

Effects of pre-commercial thinning on the growth and yield of reforested lodgepole pine stands

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Introduction

The Regenerated Lodgepole Pine (RLP) trial was designed to assess the effects of planting, weeding, and pre-commercial thinning (PCT) on stand development following harvesting and planting of lodgepole pine. It consists of 102 whole-plots (“installations”) planted at 6 different target planting densities: 0, 816, 1111, 1600, 2500 and 4444 stems per ha. Each installation is divided into 4 sub-plots (“treatment plots”): control (C), weed (W), thin (T), and weed plus thin (WT). We thinned the C and WT plots at stand ages between 11 and 15 years (average 13 years), when crowns were approaching closure and the average height of pine was 3 - 5m. In planted installations we thinned to the target planting densities of lodgepole pine, removing excess natural regeneration of both hardwoods and softwoods. In the non-planted “0” density installations the target retention of pine was 4444 trees per ha (average spacing 1.5m). The retained trees were, to the extent possible, well-spaced, healthy, co-dominant or dominant lodgepole pine with good form and vigour and no serious disease or damage. All hardwoods and shrubs over 30cm in height were cut down.



Photo courtesy of Blue Ridge Lumber.

In order to estimate the effect of PCT on mean annual increment (MAI), we used GYPSY, a growth and yield model developed and approved by the Alberta government, to project merchantable MAI (15/10cm utilization standard) to culmination age from top height, age, density, percent stocking and basal area of pine and hardwoods (trembling aspen and black poplar). We obtained these inputs by measuring the RLP trial 17 years after planting, at an average stand age of 18 years since cut and about 5 years after thinning.

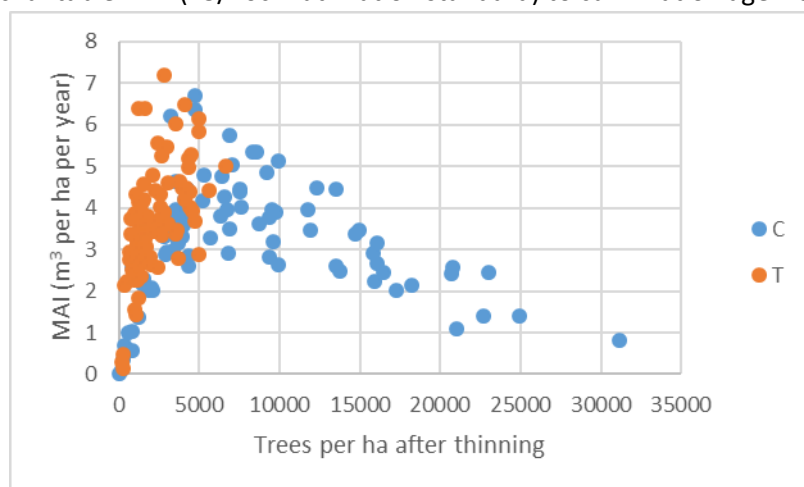


Figure 1. Projected MAI's for thinned (T) and control (C) plots.

Results

Figure 1 shows merchantable MAI of lodgepole pine projected to culmination age for thinned and control treatment plots, in relation to pine density (trees per ha ≥ 1.3 m in height) at the age of projection. MAI increases with density between 0 and 5000 trees per ha (logarithmic trend $R^2 = 0.44$),



shows no statistically significant trend between 5000 and 10,000 trees per ha, and thereafter decreases with increasing density (negative exponential trend $R^2 = 0.73$).

When evaluating the potential effects of PCT we took into account whether plots were weeded during the establishment phase. Figure 2 shows projected merchantable MAI of lodgepole pine (“MAI_PL”) by weeding and thinning treatments, averaged across all planting densities. In installations where pine densities (planted stock and natural regeneration combined) exceeded 10,000 stems per ha in control plots at 18 years, weeding has no significant effect, and PCT increases merchantable MAI by 38%, from an average of 2.68m³/ha/year for the C and W

