tree selection. One known exception to this is the Blustry site where rust levels were high enough that in addition to general planting, a subset of seedlings was established in monitoring transects to better track survival in this high rust environment. A subset of health monitoring transects established in 2014 will be re-measured in 2019, the results of this health sample will be used to guide future work for cone collections and restoration work.

Table 3. Summary of Seedling Types (From Moody and Pigott, 2017).

Seedling Type	Production Method	Contribution to Species' Recovery	Relative Availability	Planting Priority
Confirmed Resistance	Seedling produced from seed harvested from a seed orchard consisting of multiple tested resistant parents, allowed to cross breed.	**High** – Both parents have demonstrated resistance.	Unavailable in foreseeable future (10 – 15 Years: 2028 – 2033)	Highest
Suspected Resistance	Seedlings produced from seed harvested from the original parent trees (plus trees) showing resistance traits in screening programs.	**Moderate to High** – Some resistance is likely present in population; only maternal genetics are controlled.	Limited (10 Years – 2028: Possibly less in some populations)	High
Putative Resistance	Seedlings produced from seed harvested from the original parent trees (plus trees) that appears to have resistance traits, but testing is incomplete or non-existent.	**Moderate to High** – Some resistance is likely present in population; some escapes may be part of this planting stock.	High (2019)	Moderate - High
Bulk Collection	Seedlings produced from bulk seed. Little may be known about individual parents.	**Low to High** – Some resistance is likely present in population; some non-resistant individuals may persist to play ecological roles. Useful in areas with low rust levels.	High (2019)	Lowest

The planting program results were discussed with Michael Murray PhD, Forest Pathologist with MFLNRO and lead for the provincial rust screening program. He suggested that perhaps planting densities should be greater, more in the 800-1000 stems/ha range in order to ensure stocking targets are hit. Although stocking to this level may ensure greater long-term stocking, this must be balanced with access constraints. Planting to this density would more than halve the treated area thus consideration must be made regarding if sites require high density whitebark pine or simply a presence of whitebark pine; further logistical issues will be introduced as on long hikes planters can only carry about 350 seedlings thus single day projects will expand into multi-day projects. As whitebark pine densities are highly

variable across the landscape, a suitable compromise may be to increase planting densities at sites with easy access and maintain the 400 stems/ha at sites with long or difficult access.

With respect to whitebark pine recovery, the Lillooet region is characterized by moderate rust levels and extensive landscape scale burns; this combination has resulted in virtually all recovery work directed at planting as there is a surplus of suitable habitat and planting putatively resistant seedlings is appropriate given local rust levels. Although this is constructive work towards recovery, some work should be directed at maintaining the mature trees on the landscape as the planted seedlings will not be cone bearing for 40 to 80 years. This may include pruning rust infections from branches, deploying verbenone to repel mountain pine beetle, incorporating whitebark pine management into harvest plans, and identifying high value trees and stands to ensure they are protected across the landscape.

5. Recommendations

The following recommendations are suggested based on the finding of work in 2018 coupled with long-term project work:

- Continue to increase nursery production of whitebark pine seedlings employing the recommendations provided by the nursery consultant;
- Continue with outreach based restoration;
- Increase planting densities to 800 – 1000 stems/ha at sites with easy access;
- Survey sites planted in 2018 in 2-years to determine if seedling quality may have improved seedling survival;
- Consider management actions to address mature tree and stand retention in addition to planting work;
- Continue project planning and tracking by updating Table 4; and
- Re-measure a subset of health transects to guide future restoration work.

Table 4. Summary of whitebark pine project work, implemented and proposed.

