MoFLRNORD Experimental Project (EP) 1162:

A Long-term Study of Uneven-aged Spruce-Subalpine Fir Stand Growth and Development relative to Basal Area Density

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PROGRESS & STATUS REPORT, 1992 - 2020:

Review of EP 1162 Trial Treatments, Monitoring, and Recommendations for Future Trial Management

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REPORT SUMMARY

Experimental Project (EP) 1162, established in 1992, is a long-term silvicultural field experiment that tests the effects of a range of residual basal area (stand density) management options for complex and uneven-aged subalpine fir-hybrid white spruce stand types of Interior British Columbia. This EP is also referred to as the Summit Lake Basal Area Density Trial. The trial examines the effects of the different basal area densities on the regeneration, growth, and development of such stands. In this way, it thereby addresses a historically-significant information gap in the data required for the silvicultural and density management, growth projections, and potential modelling of subalpine fir- spruce stands in BC Northern Interior forest types.

The study and experimental design, treatments, and monitoring protocol are guided by the EP 1162 Working Plan (Jull, 1992) approved at that time by the BC Ministry of Forests. Modifications or adjustments to the EP since 1992 are described in this report. This long-term, large-scale field experiment is nearing 3 decades in duration since establishment. The most recent EP 1162 maintenance and remeasurements – of 19 permanent sample plots - were completed in the 2019 field season.

The three main purposes of this 2020 field trial progress and status report are:

1. To provide a summary and compendium of information related to the establishment of treatments, monitoring, and intervening history of the EP 1162 field research trial over the last 28 years, from 1992 to 2019.

2. To provide additional detail on the trial and its treatments that will provide further information for analyses and interpretation of the trial. And;

3. To provide an opportunity to consider the future of the EP 1162 research trial area from 2020 onwards, and to make recommendations for its future research and silvicultural management.

The EP 1162 trial site is located 50 km north of Prince George, on gently rolling terrain and mesic to sub-hygric sites, in the moist cool SBSmk1 biogeoclimatic subzone (DeLong et al, 1993) near Summit Lake, B.C. The site has good permanent road access via Hwy 97 N and the Caine Creek FSR. This stand was marked-to-cut and selection harvested in Winter 1991/1992 to prescribed target conditions and ranges of treatments as per the EP 1162 Working Plan.

Three target residual basal area density levels (*10 m^2/ha*, *20 m^2/ha*, and a *30 m^2/ha "control")* were prescribed and replicated six times each within the nineteen 0.25-hectare treatment units systematically located pre-treatment within the trial area. The 3 basal area density treatments were randomly allocated to the available treatment units, and basal areas were adjusted to their prescribed levels during timber harvest planning, selection logging, and subsequent sanitation thinnings. The surrounding stand was also selection cut to an intermediate density. For monitoring of post-treatment stand growth and development, a permanent sample plot (PSP) was located within the centre of within each of 19 treatment units; these PSP's were initially measured in Spring 1992 and remeasured in the Fall of 1994 and 1997, Spring of 2009, and Fall of 2019.

As a long-term field trial, EP 1162 is designed to span multiple decades, potentially up to 50 years or more. Analyses of long-term data from this EP (now 27 years) will examine the effects of post-harvest residual basal area density on stand volume and basal area growth; forest carbon; diameter and height growth of spruce and subalpine fir; individual tree growth and quality, tree mortality, and regeneration recruitment. The results of this trial will inform future silvicultural planning and decision-making for partial-cutting in similar stand types.

Acknowledgements

Sincere thanks are extended to the following individuals who played essential roles in the preparation, implementation, funding, and planning of fieldwork and data analyses for this long-term trial over the last 3 decades.

While a full list of participants over 28 years of trial management is unfortunately not possible, I appreciate all the hard work during buggy and/or rainy field days by many that went into the establishment and maintenance of this trial. I would especially like to acknowledge the following people who played roles in both establishing this trial and helping to realize its potential over 28 years, to the current day:

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Data Collation and Preliminary Analyses (2019-20)

Samantha Gonzalez RPF (field project manager), Hardy Griesbauer RPF

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- Dr. Oscar Venter and Dr. Che Elkin, University of Northern British Columbia (UNBC), Ecosystem Science and Management Program;
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- Caren Dymond, Forest Carbon Initiative, Climate Change and Integrated Planning Branch, MoFLNRORD

Last but not least, I'd like to acknowledge my colleague Dr. Gordon Weetman (now Professor Emeritus, UBC Faculty of Forestry) whose discussions of uneven-aged selection management and basal area stocking concepts helped inspire this study.

With appreciation,

Mike Jull RPF
Aleza Lake Research Forest Society
January 2020

Cover page photo:
Hardy Griesbauer and Samantha Gonzalez at a remeasured permanent sample plot at Summit Lake EP 1162, October 2019

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1. INTRODUCTION & BACKGROUND

In moist and wetter sub-boreal and subalpine forests of Interior British Columbia, there has been a long history of partial-cut harvesting of timber and natural regeneration in multi-aged hybrid white spruce and subalpine fir (or "balsam") stands (Weetman and Vyse, 1990). Such practices were frequent historically from the early 1900's to the mid- 1970's, and less frequent but not absent, from the late 1970's to the present day.

Typical historical partial-cutting practices in these forest types were relatively short-term in focus and prioritized the extraction of better-quality harvestable trees with relatively little or no attention to the condition of the residual post-harvest stand. The historical lack of silvicultural planning or prior understanding of spruce-balsam stand growth and dynamics in response to partial-cutting practices has led to many undesired or unanticipated silvicultural outcomes. Resulting residual stands were often highly irregular in stocking and conditions, varying widely in density, species composition, and the age and quality of advance regeneration.

Over the last half-century, clear-cutting followed by planting has become the dominant silvicultural system in central northern BC. However, despite this predominance, interest remains among many forest land managers, forest practitioners, and the general public in alternatives to clearcut systems, via the management of complex stand structures, partial-cutting techniques and related silvicultural systems, to meet a wide variety of integrated resource management goals (Bankowski, 2018). There have been numerous regional examples and trials of operational partial-cutting treatments in spruce-balsam types, implemented in the 1990's and early 2000's (Stevenson et al, 1999; Waterhouse et al, 2011) But aspirations for more extensive use of partial-cut silvicultural systems and management of more complex stand structures have been inhibited, from a silvicultural perspective, by limited scientific knowledge and lack of science-based stocking standards for such forest types.

EP 1162 was established in 1992 as a long-term silvicultural field experiment to address such scientific questions and silvicultural knowledge gaps. This trial, located 50 km north of Prince George, BC (See Map Appendix 1), was designed to systematically examine the silvicultural outcomes that may result from a range of residual basal area densities in complex and uneven-aged subalpine fir-hybrid white spruce stand types of Interior British Columbia. Such outcomes may include density-dependent effects on the regeneration, growth, and development of stands.

EP 1162 was established by the report author and principal investigator (Jull) under the BC Ministry of Forests' Silvicultural Systems Program, a 1990's provincial government initiative that sought to test and extend the use of alternatives to clearcut harvest systems in BC forestry. This trial was funded and remeasured under this program between 1991 and 1997.

The management of long-term field research projects is always challenging, as external funding and priorities vary over time. Following the 1997 remeasurement, changes in regional and provincial forest research priorities during the early 2000's to mid-2010's limited the frequency of remeasurement and maintenance of the EP 1162 trial. Nevertheless, remeasurements were made at periodic intervals whenever feasible.

In May 2009, nineteen EP 1162 PSP's were maintained and remeasured by the staff of the Aleza Lake Research Forest Society (ALRF), directed by the author. And ten years later, in 2019, MoFLNRORD's Forest Carbon Initiative (FCI) provided provincial funding to maintain, and remeasure this trial, in partnership with the MoFLNRORD, UNBC's Ecosystem Science and Management Program, and the ALRF Society.

