

# The effects of soil resources on tree neighborhood dynamics in sub-boreal spruce forests of British Columbia

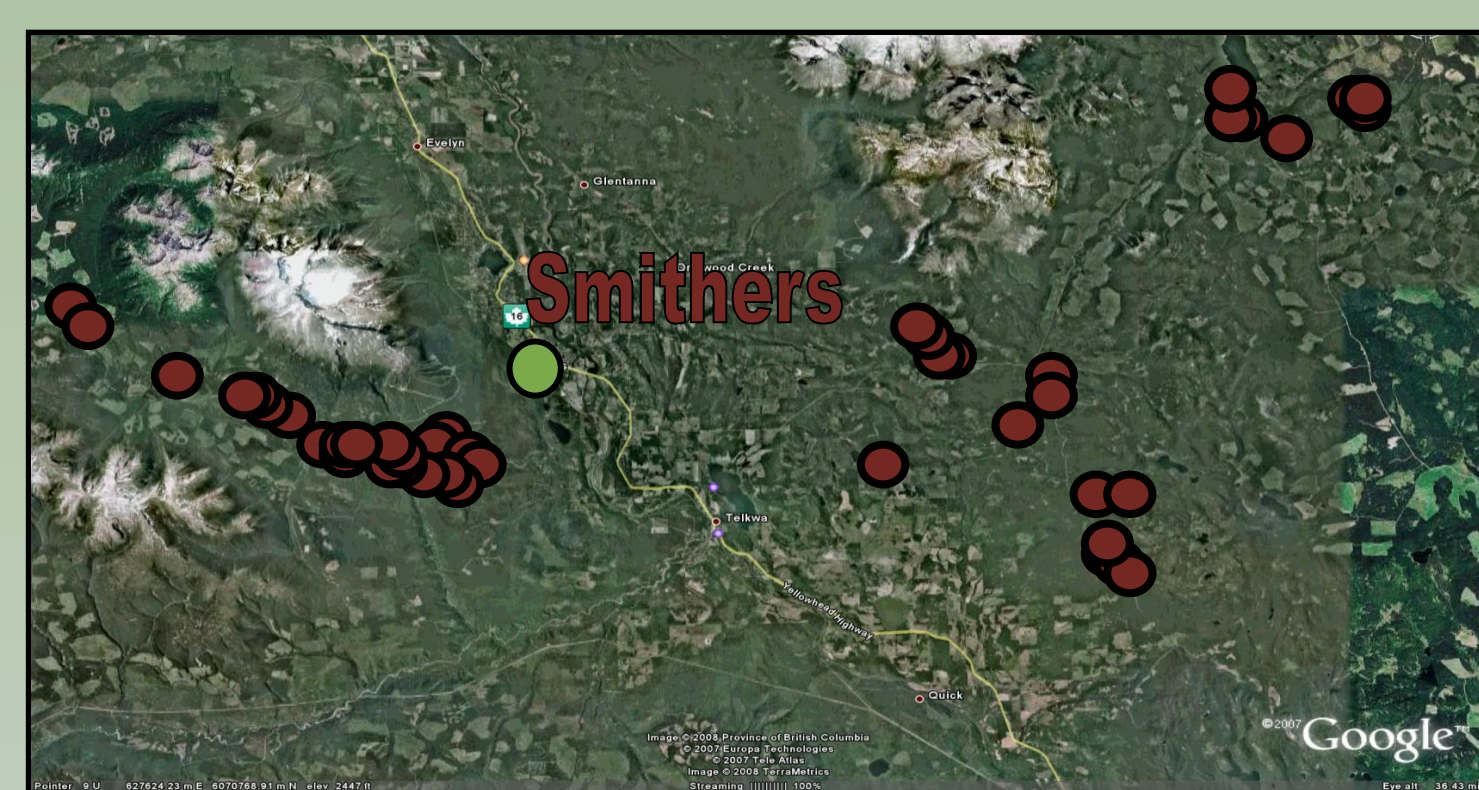
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## INTRODUCTION

Under the theory of multiple resource limitation, we would expect light and soil resources to both limit tree growth (Chapin et al. 1987) and for competition for light and soil resources to be major influences on forest community dynamics. Tests of forest neighborhood dynamics models have confirmed the importance of shading and crowding by neighboring trees on individual tree growth rates (e.g. Canham et al. 2004), but there has been little previous investigation into the effect of soil nutrient availability on competitive interactions in forest communities.