Activity	2013	2014	2015	2016	2017	2018 Work Plan	2018 Work Completed	2019 Work Plan	Future Plans
Cone Collections	Cones collected from 10 trees at Poison Mountain.	Cones collected from 46 putatively resistant trees.		Cones collected from 53 putatively resistant trees at 6 sites.	No cones collected in 2018.	Cones to be collected from putatively resistant trees, funded by Forest Enhancement Society.	Cones Collected from over 100 trees from South Chilcotin PP to Clinton.	Collect cones from putatively resistant trees if large crop is present. Large crop is not expected due to large crop in 2018.	Cone collections from putatively resistant trees as needed.
Seedling Production	Seedling produced from previous collections funded by Environment Canada			Review by nursery consultant to improve practices. Enough seed in production to produce 7,000 seedlings in 2017 (large die-back greatly reduced this number). Seed sent to Skimikin Nursery for production to buffer against any die-back.	Approximately 5,600 seedlings produced (1,400 at Skimikin and 4,200 at Splitrock). 2,000 seedlings sold to Xeni Gwet'in First Nation.	Continue production of all seed collected in 2016 to support a large planting program in 2019.	Seeds put into stratification for planting in 2020. No seedlings in production for use in 2019.	Continue with seedling production; may be divided into multi-year deployments depending on number of seeds collected in 2018.	Continue with seedling production; may be divided into multi-year deployments depending on number of seeds collected in 2018.

Activity	2013	2014	2015	2016	2017	2018 Work Plan	2018 Work Completed	2019 Work Plan	Future Plans
				Seeds from three sites were entered into production for planting in 2018.					
Seedling Planting	500 seedlings planted over 1.5 ha at Yalakom Provincial Park.			2,250 Seedlings planted over 7.5 ha.	2,1000 seedlings planted in St'at'imc Territory (1,400 from Skimikin and 700 from Splitrock).	Minimum of 1,500 seedlings to be planted in 2018, with an additional 600 in rust screening plots. Skimikin Nursery may have an additional 2,000+ seedlings for this location. Monitor previous plantings. Confirmed funding co-funded by American Forests and Forest Enhancement Society.	3,248 Seedlings planted at Blustry (900), Big Dog (608) and Yalakom PP (1740)) for a total of 6.87 ha planted.		Large planting depending on nursery production levels. Target of 10,000. Continued planting is not limited by the availability of habitat. Large-scale fires created thousands of hectares of suitable restoration habitat, which could only be fully restored over decades.

Activity	2013	2014	2015	2016	2017	2018 Work Plan	2018 Work Completed	2019 Work Plan	Future Plans
White Pine Blister Rust Screening				High rust and mortality site for field-based screening identified at Blustry .	Trial not established due to high fire hazard in late summer, seedlings are being held in nursery for planting in 2018.	Planting trial to be planted at Blustry. Confirmed funding co-funded by American Forests and Forest Enhancement Society.	Planting trial of seedlings from 6 parent trees established at Blustry.	Monitor seedlings for survival to ensure when rust is the cause of mortality	Monitor seedlings for survival to ensure when rust is the cause of mortality
Mechanical Options – Thinning and Pruning				Competition removal site identified at Blustry.	Competition removal not completed due to smoke and fire hazard; to be completed in 2018.	Work to be completed by Xaxli'p Community Forest Crews, work is in-kind to support crew training.	Xaxli'p forestry workers hiked into Blustry and initiated this thinning work.	Expansion of competition removal program will depend on success of 2018 implementation.	Expansion of competition removal program will depend on success of 2018 implementation. Identify trees and stands for rust pruning to increase longevity of trees and cone bearing potential of stand.
Outreach	Planting at Yalakom Provincial Park implemented as an outreach event.		Outreach events conducted at Splitrock Environmental including classroom session followed by field visit.	An information meeting was held to teach the public about the plight of whitebark pine.	A small amount of field-based outreach was conducted by direct invitation to locals not previously involved. Limits were placed due	Expand outreach to include combined talks with other biologists, nursery tours, remote communities, and open		Expand outreach to include combined talks with other biologists, nursery tours, remote communities, and open invitations to assist with restoration work.	Expand outreach to include combined talks with other biologists, nursery tours, remote communities, and open invitations to assist with restoration work.