This EP 1162 status and progress report is a synthesis of information on this trial over its several-decade history, from the trial establishment to 2020, the date of this report. The documentation provided in this report will support future management of this EP, and the analyses and interpretation of its results.

The primary purposes of this progress and status report are:

1. To provide a summary and compendium of information related to the establishment, monitoring, and intervening history of the EP 1162 field research trial over the last 27 years, from 1992 to 2019.

2. To describe stand characteristics and history, trial layout, and additional detail on the trial and its treatments, for further information and context related to current and future interpretation of the trial.

3. To describe past modifications to the design and protocols of this research trial, necessary for adapting to budgetary and logistical limitations during the life of the trial. And;

4. To provide an opportunity to consider the future of the EP 1162 research trial area from 2020 onwards, and to make recommendations for its future research and silvicultural management.

Finally, and more broadly, this report considers the relevance of this trial relative to future challenges of regional forest management needs, forest carbon management, mid-term timber supply, the balancing of timber and non-timber (social and biodiversity) objectives, and the effects of ongoing anthropogenic climate change.

2. APPLICATION OF THIS STUDY TO BC FOREST MANAGEMENT

The overall goal of this EP 1162 study is to provide scientific data that will improve our understanding and prediction of short- to long-term trends in uneven-aged stand development and growth patterns, over a wide range of possible residual basal area densities in sub-boreal spruce-subalpine fir forest types. Trial findings will aid forest managers and practitioners in the prescription and application of partial-cut silvicultural systems, and in the consideration of different silvicultural systems for the management of stand-level forest carbon.

In the extensive forests of low- to mid-elevation Sub-boreal Spruce (SBS) and mid- to high-elevation Engelmann Spruce-Subalpine fir (ESSF) biogeoclimatic zones of B.C.'s Central Interior, there may be continuing opportunities for selection (or 'uneven-aged') management of mixed stands of white spruce (*Picea glauca*) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.). Many factors influence the silvicultural and stand management objectives for any given stand and site. However, the silvical and structural characteristics of many SBS and ESSF spruce-balsam stands that potentially make them good candidates for selection management are:

1. Moderate- to high shade-tolerance of both tree species, and demonstrated ability to establish and grow in smaller canopy gaps;
2. Variable, and often multistoried stand structures which contain a wide range of intermingled diameter and height classes and tree species, and;
3. Relatively open, multilayered canopies, with opportunities for the retention of windfirm secondary structure, understory regeneration, and individual leave-trees, after moderate partial harvest of selected trees.

Quantitative, field-validated guidelines will support silvicultural planning and setting of stand management objectives for selection and similar partial-cutting prescriptions. The basic elements of complex stand management which need to be better understood and quantified for central and northern BC spruce-subalpine fir forest types include:

1. Appropriate post-harvest residual basal area stockings.
2. Residual tree size and species distributions for specific stand management objectives.
3. Expected species and amount of regeneration.
4. Post-harvest volume increment from (growth and yield of) complex stands. And;
5. Expected harvest return intervals (cutting cycles).

Specifically, EP 1162 aids this improved understanding and future guideline development, by examining the influence of residual basal area densities in these forest types, on post-harvest rates and patterns of:

a) stand volume and basal area growth, and corresponding forest carbon sequestration and storage.
b) diameter and height release of spruce and subalpine fir in all canopy layers.
c) natural regeneration establishment and species composition.
d) possible mortality and blowdown. And;
e) long-term effects on individual tree growth and quality.

Use of selection and other partial-cut silvicultural systems, assisted by improved knowledge, will have application in regional stand-level prescriptions and strategies for various silvicultural situations including:

- Treatment of stands affected by biotic factors including insect-induced spruce or *Abies* mortality (such as for spruce beetle or balsam bark beetle);
- Modified harvest practices in special management areas where wildlife habitat, ecological sensitivities, and/or social-cultural factors limit the acceptability of conventional clearcut silvicultural prescriptions.
- Modified silvicultural strategies for the management of forest carbon. And/or;
- Stands affected by abiotic wind or ice/snow damage, or stresses and partial mortality due to climate change.

Photo # 1: Mike Jull at EP 1162 Plot # 10, October 2019, during PSP remeasurements.

3.0 SILVICULTURAL TREATMENTS, IMPLEMENTATION, & OUTCOMES

3.1 Pre-harvest Basal Area Densities

1991 pre-harvest research data collection and harvest planning activities on the EP 1162 site included: (1) the systematic location and identification of treatment units within the proposed EP area, (2) randomized allocation of one of three possible basal area treatment classes to each treatment unit, and (3) inventory and tallying of the total pre-harvest population of live trees within each 0.25-hectare treatment unit. Live-tree basal area within each treatment was quantified by basal area sweeps using a 4 BAF (basal area factor) prism. Pre-harvest basal areas were averaged for all treatment units within a basal area treatment class, as summarized in Figure 1.

Pre-harvest basal area across all treatment units averaged 33.6 m^2/ha. Pre-harvest basal areas had a moderate range of variation, from a low of 30.1 to a high of 37.1 m^2/ha, with standard deviations of 4.3 to 5.7 m^2/ha within each treatment class. Descriptive statistics for each treatment class are shown in Table 1 below.

Table 1: Mean 1991 pre-harvest basal areas and variability within each randomly-allocated EP 1162 treatment class.

Basal Area Treatment Class (Prescribed)	**Mean Pre-harvest Basal Area**	**Range (Min. to Max.)**	**Standard Deviation**	**Sample size**
	(m^2/ha)	(m^2/ha)	(m^2/ha)	(n)
"Low" (target of 10 m2/ha)	30.4	24.0 - 41.3	5.9	6
"Medium" (target of 20 m2/ha)	37.1	26.7 - 50.7	9.3	6
"High" (target of 30 m2/ha)	33.1	29.3 – 38.7	5.0	7

Photo 2: Pre-harvest oblique view looking east across the EP 1162 study area in Summer 1991, prior to selection harvesting which occurred the following winter. Visual landmarks in the photo include the Crooked River in the foreground, Highway 97 North in the background, and a gravel pit to the left (north) of the photo.

3.2 Prescribed Basal Area Removals by Commercial Timber Harvesting and Sanitation Felling

Planning and implementation of prescribed basal-area reductions in each treatment unit were conducted in the following sequence:

<u>Phase I</u>: Pre-harvest planning and Marking-to-cut (Summer / Fall 1991)

Based on pre-harvest tree-inventory and live-tree basal area for each treatment unit, trees were systematically marked-to-cut (with a red paint ring around each tree to cut at 1.5 to 2 m height), using the preferential criteria for cut vs leave trees outlined in the EP 1162 Working Plan. For each treatment unit, research marking crews adjusted the intensity of tree harvest and leave-tree retention in each treatment unit to meet the approximate prescribed (and randomly selected) basal area retention level identified in the Working Plan.

<u>Phase II</u>: Commercial Harvesting of Selected Trees (Winter 1991/92)

Selection harvesting throughout the trial area occurred in Winter 1991/1992 but used two different logging methods. The southern 25% of the selection area (TSL A28480) was "hand-felled" by chainsaw-equipped faller personnel, and skidded with a team of horses; the northern 75% of the selection area (TSL A28481) was similarly hand-felled, but with mechanized skidding (forwarding) to designated landings using D4 line skidders (with cable winches). Logging crews on both timber sales were instructed to selectively remove only marked trees within each treatment unit and to minimize damage or incidental harvest of other, unmarked trees.

Appendix 2 provides a map of the two single-tree selection timber sale boundaries, overlaying the experimental treatment units described in this report.

Photos 3, 4 The log-skidding methods used for selection logging at the Summit Lake EP 1162 study area, included a D4 Hi-Drive line skidder (left) on TSL A28041 and horse-logging (right) on TSL A28040. Both photos were taken during Winter 1991/92 harvest operations at the EP 1162 site.

