Foothills Growth and Yield Association
Quicknote 10

April 2008 *By: Sharon Meredith*

Effects of Juvenile Spacing on Lodgepole Pine Stand Height

Background

The Gregg Burn experimental spacing trial is located approximately 40 km south of Hinton, Alberta in an area that regenerated naturally to pure lodgepole pine after wildfire in 1956. The trial was established and spaced by the Canadian Forest Service 7 years after the fire to examine how stand development is affected by spacing and to develop site-specific density management guidelines for juvenile stands.

Plots were established on 3 sites classified as high, medium and low productivity. Two replicates of each of 5 spacing treatments were established on each site in a semi-randomized complete block design. Plots were designed to contain 100 trees. As a result, plot sizes varied depending on the target density (Table 1). Control plots were established on the low and high productivity sites in 1996 and on the medium productivity site in 2004.

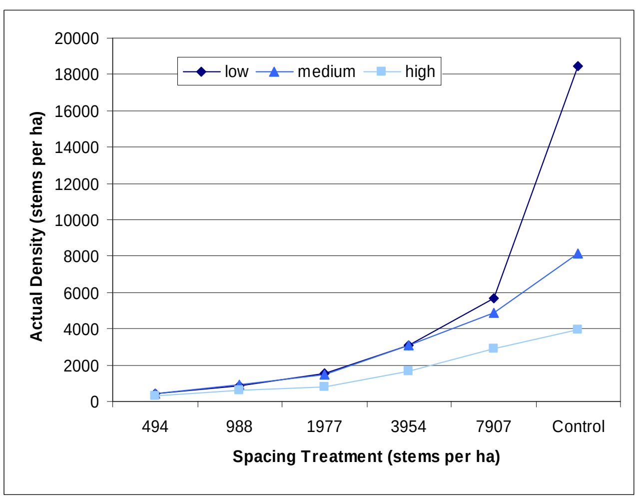
Table 1. Plot sizes (area of each plot in m²)

Site	Rep	Spacing Treatment					
		494	988	1977	3954	7907	control
Low	1	2002	992	495	256	121	35
	2	2048	977	529	264	132	49
Medium	1	2025	992	506	225	100	100
	2	2025	992	506	225	121	100
High	1	2025	1024	484	256	121	121
	2	1936	992	518	256	121	285

Methods

The most recent complete measurements, taken in 2006 by the Foothills Growth and Yield Association (FGYA) 50 years following the stand's fire origin, were the basis for this analysis. Trends in densities measured in 2006 are shown by site and spacing treatment (Figure 1).

Figure 1. Stand density by site and treatment



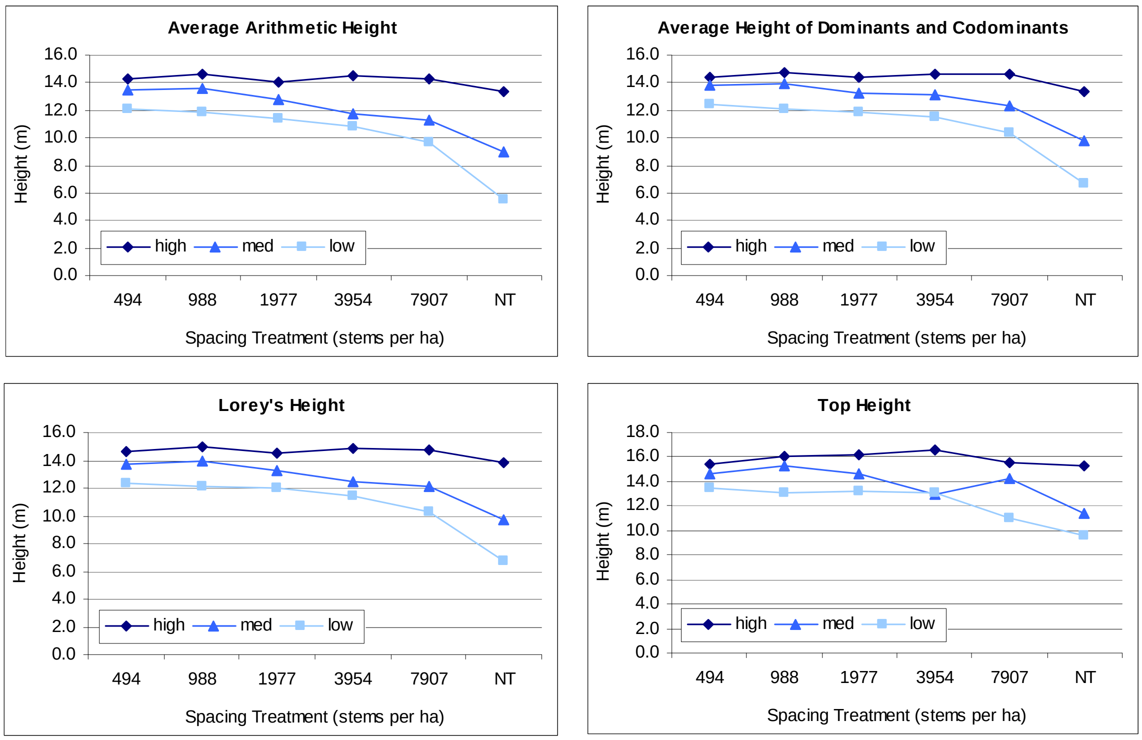
The small plot sizes at high densities (see Table 1) resulted in only one tree being sampled per plot for top height (average height of the 100 largest-diameter trees per ha) in the controls and the 7907 spacing treatment. The 2 low-site control plots (less than 100m²) were revisited in 2008 to obtain a confirmed top height tree observation. For this purpose the largest diameter tree (free of top damage) within a 5.64m radius of the plot centre was identified and measured. In both plots, the selected top height tree was a tree tagged as part of the original control plot, and the 2006 measurements were used.

