Whitebark Pine Planting in East Kootenay Wildfire Areas

Prepared for: Fish and Wildlife Compensation Program

CBT Project #16067

FWCP # COL-F21-W-3272

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Prepared with financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and Public Stakeholders.

31-March-2021

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. To recover whitebark pine we planted putatively resistant seedlings, which may have resistance to white pine blister rust; removed competition from around naturally regenerating whitebark pine seedlings and saplings, surveyed cutblocks to identify their role in recovery, and conducted outreach with youth, ski areas, and plant nurseries. In total we restored 24.75 ha of whitebark pine habitat. In Kianuko Provincial Park we planted 4,500 seedlings over 4.29 ha; at Hourglass Lakes we planted 700 seedlings over 3.3 ha including 540 seedlings planted directly in monitoring transects; and at Kootenay Pass we planted 500 seedlings over 0.96 ha. We removed competition from around whitebark pine trees at two locations on Mount Puddingburn and Bootleg Mountain totalling 16.2 ha. At each location, an intensive clearing area within a sample plot was established where the majority of non-whitebark stems were removed including 1800 stems per ha at Puddingburn and 2050 stems per ha at Bootleg; at Bootleg the majority of area cut was done in a random method throughout the treatment area. Competition removal may be an appropriate treatment in areas where suitable planting areas are not present or where rust hazards are low; this is especially important in cutblocks where regeneration is common but pathways to reproductive maturity appear doubtful. Outreach was conducted with youth, ski areas, and nurseries. Youth demonstrated a keen interest in growing whitebark pine and should be included as participants in future projects; four ski areas were identified to participate in whitebark pine recovery work; and a professional relationship with U.S. nurseries was created to aid Canadian nurseries in whitebark pine seedling production.

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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 northermost 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 namely 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 the whitebark pine and 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 and 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 behaviour results in the trees occurring on sites best suited to seed recovery due to low snow cover such as sites on south 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 rate of 1.5-3.5% per annum (COSEWIC 2010), largely due to rust impacts, with several large decline events attributed to the mountain pine beetle epidemic. Further to these losses, many trees are ecologically compromised due to high competition levels resulting in trees being outcompeted by more shade tolerant species resulting in poor growth 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 seedings and maintaining a range of age-class across the landscape by reducing competition around naturally occurring whitebark pine.
- 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 (CBT), Fish and Wildlife Compensation Program (FWCP), BC Parks License Plate Fund, BC Ministry of Transport, 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) Restore whitebark pine by removing competition from around naturally regenerating whitebark pine in open stands;

3) Conduct surveys of logged areas to determine what role timber harvest may play in the natural regeneration of whitebark pine; and

4) 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 in the region. Planting work was conducted at Hourglass Lakes, Kianuko Provincial Park, and Kootenay Pass; competition removal and surveys were conducted at Mount Bradford, Bootleg Mountain, and Mount Puddingburn (Figure 1).

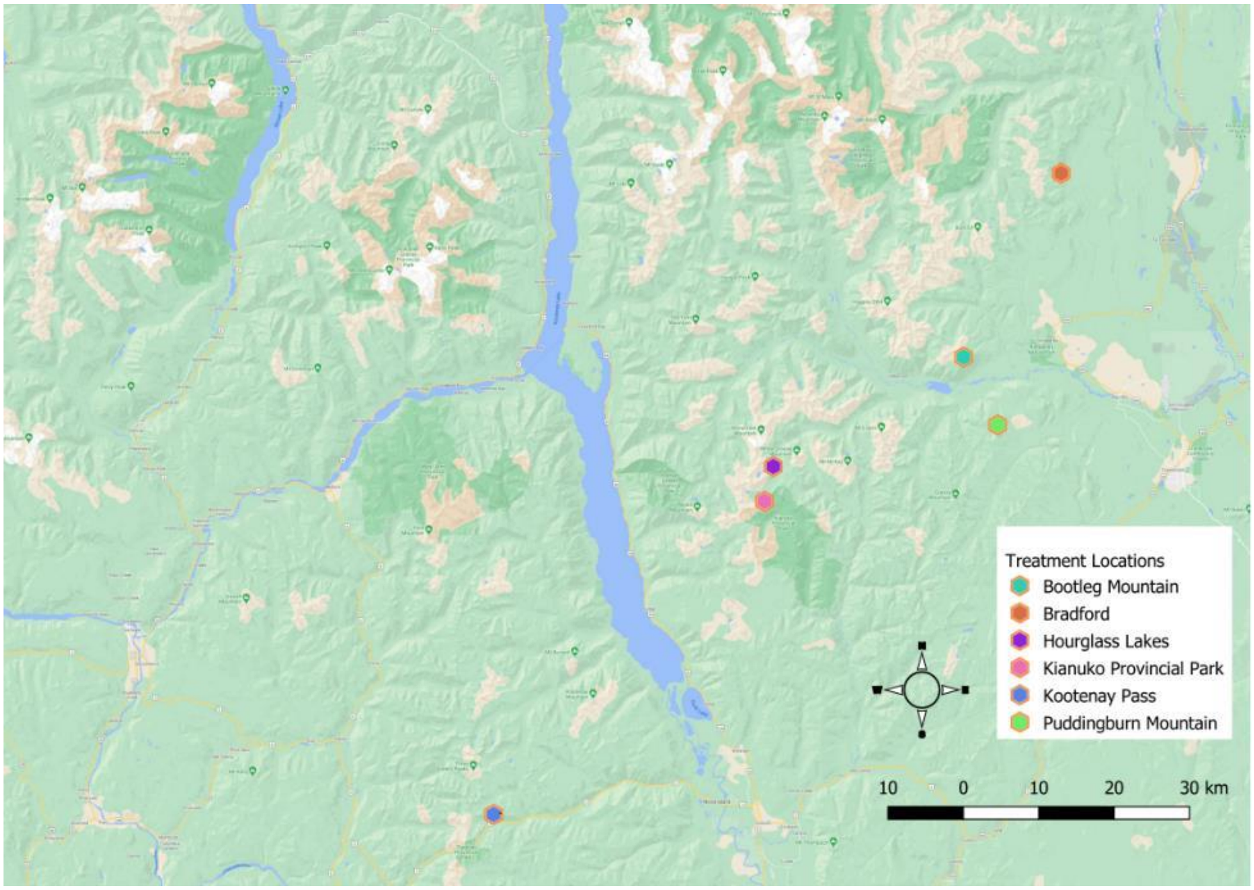

Figure 1. General locations where whitebark pine field work was conducted in 2020.

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. 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, that is 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.).

To map planting areas, 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 site seedlings were directly planted in three replicate monitoring transects; each transect was 30 m in length with seedlings planted at one metre intervals; each transect was planted as single seedlings (30 seedlings), double seedlings (60 seedlings), or triple seedlings (90 seedlings) at each planting location. This set of transects was replicated on a warm aspect, level aspect, and low elevation site. Surplus seedlings on this site were simply planted in the vicinity of the transects.

Competition Assessment and Removal

To assess competition levels in cutblocks, five cutblocks within whitebark pine habitat were identified. Five systematic plots at 50 m spacing were established from a randomly selected starting point. At each plot an 11.28 m radius plot was established, and all tree species were tallied along with tree heights, diameters (when trees exceeded 1.3 m tall), and health data regarding whitebark pine was collected.

Competition removal was conducted using a multi-phase process. First a representative 11.28 m fixed-radius plot was established as described above; next, all non-whitebark pine trees were removed using hand tools and were documented in the plot data; finally, a greater area had non-whitebark pine species cut and the treatment area mapped.

Outreach

Due to health restrictions, the level and type of outreach was greatly constrained. Outreach was conducted by continuing communication with the Kimberley Youth Action Network (KYAN), with professionals at ski areas in the region, and with tree nurseries growing whitebark pine seedlings.

Results

Planting

Planting was conducted at three separate locations, Kianuko Provincial Park, Hourglass Lakes, and Kootenay Pass. Planting in Kianuko Provincial Park located between Kimberley and Creston was conducted on September 21-22 (Figure 2 and Figure 3). Seven planters planted on the 21st and four planters planted on the 22nd for a total of 11 planter days. A total of 4,500 whitebark pine seedlings were planted over 4.29 ha; for a planted density of 1048 seedlings/ha (Figure 3). This density was at the upper end of the prescribed density.

We established a series of nine planting monitoring plots at Hourglass Lake over 3.3 ha (Figure 2 and Figure 4). The plots consisted of three sets of three transects planted as single, double, and triple seedling plantings. In total 720 seedlings were planted across the site including 540 directly within monitoring transects for a total planted density of 218 stems/ha.

On September 23, planting was conducted in Kootenay Pass using three planters for a single day of planting. Helicopter access was provided by the Ministry of Transport. In total 500 seedlings were planted at two locations with 250 planted at each location over 0.44 and 0.52 ha for a collective planting density of 520/ha (Figure 5).

Figure 2. Whitebark pine planting at Kianuko (l) and Hourglass Lakes (r). Note rock on upper slope to deflect snow and rock on lower slope to protect root collar from excessive insolation (l); and transect line along which seedlings were planted for monitoring purposes (r).

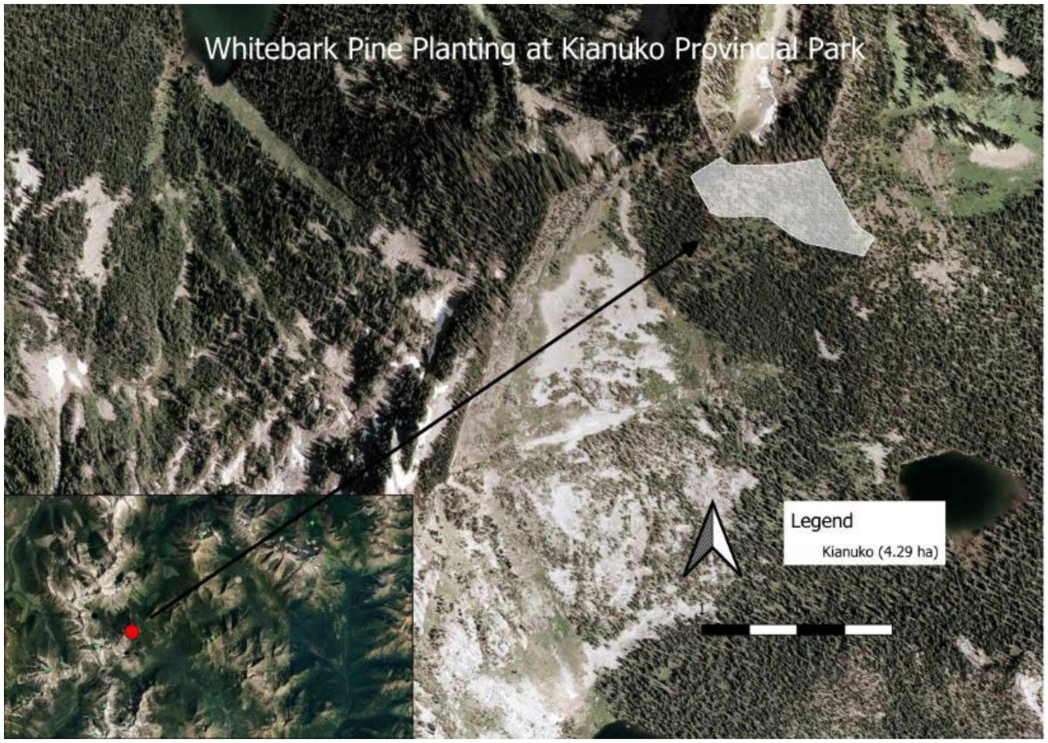

Figure 3. Planting area in Kianuko Provincial Park; 4,500 whitebark pine seedlings were planted over 4.29 hectares; this planting was done in conjunction with BC Parks.

