FP Project Description

Return to Full Proposal #: Y092022

Title: The effect of site type and stand structure on the relationship between growth and light availability for understroy trees

Project Description: Complex stand management is becoming more prevalent in northern interior forests due to changing management practices and the mountain pine beetle (MPB) epidemic. The MPB epidemic is creating vast areas of complex multi-storied stands. To predict growth of complex stands it is essential to understand the factors controlling growth of understory trees. Considerable work has been undertaken on mesic (average) sites to predict understory tree growth as a function of light availability. Light availability is the primary driver of photosynthesis and is bound to have an effect on understory tree growth. Additionally, light availability has shown good correlation with understory tree growth on mesic sites in northern temperate, sub-boreal and boreal forests (e.g. Wright et al. 1998; Stadt et al. 2005; Astrup and Coates in review). It is important to expand this work to a broader range of site types to aid the further development individual tree based complex stand growth models (e.g., SORTIE-ND, TASS 3).

Light availability is not the only resource affecting growth of understory trees in complex stands. Below-ground competition for moisture and nutrients is important for understory tree growth (Coomes and Grubb 2000) and landscape-level variation in nutrient and moisture availability has been shown to alter the relationship between light and growth for understory trees (Kobe 2006). Within a region of uniform climate, the ecological classification system in BC is based on identification of unique site types (site series) that cover a gradient from dry-poor to moist-rich sites (Banner et al. 1993). Different site types have different levels of available belowground resources. Thus, site type can be expected to affect the light-growth relationship for understory trees in the sub-boreal forests of BC. We intend to develop site-type specific relationships between light availability, tree size and growth for understory trees in sub-boreal BC. For most tree species in northern BC, the effect of site-type on the light-growth relationship has never been investigated.

The composition, abundance and spatial distribution of canopy trees determines the availability understory light in forests (e.g. Canham et al. 1999) and affects the availability of below-ground resources through competition. For prediction of individual tree growth, below-ground competition is often represented with a competition index (e.g. Ledermann and Stage 2001). For canopy trees, it has been shown to be advantageous to use both light availability and a distance-dependent competition index in models of individual tree growth (Canham et al. 2004). We intend to explore if this also is the case for understory trees and will use a similar approach and analysis as described by Canham et al. (2004) for canopy trees. Specifically, we intend to explore if our initially developed site-type specific light-growth models can be improved by utilizing light availability in combination with a distance-dependent competition index as predictor variables. For understory trees in northern BC, the combined effect of light availability and below-ground competition (represented as a competition index) has never been investigated.

Our primary objective is to understand the factors that control understory tree growth and to develop statistical models that can be used, in conjunction with simulation models, to predict understory tree growth. To meet this objective we propose to: (1) investigate how the relationship between light availability and growth differ between site types (site series) ranging from dry and poor to rich and moist, and (2) investigate if utilizing light availability, site quality and a competition index improves our predictive models of understory tree growth.

The simple site-series and species-specific regression models can be readily used in combination with existing light models to predict the growth of understory trees on a specified site-type. Thus, the models can be used as a decision support tool for silvicultural decisions in complex stands. The best models will be incorporated into the stand-level growth model SORTIE-ND and can be used for projections of understory tree growth in complex stands including stands impacted by the MPB. SORTIE-ND has the ability to predict growth of complex stands but parameter estimates for understory trees on dry poor sites do not exists. As most MPB stands are found on drier sites, it is of great importance that these parameter estimates are obtained. Development of these models for dry sites can aid in future timber-supply analysis related to MPB and complex stands.

References:

Astrup and Coates in review. Light availability and growth of understory aspen and spruce in western boreal Canada.

Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. B.C. Ministry of Forests, Victoria, B.C. Land Manage. Handb. 26.

Burnham, K.P. and Anderson, D.R. 2002. Model selection and multimodel inference, a practical information-theoretic approach. Second edition. Springer-Verlag New York, Inc. 488 p.

Canham, C.D., Coates, K.D., Bartemucci, P and Quaglia, S. 1999. Measurement and Modeling of Spatially-explicit Variation in Light Transmission Through Interior Cedar-Hemlock Forests of British Columbia. Can. J. For. Res. 29:1775-1783.

Canham, C.D., LePage, P.T., and Coates, K.D. 2004. A neighborhood analysis of canopy tree competition: effect of shading versus crowding. Can. J. For. Res. 34: 778-787.

Coomes, D.A. and Grubb, P.J. 2000. Impact of root competition in forests and woodlands: a theoretical framework and review of experiments. Ecological Monographs 70: 171 - 207.

Kobe, R.K. 2006. Sapling growth as a function of light and landscape-level variation in soil water and foliar nitrogen in northern Michigan. Oecologia 147: 119-133.

Ledermann, T. and Stage, A.R. 2001. Effects of competitor spacing in individual-tree indices of competition. Can. J. For. Res. 31: 2143-2150.

Stadt, K.J., Lieffers, V.J., Hall, R.J. and Messier, C. 2005. Spatially explicit modeling of PAR transmission and growth of Picea glauca and Abies balsamea in the boreal forests of Alberta and Quebec. Can. J. For. Res. 35: 1-12.

Weigelt, A. and Jollifee, P. 2003. Indices of plant competition. J. Ecol. 91: 707-720.

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

PRICEWATERHOUSECOOPERS

RIMS - Research Investment Management System

Home | Site Map | Help

Welcome Kirsteen Laing

[Sign Out]

Information | Full Proposal | My Account

FP Project Objectives

Return to Full Proposal #: Y092022

Title: The effect of site type and stand structure on the relationship between growth and light availability for understroy trees

Project Objective: Short Term Objectives:

(1) Investigate how the relationship between light availability and growth differ between site types (site series) ranging from dry and poor to rich and moist.