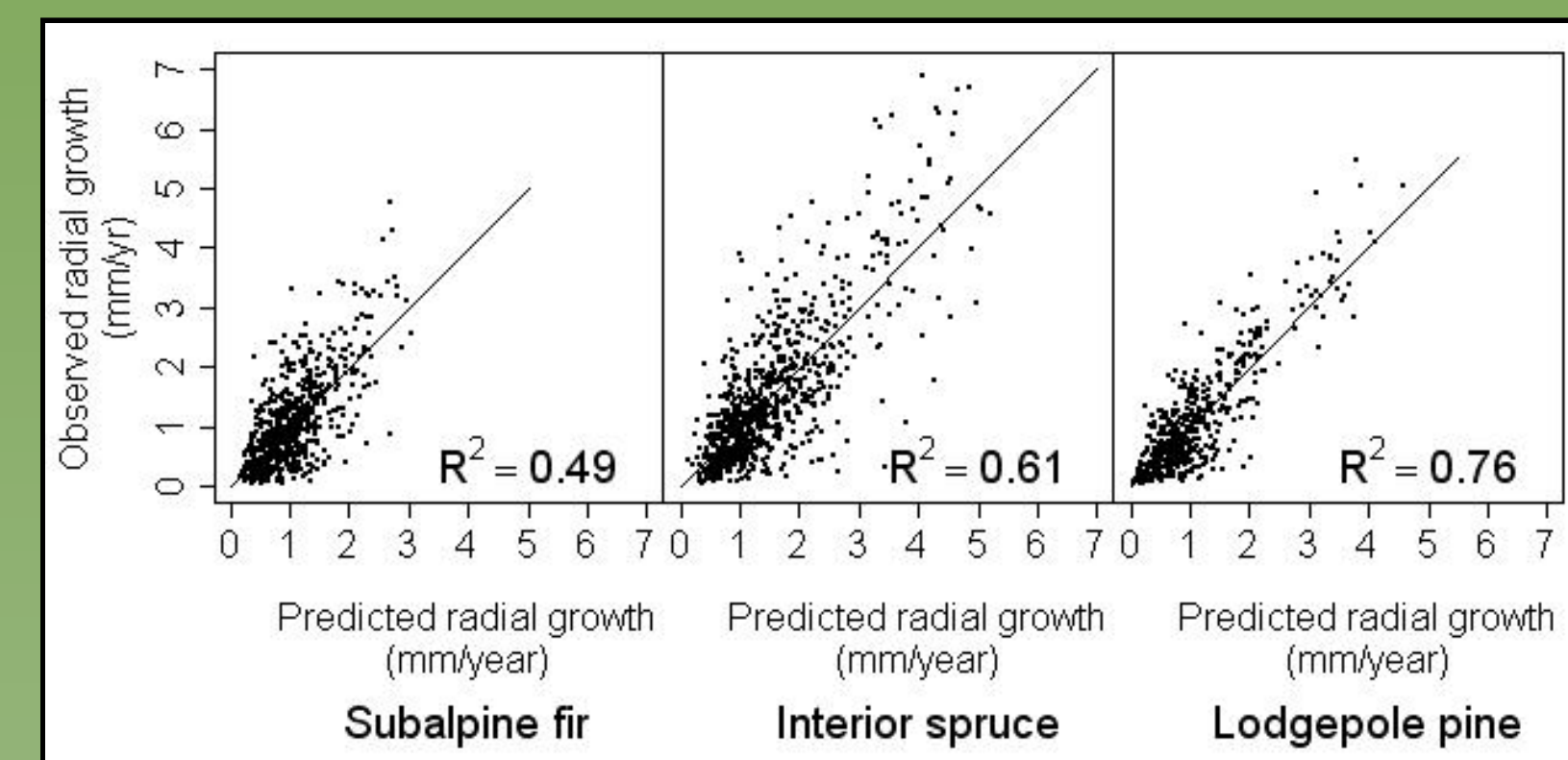
## RESEARCH QUESTION

How do soil resources affect above- and below-ground competitive interactions among trees in the sub-boreal forest?

