Bulkley Valley Research Centre

Restoration of Endangered Whitebark Pine (*Pinus albicaulis*) in the Wetzin'Kwa Community Forest and Environs

Wetzin'Kwa Community Forest

2013-2014 Community Grant Final Report

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July 2014

Executive Summary

The Bulkley Research Centre and the Wetzin'Kwa Community Forest Corporation (WCFC), working closely with the Office of the Wet'suwet'en, Woodmere Nursery, UNBC, Skeena Region FLNRO and other community partners, undertook restoration of endangered whitebark pine (*Pinus albicaulis*) ecosystems on the slopes of Hudson Bay Mountain in and adjacent to the Wetzin'Kwa Community Forest in 2012. This report summarizes the results of the second full year of the restoration project, partially funded through a $10,000 Wetzin'Kwa Community Grant. Accomplishments for 2013/14 include:

(1) **Restoration plantings:** the low, mid and high elevation trial sites established in 2012 with seedlings from southern BC provenances were maintained and monitored. A fourth (transitional) trial site planted with our first 129 locally-grown Telkwa River seedlings was planted in June 2014. Two-yr survival was 96% and 2-yr height growth averaged 3 cm. Many (21%) of the low elevation seedlings suffered snowshoe hare damage in October 2013 but were fitted with donated browse protectors by a WCFC crew and emerged in spring 2014 in good condition (see cover photo).

(2) **Seed collection:** The 2013 cone crop exceeded expectations and we collected 320,000 seeds from 92 apparently blister rust-free parent trees across the region. For WCFC we collected, dried and extracted 1.2 kg (13,650 seeds) from 23 parent trees at 3 locations on Hudson Bay Mtn (above Duthie Mine, Miller Creek, Hudson Bay Mtn ski area) and at Hunter Basin in the Telkwa Mountains. These seeds are in storage at BC's Surrey Tree Seed Centre. Seeds from the Smithers area continue to be smaller and of lower quality than those collected south of the Morice River.

(3) **Rust resistance screening:** With support from WCFC we contributed 4800 seeds from 16 of our most promising parent trees to a provincial FLNRO-led rust-resistance screening trial to be outplanted in 2016. We have also arranged to contribute 3600 seeds from 6 additional parent trees to a US Forest Service blister rust screening trial in Idaho. These long-term projects will identify a genetically-diverse set of parent trees that can be used in breeding programs to ensure that future generations of whitebark pine will be more resistant to the white pine blister rust fungus (*Cronartium* ribicola) that has decimated 5-needle (white) pine stands across North America.

(4) **Communications and Outreach**: In 2013/14 we gave one public presentation in Smithers, contributed information for two information signs, published three short technical articles and had various online postings describing our whitebark pine project.

Overall, accomplishments for 2014 exceeded objectives, but seed stratification was delayed to late summer 2014 to allow for an extended stratification period prior to sowing.

ACKNOWLEDGEMENTS

We thank the Wetzin'Kwa Community Forest Corporation and Board for continuing support of whitebark pine restoration in the Bulkley Valley through their Community Grant Program. Special thanks to Bill Golding WCFC Manager for consistent logistical support and advice, and former Board member Marie-Lou LeFrancois for promoting tree species diversity and climate change adaptation/assisted migration research. The Office of the Wet'suwet'en, especially Mike Ridsdale, David DeWit and Francois Depey, have championed the cultural and ecological significance of Whitebark Pine and considerably raised the profile of this important non-timber tree species within traditional Wet'suwet'en territories.

Joe Wong and many technicians at Woodmere Nursery produced the Telkwa River (Jonas Creek) seedlings at no cost and provided tremendous assistance in preparing these seedlings for planting. Other important supporters include Don Pigott, Yellowpoint Propagation; Phil LePage and Dave Coates, FLNRO, Smithers; Dave Kolotelo, FLNRO, Surrey Tree Seed Centre; Dave Duncan, BC Timber Sales, Smithers; Charlie Cartwright, Vicky Berger and Michael Moore FLNRO (rust resistance screening), Linda Tackaberry and Hugues Massicotte, UNBC; and Brian Edmison, Nora Holdings Ltd (drying room). Additional funding support from BC Habitat Conservation Trust Foundation, BC Timber Sales, BC Forest Genetics Council, and Shell Fuelling Change for the seed collection was also important.

John Kelson provided expert tree climbing for cone caging and collection. Additional field and lab assistance was provided by Al Gamble, Theresa White, Alana Clason, Denise Kelly, Nata de Leeuw, Mark Wong, Laura Grant, Michelle Yarham, Deirdre Goodwin, Cheri Lush, Lynn Westcott, Bob Westcott, Dane Drzimotta (Sitka Ck. Tree Services), Anderson Assuah and Susanne Haeussler. Andrew Sheriff, Chris Howard and his crew of tree planters assisted with the 2012 plantings. Nata de Leeuw produced the maps and appendix tables.

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Introduction

Whitebark pine (*Pinus albicaulis)* is a western North American stone pine or five-needled soft pine that reaches the northwest limits of its geographic distribution near Smithers, BC. Whitebark pine is considered a keystone species in mountain ecosystems of western North America because of its foundational role in establishing forest cover on harsh, exposed sites, and because its large, nutritious seeds (pine nuts) are very important to subalpine birds (notably Clark's Nutcrackers), rodents (notably red squirrels) and larger mammals (notably grizzly and black bears). The tree is also culturally significant to the Wet'suwet'en and other BC First Nations who recognize its many values and harvested pine nuts for food.

Like other western pines, the whitebark pine has experienced heavy mortality from mountain pine beetles (*Dendroctonus ponderosae*), which killed most of the largest, cone-bearing trees in west central BC during outbreaks in the late 1980s and 2000s. Smaller trees at higher elevations historically escaped damage from the beetle, but as the climate warms there is an increasing tendency for high elevation populations to also be attacked. More insidiously, whitebark pines of all sizes and ages are steadily dying from an introduced Eurasian disease, the white pine blister rust (caused by *Cronartium ribicola)* that has spread across British Columbia over the past century. A third important damaging agent near Smithers is the pine leaf adelgid (*Pineus pinifoliae)* that alternates between whitebark pine and interior spruce, causing heavy foliage loss and weakening already-stressed pines to the point where they either die pre-maturely or fail to produce cones and seeds. Recent wildfires have contributed to losses of mature cone-bearing trees in some areas (e.g., Morice Provincial Park) while a lack of wildfire in other areas has led to gradual loss of whitebark pine through succession to more shade tolerant true fir and hemlock species.

In 2012, whitebark pine was listed as endangered under Canada's federal Species At Risk Act (SARA) due to cumulative effects of white pine blister rust, mountain pine beetle, changes in wildfire regimes, climate change and other factors (COSEWIC 2010). Provincial agencies and land tenure holders are now called upon to protect existing whitebark pine trees and to undertake restoration of damaged whitebark pine ecosystems. Newly released landscape level tree species selection benchmarks for the Bulkley Timber Supply Area recommend planting up 1% whitebark pine on suitable sites in ESSF subzones over the next 5 years with a long term goal of 5% for the ESSFmc subzone (Table 6 in Mah and Astridge 2014).

The Bulkley Valley Research Centre began research on endangered whitebark pine ecosystems in 2007 (www.bvcentre.ca/whitebark/research) and in 2011 initiated a program of seed collections, nursery seedling production, and whitebark pine restoration and assisted migration plantings in recent wildfires, beetle-killed forests and alpine/parkland areas

(www.bvcentre.ca/whitebark/restoration). Our partnership with the Wetzin'Kwa Community Forest Corporation began in 2012 with the establishment of an assisted migration planting trial at low (1100 m), medium (1300 m) and high (1600 m) elevations using 373 seedlings grown at UNBC Prince George from seeds collected in central and southern BC, Alberta and Washington.

In 2013 the Bulkley Valley Research Centre received a $10,000 Community Grant to maintain and expand the whitebark pine restoration trials in the Wetzin'Kwa Community Forest and adjacent lands with an emphasis on locally collected seeds and locally-grown seedlings. This report summarizes our accomplishments for the period July 2013 to June 2014.

OBJECTIVES

Phase 1 Restoration Trials: *To maintain the Whitebark Pine Restoration Trial established in 2012 at 3 locations in and adjacent to the Wetzin'Kwa Community Forest on Hudson Bay Mountain.*

Phase 2 Seed Collection: *To provide local seed from putatively blister rust resistant parent trees for nursery stock to expand whitebark pine plantings in the Wetzin'Kwa Community Forest.*

Phase 3 Rust Resistance Screening: *To provide local seed for rust resistance screening and selection of blister-rust resistant whitebark pine from the local area.*

ACTIVITIES AND METHODS

Phase 1: Restoration Plantings

- **July 2013:** we revisited the low, medium and high elevation whitebark pine restoration trials on Hudson Bay Mountain to determine overwinter survival, to straighten pigtail stakes and to remove competing vegetation, invasive plants introduced in planting stock, and *Ribes* shrubs. *Ribes* (native gooseberries and wild currants) are the primary alternate host for the white pine blister rust fungus.
- **July and Sept 2013:** Sybille Haeussler and Amelie Goebel travelled to McBride BC to assist UNBC with the installation of a partner trial to the Wetzin'Kwa trial in the McBride Community Forest.
- **October 2013:** we completed 2nd growing season measurements of all 2012 seedlings. We recorded seedling height to the base of the terminal bud, basal diameter with a caliper in 2 directions to the nearest mm, colour of new and old foliage (R=red, Y=yellow, G=green, YR =

yellowish red, which is more red than RY = reddish yellow, etc); vigour (dead, moribund, poor, moderate, good, excellent) and any damaging agents.

- **October 2013:** plastic browse protection guards (see cover photo) were installed on the 93 seedlings at the low elevation restoration trial site located at the Duthie West trailhead (above km 9, McDonell Lake Rd) by WCFC's silviculture crew. The browse guards were obtained free-of-charge through Phil LePage, Research Silviculturist from the Skeena-Stikine District Office of Ministry of Forests, Lands and Natural Resource Operations (FLNRO).

- **June 2014:** overwinter checks and spring maintenance were done on the three 2012 restoration planting trials. Seedling and perimeter maps were GPS'd and prepared for all sites.

- **June 2014**: a fourth restoration trial was established near the base of the Piper Down mountain trail on Hudson Bay Mtn with 129 two-year old seedlings from seed collected at Jonas Creek in the Telkwa River valley in 2011 and grown at Woodmere Nursery. All seedlings were tagged by parent tree, measured (as above) and mapped. Information on the planting microsite and surrounding vegetation was also recorded for each seedling. Inclusion of this trial was a departure from our study plan as these seedlings were originally scheduled to be planted in the 2010 Gosnell Wildfire. These were the first locally collected and locally grown whitebark pine seedlings to be planted in northwest British Columbia.

- **February – June 2014:** seedling data were entered and preliminary analysis of the data was conducted. Maps were prepared for all restoration planting sites (Appendix I).

Phase 2: Seed Collection

- **July 2013:** A reconnaissance helicopter flight was taken from Smithers to Tahtsa Lake to locate whitebark pine seed crops (Helicopter time supplied by BC Timber Sales)
- **early August 2014:** Apparently blister rust parent trees were located, tagged and mapped in the Telkwa Ranges (helicopter supplied by BC Timber Sales) and at 3 sites on Hudson Bay Mtn (hiking access) and cone cages were installed.
- **late September –early October 2013:** Cages and cones were collected from all parent trees.
- **October-November 2013:** Cones were air dried for 2 months in a heated, ventilated room (supplied by Brian Edmison, Nora Holdings Ltd.)
- **December 2013:** seeds were manually extracted, cleaned and weighed by parent tree and sent to the FLNRO's Surrey Tree Seed Centre for storage.