Photos 5, 6: Trees were selected for partial-harvest removal by a “marking to cut” method using a band of red spray paint at about 2 m height, to indicated desired trees for removal. This method allowed selected trees to be removed based on past damage or other physical indicators (left). A log deck on the timber sales shows red-marked balsam trees (subalpine fir) making up the log deck.

Photo 7: Eastward view from the western access road, across logging landing during TSL 28481 selection logging operations, Winter 1991/92. Viewed area of cutblock is just north of PSP # 12.

Photo 8, 9: Stand-edge profile views of post-harvest selection-cut stand (Winter 1991/92). The above photo is from the gravel pit on the NW side of the study area, looking S-SE, just north of PSP # 20. The exact location of the photo below is unknown but is believed to be in TSL A28480, in the southern horse-logged portion of the study area.

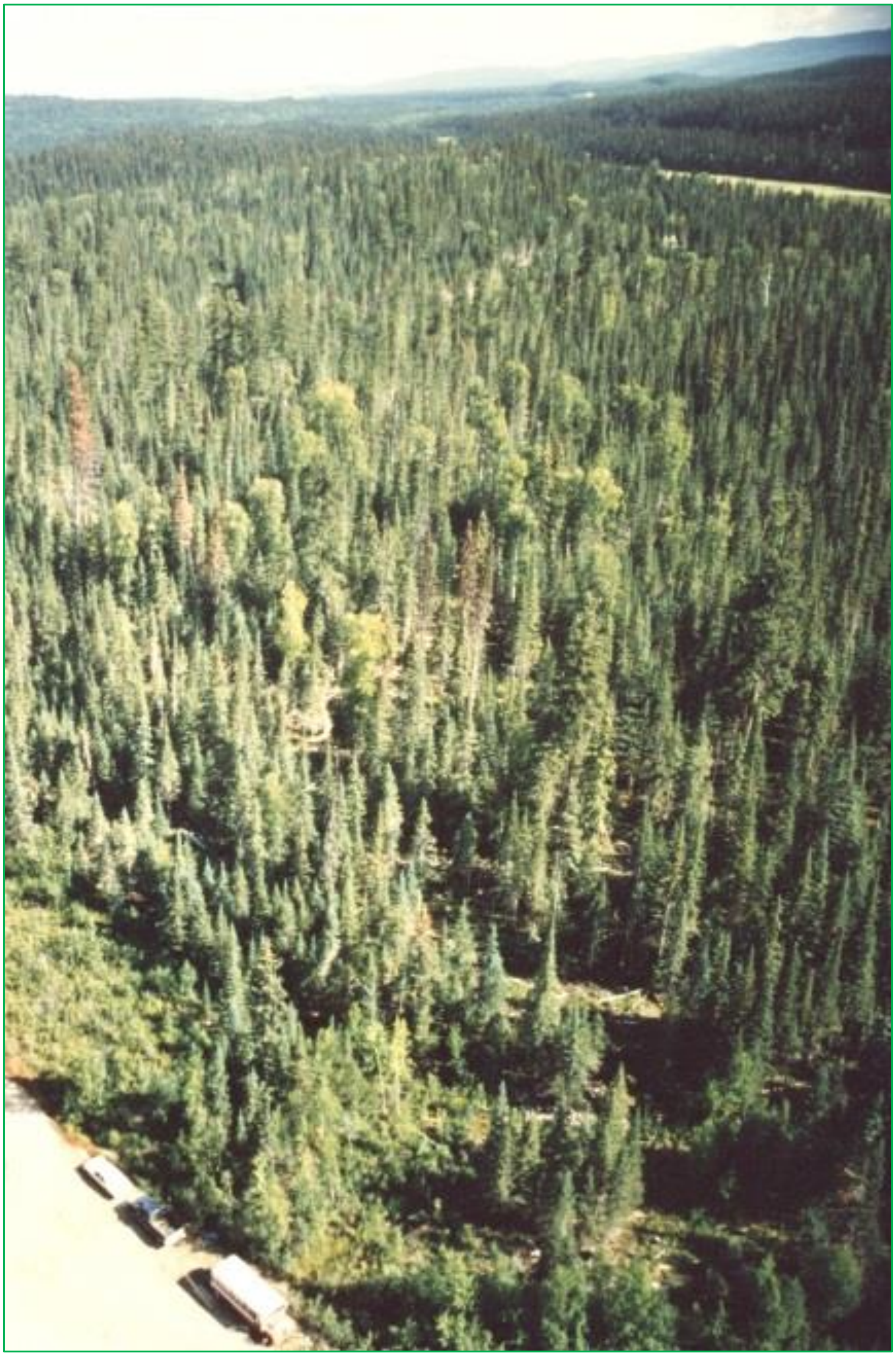


Photo 10: Post-harvest oblique aerial view of EP 1162 selection trial following selection harvesting (TSL's A28480 and A28481). This view faces approximately NE from above the junction of Caine Creek FSR and unnamed western access road (Summer, 1992).

<u>Phase III</u>: Post-logging Stand Assessment and assessment of treatment impacts (Summer 1992)

In the Spring and Summer of 1992 following the Winter 1991/92 selection harvest of these timber sales, research crews re-visited all the treatment units and assessed the condition and post-harvest basal area of each unit. For each, a complete post-harvest live-tree inventory was conducted, and PSP's established, to quantify the actual level of basal area retention achieved. Trees significantly damaged by logging with limited prospects for recovery (e.g. major logging scars or broken tops) were marked to cut in the same way as done pre-harvest, in 1991. Paper birch within the treatment units were girdled with axes, to concentrate residual basal area within the units within the coniferous growing stock. Paper birch and deciduous trees outside the 0.25-hectare treatment units remained untreated. Where necessary to more closely approximate the prescribed basal area density for each treatment unit, minor additional poorer-quality coniferous trees were marked-to-cut.

<u>Phase IV</u>: Sanitation Felling of Designated Trees (Summer 1992)

In July-August 1993 and 1994, contract falling crews undertook non-commercial sanitation felling of marked-to-cut damaged and poor-quality live trees within each treatment unit, including trees within the PSP's. To reduce long-term slash loading and to speed the decay of felled trees, felled trees were bucked to 2-metre lengths.

<u>Phase V</u>: Quantification of Final Basal Area Densities (1994)

Mean post-treatment 1994 percent basal area retention level and basal area density statistics by prescribed treatment classes are described in Table 2 below, based on comparisons of Fall 1994 PSP data for each of the basal area density treatment classes.

Table 2: Mean 1992-1994 initial post-harvest basal areas and range of variation within the 3 basal area treatment classes in EP 1162. Percent of basal area retention statistics are relative to measured pre-harvest data.

Basal Area Treatment Class (Prescribed)	**Percent of Basal Area Retention**	**Mean Post-harvest Basal Area**	**Range (Min. to Max.)**	**Standard Deviation**	**Sample size**
	%	(m^2/ha)	(m^2/ha)	(m^2/ha)	(n)
"Low" (target of 10 m2/ha)	29.8 %	9.05	3.0 - 14.7	4.3	6
"Medium" (target of 20 m2/ha)	43.1 %	16.0	8.2 – 18.6	4.4	6
"High" (target of 30 m2/ha)	82.5 %	27.3	24.1 – 31.3	3.7	7

As per Tables 1 and 2 and Figures 1 and 2, the experimental design and treatment regime achieved three different levels of systematic stand basal area reductions to the pre-harvest stand, across the trial area. Actual residual basal area *removals* in the Low and Medium basal area treatments were 10 to 20% higher than anticipated; as a result, mean basal area levels in these two treatment classes were 90 and 80% of basal area density targets. The achieved mean density of the "High" basal area treatment units was 91% of the target of 30 m^2/ha., on average.