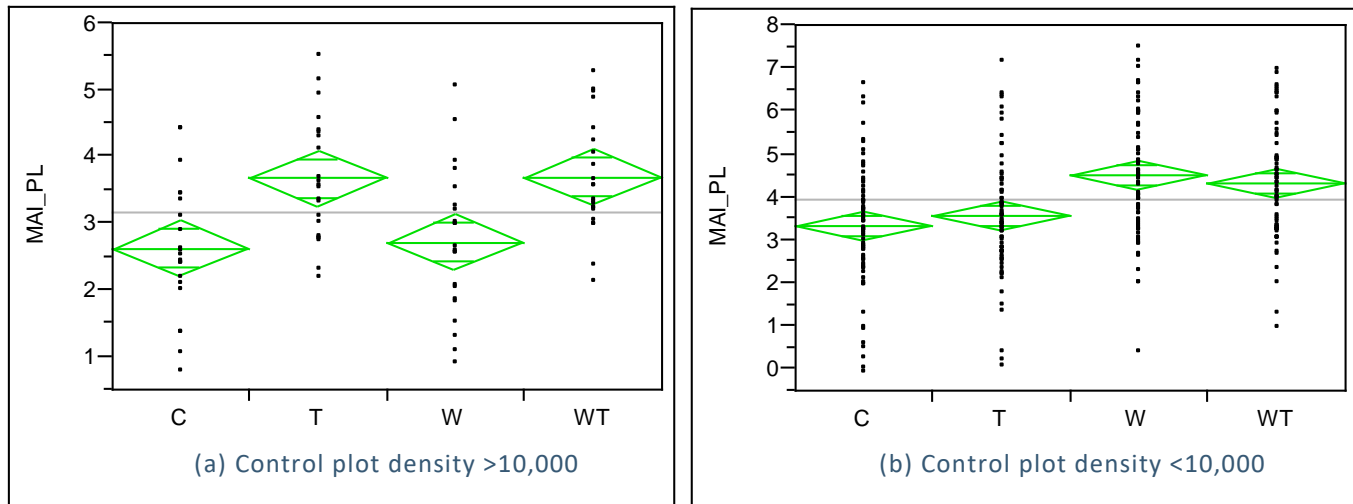


Figure 2. Variation in MAI with weeding and thinning, in (a) high and (b) lower density installations. The black dots indicate individual sample plots and the grey horizontal lines show the overall sample mean. The green horizontal line across the middle of each diamond illustrates the treatment class mean. The diamond’s vertical span represents its 95% confidence interval. The short lines above and below the mean are overlap marks. Overlapping marks between any two diamonds indicate that the two means are not significantly different.

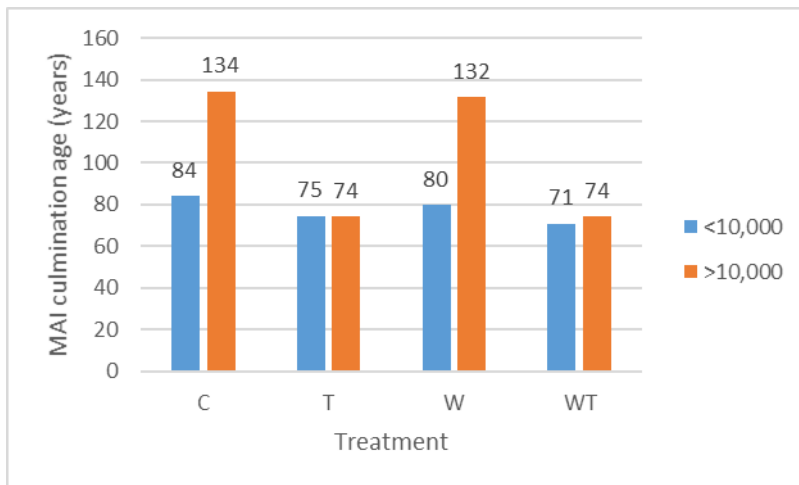


Figure 3. Effect of weeding and thinning on projected culmination age of mean annual increment in high (>10,000) and lower (<10,000) density installations. Average ages in the non-thinned plots of high-density installations are significantly higher than in other treatment combinations.

treatments to 3.69 for the T and WT treatments. PCT does not significantly affect average MAI at lower densities (Figure 2b).

PCT dramatically reduces the age of MAI culmination in high density installations, but again has much less effect at lower densities (see Figure 3).

The effect of thinning on reducing hardwood competition is influenced by whether the plot has been previously weeded, as shown in Figure 4. Density of hardwoods $\geq 1.3m$ in height (“Den_AW”) in installations with more than 1000 hardwood trees at age 18 years and 5 years after thinning, is significantly reduced by weeding and thinning. However, thinning on its own has less effect than chemical weeding (W), or weeding plus thinning (WT). Note in Figure 4



that hardwood densities in the thin-only treatment (T) are more variable and on average significantly higher than those in the weeded treatments (W and WT). This may result from suckering being stimulated by manual thinning with no previous chemical weeding.