Phase 3: Rust Resistance Screening

- **August 2013:** FLNRO researchers Charlie Cartwright and Michael Murray confirmed that a province-wide blister rust screening trial would be undertaken in British Columbia and requested contributions of seeds from tagged and mapped parent trees in northwest BC. This was a welcomed departure from our study plan as we had originally planned to send trees to Washington State for blister rust screening.
- **December 2013:** seeds from 16 putatively blister rust resistant parent trees were sent to FLNRO's Cowichan Lake Research Station for inclusion in the first whitebark pine blister rust field screening trial for British Columbia.
- **June 2014:** USDA Forest Service Regional Geneticist confirmed that 6 seedlots from 6 whitebark pine populations (3600 seeds) in west central BC can be included free-of-charge in a whiteb pine blister rust screening trial to begin September 2014 in Moscow, Idaho.

RESULTS

Phase 1. Whitebark Pine Restoration Plantings

Four whitebark pine restoration trial sites have now been established in and adjacent to the Wetzin'Kwa Community Forest on the southwest side of Hudson Bay Mountain with good road access from Smithers (Table 1, Figure 1, Appendix I). The WL site has 2-wheel drive access when the road is recently brushed (as of June 2014), while the other 3 sites involve a steep 15-30 minute hike.

Table 1. Location and planting information for the 2012 and 2014 Wetzin'Kwa restoration planting trials. See Appendices I and II for additional details.

GPS label	Site	Location	Elev. (m)	BEC unit	Seedlings Planted	Stock Type	Provenances (Table 2)	Planting Date
WL	Wetzin'Kwa Low elevation	Duthie West trailhead	1033	SBSmc2	94	4-yr-old, extra-large plug, UNBC	JU, MP, SW, TA, TW	June 8, 2012
WM	Wetzin'Kwa Mid elevation	Piper Down - Upper	1340	ESSFmc	93	4-yr-old, extra-large plug, UNBC	JU, MP, SW, TA, TW	June 22, 2012
WH	Wetzin'Kwa High elevation	Hudson Bay Mtn Prairie	1650	BAFA	89 trees + 33 caches of 5 seeds each	4-yr-old, extra-large plug, UNBC	JU, MP, SW, TA, TW	July 17, 2012 (caches July 2011)
WT	Wetzin'Kwa Transitional	Piper Down - Lower	1100	SBSmc2/ ESSFmc transition	129	2-yr-old 80 cm^3 plug, Woodmere	JC (6 parent trees)	June 6, 2014

The WL, WM and WH sites were planted in 2012 with seedling and seed stock collected at 5 locations in central and southern BC, Alberta and Washington (Table 2) and grown by Linda Tackaberry at UNBC for a mycorrhizal laboratory study. These were bulked seed collections from unidentified parent trees. In the nursery, the seedlings were grown in alpine or subalpine soil from two locations (PA = Perkins Peak alpine; PS = Perkins Peak subalpine; MA = McBride Peak alpine; MS = McBride Peak subalpine) to test the hypothesis that subalpine soils will support better growth because they will be inoculated with whitebark pine-compatible mycorrhizae whereas alpine soils will not. Both the provenance and the nursery soil were recorded for each numbered tree seedling at WL, WM and WL to allow for future field-based studies on these seedlings.

Table 2. Whitebark pine provenances and parent trees included in the 2012 (WL, WM, WH) and 2014 (WT) Wetzin'Kwa restoration trials.

Abbrev.	Site Description	Parent Trees (FGC tag)*	Coordinates (decimal degrees)	Elev. (m)	Planted at: (# of seedlings)
JC	Jonas Creek, west of Telkwa, BC	JC1 (1018) JC2 (1016) JC3 (1017) JC6 (1014) JC7 (1013) JC9 (1020) JC10 (1021) JC11 (1023) JC12 (1022)	54.63889796 -127.417941 54.63947497 -127.418154 54.63982802 -127.418643 54.63839203 -127.416969 54.63771603 -127.417386 54.63520498 -127.406664 54.63607402 -127.407568 54.63771603 -127.408201 54.63803002 -127.407836	1195 1211 1217 1208 1184 1216 1226 1300 1315	WT (15) WT (7) WT (11) WT (2) WT (10) WT (31) WT (32) WT (18) WT (3) Total: 129
JU	Junior Peak near Entiat, Washington	None, bulk collection at each site	47.99005 -120.40527	2438	WL (20) WM (19) WH (21)
MP	Blackwell Peak in Manning Park , BC		49.1 -120.76	~2000	WL (20) WM (19) WH (19)
SW	Mt. Sidney Williams, north of Fort. St. James, BC		54.88415 125.37427	1490	WL (16) WM (16) WH (14sl, 165sd)[ǂ]
TA	Table Mtn, W of Pincher Creek, AB		49.36641 114.25193	2204	WL (18) WM (18) WH (16)
TW	Heckman Pass, Tweedsmuir Park, BC		52.53990 125.81197	1541	WL (20) WM (21) WH (19)

*the FGC tag is a unique number tag assigned to each putatively blister rust whitebark pine parent tree by the BC Forest Genetics Council and nailed to the tree stem from which cones were collected. Cones from adjacent stems are not collected because they could be genetically distinct trees from a seed cache.

ǂ sl = planted seedlings; sd= seeds planted in 33 five-seed caches

The WT (2014) site was planted with 129 locally grown seedlings grown from seeds from 9 putatively blister-rust rust resistant parent trees collected at Jonas Creek, a tributary of the Telkwa River (Table 2). Although there was heavy blister rust infection in the Jonas Creek stand, the selected trees had minimal or no evidence of blister rust. Each of the parent trees was mapped and tagged with a unique number assigned by the BC Forest Genetics Council. Descriptive information was collected for each parent tree and is also archived by the BC Forest Genetics Council who have a collection of 200 – 1270 seeds from each parent tree in long-term storage for in-situ gene conservation. A July 2014 field check indicated that the health of four of these parent trees (JC4, JC5, JC6, JC7) has deteriorated since 2011. JC4 has a large white pine blister rust stem canker, while the other trees appear to be declining from drought or climatic stress as they have abundant red needles but no evidence of pests or pathogens.

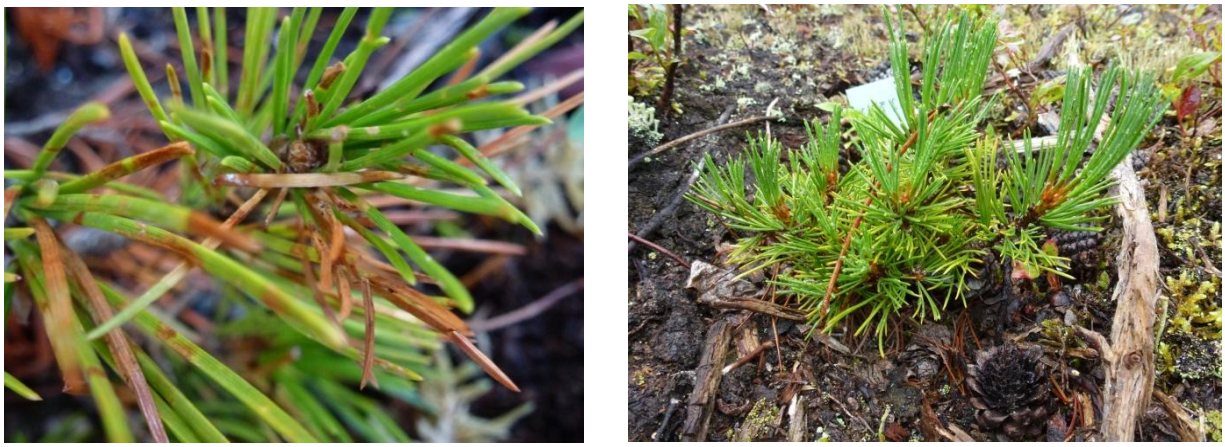
Seedling Performance - 2012 Plantings:

The five provenances were evenly distributed among the low (WL), mid (WM) and high (WH) elevation sites and there were no significant differences in seedling size or condition among the 3 sites at planting (June-July 2012). Seedling survival across all sites was 96% two full years after planting and decreased very slightly with increasing elevation (Table 3). The seedlings averaged 8 cm height and 0.6 cm in basal diameter when planted in spring 2012 and 11 cm in height and 0.7 cm diameter in fall 2014. This is too little growth to detect any differences by site or provenance. Vigour in Fall 2013 was also similar, averaging 3.1 on a scale of 0 to 5 (Table 3), but seedling damage differed among the three sites.

Table 3. Performance of whitebark pine seedlings planted in June-July 2012

Site	n	Survival			Mean Height (cm) ± s.d.			Diam. (cm) ± s.d		Vigour ±s.d.
		Oct 2012	Oct 2013	June 2014	June 2012	Oct 2012	Oct 2013	June 2012	Oct 2013	Oct 2013
WL	94	100%	98%	98%	8.0±2.4	10.2±3.1	10.8±3.3	0.7±0.2	0.6±0.1	2.9±0.7
WM	93	99%	98%	97%	6.6±2.7	8.5±1.8	10.6±2.9	0.6±0.1	0.7±0.1	3.2±0.9
WH	89	98%	94%	93%	9.6±2.7	10.5±2.6	11.7±3.0	0.6±0.1	0.7±0.1	3.2±1.1
All	276	98%	97%	96%	8.0±2.8	9.9±30	11.0±3.5	0.6±0.1	0.7±0.2	3.1±0.9

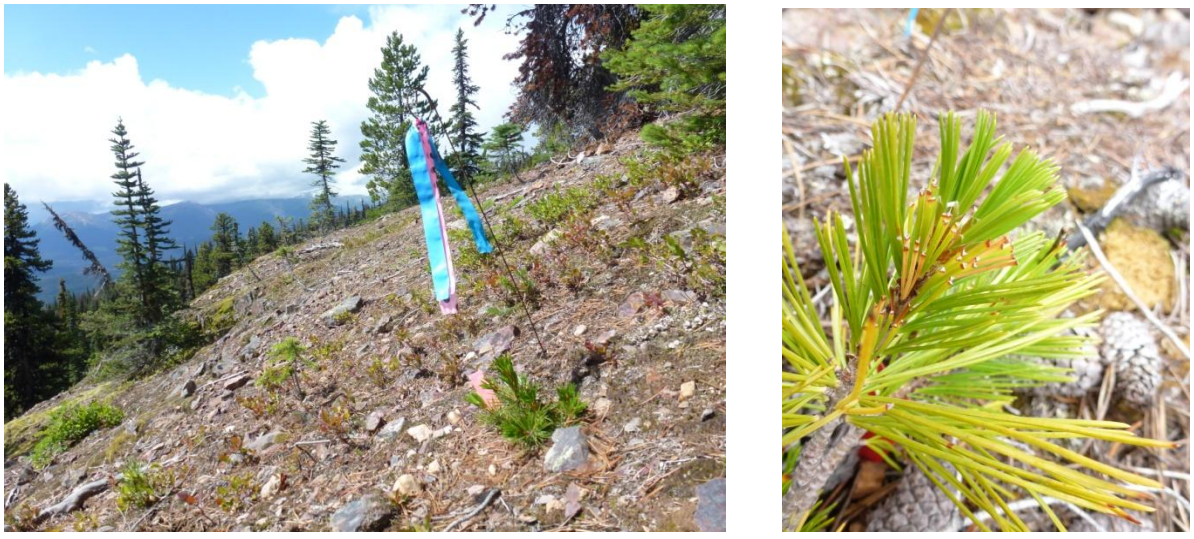
At WL, 7% of seedlings suffered substantial heat and desiccation damage in the first growing season and most seedlings experienced needle loss or discolouration (yellowing) from heat and drought stress (Fig. 1a). Most seedlings looked better in June 2013 with healthy green new foliage (Fig. 1b), but at the end of the second growing season 21% of the seedlings had new growth clipped by snowshoe hares. Snowshoe hare browse protectors installed in October 2013 were highly effective and no further hare damage was noted in June 2014. Clipped seedlings were resprouting well and undamaged seedlings appeared to be benefitting from the additional warmth inside the plastic exclosures with 5% of seedlings having 2014 leaders in the 12-20 cm range (cover photo).



