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Extension Note 4

Allometric Relationships of Seedlings and Saplings of Sub Boreal Spruce Tree Species

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Introduction

Forest stands in north central BC damaged by the mountain pine beetle epidemic are managed by a range of strategies from full salvage to partial or no salvage. An array of stand structures and conditions for juvenile tree growth results. Managers need precise allometric models to predict stand development, in order to address stewardship and sustainability concerns.

Research has shown that small tree allometry may vary with light levels (Wright et al. 1998, Coates and Burton 1999, Astrup and Larson 2000). However SORTIE-ND[1] allometry functions are derived from analysis of mature trees where light was not included as a variable.

In this study we tested the importance of including light level in allometry relationships for seedlings and saplings in sub-boreal forests of BC.

Allometry Dataset

To assemble the data we sampled small interior spruce, subalpine fir, lodgepole pine, and trembling aspen seedlings on uniform, mesic sites in the SBSmc2 and SBSdk subzones. We selected trees from a full range of light levels and avoided areas of recent disturbance where light levels would have recently changed. We selected natural regeneration only. Selected trees were free of vegetative competition and unaffected by disease or injury. For each sample tree we measured total height (Ht), diameter at 1.3 m (diameter at breast height: DBH), diameter 10 cm above the ground (D10), basal diameter (D0), and crown diameter (CD), measured at the widest point of the crown and then perpendicular to the first measurement. Height to live crown (LC) was measured as the distance from ground level to the first whorl containing at least three live branches and constitutes the base of the effective tree crown. Growing season light availability was calculated for each sample tree. The dataset was combined with previously collected allometry datasets.

[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.

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 several allometric relationships. We analysed eight seedling and sapling allometry relationships. In this note we present the best models and associated parameter values.

1. D10-Height Relationship

The best model for predicting height of trembling aspen, subalpine fir, and lodgepole pine is:

$$Ht = 0.1 + (30 + \beta_1 \times GLI) \times (1 - \exp(-\beta_2 \times D10))$$

Where GLI is % of full sunlight and β_1 and β_2 are estimated parameters. These relationships are shown in Figures 1, 2, and 3. The best model for interior spruce is:

$$Ht = 1.3 + \beta_1 \times Dbh + \beta_2 \times GLI$$

This relationship is shown in Figure 4. These results indicate that for trembling aspen, subalpine fir and lodgepole pine including light level improves the prediction of tree height from D10. However, including light level has a limited effect on the prediction of interior spruce height.

Table 1. D10 to Height Parameters

Species	β_1 (Std. Error)	β_2 (Std. Error)
Trembling aspen	-0.110897 (0.0082)	0.054149 (0.001594)
Subalpine fir	-0.098323 (0.0089)	0.021309 (0.000476)
Lodgepole pine	-0.171623 (0.0089)	0.036107 (0.001086)
Interior spruce	0.6503 (0.01338)	-0.004646 (0.00085)

2. Relationship of D10 to D0

Our results show that D10 can be predicted directly from D0 as is evident from the R^2 values listed below. Parameter estimates for this function are presented in Table 2.

Table 2. Parameter estimates for $D10 = \beta_1 \times D0$

Species	β_1 (Std. Error)	R^2
Trembling aspen	0.897 (0.005)	0.997
Subalpine fir	0.912 (0.003)	0.998
Lodgepole pine	0.906 (0.003)	0.998
Interior spruce	0.899 (0.004)	0.997

3. Relationship of DBH to D10

The recommended model for predicting DBH as a function of D10 is:

$$DBH = \beta_0 + \beta_1 \times D10$$

Table 3. Parameter estimates for $DBH = \beta_0 + \beta_1 \times D10$

Species	β_0 (Std. Error)	β_1 (Std. Error)	R^2
Trembling aspen	-0.5038 (0.0621)	0.8978 (0.0621)	0.95
Subalpine fir	-1.317 (0.1747)	0.8750 (0.0339)	0.90
Lodgepole pine	-0.4853 (0.0577)	0.8526 (0.0112)	0.96
Interior spruce	-0.8268 (0.0818)	0.8268 (0.0158)	0.91

