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**Key Words:**

assisted migration

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# Quicksheet #27

## Ten-year Performance of Ponderosa Pine and Western Larch Planted North of Natural Ranges

Research Project # 05-03

### Introduction

This study compares growth performance of western larch (*Larix occidentalis*)<sup>1</sup> and ponderosa pine (*Pinus ponderosa*)<sup>2</sup> planted north of their natural ranges among four biogeoclimatic units in the Cariboo region of interior British Columbia. This note summarizes ten growing seasons.

### Study Sites and Methods

The study sites are in the Gavin Lake Block of the Alex Fraser Research Forest as well as near 100 Mile House and 70 Mile House, B.C. Treatments are: Sub-Boreal Spruce dry warm biogeoclimatic subzone in the Horsefly variant (SBSdw1), the Interior Cedar-Hemlock moist cool biogeoclimatic subzone in the Horsefly variant (ICHmk3), Interior Douglas-fir dry cool biogeoclimatic subzone in the Fraser variant (IDFdk3), and Sub-boreal Pine and Spruce moist cool biogeoclimatic subzone (SBPSmk) (Lw only). Sites were planted in May 2005 within two years of clear cutting. Using a completely randomized design, treatment unit locations and species allocations were randomly assigned and replicated three times (except in the IDFdk3 where there were two Lw plots and four Py plots). Assessment plots having 11.28 m radii (0.04 ha) containing an average of 43 trees each were nested within 15.1 m radius (0.072 ha) treatment plots. The same seed lots and stock types were used in all treatment plots. Tree height and root collar diameter were measured and tree condition assessed following the second growing season (see Quicksheet #23<sup>3</sup>) and the fifth growing season (see Quicksheet #25<sup>4</sup>). Tree condition for each tree was assessed as good, fair, poor, moribund, or dead. A tree with "good" condition showed vigorous growth with no obvious form or health issues.

Statistical interpretations of mean annual growth from Years 5-10, and Year 10 height and root collar diameter used one-way analyses of variance with 95% confidence intervals ( $\alpha = 0.05$ ). Tukey's HSD test was then used to compare those values between the biogeoclimatic units for each species (R software V3.1)

### Results

#### Ponderosa Pine

Cumulative mortality since Year 5 increased slightly in the ICHmk3 (18% to 19%), the IDFdk3 (9% to 13%) and SBSdw1 (8% to 11%) (Figure 1). Between Year 5 and Year 10 the percent of pine ranked as "good" condition decreased in the ICHmk3 (61% to 46%) and IDFdk3 (75% to 57%) while it remained at 35% in the SBSdw1. At all locations, terminal damage resulting in multiple

1 Lw Seed Lot #60748 Lw 1-0 PSB 313B seedlings, elevation 950 m, source Kalamalka Research Station orchard, Vernon, B.C.

2 Py Seed Lot #45260 Py 1-0 PSB 410A seedlings, elevation 900 m, source SW of Kamloops, B.C.

3 Koot, C. 2007. Performance of ponderosa pine and western larch planted north of natural ranges. Quicksheet #23. UBC/Alex Fraser Research Forest.

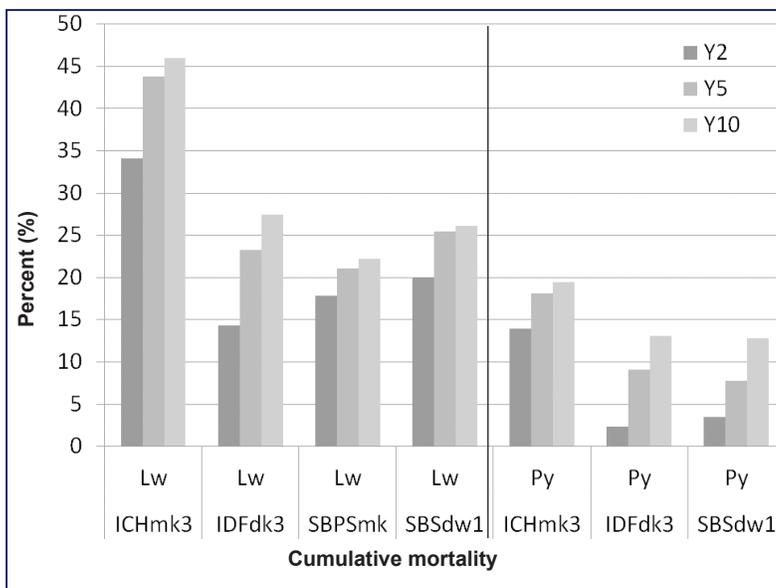
4 Koot, C. 2009. Five-year performance of ponderosa pine and western larch planted north of natural ranges. Quicksheet #25. UBC/Alex Fraser Research Forest.