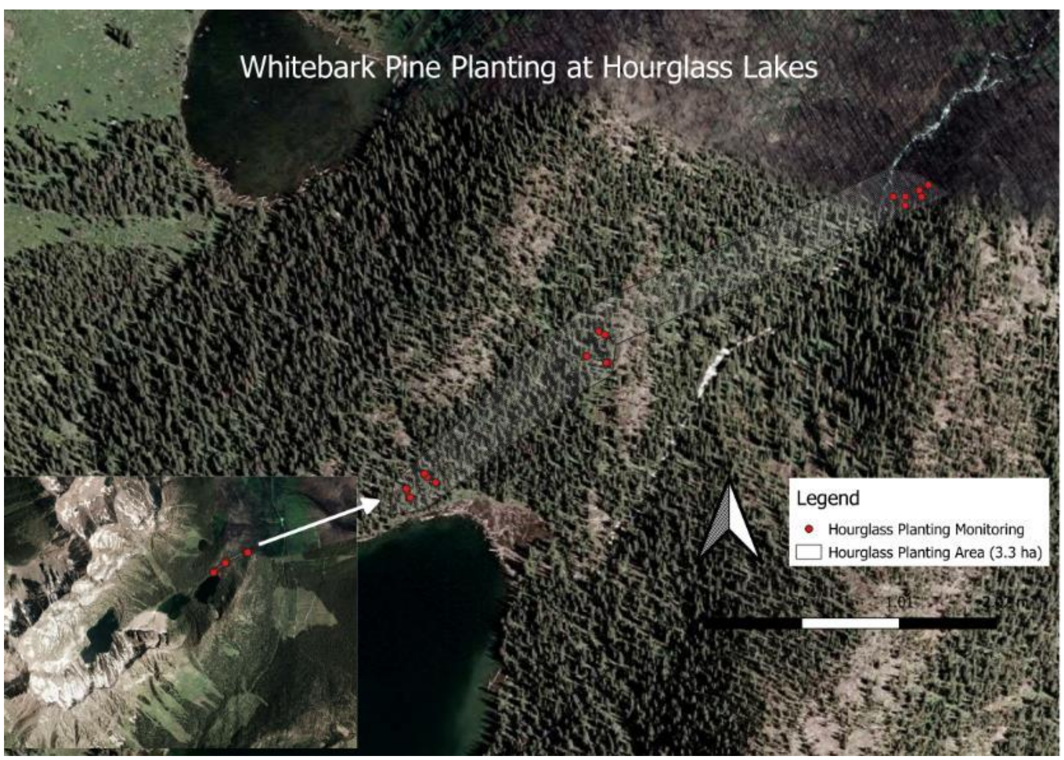

Figure 4. Location of seedling planting at Hourglass Lakes; 720 seedlings were planted over 3.3 ha with 540 seedlings planted in monitoring transects.

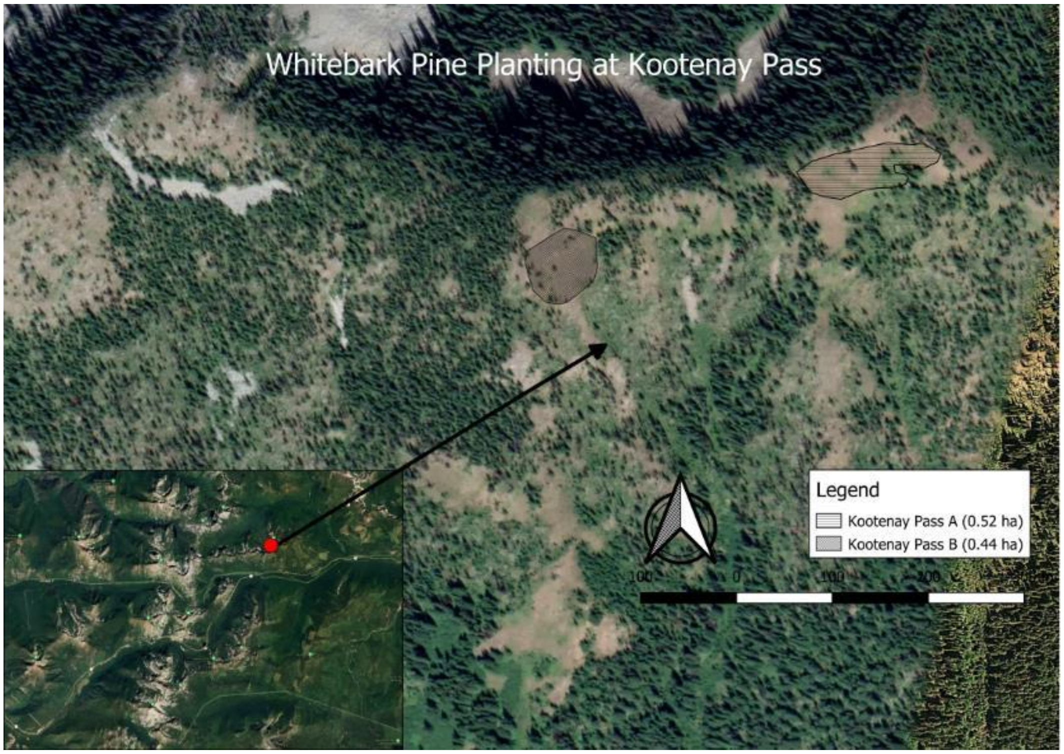

Figure 5. Location of seedling planting at Kootenay Pass where 500 seedlings were planted at two locations covering 0.96 ha; this planting was done in conjunction with BC Ministry of Transport.

Competition Assessment and Removal

Competition was surveyed in five cutblocks ranging in age from six to 26-years. At no location was whitebark pine the most common or the tallest cohort in the cutblock (Table 1, Appendix A, Appendix B). Recruitment in cutblocks was greatest on Bootleg Mountain, which also had the greatest annual recruitment rate but also had the greatest density of competition (Table 1, Appendix A, Appendix B). The youngest cutblocks also had the lowest densities of whitebark pine but also showed no signs of rust infection. Annual recruitment rates based on the overall density as a function of cutblock age were highly variable ranging from 3 to 84 stems per annum. Blister rust levels were generally low in the cutblocks with Puddingburn B showing the highest infection at 18% and the two youngest cutblocks showing no rust infection.

Table 1. Summary of natural whitebark pine recruitment in cutblocks.

Site	Harvest Year	Whitebark Pine Density (stems/ha)	Recruitment per Annum	Rust Infection Level (%)	Competition Density (stems/ha)	Whitebark Pine Stand Composition (%)
Bootleg	2003	1435	84.4	4	4010	26.3
Bradford	2012	115	14.4	0	3025	3.7
Puddingburn A	1995	570	22.8	8	1745	24.6
Puddingburn B	1994	355	13.7	18	1735	17.0
Puddingburn C	2015	15	3.0	0	1215	1.2

Competition removal was conducted at two locations, Bootleg Mountain and Mount Puddingburn; at both locations a single 11.28 m fixed radius plot was established to document competition removal. At

Bootleg a general random clearing area was treated whereby competition was removed when encountered using a random meander method, this approach treated 12.7 ha; an intensive clearing approach was also established over 1.6 ha where all trees in direct competition with whitebark pine were removed (Figure 6). At the Bootleg site the most common species removed was subalpine fir whereby the density in the intensive area was reduced by 1950 stems/ha; 25 stems/ha of lodgepole pine and 75 stems/ha of Engelmann spruce were also removed (Figure 6 and Figure 7).

At Mount Puddingburn competition was removed over 1.9 ha in a region where forest encroached into an existing powerline corridor. A total of 1800 stems/ha of competing species were removed from around whitebark pine trees and whitebark pine was maintained at a density of 1875 stems/ha (Figure 8 and Figure 9).

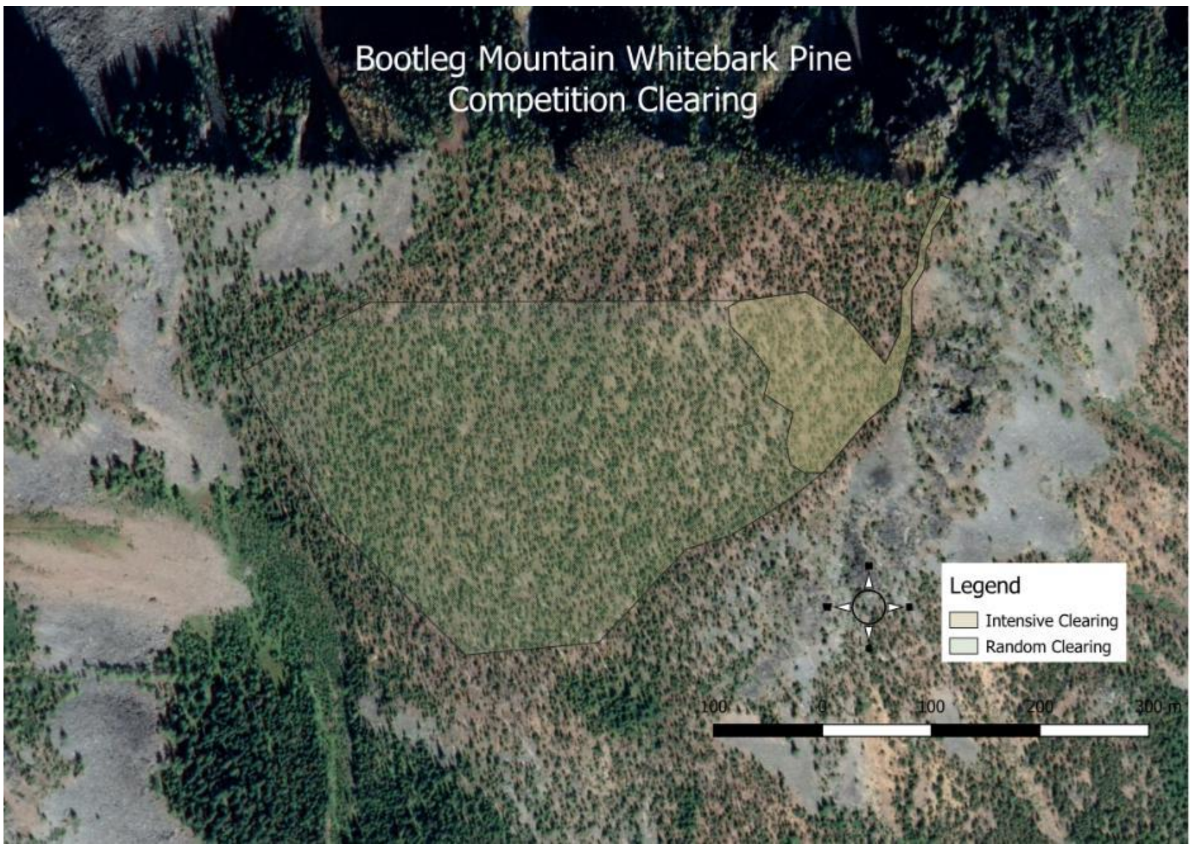

Figure 6. Competition removal area on Bootleg Mountain, the intensive area (1.6 ha) where a plot was established and the majority of all competition removed; and the random clearing area where competition was removed when it was encountered (12.7 ha).