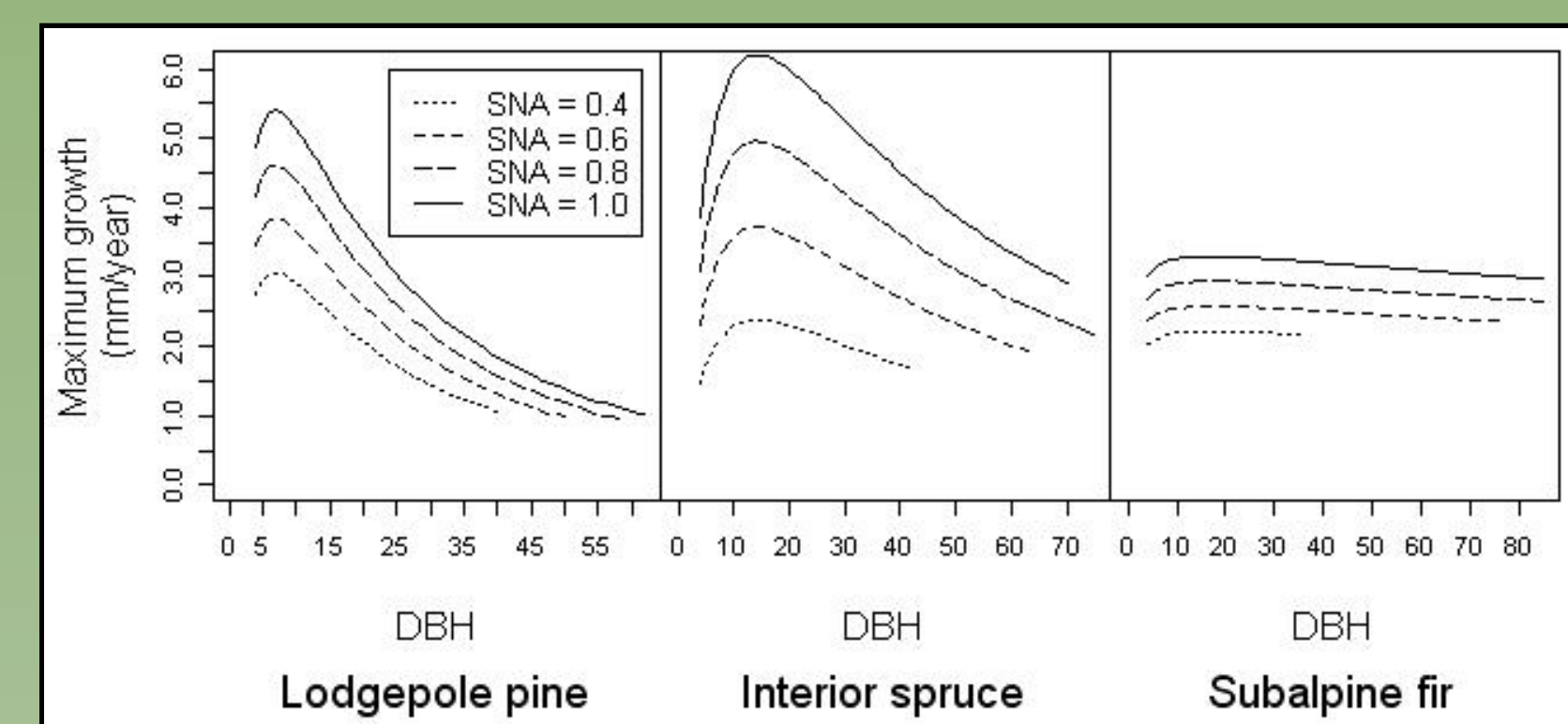


## METHODS

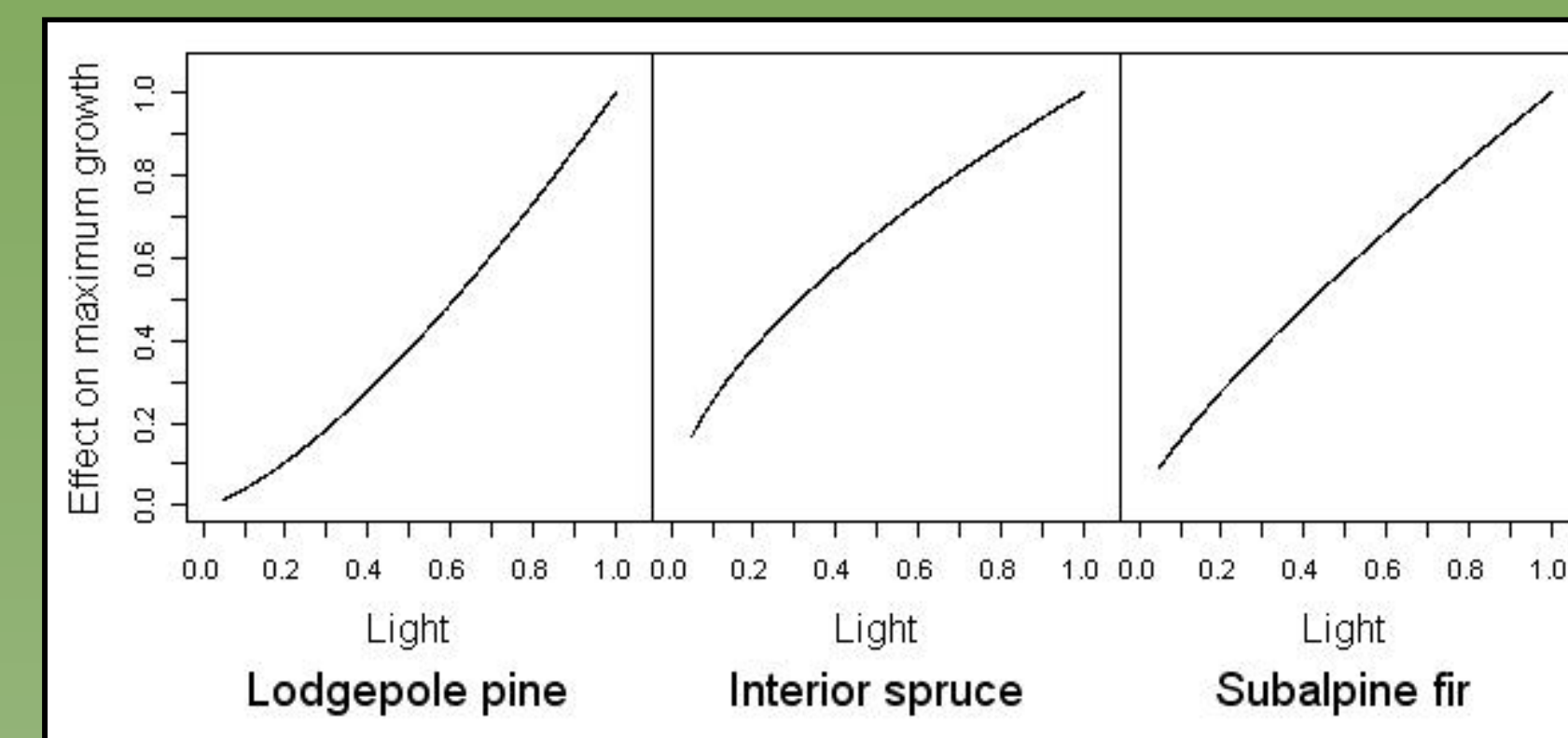
Study sites were located near Smithers, BC, in the Sub-Boreal Spruce subzone (SBSmc2). Subalpine fir (n=651) interior spruce (n=825), and lodgepole pine (n=484), the dominant coniferous tree species, and neighbouring trees, including aspen, were sampled in mapped stem-plots across gradients of soil resources, stand type, density and composition, and across tree size. Soil nutrient availability (SNA), scaled from 0 to 1, was assessed in soil pits according to the BC Biogeoclimatic Classification System (Banner et al. 1993). Using maximum likelihood methods and model selection criteria, five alternative hypotheses were compared by AIC.