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leaders, crooks and forks, and chorosis due to unknown causes were observed in the specimens that ranked less than "good". Browsing by hares on lower branches and brush competition continues in the SBSdw1.

Significant differences were observed between the mean Year 10 heights for Py in the ICHmk3 (2.1 m), IDFdk3 (1.3 m), and SBSdw1 (1.8 m) (Figure 2A). Height growth rates since Year 5 were all significantly different with the ICHmk3 continuing to exhibit the greatest rate among the zones (0.28 m/year), followed by the SBSdw1 (0.21 m/year) and IDFdk3 (0.17 m/year) (Figure 3A).

The mean Year 10 root collar diameter in the ICHmk3 (6.7 cm) was significantly greater than that in the IDFdk3 (4.4 cm) and the SBSdw1 (4.2 cm) (Figure 2B). There was no difference between the IDFdk3 and SBSdw1. Significant differences were observed between the root collar diameter growth rate in the ICHmk3 (0.9 cm/year), SBSdw1 (0.5 cm/year), and IDFdk3 (0.6 cm/year) (Figure 3B).



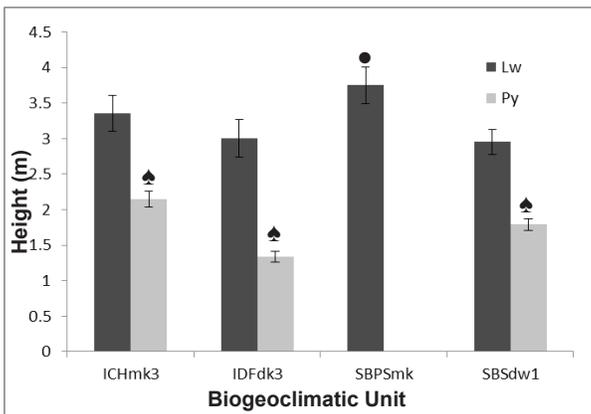
**Figure 1:** Cumulative mortality by species (ponderosa pine, Py, and western larch, Lw) and biogeoclimatic unit through Year 10

### Western Larch

The cumulative mortality at each site stayed relatively similar between Year 5 and Year 10 with the IDFdk3 showing the greatest increase from 23% to 27%. There was a 2% increase in mortality in the ICHmk3 to 46%, and a 1% increase in the SBPSmk, and SBSdw1 to 22% and 24% respectively. From Years 5 to 10 the percentage of larch whose condition ranked as "good" decreased in the ICHmk3 from 29% to 25% and increased in the IDFdk3 (43% to 52%), SBPSmk (33% to 56%), and SBSdw1 (37% to 45%). In the specimens that ranked less than "good", terminal damage resulting in multiple leaders, crooks and forks due to unknown causes were observed at all locations.

The mean Year 10 heights in the SBPSmk (3.8 m) were significantly greater than heights in the IDFdk3 (3.0 m) and the SBSdw1 (2.9 m) and similar to that in the ICHmk3 (3.4 m) (Figure 1A). The Lw in the SBPSmk has been growing at a significantly greater height growth rate than in any other biogeoclimatic unit since Year 5 (0.6 cm/year) (Figure 2A). Although the height growth rate in the ICHmk3 was higher than that in other units during the first five years (see Quicksheet #25), there were no significant differences between it and those in the IDFdk3 and SBSdw1 during the period from Year 5 to Year 10 (0.4 cm/year).