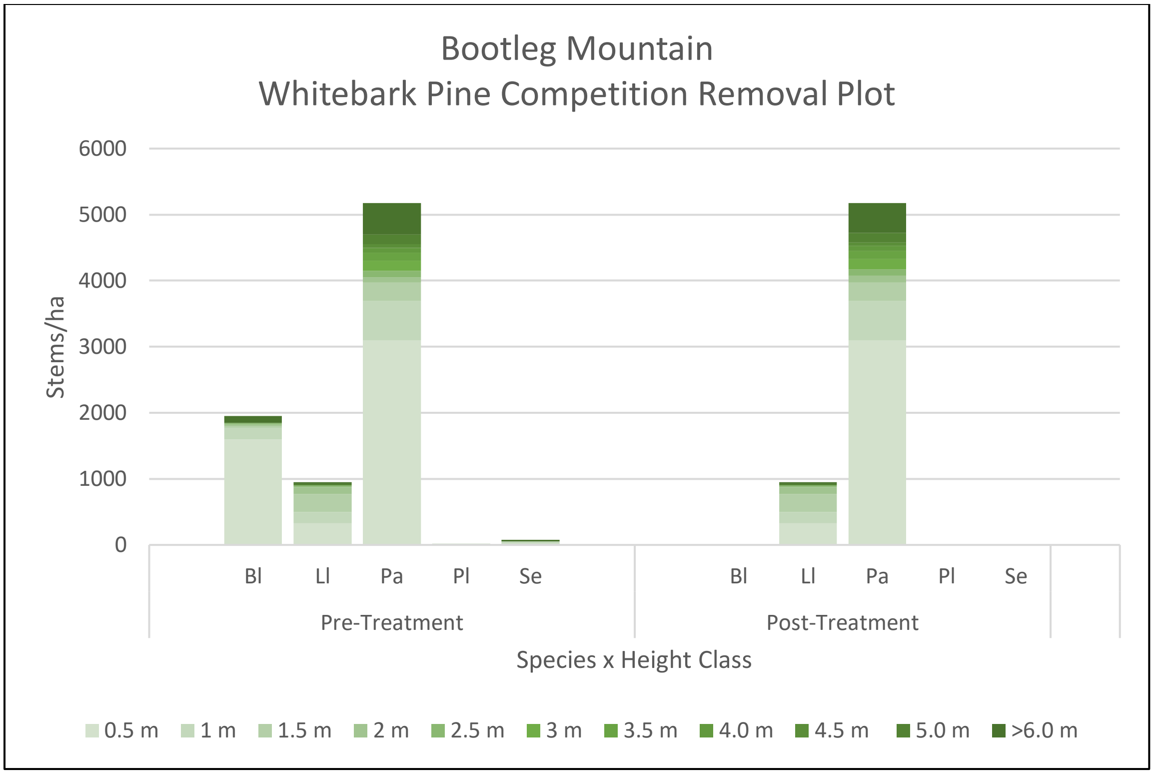

Figure 7. Summary of competition removal in the intensive treatment area at Bootleg Mountain.

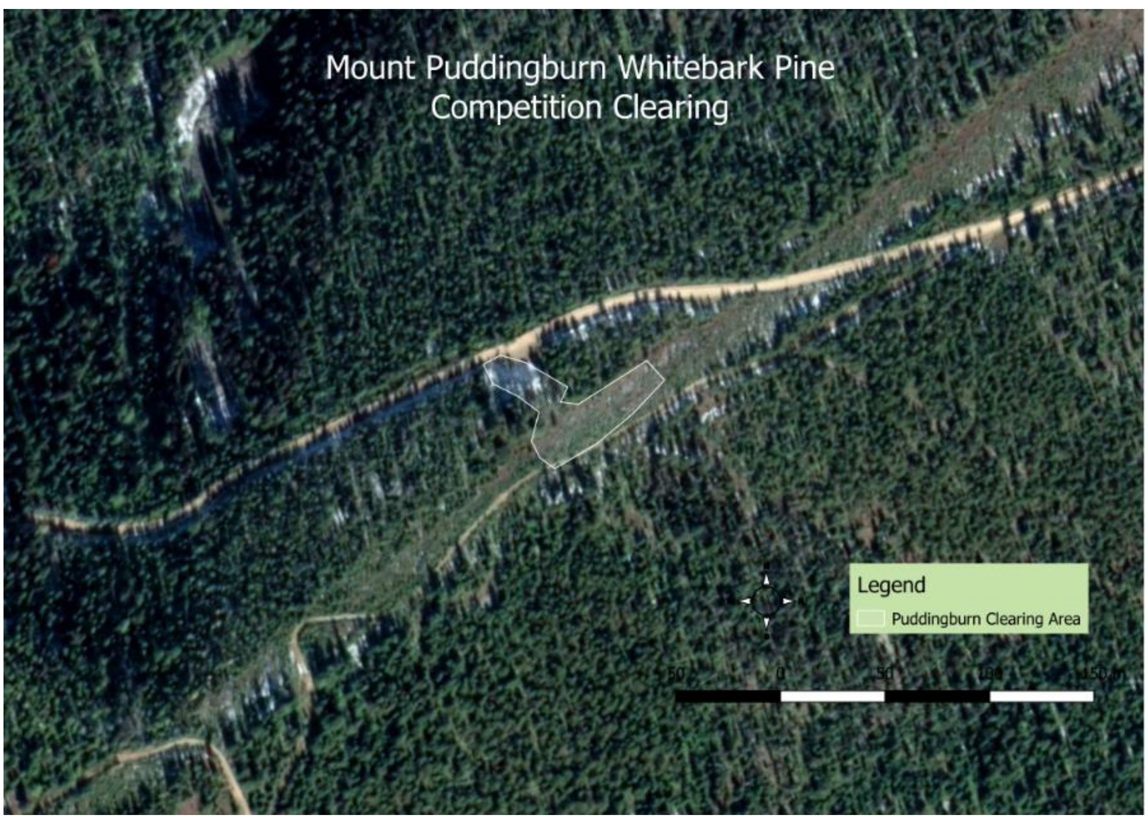

Figure 8. Mount Puddingburn competition removal area of 1.9 ha.

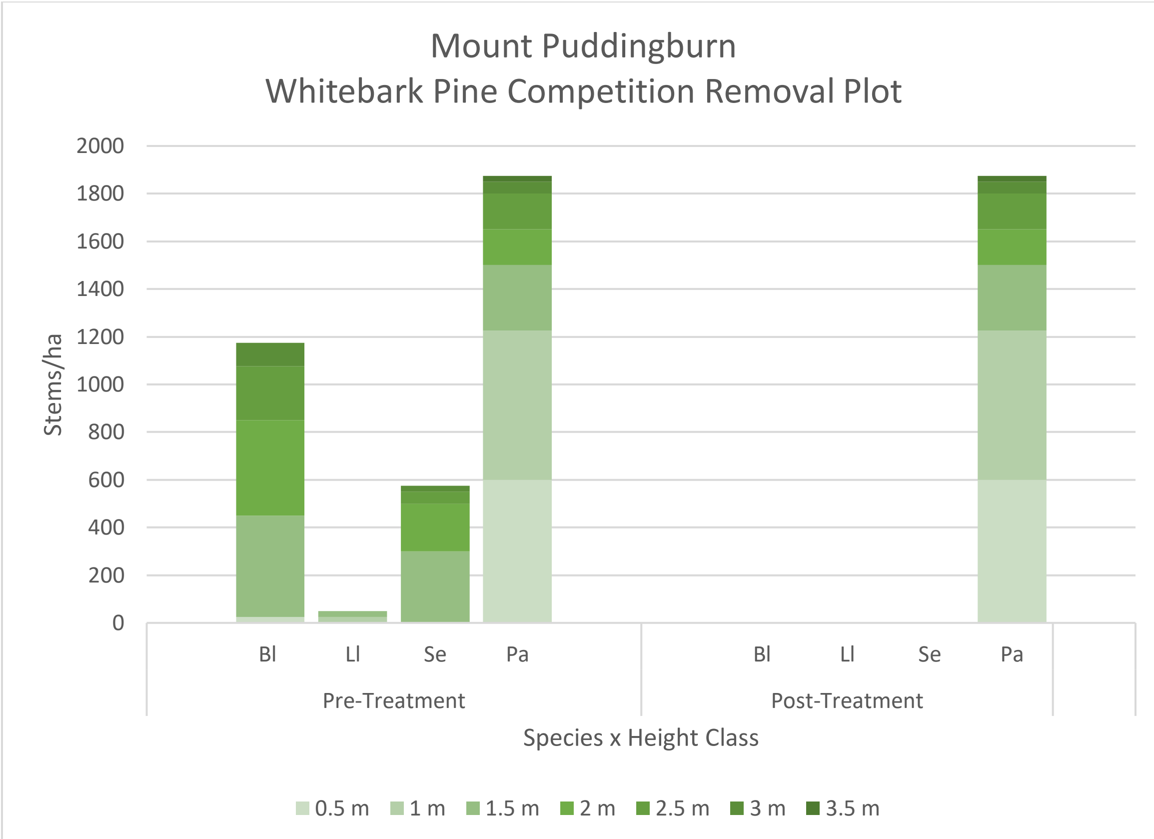

Figure 9. Summary of competition removal at Mount Puddingburn.

