Bulkley Valley Centre for Natural Resources Research & Management

www.bvcentre.ca

Extension Note 3

Improving Prediction of Juvenile Tree Growth in Mountain Pine Beetle Damaged Stands

Prepared by:

K. David Coates[1, 2]

Erin C. Hall[1, 2]

Rasmus Astrup[3]

[1]Bulkley Valley Centre for Natural Resources Research & Management, Box 4274, Smithers BC V0J 2N0

[2]BC Forest Service, Research Section, Bag 6000, Smithers BC V0J 2N0

[3]UBC Faculty of Forestry, Department of Forest Sciences, 2424 Main Mall, Vancouver BC V6T 1Z4

FSP Project Y061151

Prepared: May, 2006

Introduction

Faced with a substantial mountain pine beetle epidemic, forest managers in north central BC need to be able to forecast growth of juvenile trees under a range of conditions in damaged stands. This is particularly important in unsalvaged areas and in stands where complex structure remains after salvage.

Previous work (e.g. Klinka et al., 1992; Chen, 1997; Wright et al., 1998; Coates and Burton, 1999; Drever and Lertzman, 2001; Claveau et al., 2002) has shown that understory light availability is a good proxy for predicting juvenile tree growth in northern, complex-structured stands. However, these models did not include very small trees and as a result, growth rates could be over estimated for very small trees.

As a component of this study we developed and tested new juvenile growth models by including very small trees across a gradient of light levels in the data set. We incorporated the new models into SORTIE-ND[1] and compared the predictions with actual juvenile growth measurements.

Growth Dataset

To build the data set we sampled very small interior spruce, subalpine fir, lodgepole pine, and trembling aspen seedlings on mesic sites in the SBSmc2 and SBSdk subzones. We selected trees from a full range of light levels and tree heights. Radial increment, height increment and age were determined by field and laboratory measurements. Growing season light availability was calculated for each sample tree. This data was combined with our existing dataset for larger seedlings and saplings.

Analysis and Model Testing Results

We tested a suite of previously developed and modified candidate models. Models were ranked based on Akaike Information Criterion (AIC) (Burnham and Anderson 2002). A model selection approach (Johnson and Omland 2004) was used to select the most efficient models for prediction of juvenile tree growth.

Model testing and selection for trembling aspen height increment was not performed due to the very small sample size and the lack of correlation to

[1] SORTIE-ND is a spatially explicit forest dynamics model that uses a combination of empirical and mechanistic sub-models to predict forest dynamics based on field experiments that measure fine-scale and short-term interactions among individual trees.

either light or tree size.

Model testing and selection resulted in development of a new model for juvenile tree growth, Equation [1].

[1] $$\hat{Y} = MinInc + MaxInc \times SizeEffect \times ShadeEffect$$

MinInc is a constant that determines: (1) the minimum increment of a tree of any size, and (2) the increment of a tree that does not have a diameter (less than 10 cm tall).

MaxInc is a constant that determines the maximum increment that can be obtained by a tree.

SizeEffect determines how the potential increment develops with tree size (Diameter Inside Bark (mm) (DIB)) and is described with equation [2].

ShadeEffect determines the effect of shade (1-light availability) on increment and is described with equation [3].

[2] $$SizeEffect = \exp\left(-0.5 \times \left[\frac{\ln(DIB + 0.0001/X0}{Xb} \right]^2 \right)$$

[3] $$ShadeEffect = \exp(-M \times Shade^N)$$

Three versions of the model were tested for radial increment. These varied by method of calculation of the X0 and MinInc parameters. Only one model version was tested for height increment.

Discussion of Growth Analysis

In our testing, Model Version 1 was the preferred model for all three conifer species. This Model has the flexibility to incorporate a wide range of tree sizes including very small tree sizes. For all three conifer species the resultant AIC values illustrated that tree size should be included as a predictor variable.

Aspen growth modeling was inconclusive - there was a large amount of variation in the aspen dataset. We found that the results of testing the candidate models illustrated this well; there is no difference in fit between an exponential, a linear, or an asymptotic function.

Table 1. Parameters for a Modified Juvenile Growth Model

Parameter	Subalpine fir	Lodgepole pine	Interior spruce
MinInc	0.1816 (0.11)	0.4384 (0.13)	0.2819 (0.11)
MaxInc	2.2379 (0.48)	9.0987 (2.27)	4.5412 (0.29)
X0	3.7566 (0.81)	4.7152 (0.51)	3.7085 (0.22)
Xb	1.2446 (0.24)	0.9360 (0.12)	0.9866 (0.10)
M	2.3775 (0.59)	3.7840 (0.59)	2.5628 (0.34)
N	2.1469 (0.75)	1.0518 (0.28)	1.3891 (0.21)
AIC	229	357	552

Comparison with Planted Tree Growth

To compare the Modified Juvenile Growth Model with measurements of actual planted tree growth we used the dataset from a study of 13 to 32 year old plantations in the Lakes Timber Supply Area (Woods and Bergerud, 2006). In that project sixty free-growing stands were randomly selected. In each block 15 plots were established and an average of 87 well-spaced trees were measured. We selected the largest 25% of the sample trees (of each species) from each sample site to ensure that sample trees grew under high light levels, and determined the average size of these trees. From the plantation history information we recorded history of brushing or spacing for each plantation.

We then plotted growth predictions of the Modified Juvenile Growth Model and the growth predictions of the current juvenile growth models implemented in SORTIE-ND against the average stand DBH over time from the clearcut plantation dataset. Figures 1 and 2 present the results.