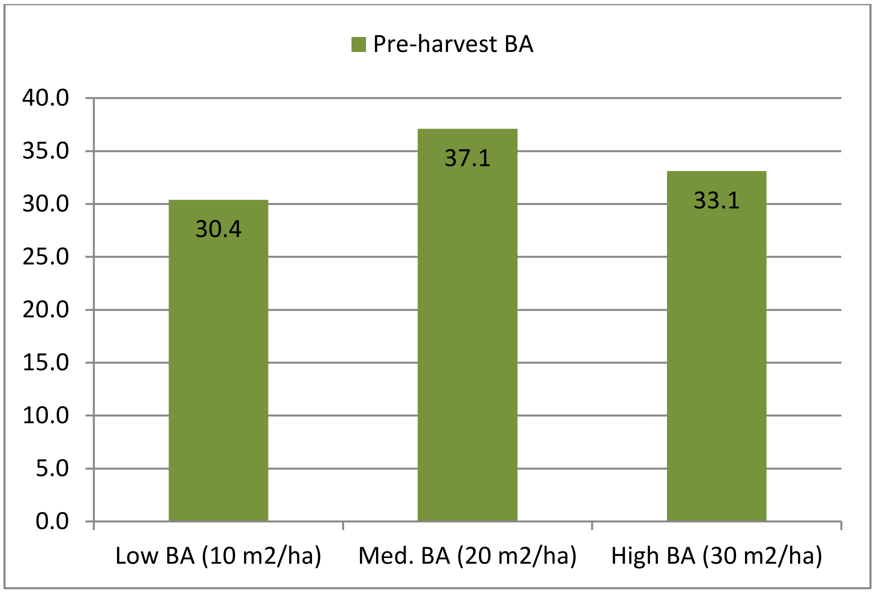


Figure 1: Mean pre-harvest basal areas for the three intended basal area treatment classes, EP 1162, Summer 1991

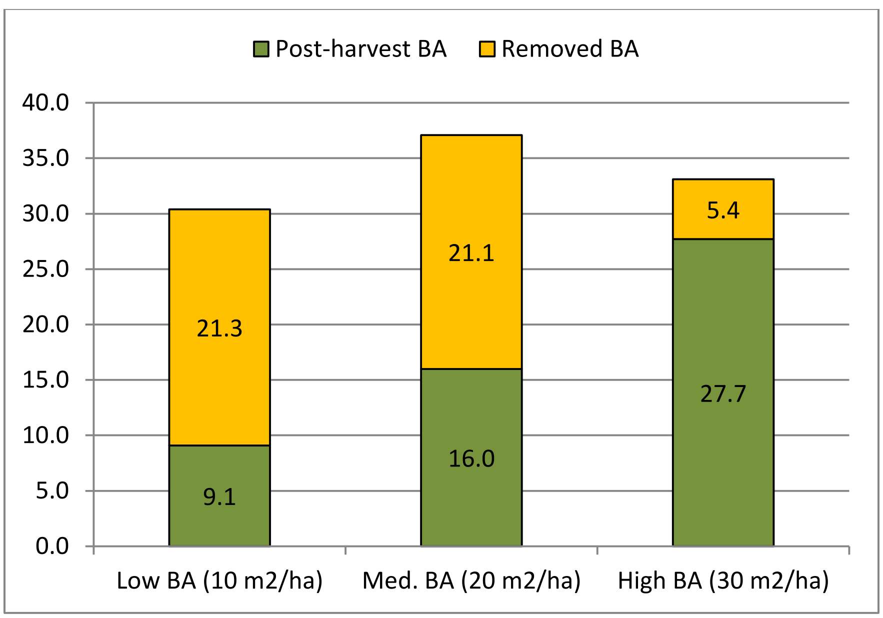
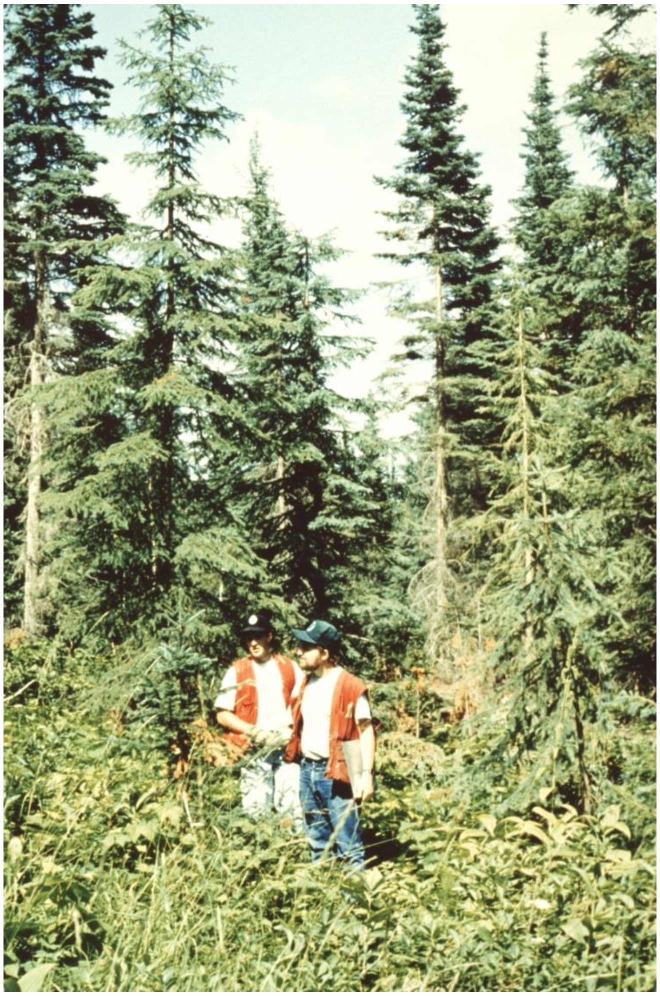


Figure 2: Mean post-harvest residual basal areas (green bars) and actual basal area removals (yellow bars) across the three intended basal area treatment classes, EP 1162, Fall, 1994. Note that post-harvest residual basal areas and basal area removals are cumulative as shown.

Photos 11, 12: Representative post-harvest views of the Low or 10 m^2/ha basal area density treatment (left) and Medium or 20 m^2/ha basal area density treatment (right), 6 months post-harvest, July 1992.

3.3 Regeneration Treatments

The Silviculture Prescriptions for the EP 1162 area (which span two Winter 1991/92 timber sales) predominantly specified and relied on advance and natural regeneration of spruce, subalpine fir, and scattered Douglas-fir where present, to meet regional Ministry of Forests regeneration standards of the time. The Prescriptions (equivalent to what are now called Site Plans under the *Forest and Range Practices Act*) also allowed for "artificial regeneration" and fill-planting of spruce and Douglas-fir where necessary to reforest large voids, skid trails, and other areas with an unsuitable natural stocking of trees.

In May 1995, the forest licensee (the Small Business Forest Enterprise Program) undertook general fill-planting of the prescription area with container-grown PSB 415 1+0 hybrid white spruce and Douglas-fir planting stock, with the goals of both restocking voids created by logging, including skid trails and other unstocked gaps, and to off-set the heavier (85-90%) subalpine fir composition of the residual stand with spruce and Douglas-fir. The average density of planted trees within the experimental area ranged from about 300 to 600 stems-per-hectare.

EP research crews fill-planted hybrid white spruce seedlings (PSB 1+0 Sx, Class A Seedlot # 6585) within 14 selected experimental treatment units, likewise targeted at establishing spruce regeneration in unstocked or poorly stocked voids based on the spatial distribution of good-quality residual trees and advance regeneration. In addition to augmenting longer-term spruce composition in these stands, this incremental underplanting provided additional research opportunities to examine the longer-term effects of different basal area densities on the survival and growth of planted trees.

Planted trees within the PSP's were marked with metal pig-tail markers, affixed with numbered plastic tags. A dataset of 1994/95 tagged planted regeneration within the PSP's is available within EP 1162 project files.