Outreach

Outreach was conducted with the Kimberley Youth Action Network (KYAN) and with regional ski areas coordinated by the Forest Carbon Initiative (FCI) and Reg Nolander of the Mountain Resorts Branch of the MFLNRORD. KYAN members initiated the production of several hundred whitebark pine seedlings in a classroom at Selkirk Secondary School in Kimberley. This took approximately 8 sessions to ensure appropriate seed stratification, sanitation, and germination; once seedlings had germinated they were tended to by the students until COVID then they were tended to by the project biologist. The youth also set-up a whitebark pine presentation at a local science fair and at a community-based climate change event prior to COVID closures. The number of students at each event ranged from two to sixteen. The original plan for this outreach was for students to also plant seedlings; however, COVID limited the ability to transport groups of students to events such as this. The seedlings produced by this group will be ready for planting in 2021.

Figure 10. Photos of Kimberley Youth Action Network (KYAN) learning about, growing, and teaching others about whitebark pine.

Outreach was also held at four ski areas: Red Mountain, Whitewater, Kicking Horse, and Panorama. At these events we met with personnel from each hill and described the ecological needs, threats, and recovery opportunities. We surveyed each ski area for potential planting opportunities and possible areas to instal outreach signage. In response to our outreach, Panorama installed a whitebark pine educational sign in whitebark pine habitat (Figure 11); of all the ski areas in western Canada, Panorama likely has the greatest concentration of whitebark pine thus this signage is fitting. It should be noted that the production of this sign was a unilateral effort by the ski area and not paid for by any of the funders involved with this project.

Figure 11. Signage installed by Panorama Mountain Resort following our outreach with resort staff.

We conducted outreach with Nupqu Native Plants (Formerly Tipi Mountain) as they have had difficulty producing whitebark pine. Their order from 2020 was for an estimated 5,000 seedlings but were only able to deliver 50 of moderate quality (Figure 12). To aid in their production, we contacted the USDA Tree Nursery in Coeur d'Alene, who is likely the largest producer of whitebark pine, and gathered information on seedling production. Interestingly, the feedback was primarily regarding seed stratification and germination, a phase of production that Nupqu excels at, seedling growth issues at the nursery are the greater issue. The personnel from the Coeur d'Alene nursery were able to provide a document regarding seedling production phases and tending approaches for use at the nursery.

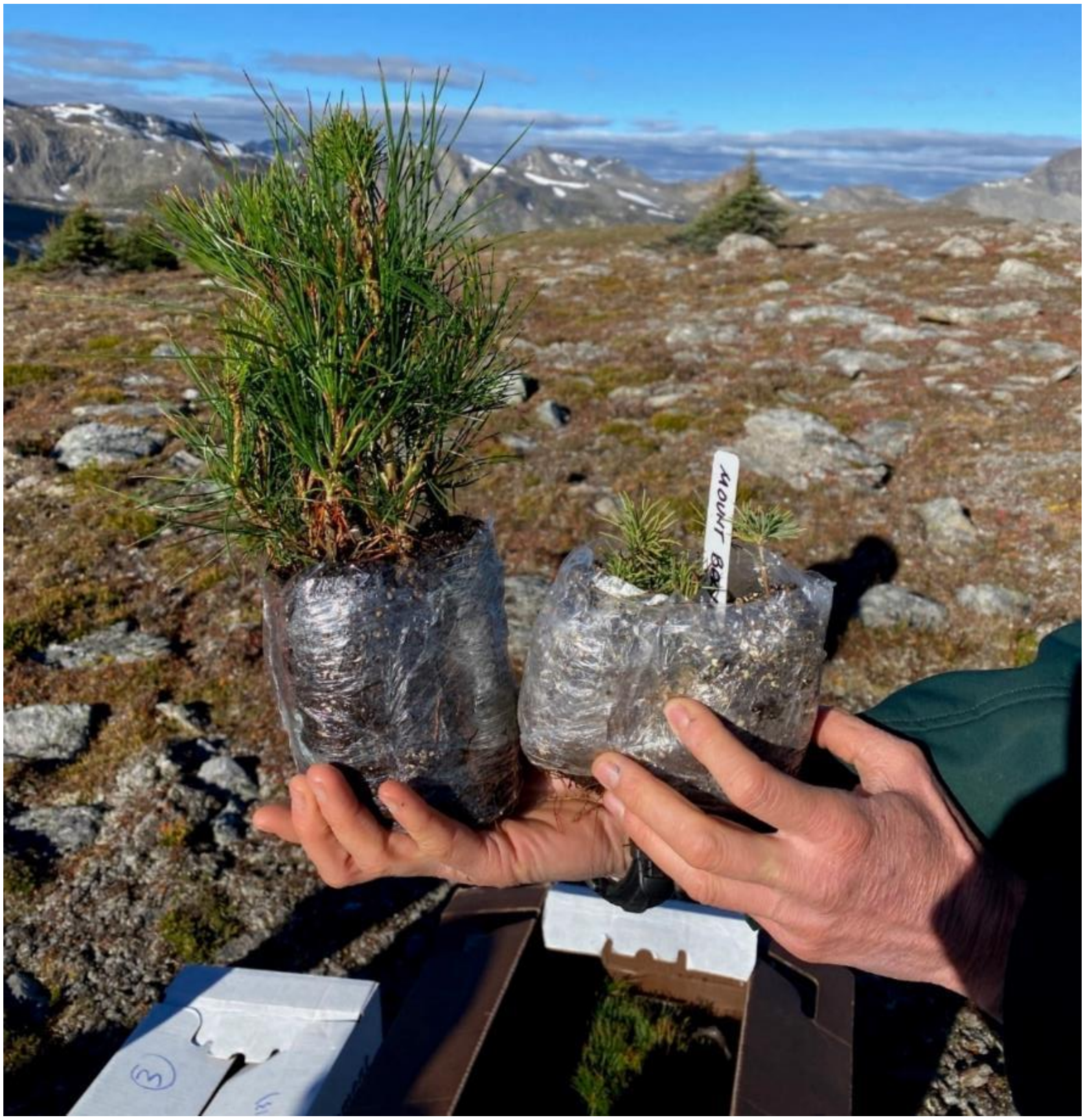

Figure 12. Example of nursery production issues on the right.

Discussion and Recommendations

Planting whitebark pine seedlings is always challenging due to logistical, production, and seedling survival issues. Logistically, utilizing helicopters for any sites greater than a 45-minute hike is a key component of maximizing productivity. Due to the logistical advantage, yet high cost, associated with helicopters the contribution of helicopter time by the Ministry of Transport was an obvious benefit to the project at the Kootenay Pass site. Original project plans included hiking into Kianuko and only using helicopters to sling seedlings, however once this was partially trialled on the first planting day the decision to only fly in created much more productive time and reduced the overall planting time by one to two days. Seedlings were packed into Hourglass Lakes and it was estimated that each planter could only pack 200 seedlings and was deemed as only marginally more efficient than flying to this site despite the relatively short hike. Despite high hourly rates of helicopters, they should always be considered when planning a planting project as long drives followed by long hikes with a minimal number of seedlings result in poor productivity, fatigued workers, and a protracted planting process.

Planters were instructed to protect seedlings from both snow creep and excessive insolation; on a south facing slope such as at Kianuko and Kootenay Pass this presented challenges as this meant protecting seedlings on both the upslope and downslope side where possible. The advantage of planting in the burn at Kianuko was clear as the burned standing and fallen trees provided numerous features to provide such protection; at Kootenay Pass where no disturbance was present planters were forced to locate landscape features such as rock outcrops, trees, and topographic features that would provide protection to the seedlings.

All planting sites for 2020 had dead whitebark pine and pockets of live standing trees scattered throughout (Figure 13). 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 series of monitoring transects established as a component of this project were established consistently within other plantings conducted this year (e.g. Manning Park and Elizabeth Mine). This more standardized sampling is expected to provide more robust sampling as previous monitoring transects were often unique to each planting site resulting in poor comparisons between sites. Where feasible, planting should be monitoring annually to ensure any stressors to seedlings are identified; where this is not feasible, Cripps et al. (2018) recommend monitoring at 2 and 5-year intervals to capture the most significant decline and the period after decline has stabilized.

Figure 13. Burned whitebark pine tree along the access trail to Hourglass Lakes.

The surveys of cutblocks were revealing as the role of forestry in whitebark pine recovery is poorly studied and its contribution is debatable as harvest may cut mature trees but the newly opened areas may be well suited to seedling recruitment; however, study is required to determine how forestry can aid in whitebark pine recovery. Although we only established plots in five cutblocks, this is the only known dedicated study of whitebark pine regeneration in cutblocks in Canada.

Whitebark pine was not the leading species in any cutblocks; this was anticipated as these areas are managed and planted with commercial species and all whitebark pine established through natural means. The density of whitebark pine regeneration in the cutblocks was greater than anticipated as planting is frequently done at densities ranging from 400 to 1200 seedlings/ha and two of the cutblocks naturally recruited to within this density and it is probable that two of the younger blocks (Bradford and Puddingburn C) may approach this density over time. Puddingburn B was the only cutblock not yet exceeding what are commonly prescribed planting densities; however, it should be considered that these planting densities are commonly implemented with an expectation of 50% mortality thus this site with only 18% infection and stocking just below the 400 stems/ha threshold may be viewed as well-stocked from a planted density perspective.

The greatest density of whitebark pine and competing species all occurred on the same cutblock, indicating that conditions here were good for tree growth in general. A commonly held view is that although whitebark pine is frequently a stress tolerator on harsh sites where it is a leading species, like other species it grows better on milder sites conducive to tree growth where it may occur as a minor component of the stand. Whitebark pine in cutblocks represents the lowest elevation and likely most productive sites it will occur on; these surveys demonstrate that it will occur in high densities on such sites but the challenge of high competition will be ever-present.

The low recruitment per annum at the Puddingburn C site may be indicative of the lack of a mast crop since the site was opened up following timber harvest. The last know mast in the region was in 2018, which may indicate a seed bank is present in the soil and germinating over time. Whitebark pine may exhibit delayed germination and sprout over time as conditions permit as opposed to immediately germinating following caching (Tomback et al. 2001). Recruitment is not likely to be present in high densities on the site until several cone masts occur; masts occur at unknown intervals generally ranging from every five to eight years.

Height-wise whitebark pine was never the tallest species in any cutblock though it approached the tallest mean height at the Puddingburn C site, which was also the youngest site. At this young site, the whitebark pine was likely advanced regeneration established at the time of or prior to timber harvest thus we anticipate that this height competitiveness will wane over time; further any new recruitment to the site will already be a minimum of 30 cm below the tallest cohort. That whitebark pine was shorter than the leading species on all cutblocks may negate any gains in whitebark pine occurring at relatively high densities in many blocks.

