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Trembling Aspen Site Index in Relation to Site Quality in Northern British Columbia

Introduction

Accurate and reliable predictions of site index (height of dominant trees at a reference age, usually 50 years at breast-height) for timber crop species is essential for silvicultural site-specific decision making. Site index can be predicted from site quality once the relationship between site index and site quality has been quantified. Site quality is defined as the sum of all environmental factors affecting the biotic community, such as the factors directly influencing the growth of vascular plants (light, heat, soil moisture, soil nutrients, and soil aeration). Since these factors vary greatly in time, indirect estimates of site quality have widely been used as predictors for site index in various multiple regression models.

Trembling aspen (*Populus tremuloides* Michx.) is the most widely distributed broadleaf species in British Columbia, especially in the Boreal White and Black Spruce (BWBS) biogeoclimatic zone. Growing this species for sustainable timber production requires a good understanding of its productivity attributes and accurate predictions of its growth. This extension note presents (1) relationships between trembling aspen site index and some indirect measures of site quality, and (2) site index prediction models using the indirect measures of site quality as predictors.

Materials and Methods

A total of 60 stands were located in the Moist and Warm BWBS(mw) subzone near Dawson Creek, Fort St. John, and Fort Nelson in northern British Columbia. The study stands were naturally established (after wildfires), fully stocked, even-aged, without a history of damage, and dominated by trembling aspen with an occasional component of balsam poplar (*Populus balsamifera* L.) and lodgepole pine (*Pinus contorta* var. *latifolia* Dougl. ex. Loud.). The stands were deliberately selected across the widest range of available soil moisture and nutrient conditions that support aspen growth. In each stand, a 0.04-ha rectangular plot, relatively uniform in topography, soil, understory vegetation, and stand characteristics, was randomly located to represent the stand. Site index was determined from stem analysis.

Site quality was measured or estimated using surrogate measures for climate, which included latitude, longitude, altitude, and topography (slope aspect, gradient, and position [crest, upper slope, middle slope, lower slope, or level]). Soil moisture regime (SMR) and soil nutrient regime (SNR) were estimated in the field using a combination of topographic and soil morphological properties. A particular combination of SMR and SNR is referred to as an **edatope**.

Relationships between trembling aspen site index and climatic and continuous topographic variables (e.g., aspect and % slope) were examined by regression analysis. One-way analysis of variance was used to examine the relationships between site index and slope position and edatope. Multiple regression models were developed after using backward stepwise procedure to exclude independent variables at $\alpha = 0.05$.

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Results and Discussion

Relationships between site index and measures of ecological site quality

Trembling aspen site index significantly increased with latitude and decreased with elevation but there was no significant relationship between site index and longitude (Figure 1). Latitude was also negatively correlated with elevation ($r = -0.89$, $p < 0.001$). In relation to topography, site index increased with aspect from cool- to warm-aspect slopes (Figure 2, $p < 0.05$). With change in slope position, site index decreased from the lower slope to the crest, and the site index for the level slope (flat sites) was in between the lower and middle slope positions (Figure 3, $p < 0.001$); however, site index was not significantly related to slope gradient ($R^2 = 0.01$, $p = 0.45$).

Changes in soil moisture and nutrient regime resulted in significant differences in trembling aspen site index among edatopes (Figure 4, $p < 0.05$). Site index increased with increasing nutrient availability on slightly dry sites, and with increasing available soil moisture on poor sites. The most productive growth occurred on fresh or moist and rich sites; the least productive growth occurred on moderately dry and very poor sites. These occurrences indicate that aspen height growth increases with increasing available soil nutrients (soil nitrogen) and increases from water-deficient to moist sites.