4. Crown Diameter Relationships

Our analysis showed that best predictor of crown diameter is the following:

$$CD = (\beta_0 + \beta_1 \times GLI + \beta_2 \times D10)$$

β_0 is species-specific

β_1 is species-specific

β_2 is species-specific

We found a differentiation between trembling aspen and lodgepole pine versus interior spruce and subalpine fir. For interior spruce and subalpine fir the predicted CD decreases with increasing light availability. This fits well with the known effect of wide "flat" crowns for shade tolerant species in low light environments. Lodgepole pine and trembling aspen show limited change in CD with light level. Figures 5 through 8 illustrate these results.

Table 4. Crown Diameter Parameters

Species	β_0 (Std. Error)	β_1 (Std. Error)	β_2 (Std. Error)
Trembling aspen	1.522 (5.70)	-0.016 (0.066)	30.31 (1.16)
Subalpine fir	42. 78 (3.38)	-0.603 (0.052)	27.70 (0.67)
Lodgepole pine	7.23 (2.46)	-0.017 (0.040)	23.66 (0.58)
Interior spruce	37.2 (3.43)	-0.473 (0.049)	29.08 (0.71)

5. Crown Length

The preferred model incorporates light, height, and species effects to predict crown length from D10:

$$CL = (\beta_0 + \beta_1 \times GLI + \beta_2 \times Height)$$

β_0 is species-specific

β_1 is species-specific

β_2 is species-specific

Results are shown in Figures 9 to 12.

Table 5. Crown Length Parameters

Species	β_0 (Std. Error)	β_1 (Std. Error)	β_2 (Std. Error)
Trembling aspen	-61.42 (10.58)	0.705 (0.117)	0.710 (0.019)
Subalpine fir	-26.54 (4.076)	0.422 (0.060)	0.814 (0.014)
Lodgepole pine	-36.71 (4.651)	0.500 (0.068)	0.833 (0.014)
Interior spruce	-25.61 (4.878)	0.437 (0.067)	0.794 (0.014)

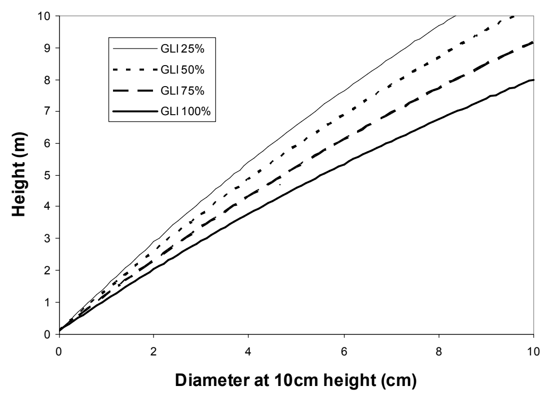

Figure 1. Trembling aspen height predicted from D10 at different light levels.

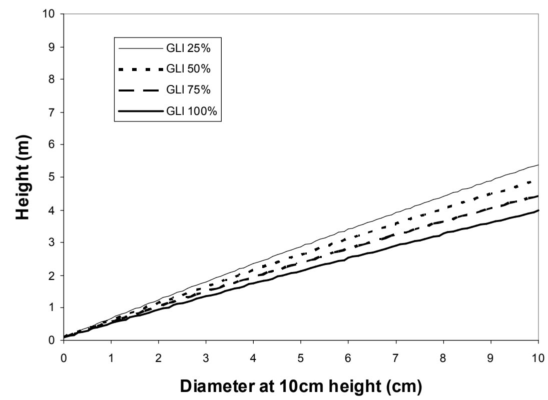

Figure 2. Subalpine fir height predicted from D10 at different light levels

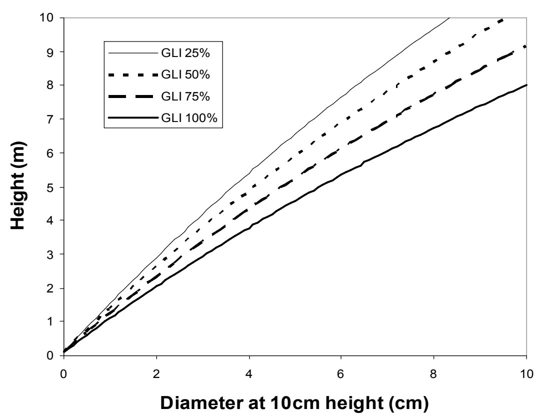

Figure 3. Lodgepole pine height predicted from D10 at different light levels.

