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Testing Site Index-Site Factor Relationships for Predicting Lodgepole Pine and Interior Spruce Productivity in Central British Columbia

Introduction

Knowledge of the potential productivity of a tree species becomes especially important when timber production is the primary management objective. However, direct determination of potential productivity is often not possible. For example, in situations where the site is unstocked, stocked with trees unsuitable for productivity measurement, or stocked with species other than the one of interest. In these cases, an indirect estimate using known characteristics of the site itself is required. Such estimates were made using regression to model site index with indirect measures of site quality for lodgepole pine (*Pinus contorta*) and interior spruce (*Picea engelmannii* × *P. glauca*) in the Sub-Boreal Spruce (SBS) zone of central BC. We tested the utility of these productivity relationship models for predicting the site index of lodgepole pine and interior spruce (Kayahara *et al.* accepted for publication).

Methods

The model development plots and the test plots were located on sites in central British Columbia (latitude 51º40' to 55º05'N, longitude 119º30' to 128º25'W, elevation 505 to 1060 m). The plots were located in the warmer montane boreal climate as delineated by the SBS zone. The climate is characterized by seasonal extremes of temperature; severe, snowy winters; relatively warm, moist, and short summers; and moderately high annual precipitation (481 to 1250 mm).

In the model development studies, site index (height of specified dominant trees at 50 years breast height age) was used as an estimate of productivity, and was the dependent variable in multiple regression equations. Subzones or variants, soil moisture regime (SMR), soil nutrient regime (SNR), and soil aeration regime (SAR) (spruce only) were used in the form of dummy variables as the independent variables (Table 1).

Table 1. "Best fit" regression models relating site index to combinations of soil moisture regimes, soil nutrient regimes, and soil aeration regimes used as "dummy" variables.

Lodgepole pine

SI = 14.69 - 3.89(ED) - 0.27(VD) + 3.25(MD) + 5.46(SD) + 5.84(F) + 8.15(M) + 6.92(VM) - 2.29(P) - 1.57(M) - 0.8(R)

adjusted R^2 = 0.84; standard error of the estimate = 1.60 m; SI = site index; SMR: ED = extremely dry, VD = very dry, MD = moderately dry, SD= slightly dry, F = fresh, M = moist, VM = very moist; SNR: P = poor, M = medium, R = rich; the intercept represents wet and very rich.

Interior spruce

SI = 6.07 + 10.41(MDa) + 14.1(SDa) + 11.18(DFr) + 14.56(Fa) + 14.28(Ma) + 12.56(VMa) + 10.35(Mr) + 6.76(Wr) - 1.51(VP) - 0.67(P) + 1.12(R) + 1.99(VR)

adjusted R^2 = 0.90; standard error of estimate = 1.17 m; variable names as for lodgepole pine with the following additions: SAR: "a" = adequate, "r" = restricted; SMR: DF = dry to fresh, W = wet; SNRs: VR = very rich; the intercept represents wet and medium sites with deficient aeration