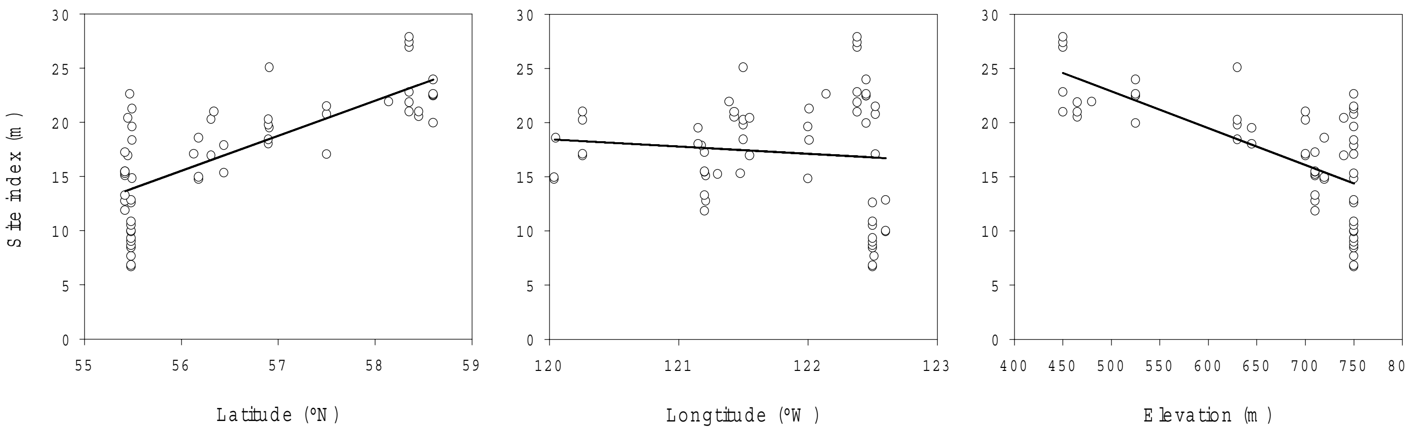

Figure 1. Site index (SI, 50 yr @ bh) in relation to indirect climatic variables (latitude (0N), longitude (0W), and elevation (m)). The regression relationships (n = 60) are: for latitude, SI = -166.3 + 3.242(latitude), $R_a^2 = 0.54$, P < 0.001; for longitude, SI = 98.86 - 0.67(longitude), $R_a^2 = 0.01$, P = 0.45; and for elevation, SI = 39.88 - 0.34(elevation), $R_a^2 = 0.47$, P < 0.001.

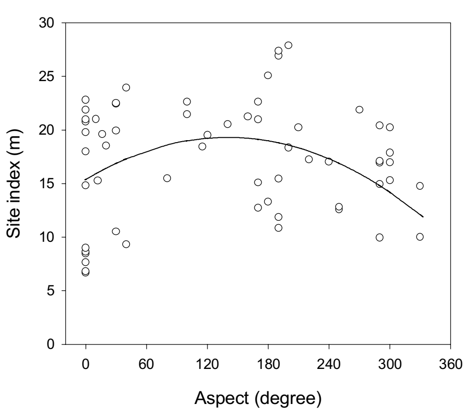

Figure 2. Site index (SI, 50 yr @ bh) in relation to aspect (degree of azimuth). The regression relationship is SI = 15.39 + 0.056(aspect) - 0.0002(aspect)^2, $R_a^2 = 0.082$, P = 0.03.

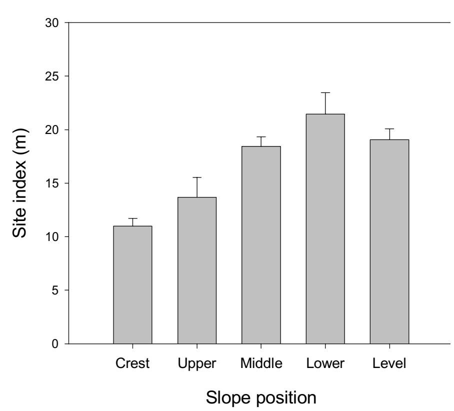

Figure 3. Site index (SI, 50 yr @ bh) in relation to slope position. Error bars represent one standard error of the mean.