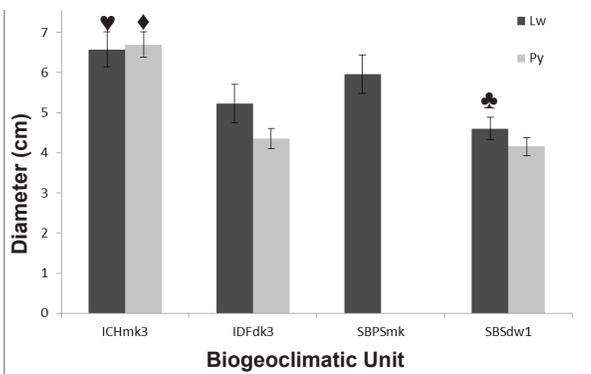
The mean Year 10 root collar diameter in the ICHmk3 (6.6 cm) was significantly greater than that in the IDFdk3 (5.2 cm) and SBSdw1 (4.6 cm) but similar to the SBPSmk (6.0 cm) (Figure 2B). The periodic mean annual root collar diameter growth was statistically similar between the ICHmk3 (0.8 cm/year), IDFdk3 (0.7 cm/year) and SBPSmk (0.9 cm/year). The diameter growth rate in the SBSdw1 (0.6 cm/year) was significantly slower (Figure 2B).



● Lw: Height in the SBPSmk is significantly greater than the IDFdk3 and SBSdw1 but not the ICHmk3.

Lw: No significant differences between the ICHmk3, IDFdk3, and SBSdw1.

▲ Py: All heights are significantly different from each other.



♣ Lw: Diameter in the SBSdw1 is significantly less than in the SBPSmk and ICHmk3 but not IDFdk3.

♥ Lw: Diameter in the ICHmk3 is significantly greater than that in the IDFdk3 and SBSdw1 but not the SBPSmk.

Lw: No significant differences between the IDFdk3 and SBPSmk

♦ Py: Diameter in the ICHmk3 is significantly greater than IDFdk3 and SBSdw1.

**Figure 2:** A) Mean Year 10 height and B) Mean Year 10 root collar diameter of ponderosa pine (Py) and western larch (Lw) planted in different biogeoclimatic units. Bars represent 95% confidence intervals.

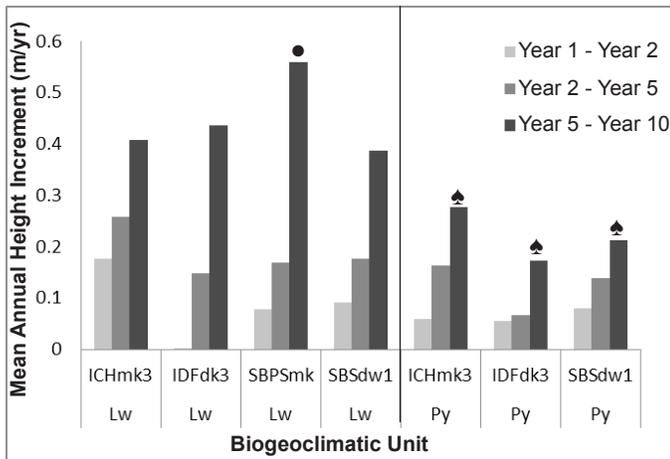
## Discussion and Conclusions

Though mortality continued to occur between Years 5 and 10 (up to 4% by species), the first five years following planting appear to be the most critical for survival in the western larch and ponderosa pine planted in this study. Since time of planting, pine suffered the least cumulative mortality with all sites below 20% while that for larch ranged from 22% - 46%. During the early years, growing season frost was the suspected cause of much of the mortality and the forking observed among both species, especially the larch (see Quicksheet 25). Terminal damage due to unknown causes and resulting in multiple leaders, forking and crooks is still occurring in both species in all units. Damage is occurring less frequently in larch in the IDFdk3, SBPSmk and SBSdw1 since Year 5 with the overall improved condition (i.e. form and vigour), while damage has increased among pine in all units and larch in the ICHmk3.