(a) **(b)**

Figure 1. Seedling performance at low elevation WL site. (a) blistering and discoloration of foliage due to high temperatures in summer 2012; (b) good new growth in summer 2013. See cover photo for excellent new growth of some browse-protected seedlings in June 2014. (S. Haeussler photos).

There was little or no seedling damage at the WM site over two years. Significant needle shedding was noted for 7% of seedlings and 1 seedling had minor browsing, perhaps by a grouse (Fig. 2). Overall, WM seedlings were the most stable, growing slowly but steadily with 3 seedlings dead and only 2 seedlings with poor vigour in June 2014.



(a) **(b)**

Figure 2. At the mid-elevation WM site whitebark pine seedlings are establishing well on the thin rocky soil (a). Minor foliage nibbling (b) was observed on one seedling. (S. Haeussler photos).

The WH seedlings are spread over 10 hectares of alpine tundra and krummholz/tundra ecotone at the edge of the Hudson Bay Mountain Prairie. These seedlings are the most exposed to solar radiation and

extreme weather and except for a few seedlings planted in sheltered depressions, their foliage was heavily discoloured from solar radiation and wind, especially after the low snow winter of 2013/14 which exposed all but the most sheltered seedlings to winter desiccation damage (Fig. 3). To date, 6 seedlings have died and 17 were described as having poor vigour in June 2014. Most have good buds and appear to be growing well despite damage to their foliage.

Figure 3. Typical winter desiccation damage on an otherwise healthy high elevation WH seedling, June 2014. Buds on this seedling appear undamaged (S. Haeussler photo).

As shown by the cover photo and Figure 3, taken 1 week apart, an important difference between the low, mid and high elevation sites is seedling phenology. The low elevation seedlings break buds earlier, but also set their buds earlier in the year. It is unknown whether the WL seedlings have a longer period of diameter and root growth or whether drought shortens the growing season to a similar length as at WM and WH –this appears to vary from year to year and among microsites. The high elevation site is located adjacent to a FLNRO alpine climate station (WH POC in Appendices I and II) (W. Mackenzie, MFLNRO ecologist, pers. comm.) but the WM, WL and WT sites are not instrumented.

The establishment rate for seeds cached in 2011 at WH was 20% and seedlings averaged 2.3 cm tall.

In July 2013 the BVRC assisted UNBC in establishing a restoration trial using the UNBC whitebark pine seedlings at McBride Peak in the McBride Community Forest in summer 2013. This trial matches the Wetzin'Kwa-Hudson Bay Mountain trial and uses the same provenances (Table 1) except that it has only a mid- and a high-elevation site (see article in Association of BC Forest Professionals newsletter).

Seedling Establishment – 2014 Planting

We planted 129 two-year old seedlings of Jonas Creek (Telkwa River) provenance from 6 putatively blister rust resistant parent trees grown at Woodmere Nursery at the WT (Wetzin'Kwa Transitional site (Fig 4., Table 3). Unlike the 2012 UNBC seedlings, these Woodmere Nursery seedlings all had deep green foliage at the time of planting with few or no red-tipped needles. A few seedlings that were undersized or had damaged roots were included in the trial rather than being discarded.

(a) (b)

Figure 4. BVRC intern Nata de Leeuw and Woodmere Nursery coop students Ash Niño Torres and Christina L (a) prepare local whitebark pine seedlings for planting. (b) newly planted seedling at the WT site, June 2014 (S. Haeussler photos)

At outplanting, the seedlings averaged 10.6 cm in height and 0.5 cm in basal diameter at outplanting and had a vigour of 3.5 on a scale of 0 to 5 (Table 4). Although they were just over 2 years old, they had completed 3 growing seasons in the nursery and had already set their 2014 buds. They were 2 cm taller than the 4-year old UNBC seedlings at outplanting (compare Table 3) with longer, greener needles, but had slightly smaller diameters and much smaller root systems, thus the root:shoot ratio (not measured) of the Woodmere seedlings was undoubtedly lower than that of the UNBC seedlings and could affect their outplanting performance.

Table 4. Mean size and condition of locally-grown Jonas Creek (JC) provenance seedlings by parent tree when outplanted at the Wetzin'Kwa Transitonal (WT) restoration site in June 2014.

Parent Tree	n	Outplanting Height (cm ± s.d.)	Outplanting Diameter (cm ± s.d.)	Outplanting Vigour* ±s.d.
JC1	15	12.8 ± 1.9	0.6 ± 0.05	3.9 ± 0.2
JC2	7	8.7 ± 2.5	0.5 ± 0.04	3.6 ± 0.6
JC3	11	10.5 ± 1.7	0.6 ± 0.08	3.8 ± 0.5
JC6	2	8.5 ± 1.8	0.5 ± 0	3.0 ± 0
JC7	10	8.8 ± 3.8	0.5 ± 0.05	3.7 ± 0.5
JC9	31	10.1 ± 2.1	0.5 ± 0.08	3.4 ± 0.6
JC10	30	11.3 ± 3.2	0.5 ± 0.10	3.3 ± 0.5
JC11	18	10.4 ± 2.7	0.6 ± 0.09	3.8 ± 0.4
JC12	3	11.9 ± 3.7	0.6 ± 0.05	3.7 ± 0.6
All	126ł	10.6 cm	0.5 cm	3.5 (moderate-good)

*0 = dead, 1 = moribund, 2=poor, 3 = moderate, 4 = good, 5 = excellent ł parent tree reported for 126 of 129 trees

Phase 2. Seed Collection

The 2013 whitebark pine cone crop was much better than expected. Due to back-to-back warmer than average summers in 2012 and 2013, it was the largest, best-maturing cone crop since we began monitoring whitebark pine cones in west central BC in 2007. With significant funding from various sources (notably $8000 in-kind helicopter time and $20,000 for seed collection from BCTS Babine Business area) we were able to scale up our seed collection efforts to take advantage of the opportunity (Figs. 5 and 6). Table 5 summarizes the full 2013 seed collection results.

Figure 5. John Kelson collecting cones from caged putatively blister rust resistant whitebark pine trees above Hunter Basin, Telkwa Mountains, September 2013. (S. Haeussler photo).

Table 5. Description and allocations of whitebark pine seeds collected by Bulkley Valley Research Centre in 2013. Costs of seed collection were shared by these projects, clients and funders. Seeds are currently stored at BC Tree Seed Centre.

Client	Objectives	Allocation of Seedlots by Geographic Area Parent trees, seed wt, seed number					
		Mt. Sweeney, S. of Houston	**Smoke Mtn., S of Houston**	**Kidprice Lk. Nenikekh Park**	**Hunter Basin, Telkwa Mtns**	**Hudson Bay Mtn, Smithers**	**Total**
Forest Genetics Council of BC (FGC)	Gene conservation: ex-situ storage of genetically diverse, apparently blister-rust resistant whitebark pine seeds	10 parents 3000 seeds 419 g	10 parents 3000 seeds 404 g	--	10 parents 2863 seeds 275 g	--	
FLNRO – Tree Improvement Branch	Inclusion in a BC-wide screening trial to identify whitebark pine parent trees that are resistant to white pine blister rust (*Cronartium ribicola*)	4 parents 1200 seeds 164 g	4 parents 1208 seeds 212 g	4 parents 1200 seeds 143 g	3 parents 900 seeds 97 g	--	15 parents 4508 seeds 616 g
BC Parks (funded by HCTF and Shell Fuelling Change)	Wildlife habitat restoration and enhancement in Provincial Parks (Nenikekh/Nanika-Kidprice, Morice Lake)	--	--	22 parents 84343 seeds 10.6 kg	--	--	30 parents 8863 seeds 1099 g
Wetzin'Kwa Community Forest (WCF)	Wildlife habitat restoration and enhancement and climate change adaptation in the Wetzin'Kwa Community Forest	--	--	--	10 parents 3994 seeds 405 g	13 parents 9657 seeds 853 g	23 parents 13652 seeds 1258 g
BC Timber Sales (BCTS)	Habitat restoration, wildlife enhancement and climate change adaptation in MPB salvage areas of the Bulkley-Babine operating area.	10 parents 33615 seeds 4393 g	7 parents 12345 seeds 1572 g	--	9 parents 3758 seeds 393 g	10 parents 9274 seeds 814 g	36 parents 59028 seeds 7172 g
Huckleberry Mine	Reclaimation of mine wastes to restore habitat.	3 parent trees 500 seeds; 71 g	--	--	--	--	3 parent trees 500 seeds 71 g
Bulkley Valley Research Centre (funded by all above)	Wildlife habitat enhancement and restoration of the Gosnell wildfire. Educational use.	10 parents 5000 seeds 664 grams	10 parents 5000 seeds 682 grams	--	10 parents 405 seeds 42 g	13 parents 853 seeds 77 g +1 addtl tree	43 parents 11258 seeds 1465 g
Total	All uses.	10 parents 43315 seeds 5.7 kg	10 parents 21553 seeds 2.9 kg	22 parents 85543 seeds 10.7 kg	11 parents 11920 seeds 12.1 kg	14 trees 19784 seeds 1.7 g	67 parents 182,200 seeds 22.2 kg

a)

b)

c)

Figure 6. Whitebark pine seed extraction is a labour intensive process: (a) Al Gamble spreads cones for drying in facility donated by Nora Holdings Ltd.; (b) manually extracting seeds from dried cones; (c) dried, cleaned seeds ready for shipping to Surrey Tree Seed Centre (S. Haeussler photos).

We collected and stored 1.3 kg of seeds (estimated 13,652 seeds) from 23 putatively blister rust resistant parent trees for the WCFC in 2013 (Table 5). Ten of the parent trees were located on a ridge immediately north of Hunter Basin in the Telkwa Mtns (Fig. 5), while the remaining 13 parent trees were located on Hudson Bay Mtn., six above the Duthie Mine, four at Miller Creek headwaters, and two at the Toboggan Hill in the Hudson Bay Mtn. ski area. Seed weight ranged from 6.2 g/100 seeds to 13.8 g/100 seeds with a mean (by tree) of 10 g/100 seeds.

As observed in 2007 and 2011, seed crops southwest of Houston (in the ESSFmk subzone from Morice Lake to Tahtsa Lake) were much better than those in the Smithers area (ESSFmc transitioning to ESSFwv). Not only were there many more, larger mature cone-bearing trees in the ESSFmk and upper SBSmc subzone in this area, but the trees also had larger cones with more, larger, heavier seeds that achieved a greater stage of maturation than those in the ESSFmc and ESSFwv subzones of the Skeena and Bulkley Ranges.

Phase 3: Rust Resistance Screening

BC Ministry of Forests, Lands and Natural Resource Operations made the decision in 2013 to proceed with an in-house program of rust-resistance screening for whitebark pine. In Dec. 2013, we were pleased to contribute 300 high quality seeds from each of 16 (4800 seeds total) of our best, apparently rust-resistant parent trees growing in west central BC to the 2014 program. In return, each of the seedlots will be X-rayed so that we have information on seed quality for the remaining stored seeds from these 16 trees. Seed stratification for this trial began in January 2014.

The organizers of the project, Charlie Cartwright (MFLNRO forest geneticist) and Michael Murray (MFLNRO forest pathologist), were very pleased with the collaboration with the Bulkley Valley Research Centre and our timely contribution of properly documented and collected seeds and are hoping to locate one of the first round of field trials in the Smithers area in 2015 or 2016. Perhaps it could be located within the Wetzin'Kwa Community Forest.

