Title: Growth and release of understory trees in partially-cut pine stands

FSP No.: Y08-1211

Project Description: Clearcutting followed by planting has been the dominant stand-scale management practice in the sub-boreal forests of British Columbia. In the past 15 years, retention of 5-15% of canopy trees has become common, but growth projections are still based on open-grown planted seedlings. Simultaneously, the mountain pine beetle (MPB) epidemic has created vast areas of complex multi-storied stands and extensive areas of MPB damaged forest will remain unsalvaged. Future timber-supply in these stands will depend on some combination of future natural regeneration, under planting, and the release of surviving understory and sub-canopy trees. We have very limited data on the performance of underplanted trees under different levels of canopy retention because of the past dominance of clearcutting. We also lack direct data on the release potential of understory trees after mountain pine beetle attacks. To develop appropriate silvicultural systems for unsalvaged MPB stands and complex stands in general, we require a good understanding of the growth and release capabilities of understory trees.

Interest and experimentation with complex stand management in sub-boreal forests was common after WW2 until the advent of widespread clearcutting in the mid- to late- 1960s. We propose to use an old experiment [Experimental Plot 591 (EP 591)], established by Dave Armit in 1962-1963, to investigate current issues in complex stand management. EP 591 was established to study natural, seeded and planted spruce performance in partially-cut lodgepole pine stands with overstory pine densities varying from approximately 400 to 1500 stems/ha. The experiment was established with 10 different treatments consisting of: (1) fall and spring planting of spruce, (2) spruce seeding on scarified and unscarified sites, and (3) no seeding on scarified and unscarified sites on a total of 15 study sites. Today, 10 of the original 15 sites still exist, but within the past two years most of the overstory lodgepole pine have been attacked and killed by MPB.

Today, EP 591 represents a unique research opportunity for answering pressing questions. The BC Forest Service measured the experiment in 1963, 1965, 1967, 1993, and 2003 providing a legacy of data on survival and growth of understory spruce under varying levels of overstory pine densities. The data have not been complied, analyzed, or published. We see four major research opportunities to address current complex stand management questions: (1) Compilation and analyze of the existing data to characterize how planted and seeded understory spruce develop in partially-cut stands, (2) use the existing understory spruce trees (with a known history) to study future survival and release under variable levels of MPB killed overstory, (3) opportunistically select other understory tree species present in the experiment for monitoring of future survival and release, and (4) monitor ingress of natural regeneration after the MPB attack.

The main objectives of this proposal are to: (1) compile and analyze the existing data from EP 591 to characterize the effect of overstory structures on development of planted, seeded, and naturally regenerated spruce and (2) re-measure EP 591 to access how understory trees (spruce, subalpine fir and aspen) release after MPB attack of vaying overstory densities.

We propose an analysis of the existing data and a refocusing of the experiment to examine understory responses to overstory mortality. In the first year of this project, we propose to: (1) compile the existing five experimental re-measurements into a single database, (2) analyze the initial 40 years (1962 - 2003) of experimental data, (3) re-measure the experiment, and (4) establish a set of new permanent experimental sub-plots to monitor ingress of natural regeneration and release of non-spruce species (subalpine fir and trembling aspen). In the second year, we will prepare a journal paper based on the analysis of the 40 years of experimental data. In the third and final year, we propose to re-measure the original plots, re-measure the sub-plots established in the initial year, and analyze the data with regard to understory release. With the measurements from 2003 and the proposed measurements in 2007 and 2009, we will have growth rates from just prior to the MPB attack until 6 years after the attack. This period should be sufficient to observe and quantify the release potential of the understory trees.

The 40-year results, from before to the MPB attack, can be used as guidelines for development and growth of underplanted and naturally regenerated spruce in partially cut stands. We believe that results from a 40-year experiment are unique in the SBS and would be very valuable given the current interest in silvicultural regimes such as variable retention, partial cutting, and underplanting.

The investigation of understory release and ingress of natural regeneration after MPB attack is crucial for predicting the future growth trajectories of MPB stands. Consequently, this study can aid in making strategic decisions related to silvicultural and timber-supply issues in MPB damaged stands and landscapes.