Based on the observations in this study, the height disadvantage coupled with the high density of competing, faster growing, shade tolerant species indicates that whitebark pine recruitment to reproductive size classes may be unlikely. The recruitment patterns in younger vs. older cutblocks indicates that recruitment is somewhat continual and should be studied in cutblocks much older than those surveyed here to identify if any recruitment patterns to taller size classes are evident. Based on the observations in this study, cutblocks largely serve as regeneration sinks whereby high levels of regeneration are occurring but their future appears uncertain. Further, this potential sink is largely due to competition, which is unfortunate as rust is the existential threat to the survival of the species and factors such as competition can be managed.

Competition Removal was done by cutting and girdling larger competing species, this approach allowed for trees of all sizes to be considered for treatement. Competition removal was conducted along two general pathways 1) eliminating direct competition of comparable size classes at the Puddingburn site, and 2) reducing future competition scenarios at the Bootleg site. At the Bootleg site, whitebark pine were generally taller than competing species but as the competing species mature and whitebark pine are lost to rust this stand has the potential to drastically shift in competition over the coming decades; thus, the competition removal aided in stalling that compositional shift as whitebark pine of all size classes were retained on site.

Removing competition from along the powerline section of Mount Puddingburn was another example of where collaboration with other stakeholders may be of mutual benefit and lead to recovery gains for whitebark pine. This section of line is cleared of vegetation every few decades (very slow growing) we are now pursuing an agreement that would allow whitebark pine to persist under the lines to a maximum height while removing all other species. Whitebark pine pruned to maintain shorter stature may still produce large cone crops despite their smaller size.

Competition removal at all sites was done using hand tools due to COVID and access constraints. Hiring a brushing crew was not successful due to COVID concerns at the outset of the field season. To address this, we utilized our small survey crew to remove competition by hand. This was not as efficient as a mechanically based crew but was successful in removing competition. Further, this change to hand tools allowed for work to be conducted in stands not requiring vehicle access.

Competition removal was conducted on the sites selected, as applying these treatments to the cutblocks described in the previous section would interfere with forest tenure obligations. The previously described cutblock sites would clearly require brushing treatments to facilitate whitebark pine recruitment, which is not the primary obligation of forestry. Forestry obligations require the tenure holder advance trees to a 'free-growing' state, cutting crop trees and retaining whitebark pine in a regenerating stand would hinder this process. Following the field surveys for this study, meetings were held with MFLNRORD personnel to discuss the application of brushing treatments to cutblocks to restore whitebark pine on these sites. Once stands have reached the free-growing state, cutblocks they become the responsibility of the government; thus, there are brushing opportunities at this stage when there is no risk to forest licensees and the government may have an interest in promoting whitebark pine recovery. To test this treatment for restoring whitebark pine we have identified suitable cutblocks with government representatives and will apply treatments in 2021. Further, the vehicle access to these sites via logging road will facilitate crew access with power tools.

When the effort and cost of planting is considered with the presence of high-density natural regeneration that at present is showing low rust infection, consideration of brushing programs in concert with planting should be considered until confirmed rust resistant stock can be planted over putatively resistant stock or this approach may be widely deployed in areas with low rust hazard. This approach may introduce some risk as whitebark that is suddenly exposed may be rapidly infected by rust; but it also introduces treatment options to areas where planting isn't suitable.

Outreach with KYAN was anticipated to be the initiation of a long-term project; however, the Coronavirus stalled the deployment of this plan. Fortunately, the commitment level of the youth to growing trees demonstrated that such a program is feasible in future years. In summary, this project will consist of trees being started and grown by one group to be field planted by the group that chronologically follows them due to the seedlings requiring two-years to produce, only the seedlings for the first group will need to be purchased and the remainder will be grown by the previous groups (Figure 14). This approach is particularly valuable in that the participants will come full-circle in starting seeds and planting seedlings for whitebark pine restoration. Hopefully this program may be re-initiated in 2022.

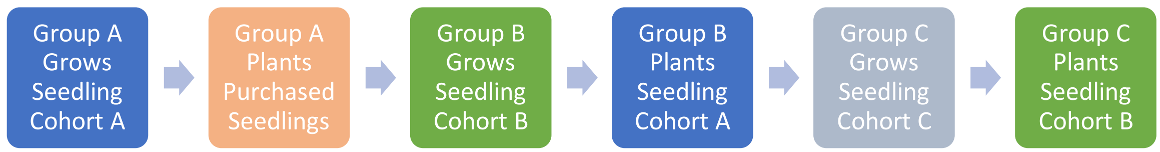

Figure 14. Summary of youth-based restoration project whereby youth both grow and plant whitebark pine seedlings, note the first cohort through will need to plant purchased seedlings.

Outreach with ski areas was particularly effective in that all areas intend to plant 5,000 seedlings in 2021. This treatment is notable in that ski areas tend to brush and remove trees; however following outreach with each area we were able to find suitable areas where skier conflict with seedling planting was low. This planting will be completed in conjunction with the Forest Carbon Initiative (FCI) program. If the 2021 planting is successful, this model may be deployed at other ski areas across the province. Further, the outreach provided by the signage installed by Panorama has a substantial reach, if other ski areas were to follow this lead, the scale of outreach across the province could increase dramatically.

The nursery outreach was meaningful in that several small nurseries have good success in germinating seed but growth of the seedlings is particularly slow. It is hoped that through deploying these new production standards that nurseries can close the gap between germination and seedling production. First Nation owned nurseries have particular interest in the production of whitebark pine as it is an endangered species and in many cases was of cultural value. If production cannot be resolved there is likely a niche market for seed stratification and germination as it is far more onerous and time consuming than other species thus several production nurseries have not been willing to grow whitebark pine due to this burdensome initiation process.

Recommendations based on project outcomes include:

- Evaluate the use of helicopters for planting access when planning a planting project; consider time savings, planter fatigue management, and ease of moving seedlings to site.
- Plant in complex environments such as post-fire habitats with exposed mineral soil and numerous barriers to moderate snow creep and excessive insolation.
- Monitor whitebark pine seedlings planted in monitoring transects at Hourglass Lake.
- Continue with competition removal on sites at risk of conversion to other tree species.
- Use power tools or brushing crews to remove competition from around whitebark pine.
- Identify older (pre-1990) cutblocks and survey for whitebark pine recruitment to larger size classes.
- Work with MFLNRORD to identify opportunities for competition removal around whitebark pine in free-growing cutblocks.
- Work with powerline corridor permit holder to develop whitebark pine maintenance program on Mount Puddingburn.
- Re-initiate project with KYAN once COVID conditions permit.
- Raise awareness about the positive actions of Panorama Mountain Resort and encourage other ski areas to develop comparable signage and whitebark pine recovery programs.
- Continue working with nurseries to develop broad expertise in whitebark pine production.

Acknowledgements

This project would not have been possible without the financial support of the Fish and Wildlife Compensation Program and these other contributors:

- Columbia Basin Trust
- Aboriginal Funds for Species at Risk (AFSAR)
- BC Parks License Plate Fund

In-kind and volunteer support was provided by:

- Kimberley Youth Action Network (KYAN)
- BC Ministry of Transportation and Infrastructure
- Forest Carbon Initiative
    - Panorama Ski Area
    - Panorama Mountain Resort
    - Kicking Horse Mountain Resort
    - Red Mountain
    - Revelstoke Mountain Resort

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Appendix A – Cutblock Recruitment Summaries

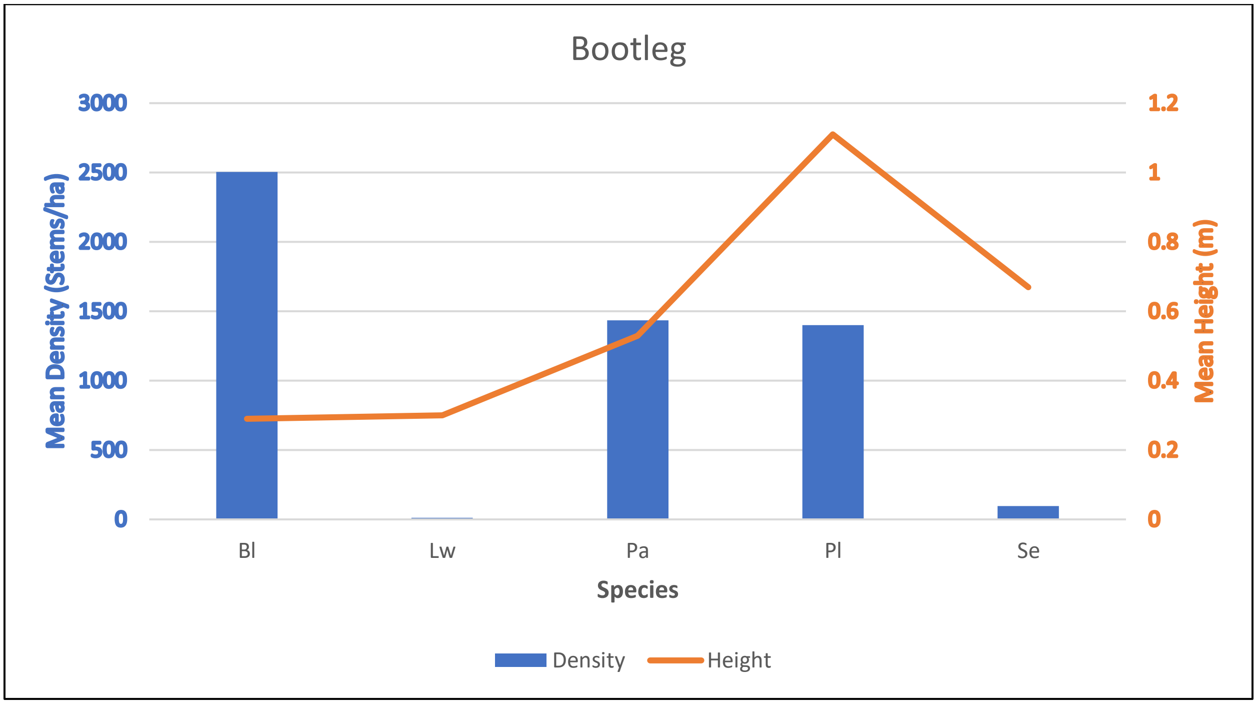

Figure 15. Bl – Subalpine fir, Lw - Western Larch, Pa - Whitebark Pine, Pl - Lodgepole Pine, Se - Engelmann Spruce