In June 2014, Mary Mahalovich, Regional Geneticist for the USDA Forest Service in Moscow Idaho contacted us to confirm that 6 seedlots of 600 seeds each (from 6 parent trees from separate populations) could be included in a U.S. range-wide blister rust genetic resistance screening trial at no cost to the Bulkley Valley Research Centre. Seed stratification for this trial will begin in September 2014.

In total, 24 parent trees from west central BC will be screened for blister rust resistance (Table 6). This is a much better outcome for the Phase 3 rust resistance program than anticipated. Wetzin'Kwa Community Forest's partial contribution to the cost of collecting, extracting and shipping these seeds was much needed and appreciated. Additional stored seeds from the 2013 crop have been set aside at the Surrey Tree Seed Centre for later contributions to the screening program. In addition, all parent trees are all fully tagged and GPS located so that additional seeds can be collected from these trees if they are found to show high levels of resistance to whitebark pine blister rust.

Table 6. Parent tree information and numbers of seeds contributed to BC MFLNRO and USDA Forest Service white pine blister rust resistance screening trials initiated in 2014.

Parent Tree (unique #)	Geographic Location	Elev. (m)	# of Seeds	Screening Trial	Stratification Date
SM01 (1026)	Smoke Mtn Road	1118	300	FLNRO	January 2014
SM03 (1028)	Smoke Mtn Road	1190	300	FLNRO	January 2014
SM04 (1029)	Smoke Mtn Road	1250	300	FLNRO	January 2014
SM07 (1068)	Smoke Mtn Road	1203	300	FLNRO	January 2014
SW01 (1072)	Mt. Sweeney Road	1513	300	FLNRO	January 2014
SW05 (1076)	Mt. Sweeney Road	1449	300	FLNRO	January 2014
SW07 (1078)	Mt. Sweeney Road	1413	300	FLNRO	January 2014
SW09 (1080)	Mt. Sweeney Road	1380	300	FLNRO	January 2014
SW10 (1081)	Mt. Sweeney Road	1322	300	FLNRO	January 2014
HUB4 (1085)	Hunter Basin, Telkwa Mtns	1486	300	FLNRO	January 2014
HUB6 (1087)	Hunter Basin, Telkwa Mtns	1450	300	FLNRO	January 2014
HUB8 (1089)	Hunter Basin, Telkwa Mtns	1454	300	FLNRO	January 2014
K1 (1030)	Kidprice Lake	919	300	FLNRO	January 2014
K9 (1035)	Kidprice Lake	1010	300	FLNRO	January 2014
K11(1037)	Kidprice Lake	1022	300	FLNRO	January 2014
K13(1045)	Kidprice Lake	1011	300	FLNRO	January 2014
K7 (1036)	Kidprice Lake	1023	600	USDA	September 2014
SM06 (1067)	Smoke Mtn Rd.	1077	600	USDA	September 2014
SW02 (1073)	Mt. Sweeney	1540	600	USDA	September 2014
HUB10 (1091)	Hunter Basin	1456	600	USDA	September 2014
DU5	Hudson Bay Mtn	1497	600	USDA	September 2014
TBA	Mt Davidson	1750	600	USDA	September 2014

Communications and Outreach

During 2013-14 BVRC researchers gave a public presentation on our whitebark pine ecosystem restoration project as part of the BVRC noon-hour seminar series (April 2, 2014).

We published 2 short technical articles describing the project in the journal Nutcracker Notes (Haeussler and Clason 2014; McKay and Krakowski 2014) and a brief overview of the Community Forest restoration plantings in the Association of British Columbia Forest Professionals news magazine. Updates on our whitebark pine work was also reported in UNBC's Natural Resources and Environmental Studies institute Newsletter and posted on the BV Research Centre and WCFC Facebook pages and on the McBride Community Forest website.

A second copy of the WCFC information sign (same as the one installed at the Silvern Gathering Place in 2012) including whitebark pine information supplied by BVRC members was posted at the BV Nordic Centre ski lodge and a new information sign prepared by BC Parks and BC Wildfire Management Branch using photos and information supplied by BVRC researchers was installed at Morice Provincial Park campground.

Budget to June 30, 2014

The WCFC whitebark pine budget (Table 7) includes: (1) restoration trial activities related to the 4 trial sites on Hudson Bay Mtn, (2) seed collection and processing at sites other than Mt. Davidson for which costs were shared, and (3) rust resistance screening processing and shipping costs. Other whitebark pine restoration work carried out by BVRC in 2013/14 at Mt. Davidson, Morice Lake, Gosnell Ck and McBride Peak are not included in this budget except as noted below for McBride Peak.

Our proposed budget included costs for stratifying seeds and nursery activities up to June 2014 but these activities have been delayed until August 2014 to ensure more complete stratification prior to sowing. The funds allocated for this work were applied instead to the cost of installing the fourth (WT) restoration trial in June 2014 (increasing Phase 1 costs). We also paid a $382 accommodation and food bills in McBride to enable S. Haeussler to assist UNBC in installing the McBride Community Forest trial that is paired with the Wetzin'Kwa Hudson Bay Mtn trial. Since UNBC provided the 2012 Wetzin'Kwa trial seedlings free of charge in 2012 and the study will benefit from results obtained at McBride, we felt this was a fair exchange and hope you will find this acceptable. All other costs for travel to and work in McBride were covered by other funders.

Table 7. Project Budget

Item	Original Budget	Total Cash	Funding Sources		
			Wetzin'Kwa	Other	In-kind
	Budget – Human Resources				
Phase 1: fieldwork Maintenance and Measurement of Restoration Trials	$2800 (WCFC = $1750)	$3028.28	$2438.33	$589.95 (CSJ, HCTF)	$1000
Phase 2: Seed Collection –field and labwork	$22,450 (WCFC = $2335)	$24,804.84	$3971.92	$ 20832.92 (HCTF, Shell Fuelling Change, BCTS, FGC, Huckleberry)	$12,299
Phases 1-3: Office & Outreach	$11,650 (WCFC = $2,925)	$2174.71	$1191.45	$983.26 (as above)	$6,200.00
Total Human Resources	$36,900 (WCFC = $7,010)	$30,007.83	$7601.70	$22,406.13 (as above)	$19,499.00
Budget – Expenses –all phases combined					
Supplies + shipping	$1420 (WCFC = $97)	$1622.69	$18.85	$1603.84 (FGC, BCTS)	$5,200
Transportation and travel	$6850 (WCFC = $675)	$7,269.66	$1,470.40	$5,799.26 (Shell, BCTS, FGC)	$8,000

Laboratory	$1000 (WCFC = $10)	$0	$0	$0	$2,500 (Nora Holdings)
Nursery Costs	$9000 ($WCFC = $1300)	$0	$0	$0	$2,500 (Woodmere)
Total Expenses	$18,270 (WCFC = $2082)	$8892.35	$1489.25	$7403.10	$18,200
Admin Fee 10%	$4732 (WCFC = $909)	$6,361.52	$909.05	$5,452.47	$0
Total	**$59,902 ($10,000)**	**$45,261.70**	**$10,000.00**	**$35,261.70**	**$46,699**

Total cash for the project was $45,262 from all sources, slightly above our proposal estimate of $42,051. In-kind contributions estimated at $46,700 greatly exceeded our budgeted amount of $7,850. Most notably, we received $8,000 in in-kind helicopter hours from BCTS which decreased our cash expenses from $14,088 (proposed) to $8892 (actual). As a result, we were able to take advantage of the good cone crop and collect 10 times more seeds (22.2 kg) in 2013 than in 2011 (2.2 kg), despite having to fly into Hunter Basin due to a bridge washout.

DISCUSSION

Restoration Plantings: After 2 years of monitoring the low, mid and high elevation seedlings on Hudson Bay Mtn. and 7 years of closely observing wild and seeded stands, it appears that the upper ESSF (ca. 1300-1500 m elevation) is currently the most stable, lowest risk elevation for whitebark pine planting in the Bulkley -Babine area. Lower elevation seedlings (ca 1000 – 1200 m) seem to be at higher risk of heat and drought injury and there is more *Ribes* host material and greater incidence of biotic damaging agents such as *Pineus pinifoliae* present at the lower elevations. At timberline elevations, seedlings may survive but it appears that they will be slow to reach tree size due to recurrent winter exposure damage when they are not beneath the snowpack. There are benefits to planting seedlings across a wider range of feasible elevations than the "current lowest risk" range if one can tolerate the increased risk to young seedlings. High elevation plantings have the possibility of serving as a nucleus for future stands under a warmer climate. We think that low elevation trees that manage to survive climatic, pest and pathogen injury are still likely to begin producing cones and high quality seeds sooner and more often than those at mid- and high elevations –just as tree seed orchards are typically located in warm dry climates (Vernon, Sidney). Thus, an adaptive management strategy for whitebark pine restoration should probably spread the risk as broadly as possible considering both short- and long-term scenarios rather than trying to determine a narrow optimal planting elevation.

To date, we have focused whitebark pine planting on mostly south-facing xeric to submesic sites in order to minimize early competition from subalpine fir, lodgepole pine, shrubs and herbaceous vegetation and reduce the need for future stand tending, but an adaptive management strategy may also include increasing the range of aspects, slope positions and microsites. The results of Alana Clason's PhD thesis which models the current and future niche for whitebark pine (expected 2015) should help guide future restoration plantings.

Direct seeding of whitebark pine is a viable but not highly effective alternative to planting given the high cost of collecting and stratifying whitebark pine seeds. Seeds cached by Alana Clason in 2011 (at Hudson Bay Mtn WH site and in the Gosnell Burn have a 15% establishment rate and average 2 cm tall after 3 years, while seeds planted at the WH site in 2007 by Sierra Curtis-McLane (not included in Tables 1 and 2) were mostly less than 5 cm tall after 7 years.

Seed Collection: The consensus of whitebark pine experts is that poor whitebark pine seed quality in the Bulkley –Babine Mtns area is likely due to a combination of marginal weather conditions for whitebark pine and poor pollination (D. Pigott Yellowpoint Propagation, D Kolotelo MFLNRO, pers. comm.). My assessment is that the ESSFmk has heavier snowpacks at equivalent elevations than the ESSFmc but also a pronounced summer rainshadow effect due to the solid Coast Mountain barrier to the west and the stabilizing effect of the Nechako Plateau landscape to the east. Growing seasons in the ESSFmc and especially the ESSFwv are influenced by coastal weather systems that penetrate the Skeena, Nass and Kitimat River systems and are further destabilized by the mountainous landscapes to the east and northeast. The ESSFmk climate ensures adequate soil moisture availability during the dry summers needed for good pollination and cone maturation –a situation that is typical of mountains in the western U.S. where whitebark and other mountain pines are so abundant. Pollination in the Bulkley and Babine Mountains is poor, not only due to typically damp and volatile spring weather, but also due to the scattered, small whitebark pine populations at the northwest edge of the range. Genetic factors such as inbreeding depression in these marginal populations may further reduce reproductive success (Shaffer 1981; Krakowski et al. 2003; Bower and Aitken 2007). In effect, positive feedbacks among climate, pollination, fitness and Clark's Nutcracker seed dispersal may cause reproductive success, cone and seed quality to decline exponentially rather than linearly from the Sibola Mountains to the Babine Mountains.

