Foothills Growth and Yield Association
Quicknote 12

December 2008 ***By: Dick Dempster***

Effects of Climate on Mortality of Young Planted Lodgepole Pine
December 2008

Background and Methods

FGYA members make heavy investments in forest regeneration and are exposed to silvicultural risks and losses in the short-term, as well as longer-term threats from climate change. Climate and its interaction with other forest influences are implicated in the risks and losses incurred already, but not well understood. Understanding of these relationships will not only assist managers in the short term, but potentially provide important insights on longer term implications of climate change.

Exploratory analyses of the relationship between climate and mortality of regeneration were initiated using observations from the FGYA regenerated lodgepole pine trial. Correlations were explored between cumulative mortality after 5 growing seasons and average climate conditions during the period 2001-2006. (The trial was planted between 2000 and 2002.) ClimateAB[1] was used to extract annual and seasonal climate data variables for each of the 85 planted experimental sites. The mortality data were not filtered or refined in any way to remove outliers, to separate years, or to separate apparent causes of mortality.

Preliminary Results

Table 1 shows r-values extracted from a larger correlation matrix for the relationships between transformed[2] mortality percent and selected climate variables: mean summer precipitation (MSP), mean annual temperature (MAT), and average seasonal temperatures (TAV) for spring (sp), summer (sm) and autumn (at). Correlations are shown for each of the 5 ecological strata ("eco-classes") recognized in the FGYA trial design. Note that:

- The best correlations were found with annual or seasonal average temperature. Temperature explained 25 -74 % of all mortality variation (including that between planting densities and vegetation management treatments) within eco-class groups.
- The relationship was more pronounced on richer sites (e.g. eco-class 4).
- The direction of trends differed by eco-class. On Labrador tea sites (classes 2 and 5) mortality decreased significantly with increasing temperature. On all other sites (classes 1,3,4) mortality increased significantly with increasing temperature.

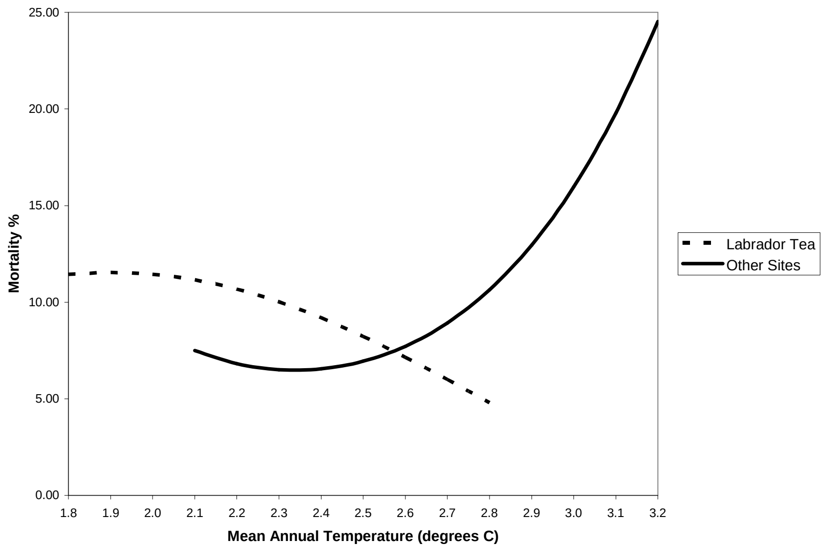
Table 1. Correlation (r-values) between mortality % and annual and seasonal climate variables

Eco-class (moisture / nutrient status)		MSP	MAT	TAV_sp	TAV_sm	TAV_at
1	submesic – subxeric / medium - low	0.40	0.50	0.51	0.49	0.47
2	mesic / poor	0.51	-0.52	-0.53	-0.61	-0.61
3	mesic / medium	-0.02	0.58	0.53	0.41	0.61
4	subhygric / rich	-0.76	0.86	0.80	0.83	0.84
5	hygric / poor	0.47	-0.57	-0.57	-0.51	-0.54

[1] A program developed by Dr. Andreas Hammann of the University of Alberta integrating climate normals, historical data and GCM predictions for genecology and climate change studies in Alberta.
[2] Arc sine transformation was used to normalize the statistical distribution of mortality percent.

On poorer sites (classes 1,2,5) mortality increased significantly with precipitation, while on rich sites (class 4) mortality decreased significantly with increasing precipitation. On medium sites (class 3) there was no significant correlation between mortality and precipitation. Addition of precipitation to the regression of mortality on temperature did not significantly improve prediction. Temperature and precipitation were significantly correlated on some sites, but not on others (positively in class 1, non-significantly in class 3, and negatively on classes 2, 4 and 5). This could explain the apparent precipitation effect.

Figure 1. Trends of mortality with temperature



Interpretation

The nature and cause of the apparent climatic effects are far from clear. Assessment of tree health and recently-dead trees, both in the FGYA and earlier studies, suggests that direct causes of mortality are frequently biotic e.g. root disease, root collar weevils and rusts. Climate effects on mortality may be both direct (e.g. summer drought, winter desiccation) and indirect (i.e. resulting from climate affecting pathogen dynamics or pre-disposing trees to pathogens). The difference in trends between Labrador tea and other sites (see Figure 1) may reflect the colder organic soils associated with Labrador tea.

One possible explanation for the observed relationships is that they simply reflect faster stand development and onset of self thinning on better and warmer sites. This warrants further attention, but was not supported by preliminary investigation. Apart from the fact that most of the plots at 5 years were not showing much indication of crown competition, there was no indication that mortality was positively linked to stand height. In fact a weak but statistically significant negative relationship was observed between mortality and 5-year average height.

The absolute range in average temperatures across the 85 sites was quite small (1.5 degrees annual, 3 degrees summer). Note in Figure 1 that small differences in temperature are associated with large changes in mortality especially on the better sites at higher temperatures. Interpretation of the preliminary results is speculative. However, the possible implication of 20% mortality in out-planted stock resulting from less than 1 degree increase in average temperature would seem to suggest that further work is indeed merited! The implied sensitivity of the regeneration phase of stand development to climate effects may overshadow or make irrelevant predictions of growth and yield at later stages of the rotation.

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