Activity	2013	2014	2015	2016	2017	2018 Work Plan	2018 Work Completed	2019 Work Plan	Future Plans
			Display put up at Salmon in the Canyon Festival.	The following day a volunteer-based planting day was conducted.	to helicopter capacity.	invitations to assist with restoration work.			
Health Monitoring	Management planning document created to address health of whitebark pine in region.		Thirteen health monitoring plots established.	Health monitoring plots established where new cone collections are conducted to identify stand health and observe trends.		Health monitoring plots established where new cone collections are conducted to identify stand health and observe trends.		Re-measure health plots to identify trends.	Establish new health plots as cones collections expand to new areas and re-measure existing plots every 5-years.

6. References

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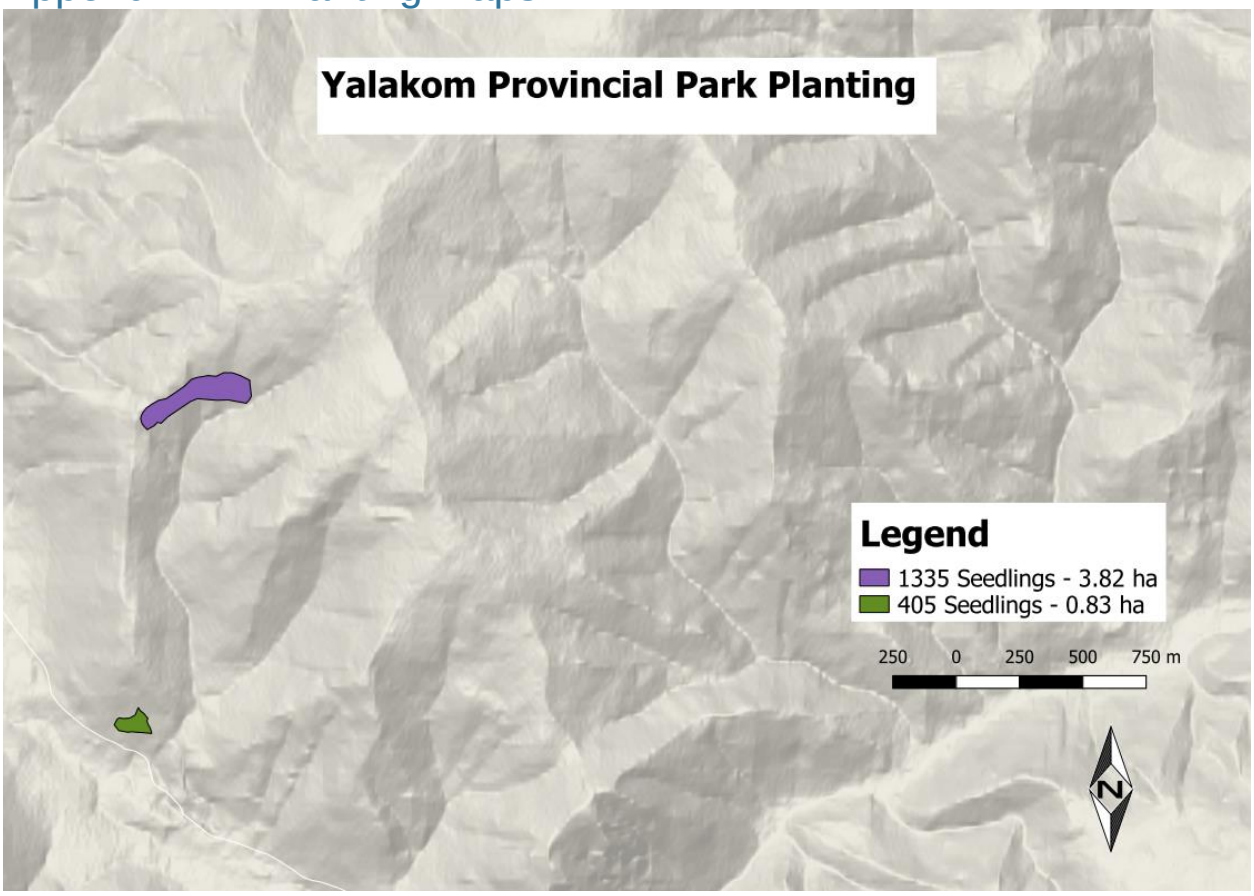
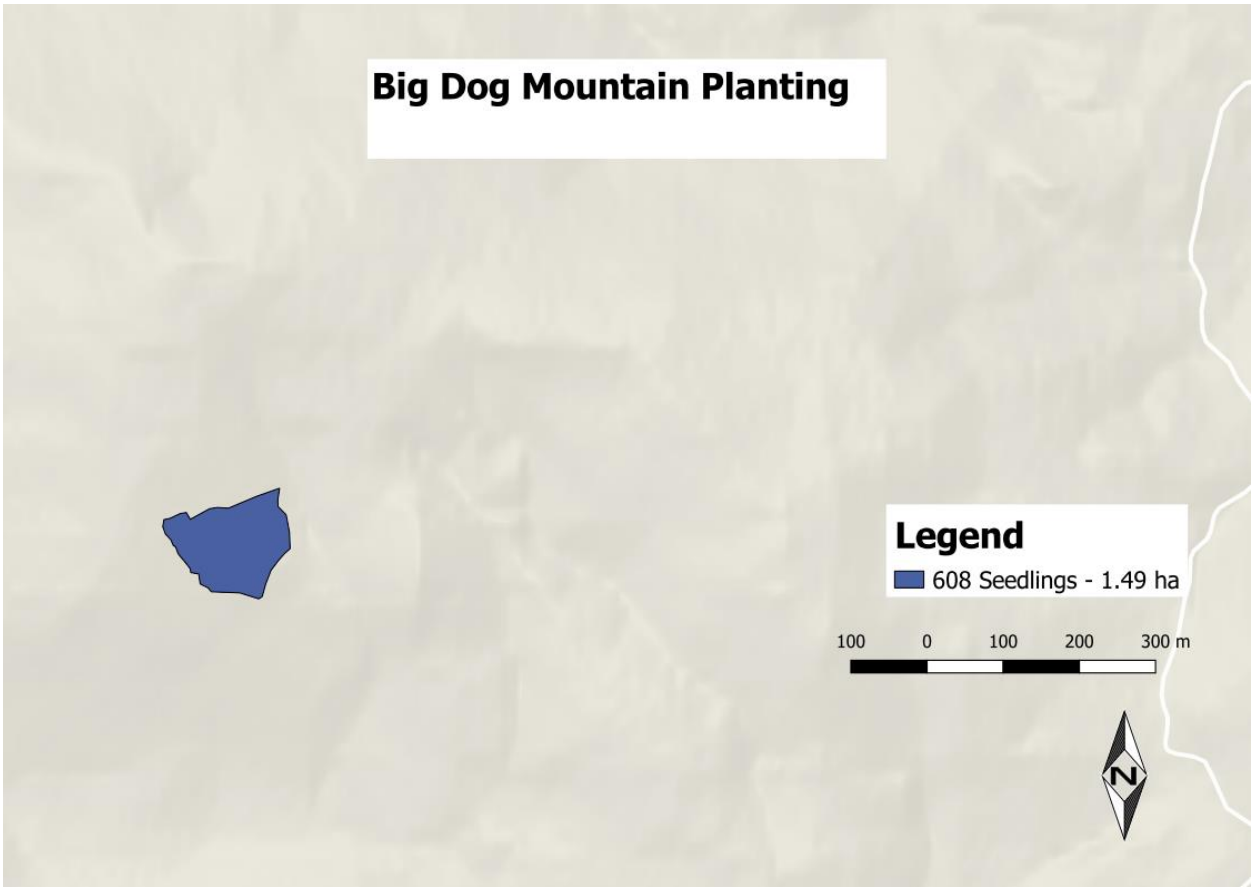
Appendix A – Planting Maps