For the Wetzin'Kwa Community Forest this means that obtaining high quality seeds of local origin for whitebark pine restoration will be difficult. It also suggests that importing seeds from further south may contribute to healthier whitebark pine populations with greater capacity to produce good seed crops in the future (see e.g., Krakowski et al. 2003; Bower and Aitken 2008 – though this hypothesis should be scientifically tested). Another implication, should the climate hypothesis be correct, is that regional topography is likely to limit whitebark pine success in the Bulkley/Babine area even as the climate becomes warmer. The Bulkley-Babine climate is unlikely to become optimal for whitebark pine (i.e., similar to the current climate of the Chilcotin Mtns and Intermountain U.S.) due to enduring features of our local topography.

Conclusions

All-in-all, the whitebark pine ecosystem restoration activities carried out in and around theWetzin'Kwa Community Forest in 2013/14 exceeded expections. Survival at the three 2012 whitebark pine trials continues to be very high (96%) and we were able to install a 4th trial using funds that were originally allocated for seed stratification and nursery work.

The 2013 seed collection was much larger than anticipated due to an excellent 2013 cone crop, better seed quality and improved fundraising over 2011. Seed production and quality in the Babine-Bulkley area continue to be poor relative to crops south of Morice Lake and since we now hypothesize that inbreeding depression could be a contributing factor we think that future plantings in WCFC should include more southerly provenances not only for climate change adaptation purposes but also to potentially improve the health and vigour of local whitebark pine genotypes. To maintain genetic diversity, it is nonetheless important to collect seed from the marginal populations in the Bulkley-Babine area. We would like to discuss this topic further with whitebark pine geneticists and also with the WCFC Board of Directors as there are ethical implications to seed transfer that require multiple perspectives to be considered.

Rust resistance screening opportunities greatly exceeded our expectations for 2014 as we were able to contribute local seeds to a new BC FLNRO screening trial and will soon ship seeds to an upcoming USDA Forest Service trial, at no cost other than seed collection, processing and shipping.

References

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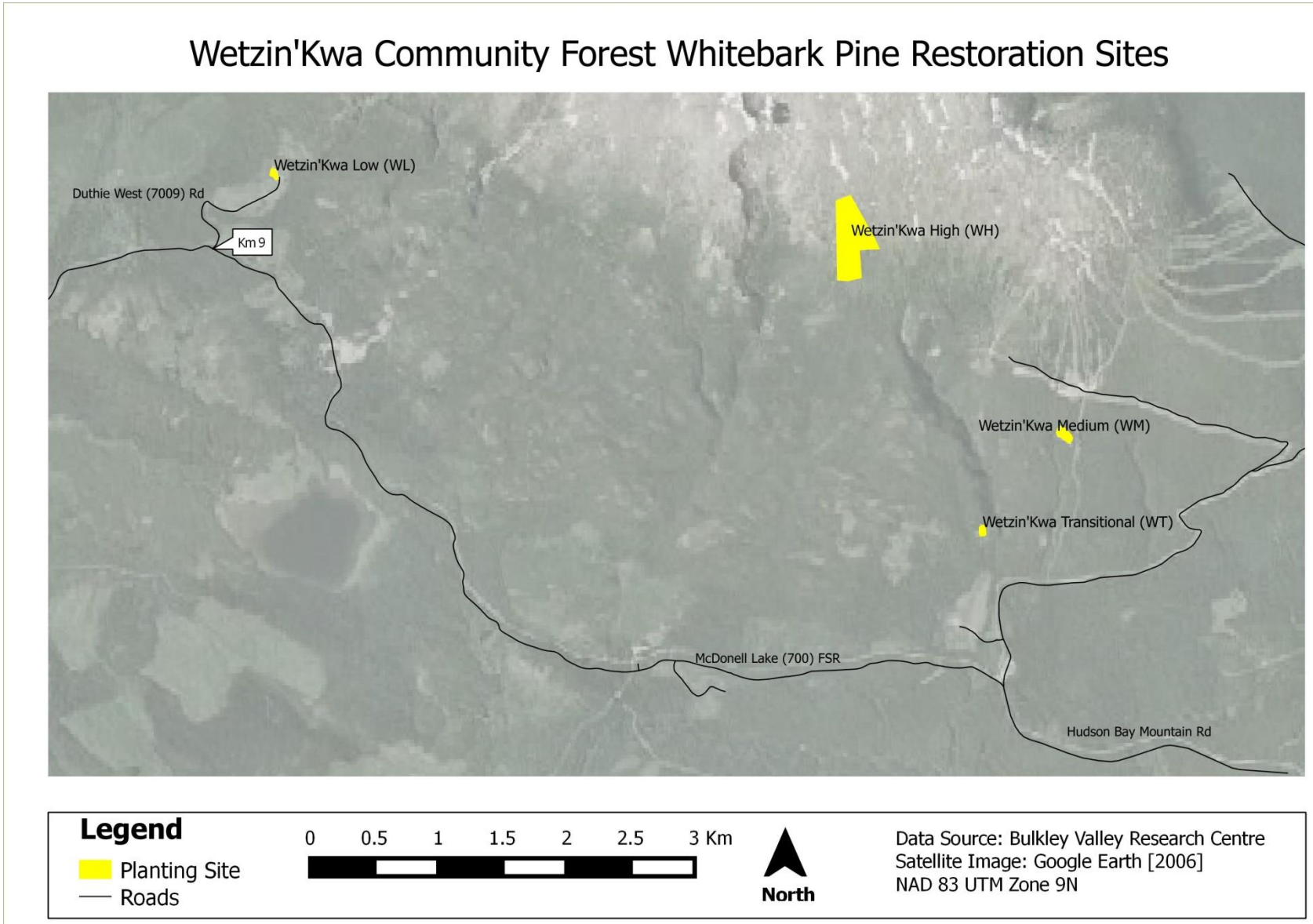
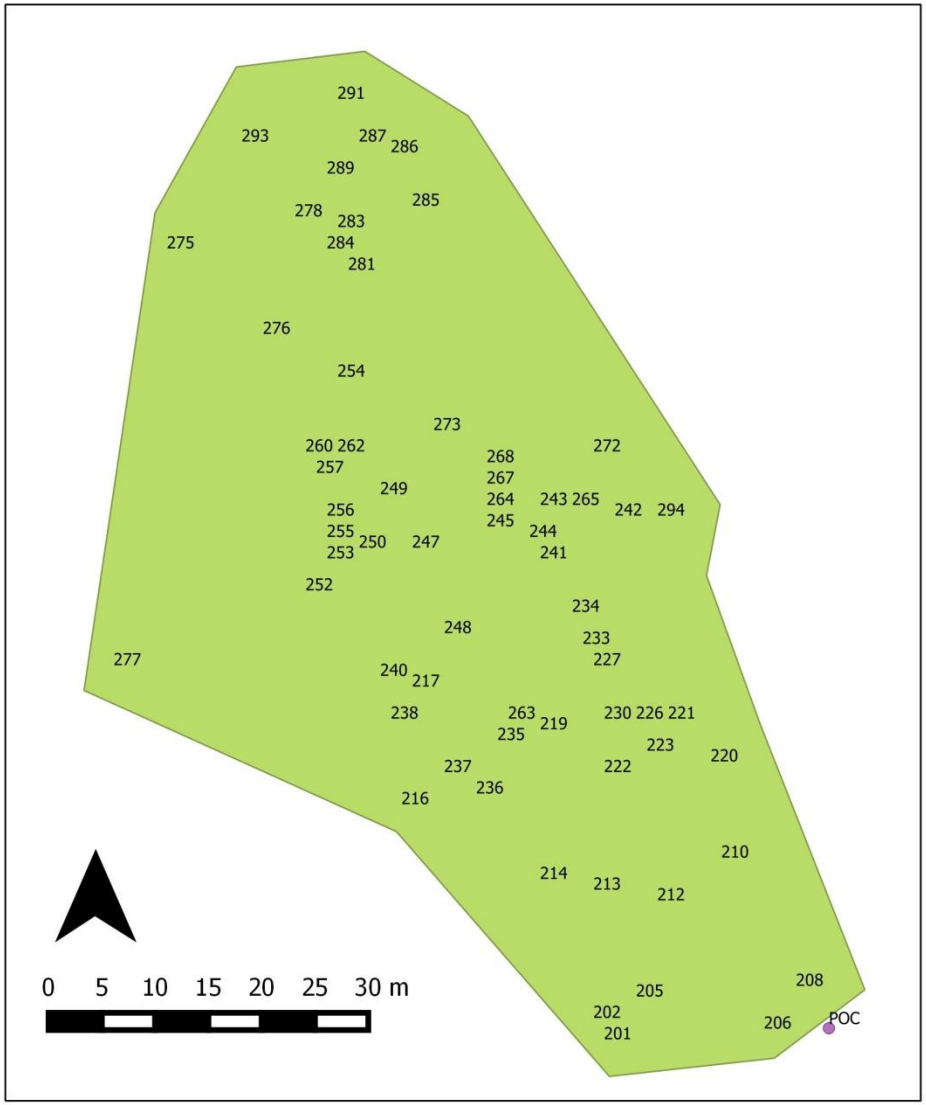
APPENDICES

Appendix I: Maps of Whitebark Pine Restoration Sites

Appendix II: GPS Coordinates of Planted Whitebark Pine Seedlings



Appendix I-a: Map of whitebark pine restoration plantings in and adjacent to the Wetzin'Kwa Community Forest as of June 2014.

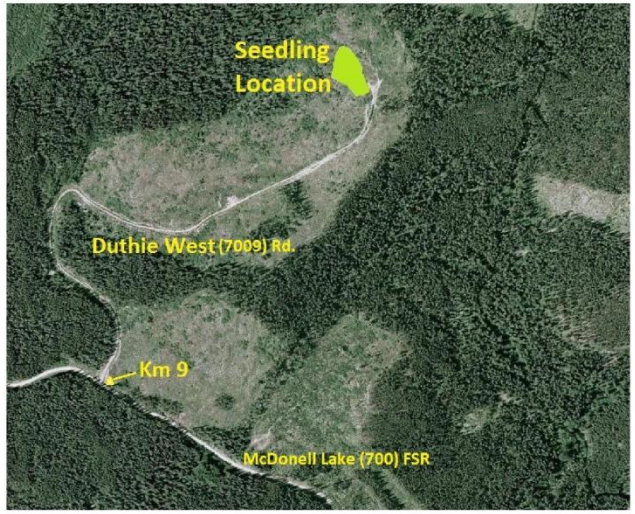


Wetzin'Kwa Low (WL): Whitebark Pine Seedling Location Map

Legend

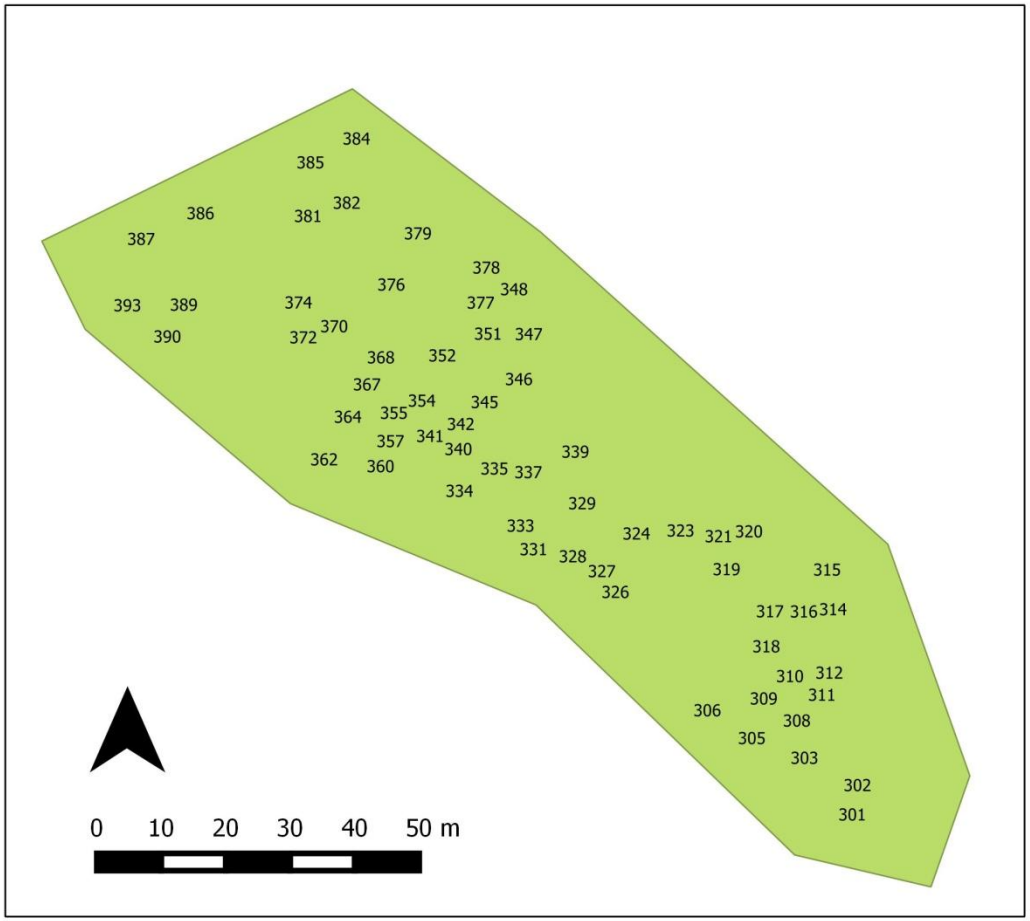
- Point of Commencement (POC)
- Number Indicates Seedling
- Total Area