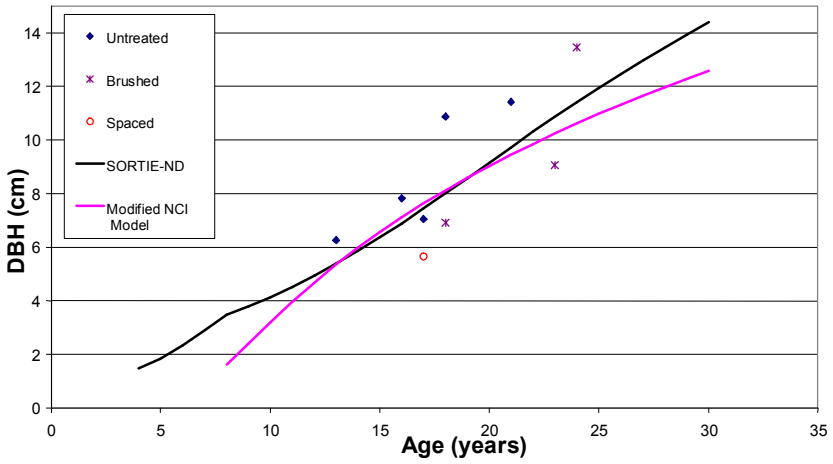

Figure 1. Comparison of Modified Juvenile Growth Model to free growing interior spruce plantations and SORTIE-ND growth predictions. (Average DBH of top 25% of Well Spaced Trees).

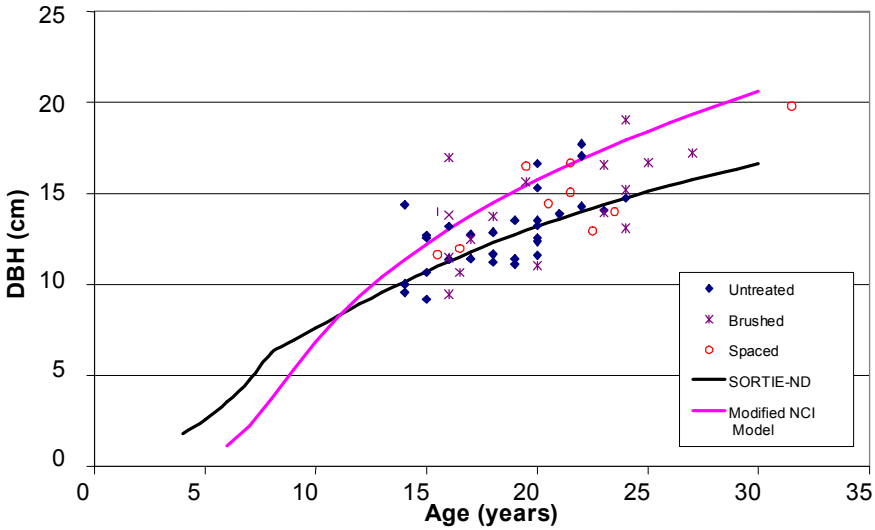

Figure 2. Comparison of Modified Juvenile Growth Model to free growing lodgepole pine plantations and SORTIE-ND growth predictions.

Literature Cited

Burnham, K.P. and Anderson, D.R. 2002. Model selection and multi-model inference: A practical information-theoretic approach. Springer.

Chen, H.Y.H. 1997. Interspecific response of planted seedlings to light availability in interior British Columbia: survival, growth, allometric patterns, and specific leaf area. Can. J. For. Res. 27: 1383-1393.

Claveau, Y., C. Messier, P.G. Comeau and K.D. Coates. 2002. Growth and crown morphological responses of boreal conifer seedlings and saplings with contrasting shade tolerance to a gradient of light and height. Can. J. For. Res. 32: 458-468.

Coates, K.D. and Burton P.J. 1999. Growth of planted tree seedlings in response to ambient light levels in northwestern interior cedar - hemlock forests of British Columbia. Can. J. For. Res. 29: 1374-1382.

Drever C. R. and K.P. Lertzman. 2001. Light-growth responses of coastal Douglas-fir and western redcedar saplings under different regimes of soil moisture and nutrients. Can. J. For. Res. 31: 2124–2133.

Johnson, J.B. and Omland, K.S. 2004. Model selection in ecology and evolution. Trends Ecol. Evol. 19(2): 101-108.

Klinka K., Q. Wang, G.J. Kayahara, R.E. Carter, B.A. Blackwell. 1992. Light growth response relationships in Pacific silver fir (*Abies amabilis*) and subalpine fir (*Abies lasiocarpa*). Can. J. Bot. 70: 1919-1930.

Woods, A. and W. Bergerud. 2006. Forest and Range Practices Act (FRPA) Effectiveness Evaluation: Are Free-Growing stands meeting timber productivity expectations? *In press.*

Wright, E.F., Coates K.D., Canham, C.D. and Bartemucci, P. 1998. Species variability in growth response to light across a climatic gradient in northwestern British Columbia. Can. J. For. Res. 28: 871-886.

The Bulkley Valley Centre for Natural Resources Research & Management

The Bulkley Valley Centre for Natural Resources Research & Management (the BV Research Centre) is a registered not-for-profit society based in Smithers, British Columbia, that conducts high quality interdisciplinary research on temperate, montane, and boreal ecosystems, including their human dimensions.

Visit our website, www.bvcentre.ca for more information on the Centre and our projects.