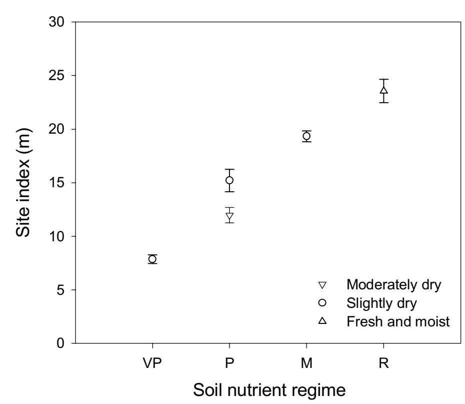

Figure 4. Site index (SI, 50 yr @ bh) in relation to edatopes (combinations of soil moisture regime and soil nutrient regime [SNR]). SNR are abbreviated as follows: VP - very poor, P - poor, M - medium, and R - rich. Error bars are one standard error of the mean.

Predictive models

The models using different measures of site quality as predictors had different levels of accountability for variation in trembling aspen site index (Table 1). Among the models using climatic variables (Model [1]), topographic properties (Model [2]), and edatopes (Model [3]), the descriptive measures (*i.e.*, R^2_a and SEE) of model performance indicated that the edatope model [3] was the best, followed by the topographic model [2] and climatic model [1]. The models using climatic variable(s) and topographic properties as predictors (Model [4]) significantly improved accountability for site index (Table 1, Model [4] *versus* Models [1] and [2]). Similarly, the model using climatic variable and edatopes as predictors improved accountability for site index (Table 1, Model [5] *versus* Models [1] and [3]).

Table 1. Models of predicting site index (SI, 50 yr @ bh)) from only climatic variables ([1]), topographic properties ([2]), edatopes ([3]), climate and topography ([4]), and climate and edatopes (n = 60 for all models). All independent variables are significant ($p < 0.05$) and models are significant ($p < 0.001$). R^2_a is the adjusted R^2. SEE is standard error of the estimate.

No.	Constituent	Model	R^2_a	SEE (m)
[1]	Climate	SI = 22.61 + 3.4344(LAT) - 1.6385(LONG)	0.587	3.44
[2]	Topography	SI = 7.57 + 0.0672(ASP) -0.0002(ASP)^2+ 2.756(UPP) + 7.268(MID) + 9.078(LOW) + 9.772(LEV)	0.527	3.68
[3]	Edatopes	SI = 7.60 + 4.10(P_MD) +7.34(P_SD) + 11.46(M_SD) + 15.69(R_FM)	0.671	3.07
[4]	Climate and topography	SI = 38.17 + 2.704(LAT) - 0.841(LONG) + 0.0393(ASP) - 0.0001(ASP)^2 + 0.75(UPP) + 4.23(MID) + 6.70(LOW) + 3.86(LEV)	0.768	2.58
[5]	Climate and edatopes	SI = -117.24 - 2.255(LAT) + 4.20(P_MD) + 6.17(P_SD) + 7.60(M_SD) + 12.75(R_FM)	0.863	1.98

Where free-growing aspen trees are absent on a site, all models presented in this study are applicable for site index prediction within the limits of the BWBSmw subzone. In the situation where mature aspen stands are present on a site, the height growth model as well as aspen site index tables and curves are recommended to determine site index. Providing that SMR and SNR can be correctly estimated, the model [5] is recommended for site index prediction. However, when SMR and SNR cannot be estimated (*e.g.*, in the winter season) or they are out of the range of the presented model, the slightly less precise model [4] can be used.

Reference

Chen, H.H.Y., K. Klinka, and R.D. Kabzems. 1998. Site index, site quality, and foliar nutrients of trembling aspen: relationships and predictions. Can. J. For. Res. 28: 1743-1755.

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