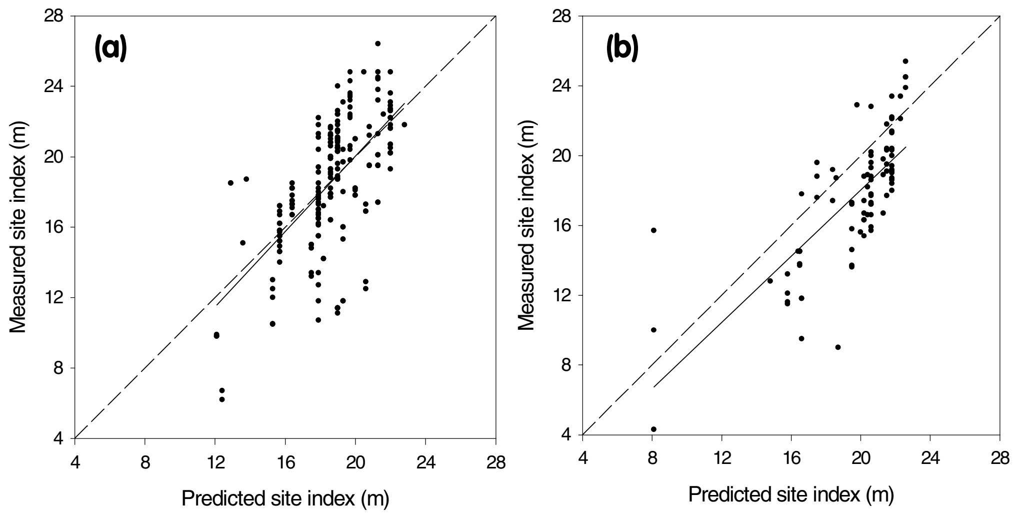
We sampled an additional 180 lodgepole pine and 89 interior spruce plots for use as test plots. These plots were located in naturally established, unmanaged, immature, even-aged, uniformly stocked (60-90% tree layer cover) stands, without a history of damage and suppression. In each stand, a 20 x 20 m (0.04 ha) sample plot was located to represent an individual ecosystem relatively uniform in soil, understory vegetation, and stand characteristics. Subzones or variants were identified using the regional field guide. Site SMR, SNR, and for spruce SAR classes were estimated. The productivity of each stand was estimated by site index (height at 50 years breast height age). In each sample plot, the five largest diameter (dominant) trees with no obvious evidence of growth abnormalities and damage were measured for age at breast height, and height. Site index was taken from height growth tables for lodgepole pine for interior spruce.

The site index test values for the combinations of SMR, SNR, and, for spruce, SAR, were compared to the values predicted using the "best fit" regression models for pine and spruce. The regression models were tested for bias by measuring the difference in mean site index between the predicted and test values using a paired t-test. Precision was measured by (1) the square root of the average squared deviation of the predicted from the test values, called the square root of the mean squared prediction error (root-MSPR); and (2) by a classification summary table. The latter procedure simply groups the test plots into classes whose site index differed from the predicted site index by increasing one metre increments.

Results

The regression model for lodgepole pine predicted an overall mean site index value that did not differ significantly (using a paired t-test) from that of the test data set (mean difference of -0.1 m; $p = 0.57$; n = 180). However, the model lacked precision having a root-MSPR of 2.80 m (Figure 1). Only 56% of the test plots had differences from the predicted values of 2.0 m or less. The regression model for interior spruce predicted an overall mean site index value that differed significantly (using a paired t-test) from that of the test data set (mean difference +2.9m; $p < 0.001$; n = 89). Similar to pine, the model lacked precision with a root-MSPR of 3.2. Only 44% of the test plots had differences from the predicted value of 2.0 m or less.

Figure 1. Scatter plots comparing the predicted to measured (from the test data) site index for lodgepole pine (a) and interior spruce (b). The dashed line is the line of equal site index



Discussion

The concern for a forest manager is that the model for lodgepole pine was unbiased and the model for interior spruce was biased towards higher site index, and neither model was very precise. Thus, autecological productivity relationships developed for central British Columbia appear to have some practical utility when applied to the prediction of the mean site index for a given area for lodgepole pine, but little utility for interior spruce. There appears to be little utility for either species for predicting site index of individual sites within an area. Forest managers requiring a site index prediction tool need to decide whether the degree of accuracy and precision provided by these models is acceptable. If not, alternative approaches will need to be developed.

References

Kayahara G.J., K. Klinka, and P.L. Marshall. 1998. Testing site index - site factor relationships for predicting *Pinus contorta* and *Picea engelmannii x glauca* productivity in central British Columbia. For. Ecol. Manage. 110: 141-150.

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Editor: Karel Klinka (klinka@interchange.ubc.ca)
Research: Gordon Kayahara (gordon.kayahara@mnr.gov.on.ca)
Production and design: Christine Chourmouzis (chourmou@interchange.ubc.ca)
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For more information contact: G. Kayahara

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K. Klinka, Forest Sciences Department, UBC,