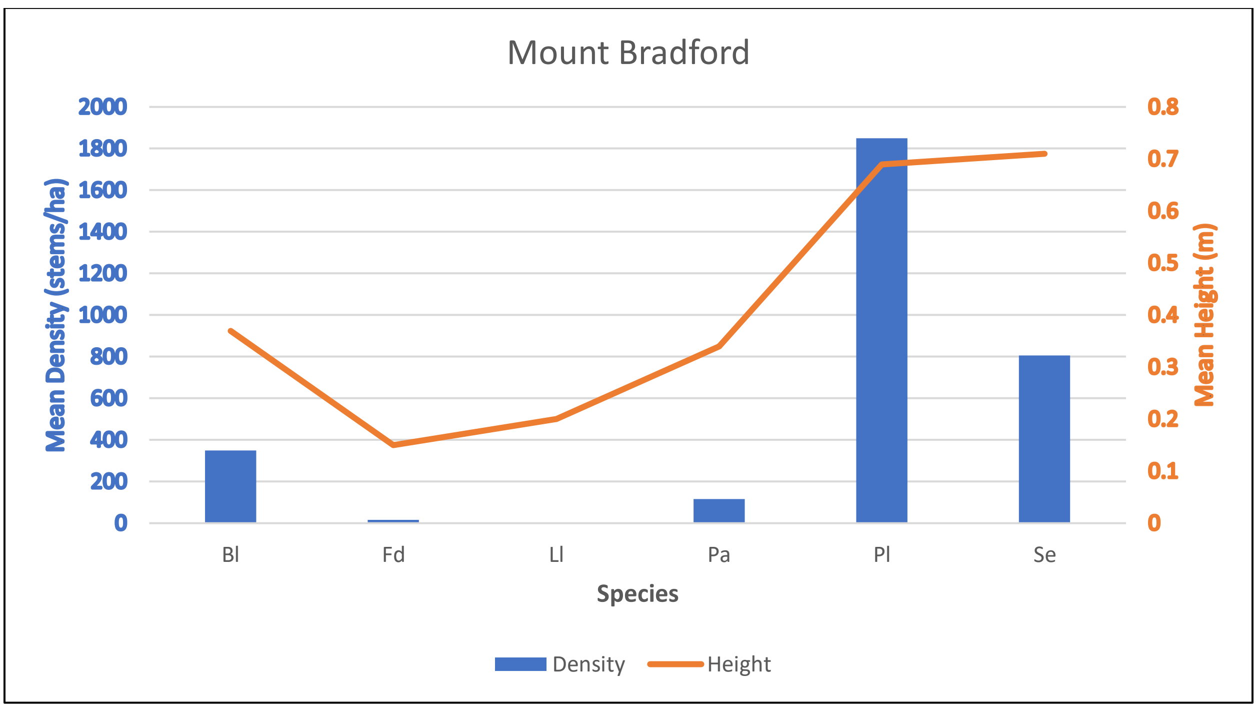

Figure 16.Bl - Subalpine fir, Fd - Douglas-fir, Ll - Subalpine Larch, Pa - Whitebark Pine, Pl - Lodgepole Pine, Se - Engelmann Spruce

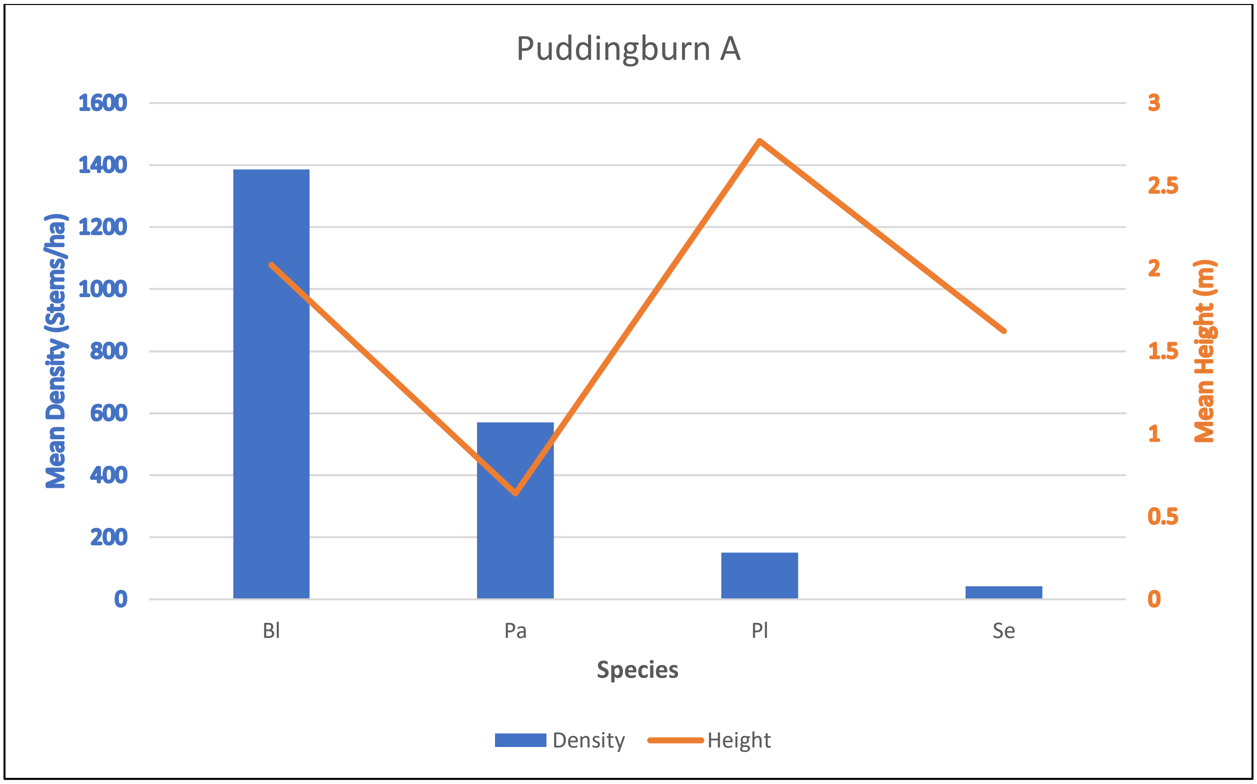

Figure 17. Bl - Subalpine fir, Pa - Whitebark Pine, Pl - Lodgepole Pine, Se - Engelmann Spruce

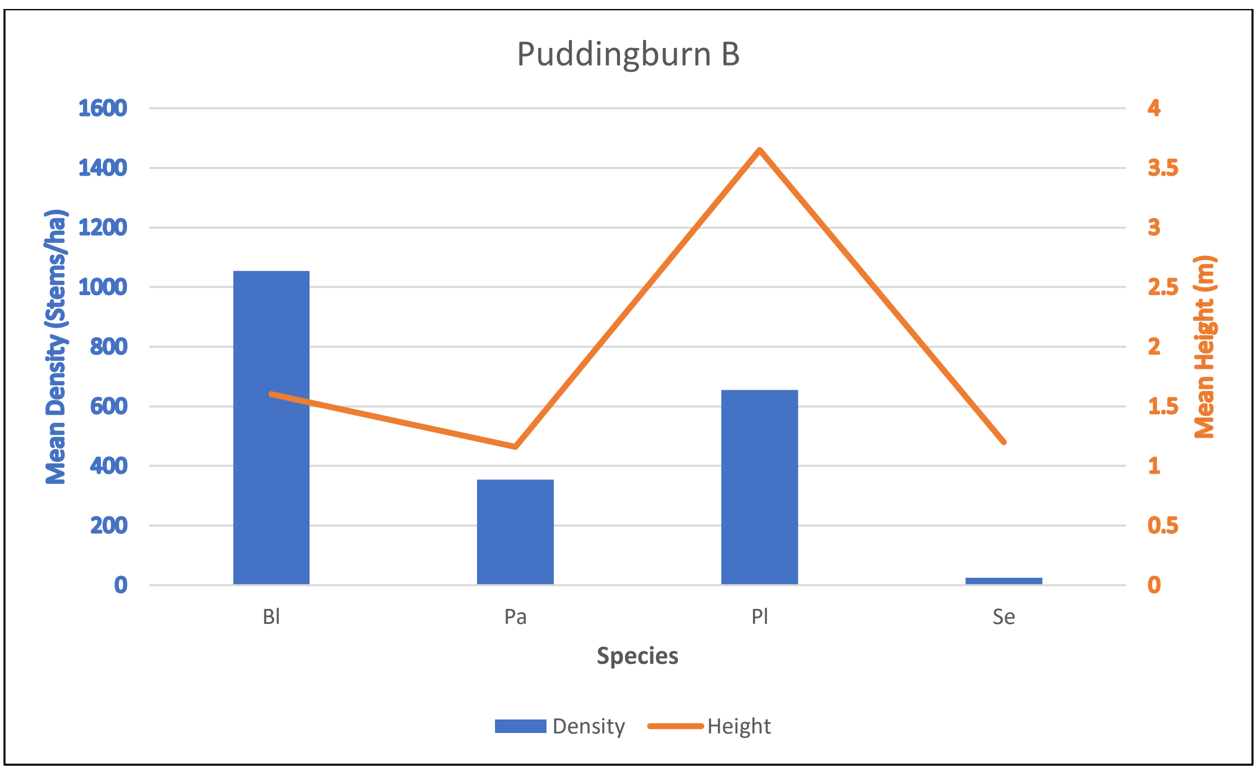

Figure 18. Bl - Subalpine fir, Pa - Whitebark Pine, Pl - Lodgepole Pine, Se - Engelmann Spruce

