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Extension Note 1

Implications of Alternate Silvicultural Strategies in Mountain Pine Beetle Damaged Stands

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Prepared:
May, 2005

Introduction

In this extension note, we describe a stand growth model developed to predict impacts of silviculture strategies – from full salvage and planting through no treatment – on mountain pine beetle (MPB) attacked stands. We report results of model simulations of understory light environments, natural regeneration survival, and effects of underplanting and delaying planting, and we compare these results with results from use of the traditional growth and yield model TASS (Tree and Stand Simulator).

Development of the Snag Submodel

We developed a snag submodel for SORTIE-ND. SORTIE-ND is a version of the spatially explicit, individual tree model SORTIE (Pacala et al. 1996; Coates et al. 2003). SORTIE-ND extrapolates from fine-scale and short-term interactions among individual trees to large-scale and long-term dynamics of forest communities.

The development of a snag submodel for SORTIE-ND first required definition of snag decay classes. We characterized three:

Class 1: Newly dead tree, where the shape of the crown is clearly defined by fine branches or twigs remaining on larger branches.
Class 2: Most fine branches are lost; the crown shape is less well defined but can be interpreted from larger branches.
Class 3: Only sparse large diameter branches remain.

Second, light transmission values for each snag class were needed. We used methods detailed in Canham et al. (1999).

Third, to incorporate snag fall down rates, we developed a model that uses available data, local knowledge and our own understanding of snag mortality rates (see sidebar, p. 2).

We selected four stands from the SBSdk subzone to represent MPB susceptible stand types in North Central BC:

Pine Minor Spruce: A mature lodgepole pine stand on a mesic site consisting of 83% pine and 17% spruce (by basal area), with a well-developed cohort of immature spruce.

Snag Fall Down Rates

We developed a Weibull equation to model snag fall down rate from data provided in Keen (1955):

S = *EXP(-(a*T)^b)*

where S = probability of snag survival, T=time since death, a is a scale and b a shape parameter of the Weibull function. We used the 'cumulative density function' for year x and subtracted from it the 'cumulative density function' from the previous year to give us a probability of fall for individual snags.

*Yearly probability of fall = (1-EXP(-((a*year x)^b))) - (1-EXP(-((a*year x-1)^b)))*

Note that for the end of year 1, the Weibull function is calculated once,without subtraction, i.e.:

*Prob. of fall after 1 year = (1-EXP(-((a*1)^b))).*

Mixed Pine – Spruce: A stand consisting of 57% pine and 43% spruce (by basal area), with a well-developed spruce understory.
Spruce Minor Pine: A diverse type with mature spruce (83% of the basal area), a minor component of pine, immature spruce and spruce veterans.
Pine Dominant: A pure lodgepole pine type from an SBSdk 03 site, chosen to represent pine out-wash sites.

To mimic severe mountain pine beetle damage, we assumed 100% kill of the larger pine trees in each stand type and 90% kill of the smaller pine trees.

Prediction of Understory Light Environments in MPB-damaged stands

Incorporating the snag submodel with the above assumptions into SORTIE-ND results in effective modeling of changes in light environments as snags deteriorate over time (Fig. 1).

Understory light levels in MPB killed stands remain low for up to 10-15 years. This is a very different regeneration environment than found after wildfire.

Natural Regeneration of Lodgepole Pine under MPB-damaged stands

To test the survival of natural regeneration of lodgepole pine under a beetle attacked canopy, we designed two simulations:

1) Survival of 10,000 stems/ha of pine seedlings established 1 year after a severe beetle attack in the *Pine Dominant* stand type.
2) Survival of 10 000 stems/ha of pine seedlings established 10 years after a severe beetle attack in the *Pine Dominant* stand type.

For both scenarios we modeled stand development for 20 years.

Simulation results: All 10,000 stems/ha of lodgepole pine seedlings established 1 year after beetle attack died within thirteen years. Only about 300 stems/ha of the seedlings established 10 years after beetle attack survived another ten years. These results confirm that the light environment under snags following MPB attack is extremely limiting for survival of pine seedlings. In addition, the light environment continues to remain highly limiting 10 to 20 years post-MPB attack.

Comparison of SORTIE-ND results with TASS

TASS has been developed to model single species, even-aged stands and is widely accepted across British Columbia. SORTIE-ND has been designed to model complex structured stands. To compare the predictions of SORTIE-ND with TASS we simulated the growth of stands of lodgepole pine, interior spruce, and subalpine fir planted at densities of 1600 stems/ha, grown without an overstory. We used Tipsy version 3.2 for the interpolation of yield tables from TASS and assumed mesic sites in the Lakes TSA (Timber Supply Area).

Results showed that, in general, SORTIE-ND and TASS predicted very similar growth rates in single-species plantations.

Development of stand types after mountain pine beetle attack

Using SORTIE-ND we simulated the development over 100 years of the four major MPB susceptible stand types, following attack, assuming no management intervention (Table 1).

At 50 years after attack, basal area of two of the three types with residual spruce, the *Mixed Pine-Spruce* and *Spruce Minor Pine* stands, had exceeded that of the pre-attack types. By about 80 years after attack the *Pine Minor Spruce* type had recovered to pre-attack basal areas.