The fourteen EP 1162 PSP's with documented under-planting treatments included PSP's # 3 to 15, and 24. Five active EP 1162 PSP's with <u>no</u> record of underplanting treatments included PSP's # 16 to 20.

Photo 13: Natural regeneration of subalpine fir and planted regeneration of hybrid white spruce on an old skid trail 27-years after selection logging, near PSP # 19, Summit Lake EP 1162 (Fall, 2019).

4.0 RESEARCH DESIGN AND WORKING PLAN MODIFICATIONS

Rationale for Modifications

The 1992 Working Plan for EP 1162 provided the conceptual framework and baseline for the design and implementation for this research trial and specified the originally desired degree of treatment replication for the trial. However, following trial establishment, the scope of the trial was moderately scaled-down in early 1994 to meet logistical and budgetary constraints. Treatment replication was reduced from 10 to 6 replicates per treatment, but the completely randomized experimental design was retained, within a smaller EP area.

4.1 Modifications to the Experimental Design

The number of actively-monitored experimental units (PSP's) in the EP was reduced in 1994 from the originally-conceived 10 replicates per treatment (or 30 treatment units) to a 6 replicates for each of the 3 basal-area treatment (i.e. – at least 18 treatment units). Inclusion of one additional (seventh) high basal area treatment replicate in the trial brought this total to 19. Please refer to Appendix 3 for a map that compares the original experimental design relative to its final experimental design layout.

In the process of scaling down the number of final treatment units from 30 to 19, the following ecological stratification criteria were considered, including:

a) Focusing long-term treatment unit's maintenance on a core area of mesic to sub-hygric site series.
b) Excluding treatment units on-site series wetter than sub-hygric (i.e. – hydric sites with high water tables). And;
c) Excluding treatment units on very droughty sites (drier than mesic) on gravelly rapidly-drained soils in the northwest portion of the study area.

These changes focused EP 1162 on 19 basal-area-density treatment units across a final trial area of approximately 40 hectares (Figure 3). GPS locations of these treatment units are provided in Appendix 4.

4.2 Implementation of Permanent Sample Plot Layout and Measurements

A 0.05-hectare (12.6 m-radius) circular growth-and-yield permanent sample plot (PSP) was established at the center of each 0.25-hectare experimental treatment unit, as specified in the EP Working Plan. 17 of the PSP's were established in 1992, and two PSP's (# 4 and 15) were established in 1994.

Minor changes were made to the PSP sampling procedures for purposes of sampling efficiency, as follows:

a) Age, radial growth, and bark thickness of height sampled trees were collected in 1992 and 1994 but not future remeasurement years.
b) For the 2009 remeasurement and onwards, the small-tree diameter measurement limit was raised from 4.0 cm dbh to 7.5 cm dbh. This change was spurred by both practical and biological considerations, as research crews found that smaller conifer saplings < 7.5 cm dbh could not be effectively tagged (i.e. – via nailing a number tag at breast height) without significant damage to the small tree stem. Also, trees $\geq$ 7.5 cm dbh were of a larger threshold tree size which signified greater growing space occupancy.
c) Regeneration sub-plots were not established for advance and natural regeneration. Instead, all understory trees above a specified dbh size limit are tracked and measured in the plots, to track regeneration ingress and recruitment into intermediate and mid-canopy tree classes.

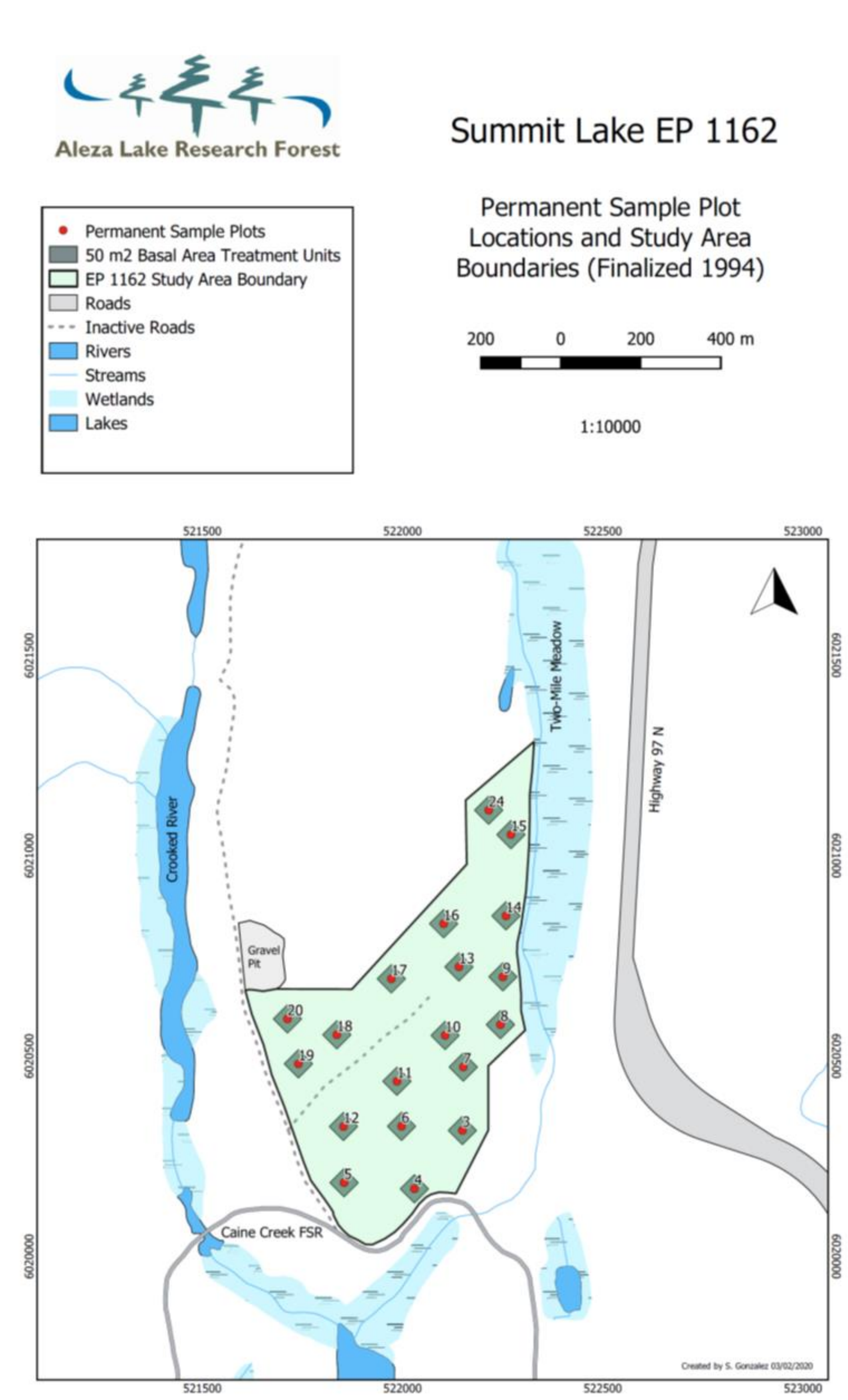


Figure 3: Map of Final EP 1162 Permanent Sample Plot (PSP) Locations and Study Area Boundaries, finalized 1994.

The original 1990 Ministry standards for PSP maintenance and measurement cited in the working plan have been updated several times since then. The most recent Vegetation Resources Inventory (VRI) methodologies for the purposes of EP 1162 are referenced in Forest Analysis and Inventory Branch (2016). Note that EP 1162 is generally consistent with *field* methodologies, not the Ministry's digital data collection methodologies.

The history of plot establishment and remeasurement for each of the 19 permanent sample plots is summarized in Table 3.