The best individual tree growth performance for the planted population of ponderosa pine continues to occur in the ICHmk3 (Figure 4A). Mortality there was highest among biogeoclimatic units, though most of the pine alive in Year 5 were still alive as of Year 10. The occurrence of condition rankings of “good” decreased considerably in both the ICHmk3 and IDFdk3 and stayed stable but at low ranking in the SBSdw1. While the pine in the IDFdk3 remain the shortest among the biogeoclimatic units, they share similar diameters and a greater diameter growth rate to those in the SBSdw1. The SBSdw1 has the most brush competition of the zones and this may have contributed to the continued slender form and unexceptional condition quality commonly observed there (Figure 4B).

For western larch, the best individual tree growth performance is now in both the ICHmk3 and SBPSmk. During the first five years in the ICHmk3, however, almost half the population was lost to mortality as compared to 22% - 27% elsewhere. Given this high initial mortality and declining condition since Year 5, the total larch volume found in the other zones may

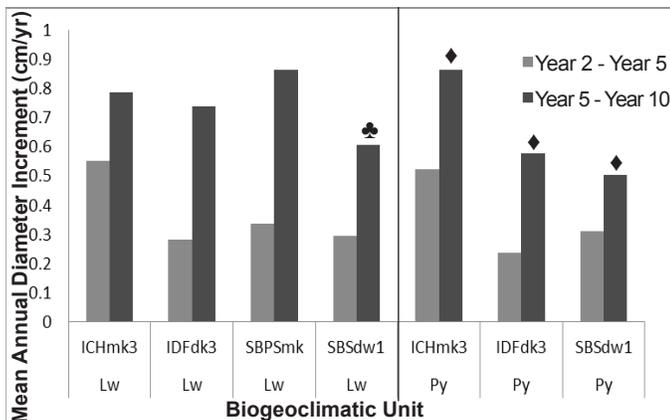
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• Lw: SBPSmk height growth is significantly greater than that in other biogeoclimatic units.

Lw: No significant differences between ICHmk3, IDFdk3, and SBSdw1.

♣ Py: Height growth rates are all significantly different from each other.



♣ Lw: SBSdw1 diameter growth rate is significantly less than the other biogeoclimatic units.

Lw: No significant difference between ICHmk3, IDFdk3, and SBPSmk.