Total Area: 0.399 ha



* Not all seedling locations shown due to issues of crowding
*Data points accurate within approximately 5 meters
GPS Coordinates Labelled WL201 etc.
Data Source: Bulkley Valley Research Centre, Google Earth
NAD83 UTM Zone 9

Appendix I-b: Map of WL (Wetzin'Kwa Low elevation) whitebark pine restoration trial site and seedling locations.



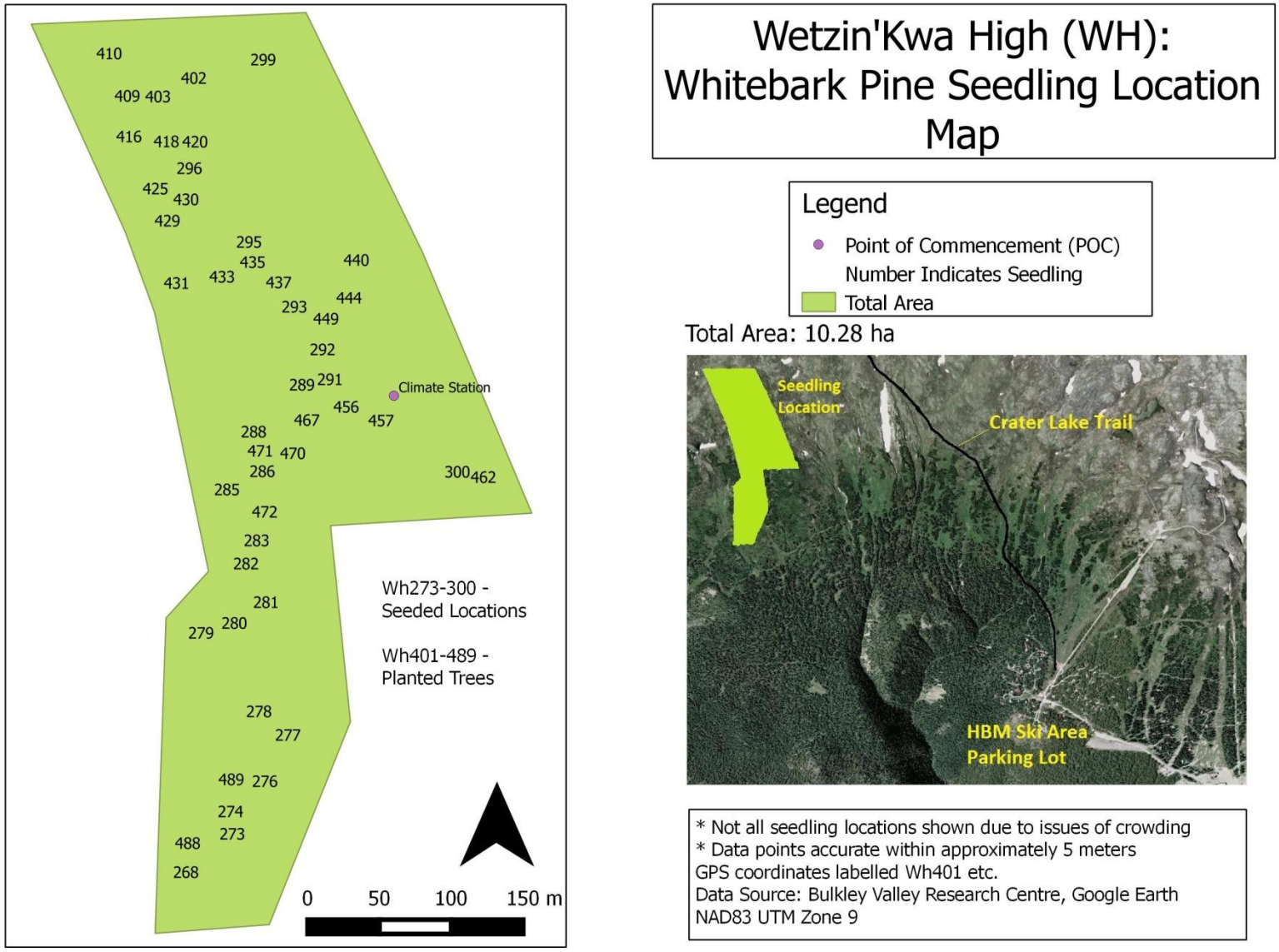
* Not all seedling locations shown due to issues of crowding *Data points accurate within approximately 5 meters
GPS Coordinates labelled Wm301 etc.
Data Source: Bulkley Valley Research Centre, Google Earth
NAD 83 UTM Zone 9N

Wetzin'Kwa Medium (WM): Whitebark Pine Seedling Location Map

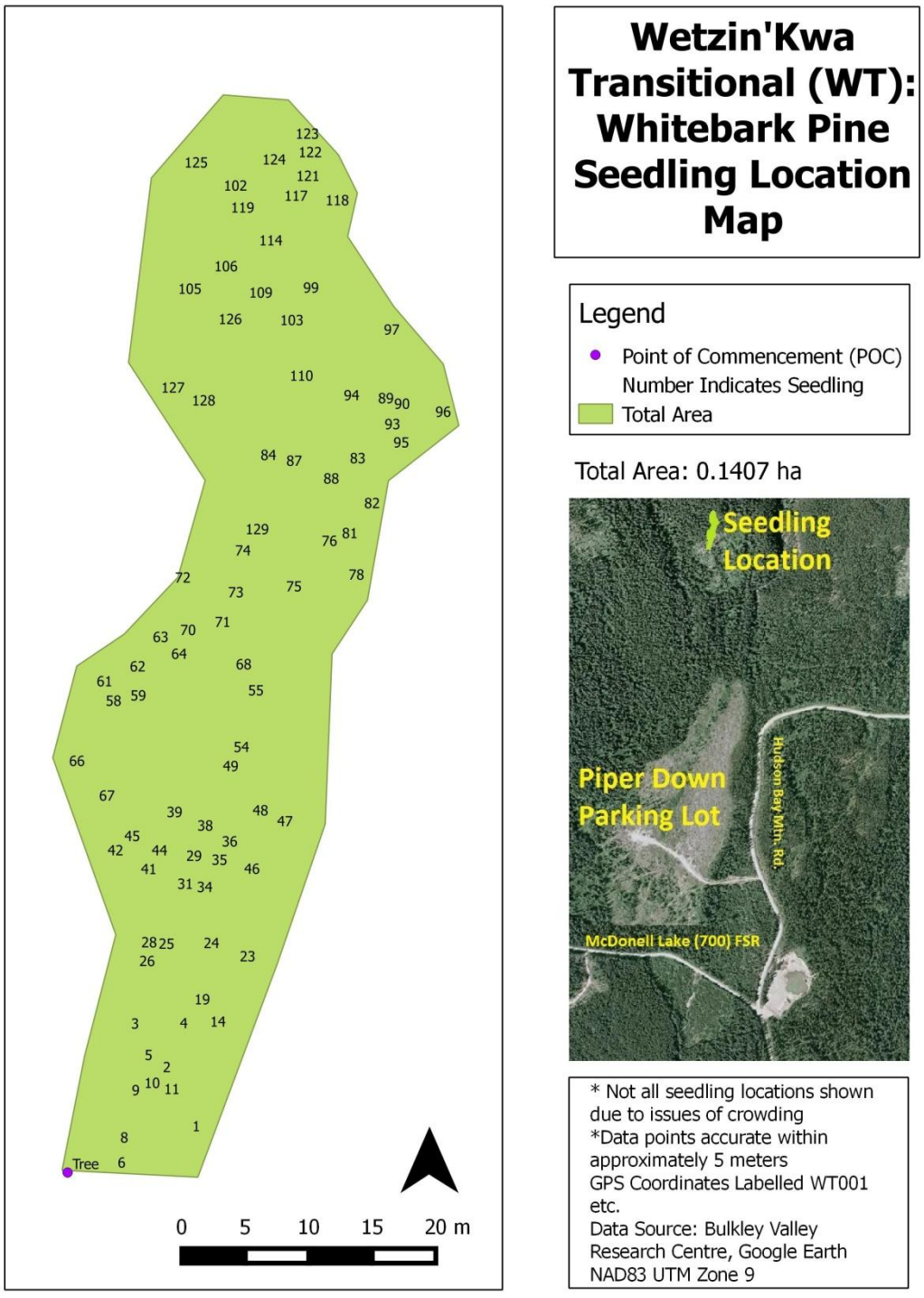
Legend
Number Indicates Seedling
Total Area

Total Area: 0.730 ha

Appendix I-c: Map of WM (Wetzin'Kwa Medium or Mid elevation) whitebark pine restoration trial site and seedling locations.



Appendix I-d: Map of WH (Wetzin'Kwa High elevation) whitebark pine restoration trial site and seedling locations.