Table 3: Summary of Establishment and Remeasurement Years and Season for Permanent Sample Plots (PSP's) at the Summit Lake Basal Area Density Trial (EP 1162)

PSP #	1992 (Mar.)	1994 Fall	1997 (Oct.)	2009 May	2019 (Oct.)
3	E	R	R	R	R
4		E	R	R	R
5	E	R	R	R	R
6	E	R	R	R	R
7	E	R	R	R	R
8	E	R	R	R	R
9	E	R	R	R	R
10	E	R	R	R	R
11	E	R	R	R	R
12	E	R	R	R	R
13	E	R	R	R	R
14	E	R	R	R	R
15		E	R	R	R
16	E			R	R
17	E			R	R
18	E			R	R
19	E			R	R
20	E	R	R	R	R
24	E	R	R	R	R

E = PSP Establishment year

R = PSP Re-measurement year

At EP 1162, the tree population within each PSP was systematically subsampled at each measurement period (except for 2009), to measure tree heights with Vertex ultrasonic hypsometers in 2019. For measuring 2019 tree heights at the Summit lake EP 1162 site, field crews followed 3 guidelines:

1. First, measure heights on any trees that had height measurements in the previous remeasurement intervals (1992 through 2009), unless the trees are dead or had major top damage at the current remeasurement.
2. Second, measure heights on all trees greater than 20 cm dbh. And;
3. Third, within the ≥ 7.5 to ≤ 20 cm dbh diameter class, measure heights on every 3rd tree in a tag number sequence (i.e. approx. 33% of the trees in this diameter class), with the exception of trees with broken tops and poor vigour. If the latter type of defective or damaged tree was encountered, the tree was skipped, and the next non-defective tree in the tree-tag number sequence was measured for height.

At each PSP, height sampling started at the North end of the plot and worked clockwise through the plot. This was varied only if field conditions and weather conditions warranted.

Photo 14: Permanent Sample Plot (PSP) centres are marked within EP 1162 by large angle-iron posts painted with red rust-resistant paint, for both visibility and durability. (May 2019)

Photo 15: During May 2019 permanent-plot maintenance activities, plots and datasets were reviewed in the field, and trees re-tagged or refreshed with anodized blue pre-numbered tree tags, attached to trees with 3“ (7.6 cm) aluminum nails.

4.3 Monitoring of Planted Regeneration

For research monitoring of planted regeneration in fourteen treatment units (PSP’s # 3 to 15, and 24), four subplots within each PSP were tagged (with pigtail markers and numbered tags) in September-October of 1995 and 1997. Measurements were taken on each tree including height, live crown dimensions, basal caliper, leader growth, and vigor.

Approximately 767 planted spruce trees were initially tagged and measured. Over 14 treatment units, planted-tree sample sizes were an average of 54 per treatment unit, and 13 to 14 planted trees per sub-plot.

These tagged planted trees have not been remeasured since 1997, but based on field observations in 2019, there is potential for relocation of a substantial proportion of marked planted trees within these plots, if revisited in the near future (e.g. 2020; Spring conditions before leaf-out are recommended to most efficiently locate markers and tags).

4.4 Data Management

Permanent sample plot data for EP 1162 have historically (and to date) been collected on water-resistant field data collection “hard copy” forms customized this trial, and updated for each remeasurement period. EP data entry and storage has been managed in MS Excel or equivalent “flat file” spreadsheets. This digital format provides an easily extractable/retrievable, stable, and durable file format for EP 1162 data management over 3 decades of research trial management. Data files are stored on large institutional computer servers (UNBC, provincial government) for legacy digital data archiving.

In addition, full printed data sets and original field sheets (or photocopies of originals) are stored in EP 1162 paper files for an additional measure of data backup and security.

Original hard copies of field data sheets for each measurement period are retained and stored in EP records, for archival purposes, and for future cross-checking and validation of data, when required.

4.5 Tree Volume Equations

For calculation of gross tree volumes and volume increments, previous volume compilation methods cited in the Working Plan (i.e. - cruise compilation methodology and generalized taper functions; B.C. Ministry of Forests, 1983) have been replaced by more recent tree volume equations for BC tree species (Nigh, 2016).

Photo 16: Cross-section of freshly-felled subalpine fir following Winter 1991/92 selection harvest operations, showing strong radial increment following earlier 1955 selective cuttings.

4.6 Photo Documentation

Older photos from the EP 1162 trial (circa 1991-2005) were historically in hardcopy print or slide format. These were digitized, described, and catalogued for EP records in January and February 2020, by the staff of the UNBC Archives.

Photos depict (a) pre-harvest conditions, (b) falling, logging, and skidding operations, (c) post-harvest photos. (d) aerial oblique photographs of the EP 1162 stand and its surrounding landscape, and (e) crew and plot work.

The original EP 1162 working plan proposed time-interval photos from fixed plot corners within the experimental units over sequential years. However, these were not feasible in practice, due to logistical challenges and limited within-stand visibility for photography, abundant understory, and dense vegetation.

4.7 Historical Maintenance Schedules to 2019

The original maintenance schedules listed in the Working Plan were sustained from 1991 to 1997. Further stand remeasurements were undertaken on a periodic basis as funding opportunities and crew availabilities allowed.

In 2009, the original principal researcher (Jull) and staff from the Aleza Lake Research Forest (ALRF) undertook PSP maintenance and remeasurements (of diameter and tree condition only) on all 19 active PSP's.

EP 1162 remained dormant from 2010 until 2018. In October 2018, Hardy Greisbauer (MoFLNRORD Research Silviculture Ecologist, Omineca Region) and Mike Jull of ALRF undertook a joint a site visit and review of EP 1162. This site visit initiated a discussion process with various research agencies (provincial agencies, UNBC, and other research partners) eventually leading to trial re-activation and remeasurement.

In 2019, supported by funding from the MoFLNRORD Forest Carbon Initiative (FCI) in collaboration with the University of Northern BC (Drs. Oscar Venter and Che Elkin), Greisbauer and Jull undertook the trial inspection, PSP maintenance activities (May 2019), and full PSP remeasurements (October 2019). Further data analyses for the 1992-2019 datasets for this trial are underway in early 2020.

4.6 Updated Research Roles and Responsibilities

EP 1162 remains a long-term silvicultural research trial under the MoFLNRORD and the Province's Experimental Project (EP) system. As of 2019/20, the current Ministry contact for this trial is Hardy Griesbauer (MoFLNRORD Research Silviculture Ecologist, Omineca Region).

5. FUTURE CONSIDERATIONS FOR MANAGEMENT OF EP 1162

Goals, priorities and actions for future management of the EP 1162 study site need to include and consider:

a) How to ensure research-site identification and protection relative to other land uses.
b) The frequency and timing of future remeasurements.
c) Evolving current and future research objectives and opportunities for the site. And;
d) The potential for future partial-cut stand entries (i.e. – basal area or volume removals) on the site, to meet specific research and silvicultural goals.

The goal of this section of this report is not to provide specific direction or prescriptions for future management of EP 1162, but rather to provide guidance for current and future forest researchers and land managers in the administration and stewardship of this area. This guidance is summarized below.

<u>Research Site Identification and Protection</u>

A key ongoing need for the EP 1162 site is to ensure site integrity, and for the research infrastructure and adjacent stand conditions to remain free of undue anthropogenic disturbances (land clearing, construction, etc.) during the life of the trial. Therefore, it is vital that information on the location and layout of the site is easily accessible and available in provincial databases, for land user proponents and government reviewers in their planning processes.

It is recommended that this issue be referred to the BC Ministry of Forests, Lands, Natural Resources Operations, and Rural Development for review, and guidance for checking on-site status, and updating of land-use databases as needed. This should include not only forest operations (timber harvesting or road activities) but also potential gravel extraction, such as in the northwest of the study area.

It is also recommended that a *minimum* undisturbed buffer distance of 50 metres (i.e. – 50 m from the edge of any experimental treatment unit, or > 75 m from a PSP plot centre) be applied to the location of any planned disturbances or land clearing activities that are not related to the purposes of the trial.