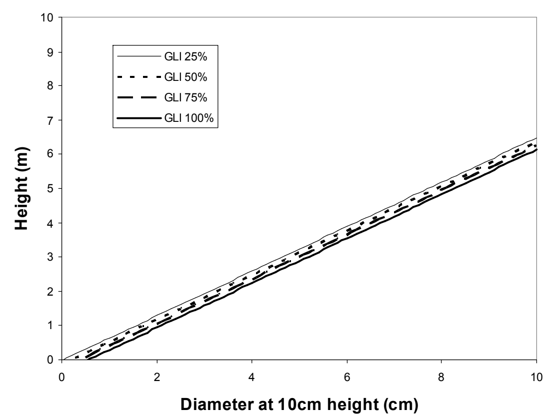

Figure 4. Interior spruce height predicted from D10 at different light levels.

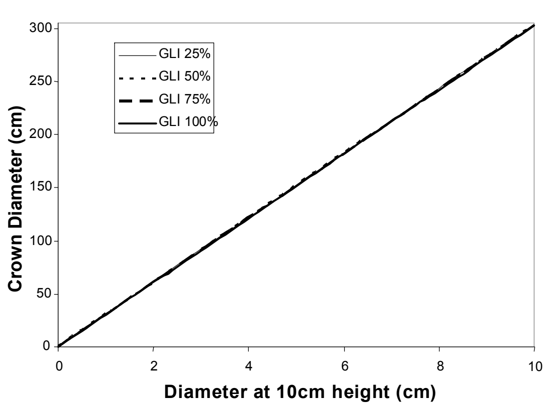

Figure 5. Trembling aspen crown diameter predicted from D10 at different light levels.

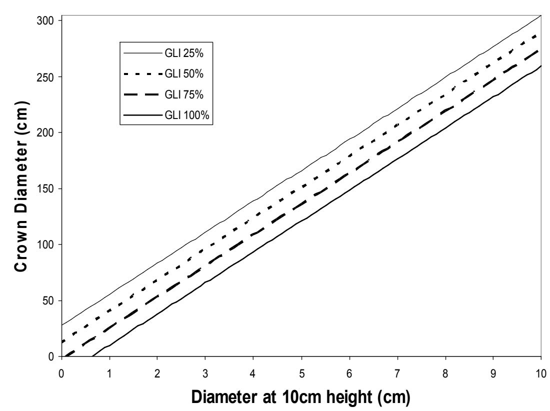

Figure 6. Subalpine fir crown diameter predicted from D10 at different light levels.

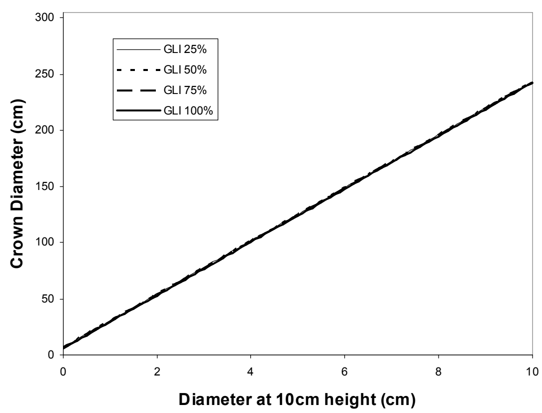

Figure 7. Lodgepole pine crown diameter predicted from D10 at different light levels.