Appendix I-e: Map of WT (Wetzin'Kwa Transitional elevation) whitebark pine restoration site and seedling locations

Appendix II-a: WL (Wetzin'Kwa Low elevation) whitebark pine seedling locations and other waypoints

Tag #	Waypt	ID #	Easting	Northing	Type
201	WL201	201	604605	6071757	Planted
202	WL202	202	604604	6071759	Planted
203	WL203	203	604605	6071758	Planted
204	WL204	204	604605	6071759	Planted
205	WL205	205	604608	6071761	Planted
206	WL206	206	604620	6071758	Planted
207	WL207	207	604621	6071759	Planted
208	WL208	208	604623	6071762	Planted
209	WL209	209	604617	6071774	Planted
210	WL210	210	604616	6071774	Planted
211	WL211	211	604597	6071771	Planted
212	WL212	212	604610	6071770	Planted
213	WL213	213	604604	6071771	Planted
214	WL214	214	604599	6071772	Planted
215	WL215	215	604597	6071771	Planted
216	WL216	216	604586	6071779	Planted
217	WL217	217	604587	6071790	Planted
218	WL218	218	604596	6071785	Planted
219	WL219	219	604599	6071786	Planted
220	WL220	220	604615	6071783	Planted
221	WL221	221	604611	6071787	Planted
222	WL222	222	604605	6071782	Planted
223	WL223	223	604609	6071784	Planted
224	WL224	224	604609	6071788	Planted
225	WL225	225	604609	6071787	Planted
226	WL226	226	604608	6071787	Planted
227	WL227	227	604604	6071792	Planted
228	WL228	228	604605	6071791	Planted
229	WL229	229	604606	6071791	Planted
230	WL230	230	604605	6071787	Planted
231	WL231	231	604605	6071788	Planted
232	WL232	232	604605	6071792	Planted
233	WL233	233	604603	6071794	Planted
234	WL234	234	604602	6071797	Planted
235	WL235	235	604595	6071785	Planted
236	WL236	236	604593	6071780	Planted
237	WL237	237	604590	6071782	Planted
238	WL238	238	604585	6071787	Planted
239	WL239	239	604584	6071788	Planted
240	WL240	240	604584	6071791	Planted

Tag #	Waypt	ID #	Easting	Northing	Type
241	WL241	241	604599	6071802	Planted
242	WL242	242	604606	6071806	Planted
243	WL243	243	604599	6071807	Planted
244	WL244	244	604598	6071804	Planted
245	WL245	245	604594	6071805	Planted
246	WL246	246	604594	6071804	Planted
247	WL247	247	604587	6071803	Planted
248	WL248	248	604590	6071795	Planted
249	WL249	249	604584	6071808	Planted
250	WL250	250	604582	6071803	Planted
251	WL251	251	604582	6071802	Planted
252	WL252	252	604577	6071799	Planted
253	WL253	253	604579	6071802	Planted
254	WL254	254	604580	6071819	Planted
255	WL255	255	604579	6071804	Planted
256	WL256	256	604579	6071806	Planted
257	WL257	257	604578	6071810	Planted
258	WL258	258	604577	6071811	Planted
259	WL259	259	604577	6071812	Planted
260	WL260	260	604577	6071812	Planted
261	WL261	261	604579	6071813	Planted
262	WL262	262	604580	6071812	Planted
263	WL263	263	604596	6071787	Planted
264	WL264	264	604594	6071807	Planted
265	WL265	265	604602	6071807	Planted
266	WL266	266	604603	6071806	Planted
267	WL267	267	604594	6071809	Planted
268	WL268	268	604594	6071811	Planted
269	WL269	269	604596	6071809	Planted
270	WL270	270	604603	6071806	Planted
271	WL271	271	604604	6071807	Planted
272	WL272	272	604604	6071812	Planted
273	WL273	273	604589	6071814	Planted
274	WL274	274	604591	6071815	Planted
275	WL275	275	604564	6071831	Planted
276	WL276	276	604573	6071823	Planted
277	WL277	277	604559	6071792	Planted
278	WL278	278	604576	6071834	Planted
279	WL279	279	604578	6071832	Planted
280	WL280	280	604580	6071830	Planted

Appendix II-a: WL (Wetzin'Kwa Low elevation) whitebark pine seedling locations and other waypoints

Tag #	Waypt	ID #	Easting	Northing	Type
281	WL281	281	604581	6071829	Planted
282	WL282	282	604581	6071832	Planted
283	WL283	283	604580	6071833	Planted
284	WL284	284	604579	6071831	Planted
285	WL285	285	604587	6071835	Planted
286	WL286	286	604585	6071840	Planted
287	WL287	287	604582	6071841	Planted
288	WL288	288	604580	6071841	Planted
289	WL289	289	604579	6071838	Planted
290	WL290	290	604578	6071833	Planted
291	WL291	291	604580	6071845	Planted
292	WL292	292	604579	6071844	Planted
293	WL293	293	604571	6071841	Planted
294	WL294	294	604610	6071806	Planted
	WLPOC		604624.8	6071757	POC

POC = point of commencement, indicated by yellow Forest Research Plot sign

Appendix II-b: WM (Wetzin'Kwa Medium or Mid elevation) whitebark pine seedling locations and other waypoints

Tag #	Waypt	ID #	Easting	Northing	Type
301	WM301	301	611372.1	6069544	Planted
302	WM302	302	611372.9	6069549	Planted
303	WM303	303	611364.7	6069553	Planted
304	WM304	304	611356.5	6069555	Planted
305	WM305	305	611356.6	6069556	Planted
306	WM306	306	611349.7	6069561	Planted
307	WM307	307	611358.3	6069554	Planted
308	WM308	308	611363.5	6069559	Planted
309	WM309	309	611358.4	6069562	Planted
310	WM310	310	611362.5	6069566	Planted
311	WM311	311	611367.4	6069563	Planted
312	WM312	312	611368.6	6069566	Planted
313	WM313	313	611366.2	6069568	Planted
314	WM314	314	611369.2	6069576	Planted
315	WM315	315	611368.2	6069582	Planted
316	WM316	316	611364.6	6069576	Planted
317	WM317	317	611359.4	6069576	Planted
318	WM318	318	611358.8	6069571	Planted
319	WM319	319	611352.6	6069583	Planted
320	WM320	320	611356.1	6069588	Planted
321	WM321	321	611351.4	6069588	Planted
322	WM322	322	611345.3	6069589	Planted
323	WM323	323	611345.5	6069589	Planted
324	WM324	324	611338.7	6069588	Planted
325	WM325	325	611334.8	6069591	Planted
326	WM326	326	611335.4	6069579	Planted (D)
327	WM327	327	611333.3	6069582	Planted
328	WM328	328	611328.8	6069585	Planted
329	WM329	329	611330.2	6069593	Planted
330	WM330	330	611324.4	6069586	Planted
331	WM331	331	611322.7	6069586	Planted
332	WM332	332	611321.8	6069587	Planted
333	WM333	333	611320.7	6069589	Planted (D)
334	WM334	334	611311.2	6069595	Planted
335	WM335	335	611316.7	6069598	Planted
336	WM336	336	611321.6	6069595	Planted
337	WM337	337	611321.9	6069598	Planted
338	WM338	338	611318.9	6069596	Planted
339	WM339	339	611329.2	6069601	Planted

Tag #	Waypt	ID #	Easting	Northing	Type
340	WM340	340	611311.1	6069601	Planted
341	WM341	341	611306.7	6069603	Planted
342	WM342	342	611311.4	6069605	Planted
343	WM343	343	611310.7	6069608	Planted
344	WM344	344	611311.4	6069609	Planted
345	WM345	345	611315.1	6069608	Planted
346	WM346	346	611320.4	6069612	Planted
347	WM347	347	611322	6069619	Planted
348	WM348	348	611319.7	6069626	Planted
349	WM349	349	611315.6	6069628	Planted
350	WM350	350	611318	6069618	Planted
351	WM351	351	611315.7	6069619	Planted
352	WM352	352	611308.6	6069616	Planted
353	WM353	353	611304.5	6069616	Planted
354	WM354	354	611305.4	6069609	Planted
355	WM355	355	611301.1	6069607	Planted
356	WM356	356	611299.1	6069609	Planted
357	WM357	357	611300.5	6069602	Planted
358	WM358	358	611296.1	6069603	Planted
359	WM359	359	611294.9	6069603	Planted
360	WM360	360	611299	6069599	Planted
361	WM361	361	611294.9	6069601	Planted
362	WM362	362	611290.3	6069600	Planted
363	WM363	363	611290.7	6069602	Planted
364	WM364	364	611293.9	6069606	Planted
365	WM365	365	611293.8	6069610	Planted
366	WM366	366	611295.1	6069610	Planted
367	WM367	367	611296.9	6069611	Planted
368	WM368	368	611299	6069615	Planted
369	WM369	369	611295	6069618	Planted
370	WM370	370	611291.8	6069620	Planted (D)
371	WM371	371	611285.6	6069620	Planted
372	WM372	372	611287	6069619	Planted
373	WM373	373	611286.5	6069619	Planted
374	WM374	374	611286.3	6069624	Planted
375	WM375	375	611289.5	6069624	Planted
376	WM376	376	611300.7	6069627	Planted
377	WM377	377	611314.5	6069624	Planted
378	WM378	378	611315.4	6069629	Planted

Appendix II-b: WM (Wetzin'Kwa Medium or Mid elevation) whitebark pine seedling locations and other waypoints

Tag #	Waypt	ID #	Easting	Northing	Type
379	WM379	379	611304.8	6069635	Planted
380	WM380	380	611308.6	6069637	Planted
381	WM381	381	611287.7	6069637	Planted
382	WM382	382	611293.7	6069639	Planted
383	WM383	383	611290.1	6069641	Planted
384	WM384	384	611295.3	6069649	Planted
385	WM385	385	611288.1	6069646	Planted
386	WM386	386	611271.1	6069638	Planted
387	WM387	387	611261.9	6069634	Planted
388	WM388	388	611266.1	6069631	Planted
389	WM389	389	611268.5	6069624	Planted
390	WM390	390	611265.9	6069619	Planted
391	WM391	391	611265.4	6069622	Planted
392	WM392	392	611259.1	6069622	Planted
393	WM393	393	611259.7	6069624	Planted

D = dead seedling as of June 2014

Appendix II-c. WH (Wetzin'Kwa High elevation) whitebark pine seedling locations and other waypoints

Tag	Waypt	ID #	Easting	Northing	Type
	WHClimate		609600.8	6071290	POC
268	Wh268	268	609456.1	6070958	Seed
269	Wh269	269	609458.8	6070964	Seed
270	Wh270	270	609461.7	6070973	Seed
271	Wh271	271	609462.3	6070991	Seed
272	Wh272	272	609476.9	6070981	Seed
273	Wh273	273	609488.3	6070985	Seed
274	Wh274	274	609487.1	6071000	Seed
275	Wh275	275	609489.6	6071022	Seed
276	Wh276	276	609511	6071021	Seed
277	Wh277	277	609527	6071054	Seed
278	Wh278	278	609506.9	6071070	Seed
279	Wh279	279	609466.6	6071125	Seed
280	Wh280	280	609489.7	6071132	Seed
281	Wh281	281	609511.8	6071146	Seed
282	Wh282	282	609497.9	6071173	Seed
283	Wh283	283	609505.3	6071189	Seed
284	Wh284	284	609485.2	6071212	Seed
285	Wh285	285	609484.6	6071225	Seed
286	Wh286	286	609509.2	6071237	Seed
287	Wh287	287	609509.4	6071251	Seed
288	Wh288	288	609503.2	6071265	Seed
289	Wh289	289	609536.8	6071298	Seed
290	Wh290	290	609550.3	6071286	Seed
291	Wh291	291	609556.3	6071301	Seed
292	Wh292	292	609551.1	6071322	Seed
293	Wh293	293	609531.5	6071352	Seed
294	Wh294	294	609512.9	6071371	Seed
295	Wh295	295	609499.9	6071397	Seed
296	Wh296	296	609458.5	6071449	Seed
297	Wh297	297	609428.2	6071486	Seed
298	Wh298	298	609464.6	6071514	Seed
299	Wh299	299	609509.8	6071524	Seed
300	Wh300	300	609644.9	6071237	Seed
401	Wh401	401	609459.7	6071513	Planted
402	Wh402	402	609461.6	6071511	Planted
403	Wh403	403	609436.7	6071498	Planted
404	Wh404	404	609431	6071491	Planted
405	Wh405	405	609429.6	6071492	Planted
406	Wh406	406	609427	6071493	Planted
407	Wh407	407	609425	6071495	Planted