As previously described, MAI decreases as stand densities decrease below 5000 trees per ha (see Figure 1). This is supported by Figure 5, which shows the relationship between lodgepole pine merchantable MAI and “planting” density classes in thinned (T and WT) plots. Recall that these plots were thinned back to the target planting densities shown in the figure, with the exception of the “0” (non-planted) class which was thinned to 4444 trees per ha where permitted by sufficient natural regeneration of pine. The highest mean MAI is obtained where densities were planted and maintained at 4444 trees per ha.

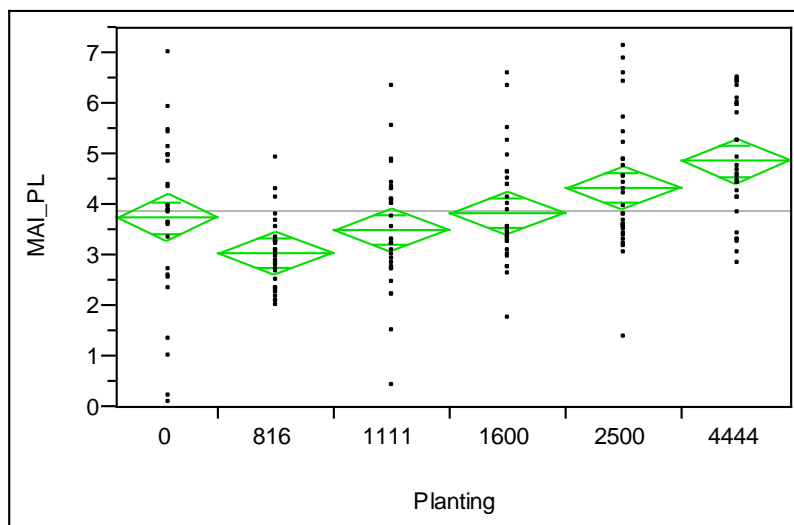


Figure 5. Effect of thinning to target densities on merchantable MAI of lodgepole pine projected to culmination age (MAI_PL). See Figure 2 and text for explanation of symbols.

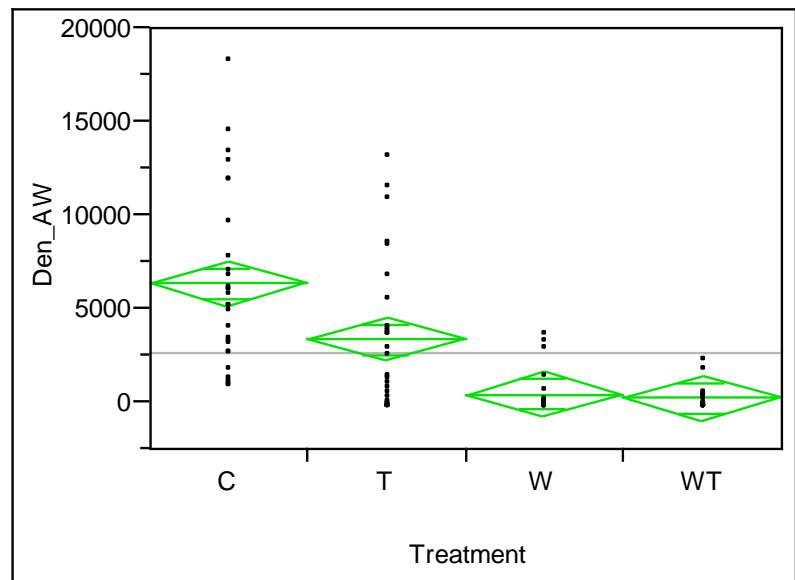


Figure 4. Effect of weeding and thinning treatments on juvenile hardwood density. See Figure 2 for explanation of symbols.

The lowest average MAI occurs at the 816 target density. It is significantly lower than that in the “0” density class.

Conclusions

MAI of lodgepole pine at the 15/10cm utilization standard appears to be maximized at juvenile stand densities of about 5000 trees per ha. PCT to below 2500 - 4444 trees per ha may reduce yields. In pine stands with densities exceeding 10,000 trees per ha, it increases average projected merchantable MAI by about 38%, and prior weeding is generally ineffective or unnecessary. At low densities thinning confers no additional growth increase to that achieved by earlier weeding. PCT is less effective on its own in reducing hardwood competition than when combined with or replaced by earlier weeding. It is potentially effective in reducing rotations in high density stands.

Caution: Long-term projections by GYPSY have not been, and currently cannot be, validated across the full range of stand conditions created by the experimental treatments of the RLP trial. This will ultimately be achievable by continued monitoring of the trial to rotation age.