<u>Frequency and Timing of Future Remeasurements</u>

Early remeasurements of trial PSP's were relatively frequent (every 2 to 3 years). However, longer-term remeasurements of this trial have historically been undertaken about once per decade. However, a measurement interval of every 10 years should be the maximum interval, and somewhat short measurement intervals (e.g. – every 5 years) are most desirable for quantifying data trends over time.

It is recommended that PSP remeasurements for this EP occur on a 5- and 10-year interval. Based on the Fall 2019 remeasurement, future measurement years will be Fall 2024 and/or Fall 2029. Remeasurements beyond 2029 will depend on future study management and objectives.

Potential for Future Partial-cut Stand Entries

The EP 1162 stand was partial cut in approx. 1955, and 37 years later, for EP 1162, in the Winter of 1991/1992. At the time of writing (February 2020), 28 growing seasons (years) have elapsed since that last selection harvest.

Based on current basal area re-growth trends, and past experience, it is estimated that this stand could (if desired) support a new partial-cut (selection) stand entry about 35-40 years after the 1991/92 selection harvest. If so, this planned new stand entry could occur between approx 2026 and 2031.

Further considerations in the timing of a new stand entry would be: (a) the increasing basal area density of all current treatment units in the trial, and (b) the nature of future research objectives and opportunities, as discussed below in this section.

In terms of 2019 basal area and stand density dynamics and trends:

The High basal area treatments are already at an average basal area of 40.5 m^2/ha, ranging from 37 to 47 m^2/ha, and there is field evidence of density-dependent tree mortality and growth reductions occurring at these high basal area levels.

To 2019, the original “Low” and “Medium” basal-area treatment units have both increased to almost 30 m^2/ha, ranging from about 21 to 35 m2/ha at the time of writing (2020). At current rates of basal area regrowth, these treatment units are forecast to increase to average basal areas of 35-40 m^2/ha within 10 years, ranging from 30 to 49 m^2/ha for individual treatment units.

Future stand entries and basal-area density regulation of these stands are recommended strategies to reduce or avoid anticipated future density-dependent mortality.

Current and Future Research Objectives and Opportunities

The original objectives of EP 1162 focused on the examination of the effects of different basal area densities on basic stand parameters and dynamics including basal area and volume growth, regeneration, species composition, and tree vigor. These durable and robust parameters are likely to continue to be of interest to the Province, First Nations, and the forest research community.

Current recent initiatives by MoFLNRORD and UNBC have also recently added forest carbon as a response variable of interest in this trial.

It also seems likely that EP 1162 could be or will be used to examine the effects of current climate shifts on forest growth and dynamics, in conjunction with forest-carbon research at this site. In the future, the trial could potentially be used or managed to test and evaluate silvicultural treatment options related to climate change adaptation strategies.

Finally, current EP 1162 and results may be applied to current and future efforts by the Province to promote a greater degree of forest and stand-structural retention in timber-harvest and beetle-salvage planning (e.g. BC MoFLNRORD, 2017).

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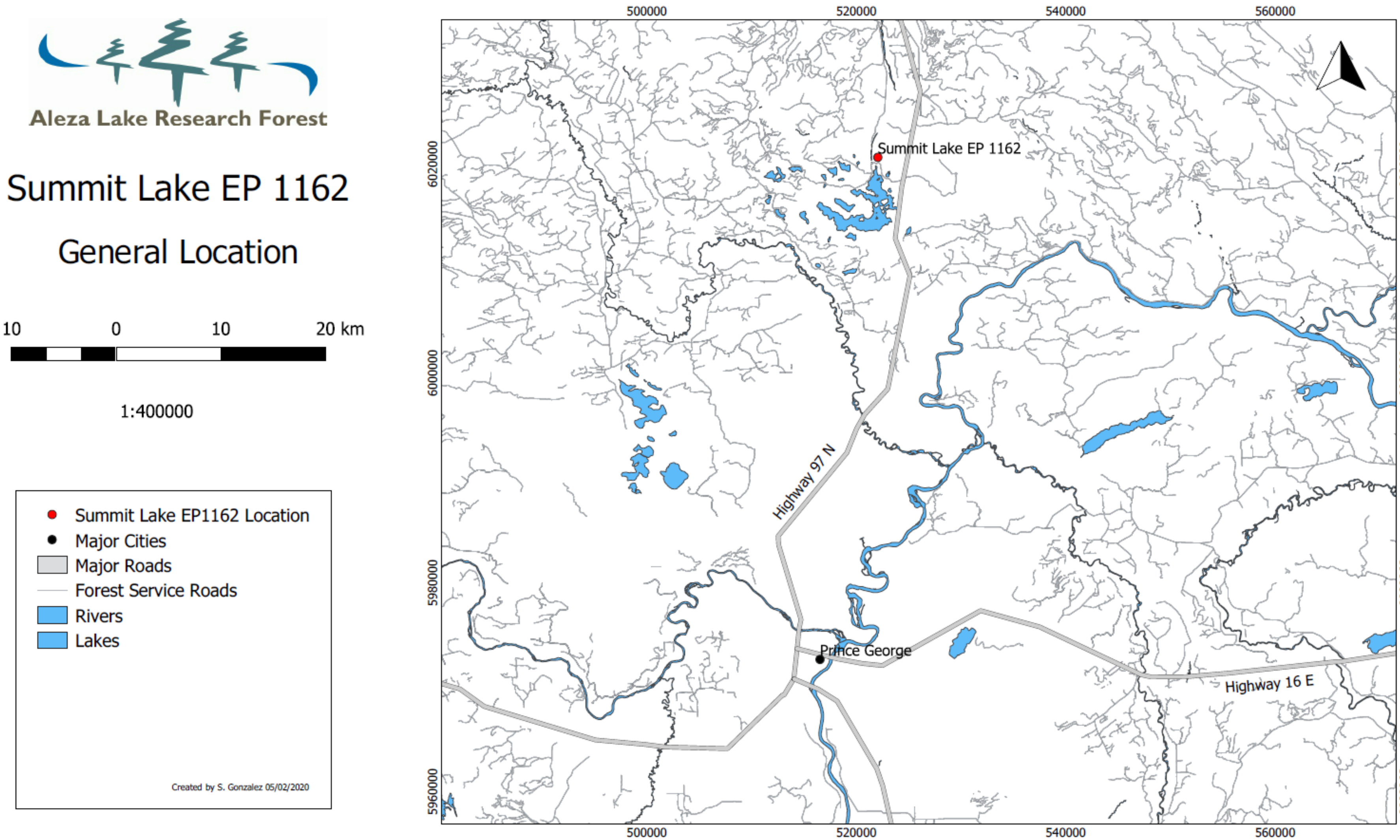
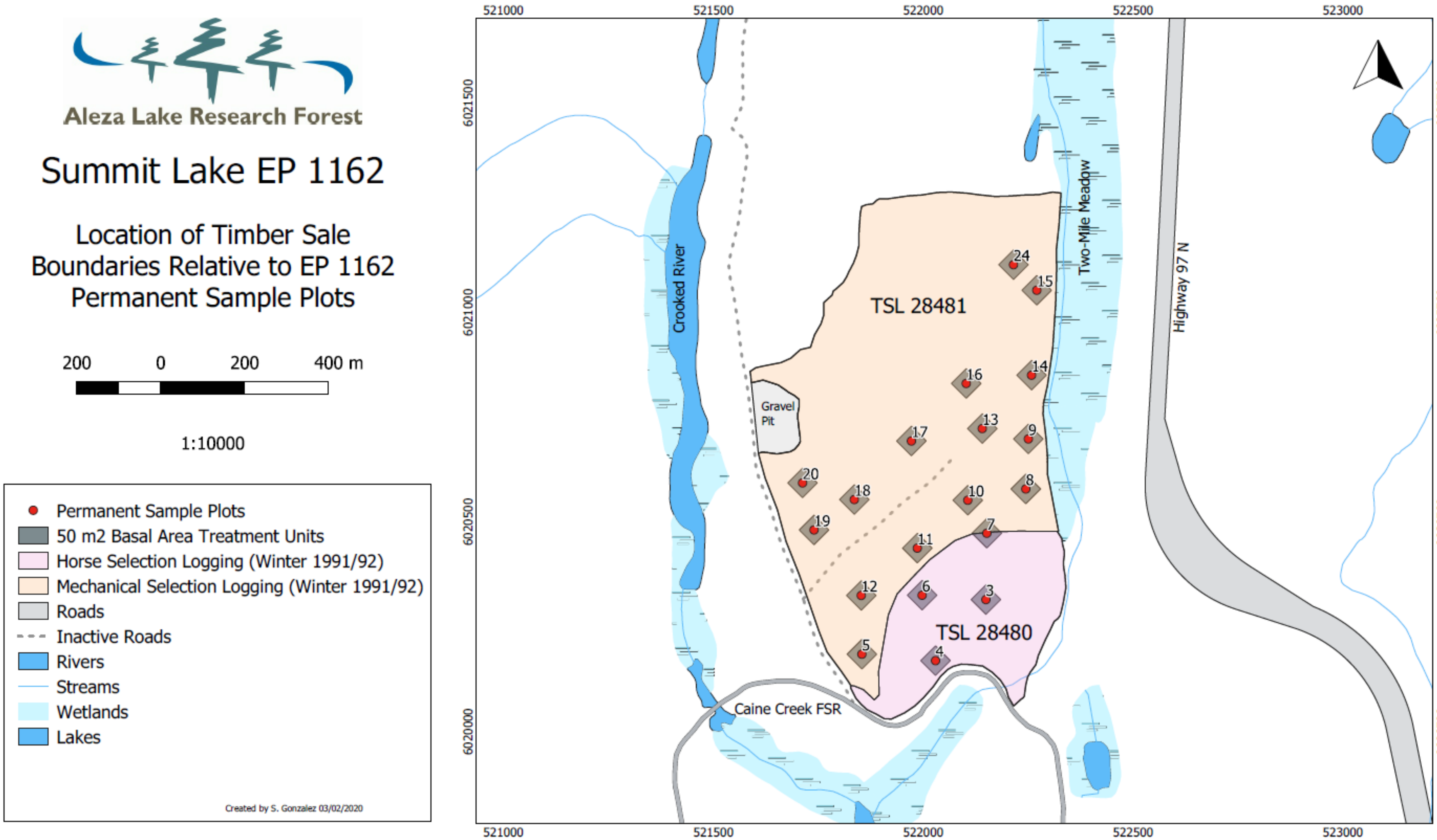
APPENDICES