Tag #	Waypt	ID #	Easting	Northing	Type
408	Wh408	408	609424.8	6071489	Planted
409	Wh409	409	609415.3	6071499	Planted
410	Wh410	410	609402.7	6071528	Planted
411	Wh411	411	609405.4	6071528	Planted
412	Wh412	412	609422.9	6071473	Planted
413	Wh413	413	609426.4	6071472	Planted
414	Wh414	414	609423	6071471	Planted
415	Wh415	415	609419.7	6071472	Planted
416	Wh416	416	609416.5	6071471	Planted
417	Wh417	417	609421.6	6071468	Planted
418	Wh418	418	609442.5	6071467	Planted
419	Wh419	419	609452	6071474	Planted
420	Wh420	420	609462.4	6071467	Planted
421	Wh421	421	609457.8	6071462	Planted
422	Wh422	422	609455	6071459	Planted
423	Wh423	423	609451.5	6071450	Planted
424	Wh424	424	609427.7	6071456	Planted
425	Wh425	425	609434.9	6071434	Planted
426	Wh426	426	609443.6	6071430	Planted
427	Wh427	427	609447.9	6071428	Planted
428	Wh428	428	609446.5	6071423	Planted
429	Wh429	429	609443.2	6071412	Planted
430	Wh430	430	609456.2	6071427	Planted
431	Wh431	431	609449.6	6071368	Planted
432	Wh432	432	609489.4	6071383	Planted
433	Wh433	433	609481.2	6071373	Planted
434	Wh434	434	609497.6	6071380	Planted
435	Wh435	435	609502.5	6071383	Planted
436	Wh436	436	609521.2	6071373	Planted
437	Wh437	437	609520.6	6071369	Planted
438	Wh438	438	609518.4	6071366	Planted
439	Wh439	439	609579.5	6071380	Planted
440	Wh440	440	609574.7	6071385	Planted
441	Wh441	441	609575.7	6071375	Planted
442	Wh442	442	609580.2	6071375	Planted
443	Wh443	443	609569.7	6071361	Planted
444	Wh444	444	609569.6	6071358	Planted
445	Wh445	445	609568.2	6071359	Planted
446	Wh446	446	609563.8	6071367	Planted

Appendix II-c. WH (Wetzin'Kwa High elevation) whitebark pine seedling locations and other waypoints

Tag #	Waypt.	ID #	Easting	Northing	Type
447	Wh447	447	609558.7	6071352	Planted
448	Wh448	448	609556.8	6071349	Planted
449	Wh449	449	609553.6	6071344	Planted
450	Wh450	450	609541.7	6071315	Planted
451	Wh451	451	609537.3	6071315	Planted
452	Wh452	452	609528.8	6071305	Planted
453	Wh453	453	609540.9	6071311	Planted
454	Wh454	454	609526.1	6071302	Planted
455	Wh455	455	609565.7	6071283	Planted
456	Wh456	456	609567.6	6071282	Planted
457	Wh457	457	609591.8	6071273	Planted
458	Wh458	458	609601.2	6071271	Planted
459	Wh459	459	609603.5	6071268	Planted
460	Wh460	460	609649.3	6071236	Planted
461	Wh461	461	609651.1	6071235	Planted
462	Wh462	462	609663.1	6071233	Planted
463	Wh463	463	609657.1	6071230	Planted
464	Wh464	464	609655.1	6071229	Planted
465	Wh465	465	609643.8	6071232	Planted
466	Wh466	466	609534.9	6071264	Planted
467	Wh467	467	609540.2	6071273	Planted
468	Wh468	468	609530.6	6071262	Planted
469	Wh469	469	609528.5	6071251	Planted
470	Wh470	470	609530.5	6071250	Planted

Tag #	Waypt.	ID #	Easting	Northing	Type
471	Wh471	471	609507.9	6071252	Planted
472	Wh472	472	609510.9	6071209	Planted
473	Wh473	473	609508	6071160	Planted
474	Wh474	474	609509.5	6071158	Planted
475	Wh475	475	609471.2	6070999	Planted
476	Wh476	476	609466.4	6070991	Planted
477	Wh477	477	609469.8	6070991	Planted
478	Wh478	478	609476	6070983	Planted
479	Wh479	479	609475.6	6070979	Planted
480	Wh480	480	609479.1	6070977	Planted
481	Wh481	481	609478.8	6070975	Planted
482	Wh482	482	609477.6	6070975	Planted
483	Wh483	483	609471.7	6070975	Planted
484	Wh484	484	609467.9	6070975	Planted
485	Wh485	485	609459.8	6070968	Planted
486	Wh486	486	609460.3	6070965	Planted
487	Wh487	487	609457.3	6070970	Planted
488	Wh488	488	609457.3	6070978	Planted
489	Wh489	489	609487.6	6071023	Planted

WHClimate: the POC (point of commencement) is a FLNRO climate station (no yellow sign)

Planted seedlings have pigtail stakes with minimal flagging tape tied at ground level

Seed: caches of 5 seeds were planted at these locations in June 2011. Blue flagging tape attached to nearest object. Look for aluminum tag inserted into soil (no pigtail stakes)

Appendix II-d: WT (Wetzin'Kwa Transitional) whitebark pine seedling locations and other waypoints

Tag #	Waypt	ID #	Easting	Northing	Type
1	WT001	1	610623.1	6068726	Planted
2	WT002	2	610620.8	6068731	Planted
3	WT003	3	610618.3	6068734	Planted
4	WT004	4	610622.1	6068734	Planted
5	WT005	5	610619.4	6068731	Planted
6	WT006	6	610617.3	6068723	Planted
7	WT007	7	610616.8	6068724	Planted
8	WT008	8	610617.5	6068725	Planted
9	WT009	9	610618.4	6068729	Planted
10	WT010	10	610619.7	6068729	Planted
11	WT011	11	610621.2	6068729	Planted
12	WT012	12	610622.7	6068734	Planted
13	WT013	13	610625	6068734	Planted
14	WT014	14	610624.8	6068734	Planted
15	WT015	15	610624.4	6068735	Planted
16	WT016	16	610624.3	6068734	Planted
17	WT017	17	610625	6068735	Planted
18	WT018	18	610623.9	6068736	Planted
19	WT019	19	610623.6	6068736	Planted
20	WT020	20	610623.3	6068736	Planted
21	WT020	21	610623.1	6068735	Planted
22	WT021	22	610619.1	6068733	Planted
23	WT022	23	610627.2	6068739	Planted
24	WT023	24	610624.3	6068740	Planted
25	WT024	25	610620.8	6068740	Planted
26	WT025	26	610619.3	6068739	Planted
27	WT026	27	610619.4	6068739	Planted
28	WT027	28	610619.4	6068740	Planted
29	WT028	29	610623	6068747	Planted
30	WT029	30	610622.1	6068745	Planted
31	WT030	31	610622.3	6068745	Planted
32	WT031	32	610623.6	6068746	Planted
33	WT032	33	610622.5	6068745	Planted
34	WT033	34	610623.8	6068745	Planted
35	WT034	35	610625	6068747	Planted
36	WT035	36	610625.8	6068748	Planted
37	WT036	37	610625.3	6068748	Planted
38	WT037	38	610623.8	6068750	Planted
39	WT038	39	610621.4	6068751	Planted
40	WT039	40	610622.2	6068748	Planted

Tag #	Waypt	ID #	Easting	Northing	Type
41	WT040	41	610619.4	6068746	Planted
42	WT041	42	610616.8	6068748	Planted
43	WT042	43	610620.7	6068748	Planted
44	WT043	44	610620.2	6068748	Planted
45	WT044	45	610618.1	6068749	Planted
46	WT045	46	610627.5	6068746	Planted
47	WT046	47	610630.1	6068750	Planted
48	WT047	48	610628.2	6068751	Planted
49	WT048	49	610625.8	6068754	Planted
50	WT049	50	610625.5	6068754	Planted
51	WT050	51	610625.6	6068756	Planted
52	WT051	52	610625.7	6068756	Planted
53	WT052	53	610625.6	6068756	Planted
54	WT053	54	610626.7	6068756	Planted
55	WT054	55	610627.8	6068760	Planted
56	WT055	56	610628	6068761	Planted
57	WT056	57	610628.2	6068760	Planted
58	WT057	58	610616.6	6068759	Planted
59	WT058	59	610618.6	6068760	Planted
60	WT059	60	610618	6068761	Planted
61	WT060	61	610615.9	6068761	Planted
62	WT061	62	610618.5	6068762	Planted
63	WT062	63	610620.3	6068764	Planted
64	WT063	64	610621.8	6068763	Planted
65	WT064	65	610623.5	6068764	Planted
66	WT065	66	610613.7	6068755	Planted
67	WT066	67	610616.1	6068752	Planted
68	WT067	68	610626.9	6068762	Planted
69	WT068	69	610623.5	6068765	Planted
70	WT069	70	610622.5	6068765	Planted
71	WT070	71	610625.2	6068766	Planted
72	WT071	72	610622.1	6068769	Planted
73	WT072	73	610626.2	6068768	Planted
74	WT073	74	610626.8	6068771	Planted
75	WT074	75	610630.8	6068768	Planted
76	WT075	76	610633.6	6068772	Planted
77	WT076	77	610633.5	6068773	Planted
78	WT077	78	610635.7	6068769	Planted
79	WT078	79	610634.9	6068768	Planted
80	WT079	80	610634.6	6068772	Planted

Appendix II-d: WT (Wetzin'Kwa Transitional) whitebark pine seedling locations and other waypoints

Tag #	Waypt	ID #	Easting	Northing	Type
81	WT080	81	610635.2	6068773	Planted
82	WT081	82	610637	6068775	Planted
83	WT082	83	610635.8	6068778	Planted
84	WT083	84	610628.8	6068779	Planted
85	WT084	85	610629.6	6068779	Planted
86	WT085	86	610628.7	6068778	Planted
87	WT086	87	610630.8	6068778	Planted
88	WT087	88	610633.8	6068777	Planted
89	WT088	89	610638.1	6068783	Planted
90	WT089	90	610639.3	6068783	Planted
91	WT090	91	610641.9	6068781	Planted
92	WT091	92	610641.8	6068781	Planted
93	WT092	93	610638.6	6068781	Planted
94	WT093	94	610635.4	6068783	Planted
95	WT094	95	610639.3	6068780	Planted
96	WT095	96	610642.6	6068782	Planted
97	WT096	97	610638.5	6068789	Planted
98	WT097	98	610638.2	6068788	Planted
99	WT098	99	610632.2	6068792	Planted
100	WT099	100	610631.2	6068793	Planted
101	WT100	101	610631.2	6068793	Planted
102	WT101	102	610626.2	6068800	Planted
103	WT102	103	610630.6	6068789	Planted
104	WT103	104	610622.3	6068791	Planted
105	WT104	105	610622.6	6068792	Planted
106	WT105	106	610625.5	6068794	Planted
107	WT106	107	610626.4	6068793	Planted
108	WT107	108	610625.7	6068794	Planted
109	WT108	109	610628.2	6068791	Planted
110	WT109	110	610631.4	6068785	Planted
111	WT110	111	610630.7	6068789	Planted
112	WT111	112	610629.3	6068795	Planted
113	WT112	113	610629.2	6068795	Planted
114	WT113	114	610629	6068796	Planted
115	WT114	115	610629.8	6068799	Planted
116	WT115	116	610629.4	6068799	Planted
117	WT116	117	610631	6068799	Planted
118	WT117	118	610634.2	6068799	Planted
119	WT118	119	610626.8	6068798	Planted
120	WT119	120	610630.9	6068803	Planted

Tag #	Name	ID #	Easting	Northing	Type
121	WT120	121	610631.9	6068801	Planted
122	WT121	122	610632.1	6068802	Planted
123	WT122	123	610631.9	6068804	Planted
124	WT123	124	610629.3	6068802	Planted
125	WT124	125	610623.1	6068802	Planted
126	WT125	126	610625.8	6068789	Planted
127	WT126	127	610621.3	6068784	Planted
128	WT127	128	610623.7	6068783	Planted
129	WT128	129	610627.9	6068773	Planted
	WPOC		610613	6068722	POC

POC = point of commencement indicated by yellow Forest Research Plot sign