The *Pine Dominant* type with little spruce residual component was unable to recover after MPB attack.

These results show the importance of priorizing stands with a low spruce component for salvage, as they will not likely recover without management intervention.

If stands with a substantial spruce component are salvaged it will be important to protect the residual spruce so these stands will become merchantable as early as possible. Stands with structure similar to the *Spruce Minor Pine* and *Mixed Pine-Spruce* types can play a critical role in reducing the expected mid-term (30-50 years) timber supply shortage when left unsalvaged or when the spruce are protected from damage during salvage.

Under-planting unsalvaged stand types after MPB attack

We simulated under-planting the four major MPB susceptible stand types with interior spruce and subalpine fir, one year after attack. Planting soon after attack mimicked conventional planting strategies including minimising risk to tree planters of planting under snags.

Pine Minor Spruce: An improved yield resulted when under-planted with both species, likely due to the low initial stocking of immature spruce.

Mixed Pine – Spruce: This type did not show a significant change in yield.

Spruce Minor Pine: A yield increase in this type can be attributed to the under-planted trees contributing to the stand basal area as the older, larger spruce fall out of the stand.

Pine Dominant: Planting substantially increased the yield after 100 years in this type.

Differences in total yield between under-planted spruce and subalpine fir were not large. However, due to higher initial mortality, the individual tree size of the under-planted spruce after 100 years was much higher.

Implications of delaying planting in MPB damaged stands

We simulated the effect of delaying planting of spruce under the *Pine Dominant* stand for 2, 4, 6, 8 and 10 years after mountain pine beetle attack. Results show that, as the light environment under the deteriorating snags improves, survival and yield of spruce seedlings significantly increases. This effect highlights the importance of considering the effect of time and changing overstory conditions when developing prescriptions to mitigate the effect of the mountain pine beetle. When considering under-planting, the improved light environment must be balanced against the increased safety hazards posed by snags and the increased levels of brush and other competing natural regeneration that will also take advantage of steadily improving light environments.

Limitations to analysis

Light levels in the first 15 years after MPB attack appear to be critically important for survival of lodgepole pine. No studies of lodgepole pine snag fall down rates or corresponding changes in light levels over time were found. We have based predictions on related studies and our own observations.

Simplification of severe beetle attack into 95% mortality in one year may result in an under estimation of the length of time in which natural regeneration grows under dark canopy environments.

We were unable to predict the extent of natural regeneration in the four stand types due to lack of data to parameterize the submodel. A 2005/2007 FSP funded study will address this shortcoming.

Despite these limitations, our simulation results are consistent with observations of foresters across the MPB affected area that there is a severe lack of natural regeneration under mountain pine beetle attacked stands.

Literature Cited

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Figure 1. Change over time of understory light levels (as percent of full sun) under mature, 100% lodgepole pine canopies with varying levels of MPB attack.

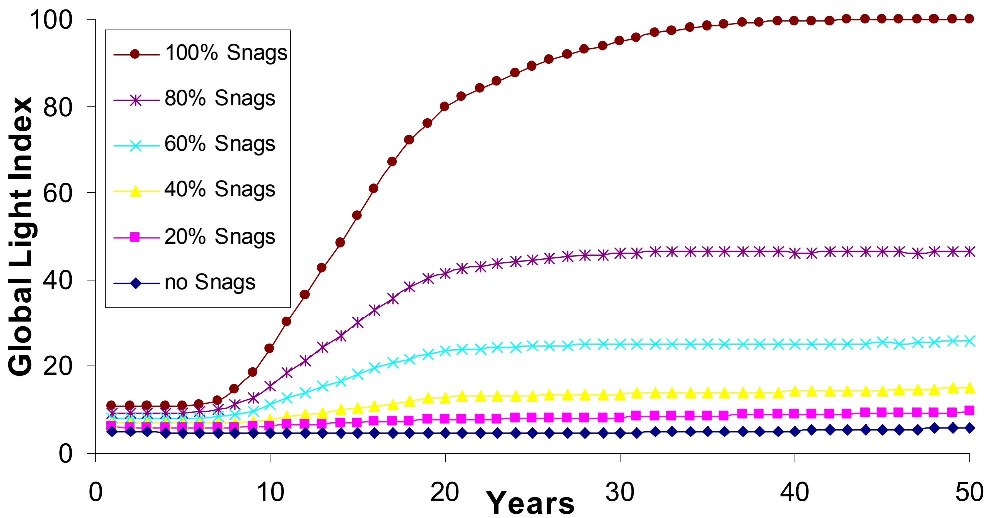

Table 1. Basal area (m^2/ha) of the four major stand types pre-attack, 50 and 100 years post-attack with no management intervention.

Stand Type	Basal Area						
	Pre-MPB	50 years post-MPB			100 years post-MPB		
		Spruce	Pine	Total	Spruce	Pine	Total
Pine Minor Spruce	47.4	33.4	1.9	35.2	45.9	1.1	47.0
Mixed Pine - Spruce	43.3	51.9	0.9	52.7	67.1	0.5	67.6
Spruce Minor Pine	46.6	53.7	0.2	53.9	53.9	0.1	54.0
Pine dominant	55.5	0.0	3.9	3.9	0.0	1.3	1.3

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