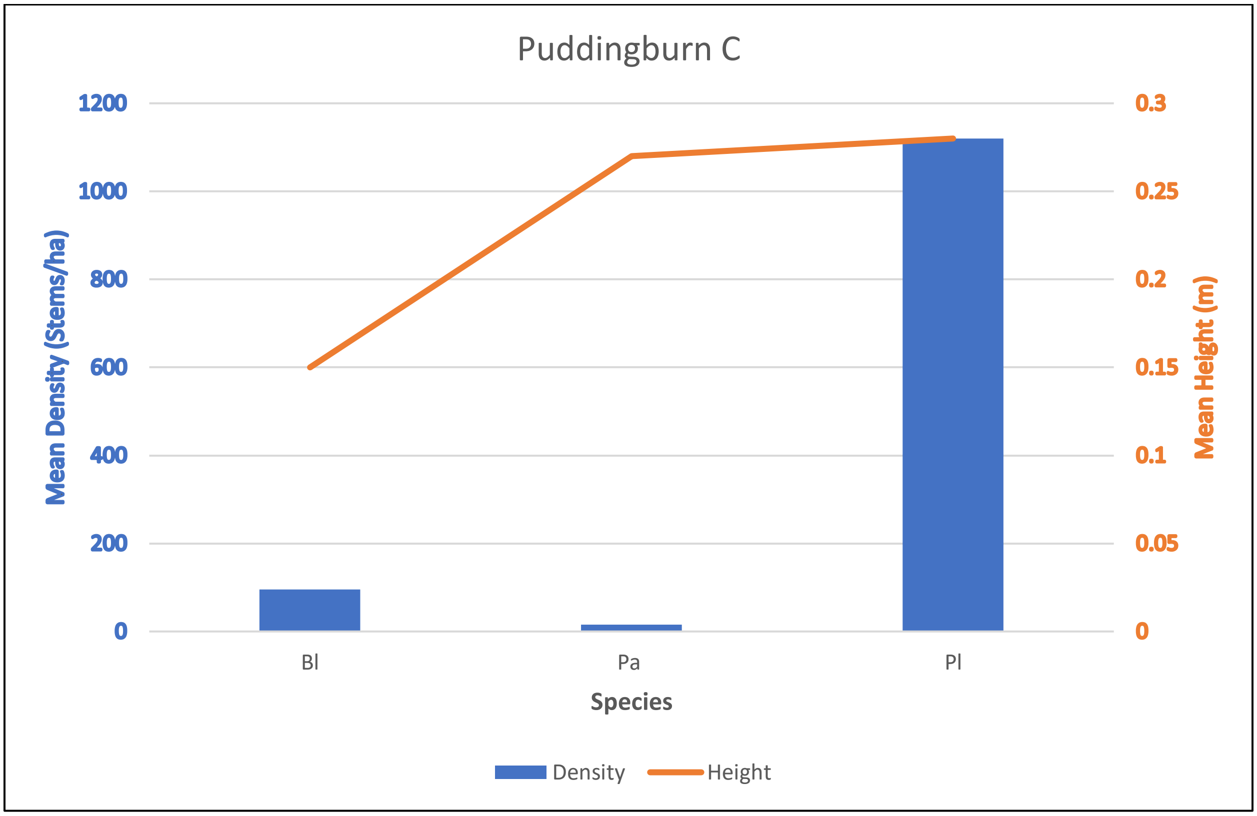

Figure 19. Bl - Subalpine fir, Pa - Whitebark Pine, Pl - Lodgepole Pine

Appendix B: Stand Composition Graphs

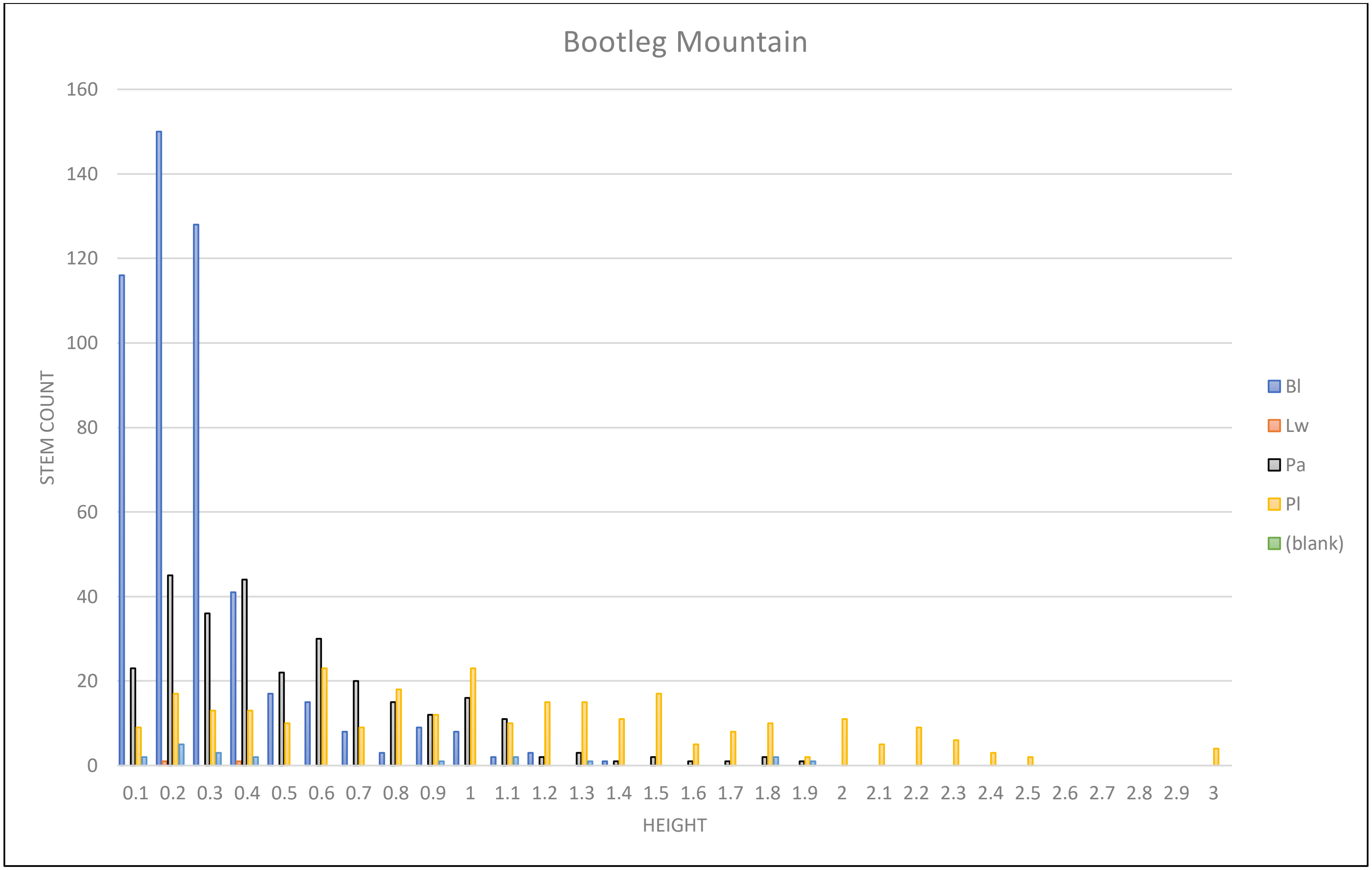

Figure 20. Bl – Subalpine fir, Lw - Western Larch, Pa - Whitebark Pine, Pl - Lodgepole Pine, Se - Engelmann Spruce

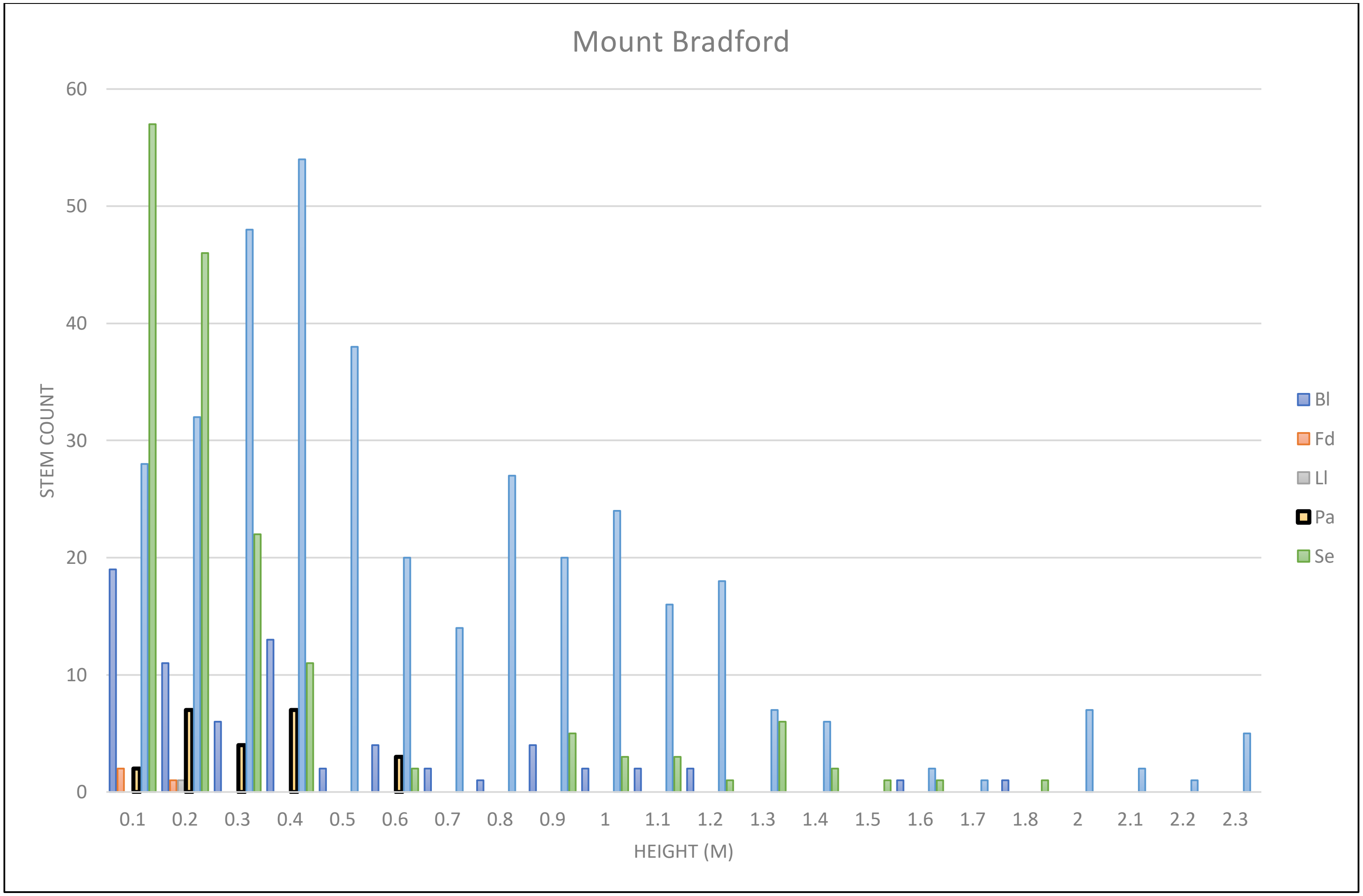

Figure 21. Bl – Subalpine fir, Fd – Douglas-fir, Ll – Subalpine fir, Pa - Whitebark Pine, Se - Engelmann Spruce