(2) Investigate if utilizing both light availability and a competition index improves our predictive models of understory tree growth.

(3) To develop alternate empirical mathematical functions that may best predict growth of understory trees.

(4) To incorporate the simple species- and site-specific regression models into SORTIE-ND.

Long Term Objectives:

(1) To further our ecological understanding of how different factors control understory tree growth and how competitive interactions among trees vary across resource gradients.

(2) To further the development of growth models for use in decision making and timber-supply analysis for complex stands in the sub-boreal forests of BC.

FP Experimental Design and Methods

Return to Full Proposal #: Y092022

Title: The effect of site type and stand structure on the relationship between growth and light availability for understroy trees

Experimental Design and Methods: We will use an extensive network of existing plots (about 60) in the sub-boreal spruce zone (SBS) as sampling sites. These plots were established to study canopy tree growth as a function of neighbor tree abundance, composition, and location (two earlier FSP projects). The plots are between 0.5- 4 ha in size, have been carefully classified to site series, and cover the full range of site types from dry and poor sites to rich and moist sites (site series 02-09). All overstory trees in these plots have been stem-mapped (two earlier FSP projects).

Our field methods will follow the well established approach of Wright et al. (1998) and Astrup (2006). We will sample subapline fir (Abies lasiocarpa), lodgepole pine (Pinus contorta), and interior spruce (Picea glauce×engelmannii). For each included site series (02, 01, 06, 09), we will destructively sample individual understory trees. For each site series, we aim at a sample size of 100 trees/species. For each tree, a disk will be taken to determine past radial increment. Height increments form the past five years will also be measured. A fisheye photo will be taken above the stump of each tree and the GLI/C software (Frazer et al. 1999) will be used to determine growing season light availability summarized with the GLI light index (Canham 1988). A leaf sample will be taken for determination of total nitrogen availability. Finally, each sampled understory tree will be mapped on the already existing stem-maps. Including the understory trees in the stem-maps, will provide the necessary spatial information for calculation of distance-dependent competition indices.

The analysis will be based on a framework of multiple working hypothesis, likelihood methods, and information theory (e.g. Burnham and Anderson 2002). The first part of the analysis investigates how the relationship between light availability and growth differ between site types (site series) ranging from dry and poor to rich and moist. This analysis will follow the approach of Wright et al. (1998) and further refinements described in Astrup and Coates (in review). We will test a number of simple regression models where growth is a function of light availability and tree size. Then we will select the best approximating model with the model selection criterion AIC (e.g. Burnham and Anderson 2002). Initially, we will fit these models to species-specific dataset for each site series. This will result in simple models that predict site- and species-specific growth of an individual understory tree as a function of light availability and initial tree size. Secondly, we will investigate three hypotheses relating to how the light growth relationship differ between site types: (1) the light-growth relationship does not vary between site types (indicates that below-ground resources do not have substantial effects on tree growth), (2) the light-growth relationship varies between site types but only at high light (indicates that below-ground resources only are important at high light availability); and (3) the light-growth relationship differs at all light levels (indicates that below-ground resources are important for tree growth at all light levels). In practice, each of these hypotheses will be represented by the previously selected "best approximating model" and the variation between site types will be represented by 0-1 indicator variables. For hypothesis (1) the model will be fitted to the pooled data from all sites series. For hypothesis (2) we will include indicator variables that allow the growth at high light to vary between sites series. For hypothesis (3) we will include indicator variables that allow the light-growth relationship to differ between site types both at high and at low light. We will then determine which model (hypothesis) is best supported by data. When the analysis is performed in a framework of multiple working hypothesis, the support of each hypothesis (model) can be determined with the model selection criterion AIC (e.g. Burnham and Anderson 2002, Kobe 2006).

The second part of the analysis will investigate if utilizing both light availability and a distance-dependent competition index improves the predictive models of understory tree growth. This analysis will build upon the approach of Canham et al. (2004) where canopy tree growth was predicted by a model that includes both light availability and a distance-dependent competition index. Thus, we will develop and test a set of models that include light availability, site type, and a distance-dependent competition index as predictors for understory tree growth.

References:

Astrup, R. 2006. Modeling growth of understory aspen and spruce in western boreal Canada. Ph.D. Dissertation. University of British Columbia, Vancouver. 159 p.

Astrup, R. and Coates, K.D. Light availability and growth of understory aspen and spruce in western boreal Canada. in review.

Burnham, K.P. and Anderson, D.R. 2002. Model selection and multimodel inference, a practical information-theoretic approach. Second edition. Springer-Verlag

New York, Inc. 488 p.
Canham, C.D. 1988. An index of understory light levels in and around canopy gaps. Ecology 69: 1634-1638.

Canham, C.D., LePage, P. and Coates K.D. (2004). A Neighborhood analysis of canopy tree competition: effects of shading versus crowding. Can. J. For. Res. 34: 778-787.

Frazer, G.W., Canham, C.D. and Lertzman, K.P. 1999. Gap light analyzer (GLA), version 2: imaging software to extract canopy structure and gap light indices from true-colour fisheye photographs. Simon Fraser University, Burnaby, B.C., and the Institute of Ecosystem Studies, Millbrook, N.Y.

Kobe, R.K. 2006. Sapling growth as a function of light and landscape-level variation in soil water and foliar nitrogen in northern Michigan. Oecologia 147: 119-133.

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