Project Objective:

Current Year Objectives:

(1) To compile the existing data from EP 591.

(2) To re-measure the experiment.

(3) To further our knowledge of planted, seeded and naturally regenerated understory trees in partially cut stands.

Long Term Objectives:

(1) To further our understanding of how different partial cutting strategies influence understory development.

(2) To further our knowledge of understory release after MPB attacks.

(3) To improve our knowledge of different silvicultural systems and their effect on growth and yield.

Experimental Design and Methods:

The initial task of this project is to compile the data from the five existing re-measurements into a single database. In its current form, the data from the initial three measurements (1963, 1965, and 1967) are in a written format but not in an electronic format. The data from the last two re-measurements (1993 and 2003) are in electronic format. We intend to compile the data from all five re-measurements into a single database. We will also create a detailed measurement protocol that outlines all previously measured variables. This measurement protocol, will then

serve as basis for our proposed re-measurements (2007 and 2009) and for all future re-measurements.

The analysis of the existing five re-measurements will focus on: (1) the effect of overstory structure on undersory spruce growth and survival, and (2) the effect of different establishment methods on understory spruce growth and survival. Initially we will investigate these two effects through graphic representation. For each of the 10 establishment treatments, we will produce two and three dimensional graphs of growth and survival against time and overstory stand density. These plot types are likely the best way to effectively and rapidly communicate the findings. For the 40-year results (1962 – 2003), we will use a regression analysis to test for the effects of establishment method and overstory density. Specifically, we will fit a regression model of understory tree size as a function overstory density. The slope of this relationship will illustrate the effect of overstory density on understory spruce growth. In this regression model, 0-1 indicator variables will be included to represent the effect of establishment method. To test for statistical differences between the establishment methods, we will use partial F-tests (Neter et al. 1996).

For our proposed 2007 re-measurement, we will repeat all measures that were taken during the previous five measurements. All previously measured understory spruce are tagged and are easy to identify. The individual tree measurements will include diameter, height, annual height increments, and crown dimensions. We will also take measurement of the overstory structure. We will know exactly which measurements to take from the measurement protocol that we will establish in conjunction with the initial compilation of the five existing re-measurements. Additionally, we will establish (1) 10 new regeneration sub-plots in each of the 10 experimental plots, (2) establish a new 15×15 meter grid of light measurement within each plot, and (3) tag and measure existing understory aspen and subalpine fir (10-20 individuals per species and site). The regeneration sub-plots will be established to follow changes in substrate types and natural regeneration after the MPB attack. Each regeneration plot will be a circular plot with a 3.99 meter radius. In the regeneration plots, we will estimate %-cover of different substrate types according to the methodology of LePage et al. (2000) and measure and tag all existing seedlings and saplings. The 15×15 meter grid of light measurements will provide information on changes in understory light levels after MPB attacks. As each plot is approximately 100×200 meters with a 50 meter buffer, the 15×15 meter grid of light measurements will result in approximately 50 light measurements per plot. To measure light availability, a fisheye photo will be taken at each grid point and the GLI/C software (Frazer et al. 1999) will be used to determine growing season light availability summarized with the GLI light index (Canham 1988). The additional measurement of subalpine fir and aspen understory trees will allows us to track differences in release rates between the species. For these understory trees we will measure height, diameter, crown dimensions, and the past five years of height increment.

For our second proposed re-measurement (2009), we will repeat all measures that were taken in the 2007 re-measurement. This will include a re-measurement of the original experimental plots, the new regeneration sub-plots, newly tagged non-spruce understory trees, and the light grid. Thus, at the end of 2009 we will have data on the following four topics after MPB attack: (1) release of all understory tree species, (2) changes in understory light levels, (3) changes in substrate types, and (4) ingress of natural regeneration. For our 2009 analysis, we will investigate these four

topics but with primary focus on release of understory trees. We will test if there are differences in: (A) release between understory trees that have grown under different overstory densities, (B) if there is a relationship between the change in the understory light environment and the observed understory tree release, (C) if there are differences in release capabilities of the understory spruce based on their life history, and (D) if there are difference in release potential between the different species.

References:

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