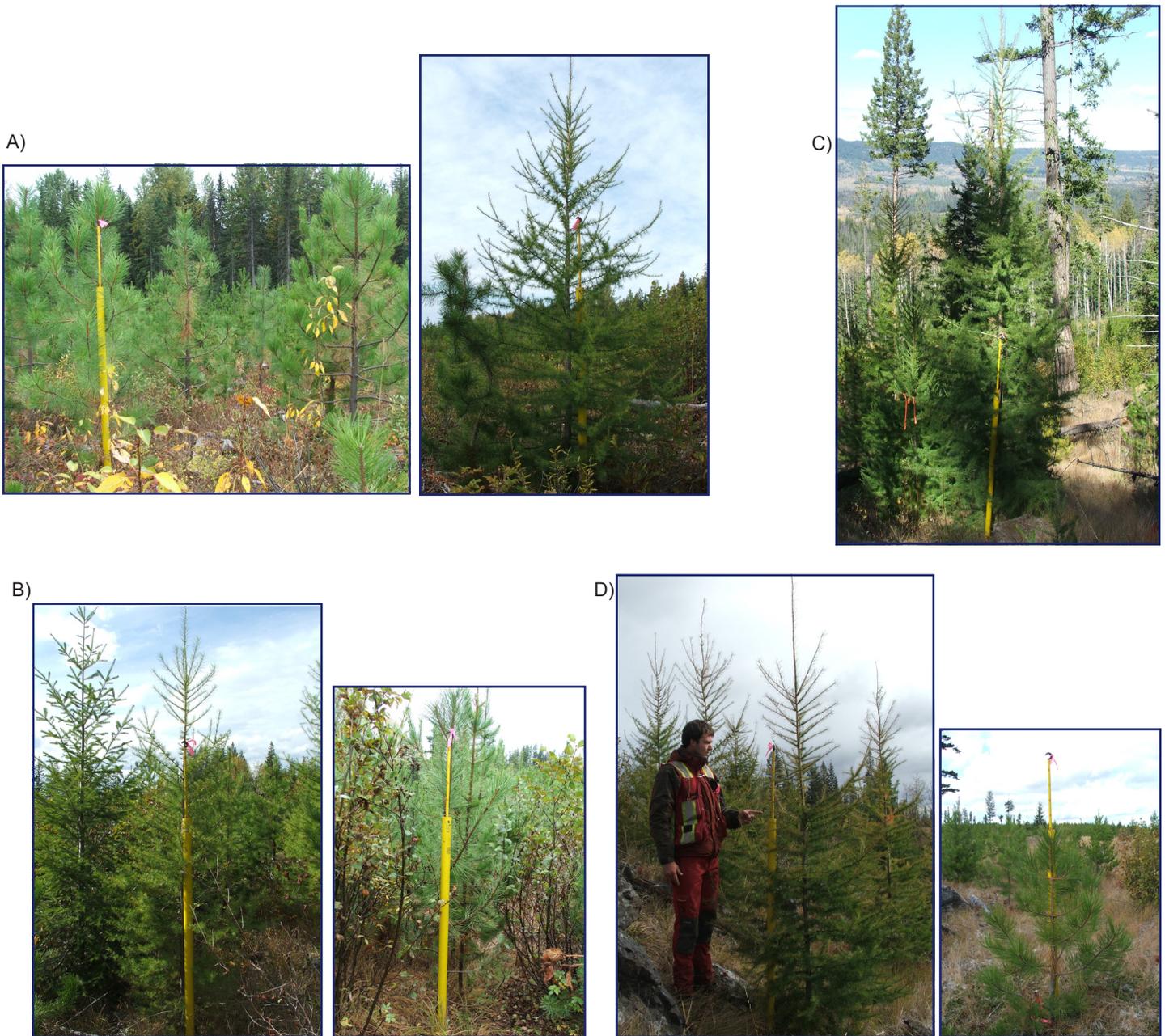
♦ Py: All diameter growth rates are significantly different from each other.

**Figure 3:** A) Mean annual height growth rate and B) Mean annual root collar diameter growth rate of ponderosa pine (Py) and Western Larch (Lw) during the period from Year 5 to Year 10, planted in different biogeoclimatic units.

outstrip that in the ICHmk3. Larch growth and survival in the SBPSmk since Year 5 has been excellent (Figure 4C). The condition ranking of “good” increased substantially in this unit and its mean height and mean annual height growth was by far the greatest. Also notable is that the height growth rate for larch in the IDFdk3 has caught up to that in the ICHmk3 and SBSdw1 and is on par with the top diameter growth rate in the ICHmk3 and SBPSmk. The larch in the IDFdk3 that have survived to Year 10 are performing very well and display a markedly improved condition over the first five years (Figure 4D). Larch in the SBSdw1 are slender in form, likely due to brush competition, yet still showed improvement in condition since Year 5 (Figure 4B).

## Acknowledgements

Cathy Koot, RPBio, with interns Karen McCloskey, Steffen Schemman and Alexander Coenen collected the data. K. McCloskey and C. Koot conducted analyses and prepared this report.



**Figure 4:** In all photos a two meter pole was used for scale. A) Good Py and Lw in ICHmk3; B) Good Lw and fair Py with alder competition in SBSdw1; C) Lw in SBPSmk showing excellent height growth D) Good Lw and Py in IDFdk3.