Big Dog Mountain Planting
Legend
608 Seedlings - 1.49 ha
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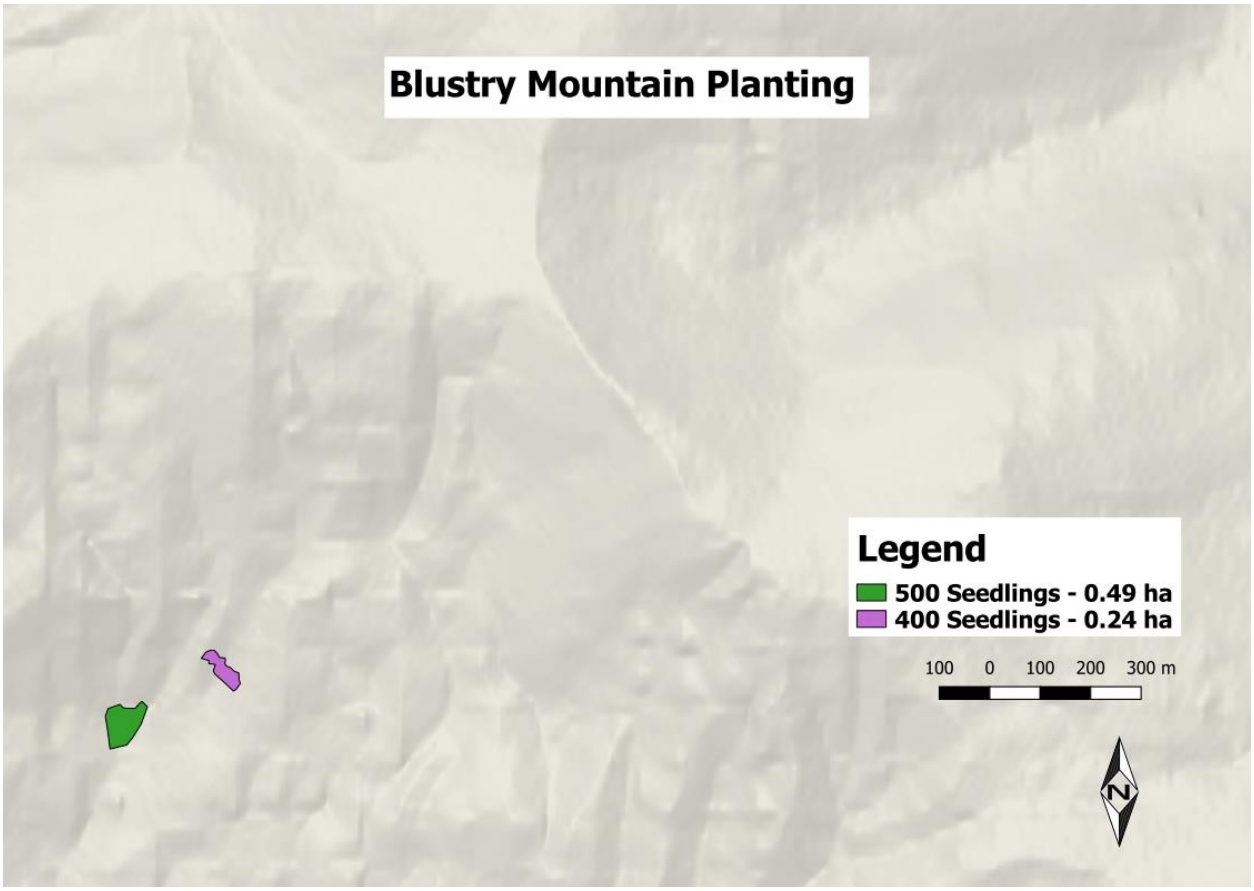
Blustry Mountain Planting
Legend
500 Seedlings - 0.49 ha
400 Seedlings - 0.24 ha
100 0 100 200 300 m
N