Arithmetic average height, average height of dominants and co-dominants, top height and Lorey's height (average height weighted by basal area) were calculated for live lodgepole pine trees on each plot. One-way analyses of variance were conducted for all sites, and for each site independently, to explore the effect of spacing on each height variable. Two-way analyses of variance were run to assess the effects of, and interaction between, treatment and site.

Results

Arithmetic average height, average height of dominants and co-dominants and Lorey's height showed a decreasing trend as density increased on the medium and low sites. Top height showed a similar trend on the low site, but the trend was less clear on the medium site (Figure 2). On the high site, heights were similar across all spacing treatments.

Figure 2. Arithmetic average height, average height of dominants and co-dominants, Lorey's height and top height by site and spacing treatment



Both site and treatment had statistically significant effects on all the height variables. There were also significant interactions between site and treatment except for top height. The effect of treatment was strongest for the low sites with significant differences between treatment and control ("NT" in Figure 2) for all height variables and all treatments, except top height in the 7907 trees per hectare spacing (Table 2). No significant differences existed between treated and control plots on the high site. On the medium site, significant differences between control and spacing treatments were observed for all height variables except top height. True top height trends may have been masked by the small sample size on higher density plots.

Table 2. Significant differences (p<=.05) compared to controls were found for the sites, spacing and height variables indicated

Site	Spacing Treatment	Height Variable			
		Average	DC	Top	Lorey's
Low	494	y	y	y	y
	988	y	y	y	y
	1977	y	y	y	y
	3954	y	y	y	y
	7907	y	y		y
Medium	494	y	y		y
	988	y	y		y
	1977	y	y		y
	3954	y	y		y
	7907	y	y		y
High	494				
	988				
	1977				
	3954				
	7907				

For more information on this or other FGYA Quicknotes, please contact: Robert Udell, Udell Consulting, Tel.: (780) 865 – 4532, Email: udellconsulting@shaw.ca, or visit www.foothillsresearchinstitute.ca.

Discussion

Previous studies by the FGYA and others have indicated that pine stands regenerated after harvesting show superior height development and site indices to their fire-origin predecessors, especially on "poor" sites (e.g. Quicknote #3). These studies were primarily based on "paired-plot" comparisons between post-harvest regeneration and adjacent old fire-origin stands. Although it was postulated that the observed differences could be attributable to managed stands being less dense, more evenly stocked, and less prone to density-induced height repression, causes for the differences could not be determined from the paired-plot studies. The compared stands had not grown at the same times and locations, and the juvenile densities and other early conditions of the fire-origin stands were not known or controlled. Furthermore, most of the post-harvest regeneration was still young, and it was not known whether the early height trajectories would be maintained to ages when height is normally indexed (typically 50 years total or breast-height age).

The Gregg trial has provided an opportunity to compare height, at or approaching site index age, in plots all grown at the same time under a controlled and replicated range of sites and juvenile spacing treatments. Caution is still required in interpreting results relative to expectations for post-harvest regeneration. For example, it is not known what, if any, was the selective effect of removing a portion of the fire-origin trees at 7 years, relative to managing a post-harvest stand with initially fewer trees. However, the observed trends were not confined to average height, but were also observed in several measures of dominant height well into the growth phase of the stand. It is therefore unlikely that they are simply a result of "thinning lift".

The analytical results show remarkable parallels to those from the earlier paired-plot comparisons between post-harvest and fire-origin stands. Variation in height attributable to site was less in the wider-spaced plots than in those more closely spaced, and especially than in portions of the stand left at natural densities. Height development was little influenced by spacing on good sites, but significantly increased on poorer sites. The primary cause of the observed height growth responses is most likely a reduction in density-induced repression.

Our findings also support previous suggestions by researchers in Alberta and B.C. that:

- Regeneration practices following harvesting that moderate densities while maintaining or improving site occupancy are likely to increase fibre production relative to that of untreated fire-origin stands;
- The main opportunities for spacing or pre-commercial thinning of lodgepole pine are on poorer sites where stands tend to demonstrate both higher densities of natural regeneration and less ability to release from the resulting height repression;
- On better sites, where these risks are lower, spacing may be ineffective or counter productive, and management should place more emphasis on ensuring full site occupancy and control of inter-specific competition.

The FGYA in cooperation with other researchers is utilizing historic research experiments such as the Gregg trial to test and apply predictive models which will enable us to more fully quantify the observed effects on growth and yield, and their implications for forest management.

If you have comments or questions regarding this note, or would like more information, please contact:

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