Appendix 1: General Location Map for EP 1162



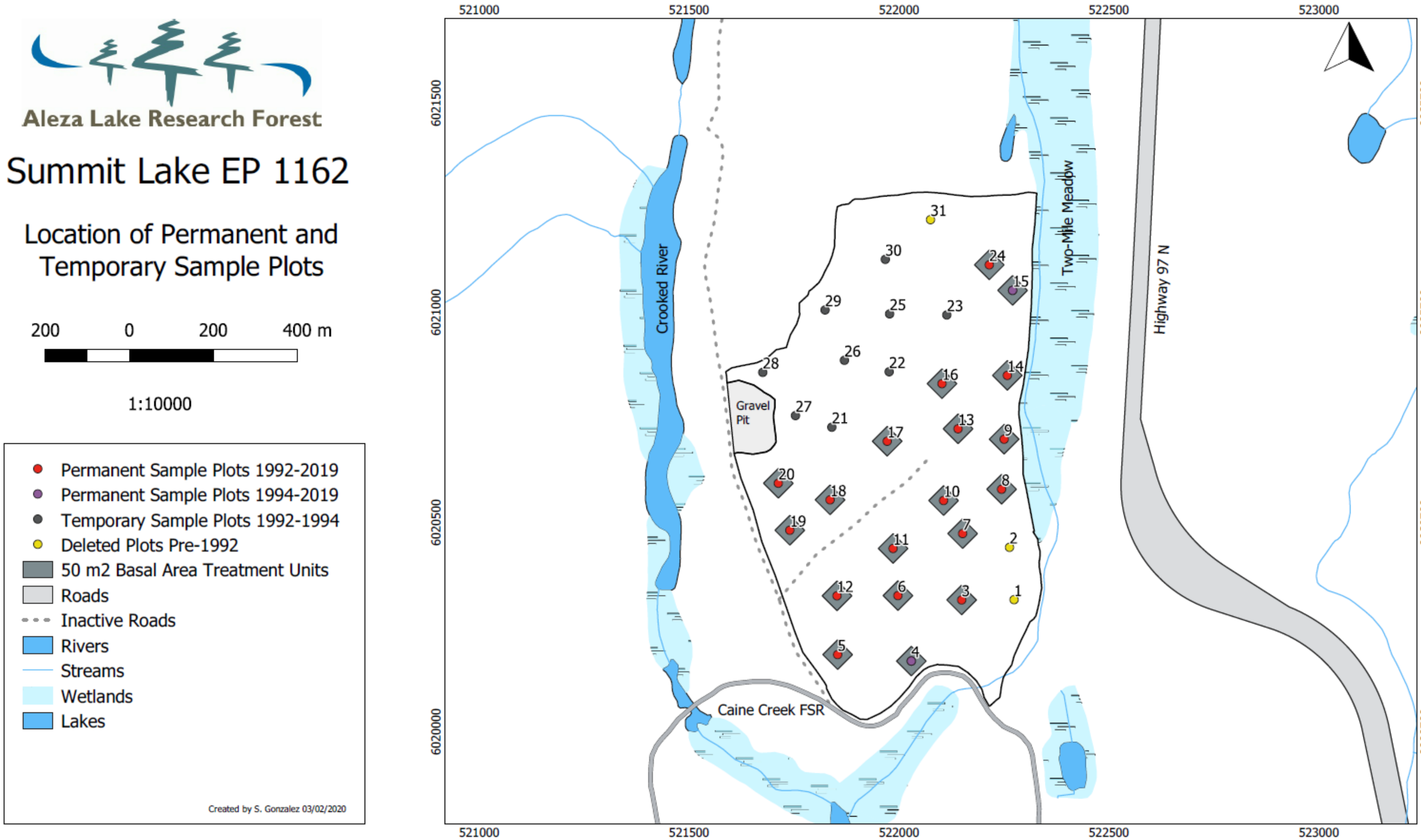
Appendix 2:

Location of Timber Sale Boundaries relative to EP 1162 Permanent Sample Plots



Appendix 3:

Summit Lake EP 1162: Location of Permanent and Temporary Sample Plots



Appendix 4:

GPS (UTM) Coordinates of Centre of 19 Experimental Treatment Units
and associated Permanent Sample Plots (PSP's) at EP 1162

PSP #	Northing	Easting
P-3	6020314.3730	522149.7251
P-4	6020168.0320	522029.4706
P-5	6020183.8820	521853.8063
P-6	6020324.7670	521997.5031
P-7	6020472.3830	522151.5631
P-8	6020578.5390	522244.6894
P-9	6020697.6250	522250.6143
P-10	6020551.1660	522106.3136
P-11	6020437.0930	521985.9094
P-12	6020324.0740	521852.4880
P-13	6020722.6850	522140.6004
P-14	6020850.1010	522258.3275
P-15	6021052.6720	522270.9985
P-16	6020830.4310	522102.3665
P-17	6020692.9460	521972.3280
P-18	6020553.2080	521835.7897
P-19	6020480.4270	521739.8941
P-20	6020592.6800	521712.7010
P-24	6021113.6000	522215.4359