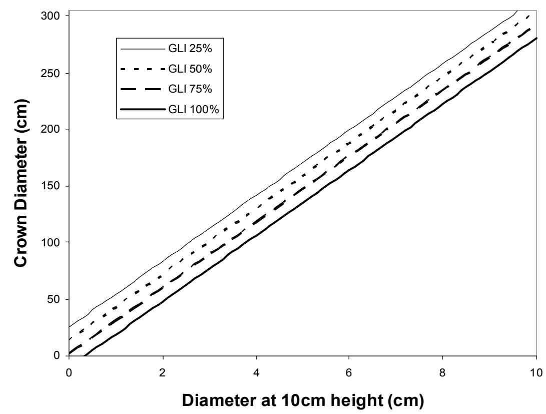

Figure 8. Interior spruce crown diameter predicted from D10 at different light levels.

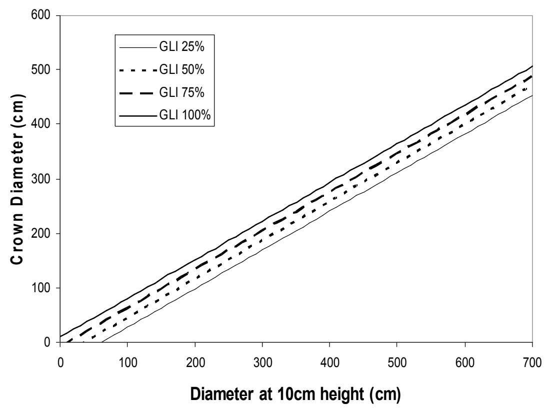

Figure 9. Trembling aspen crown length predicted from D10 at different light levels.

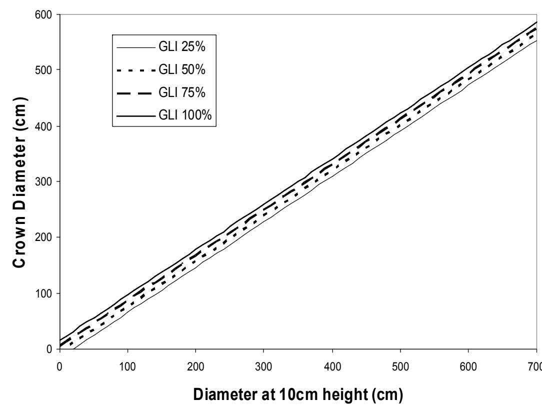

Figure 10. Subalpine fir crown length predicted from D10 at different light levels.

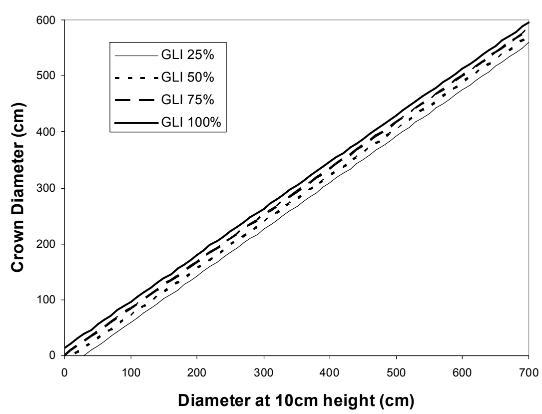

Figure 11. Lodgepole pine crown length predicted from D10 at different light levels.

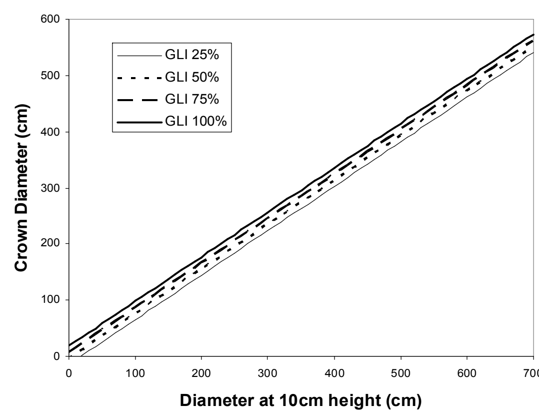

Figure 12. Interior spruce crown length predicted from D10 at different light levels.

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