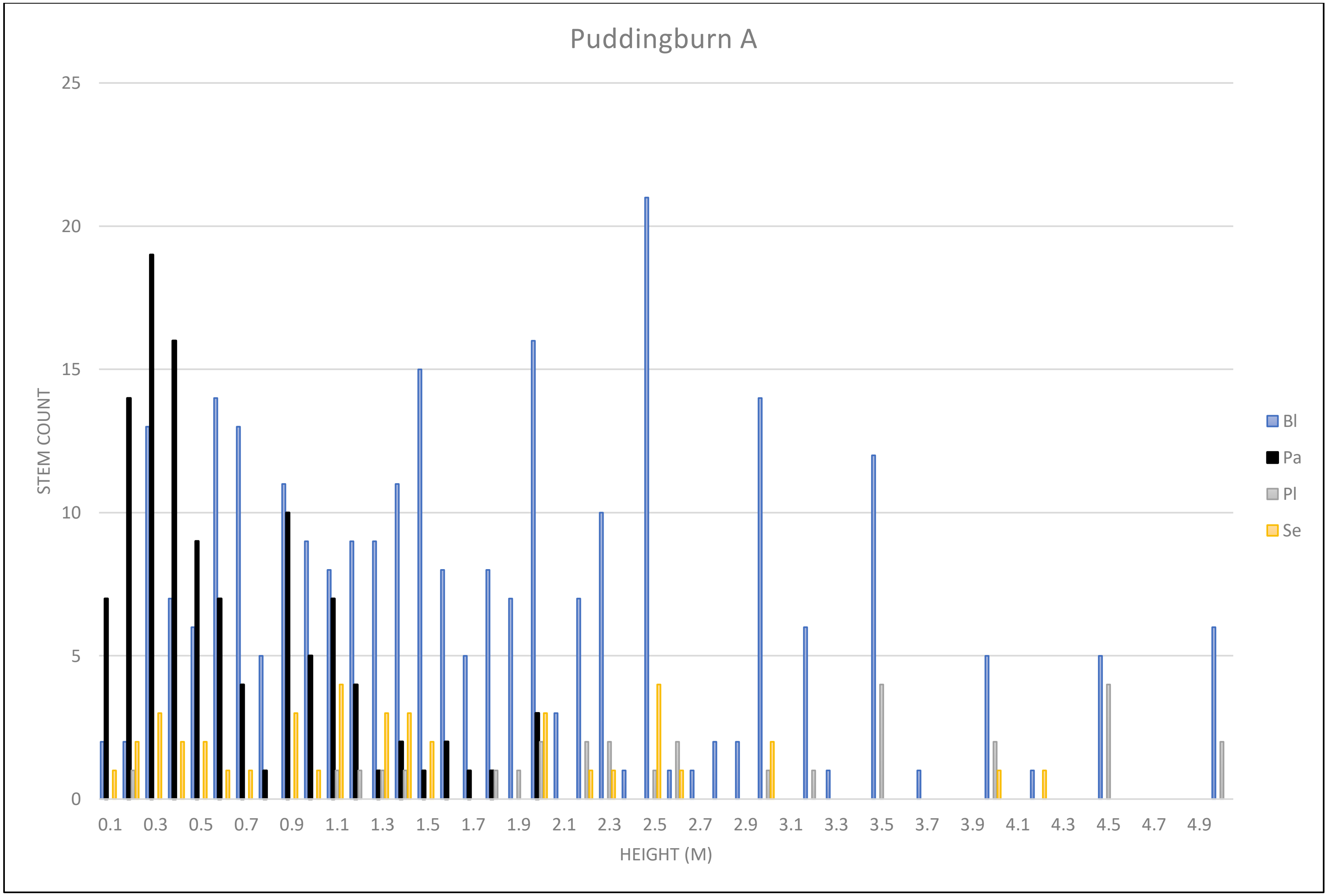

Figure 22. Bl – Subalpine fir, Pa - Whitebark Pine, Pl – Lodgepole Pine, Se - Engelmann Spruce

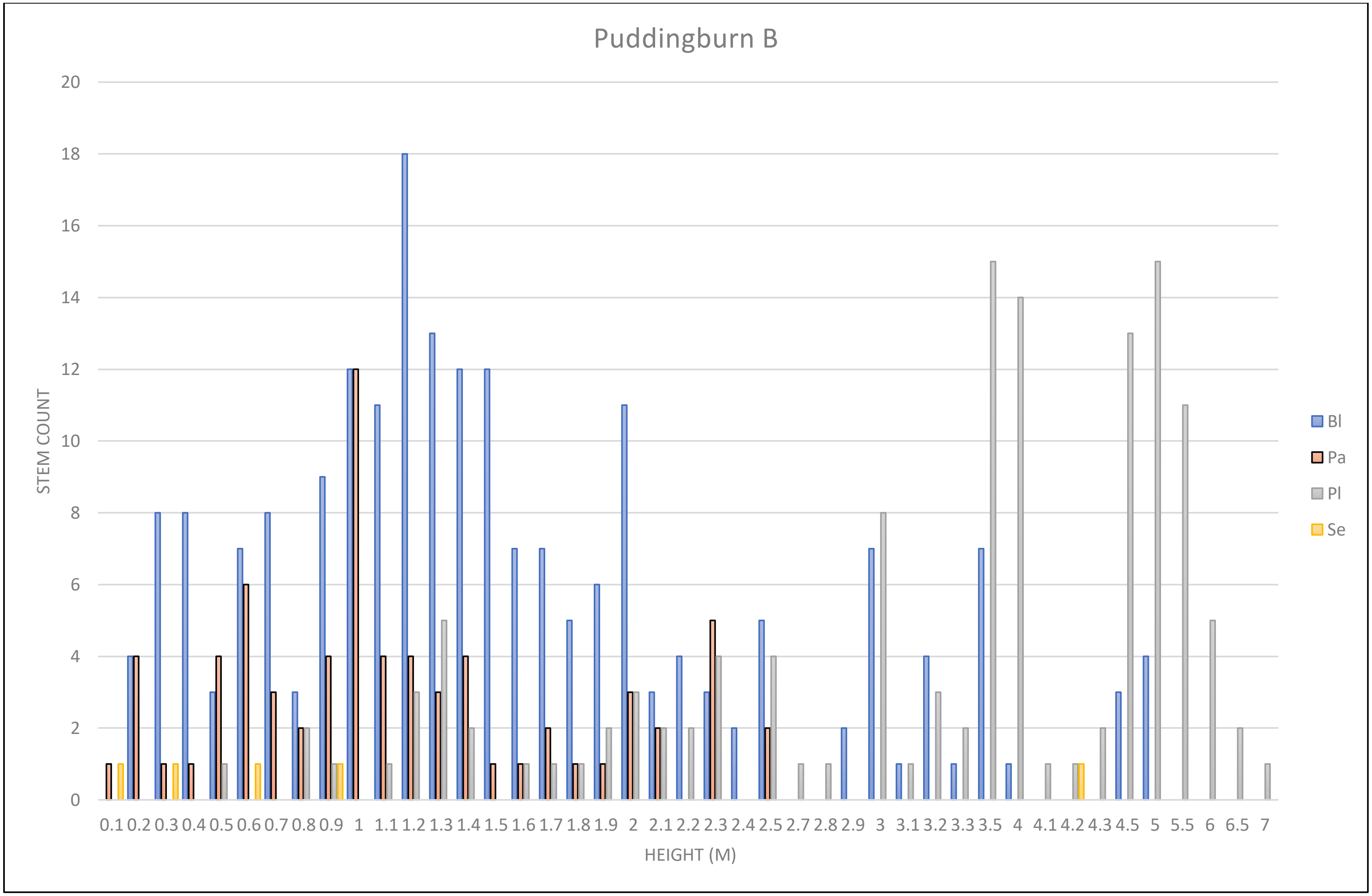

Figure 23. Bl – Subalpine fir, Pa - Whitebark Pine, Pl – Lodgepole Pine, Se - Engelmann Spruce

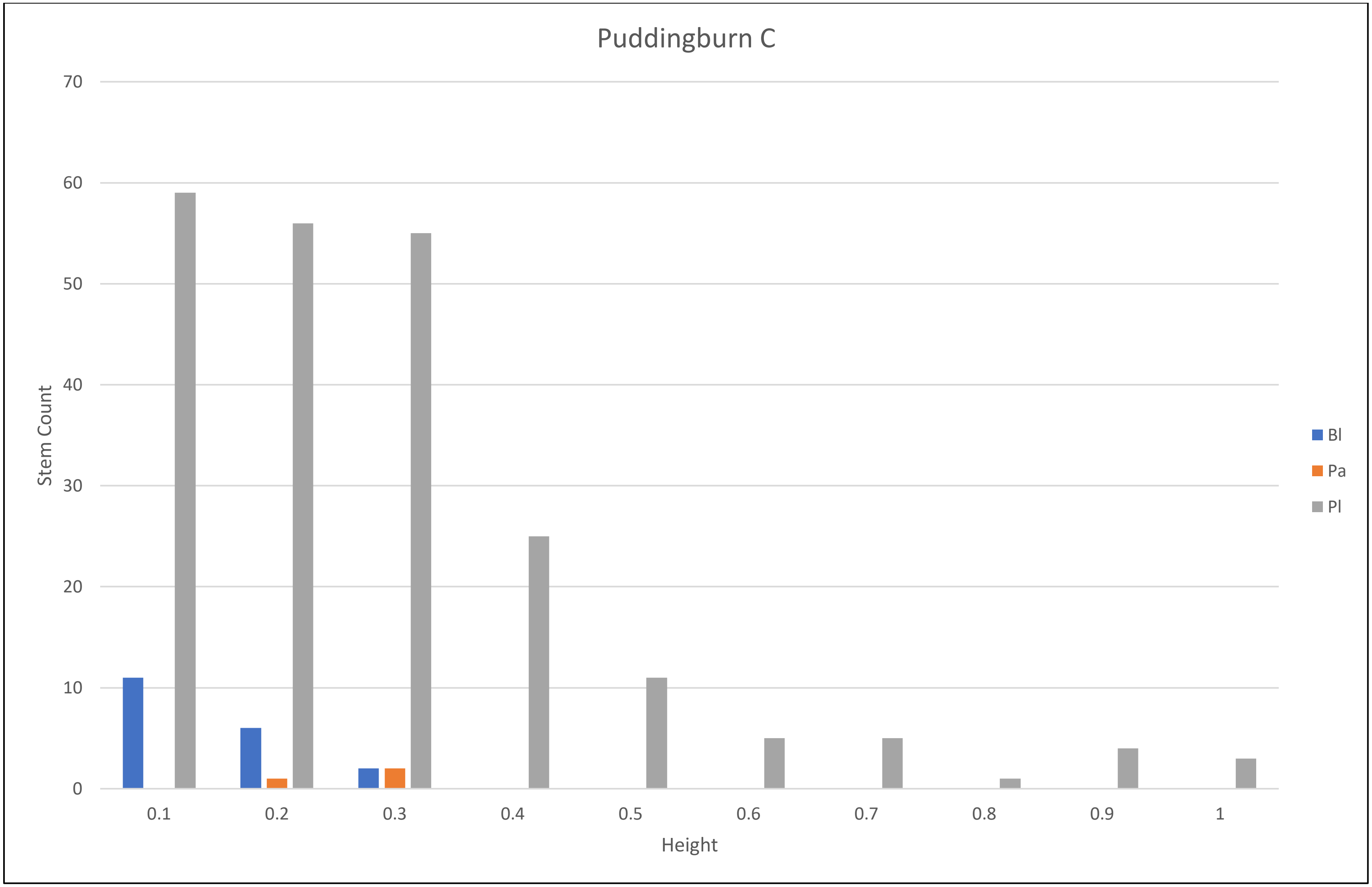

Figure 24. Bl – Subalpine fir, Bl - Pa - Whitebark Pine, Pl – Lodgepole Pine