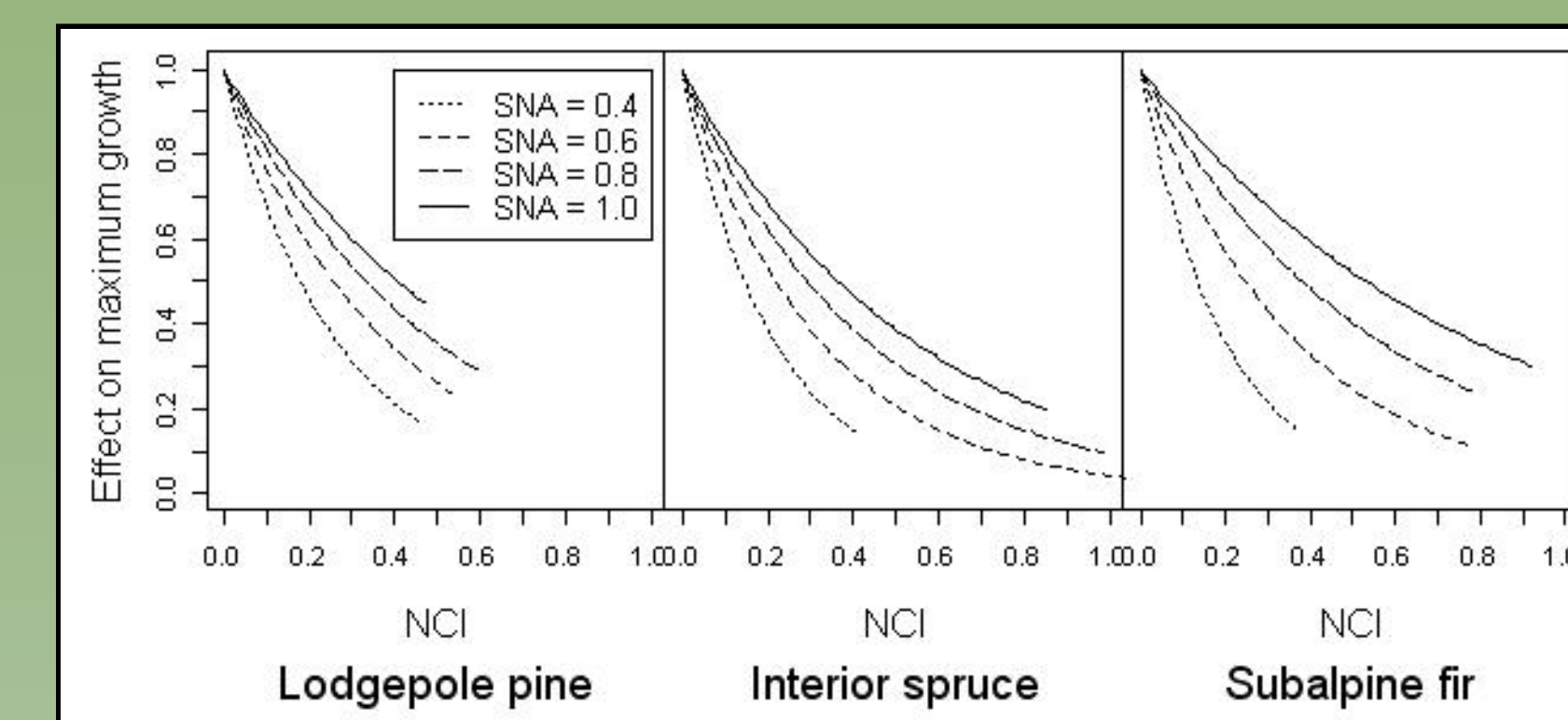
Goodness of fit of the analysis - observed radial growth versus predicted radial growth (Model 6).



Predicted maximum potential radial growth as a function of tree diameter. Predictions generated by Model 6 for four levels of soil nutrient availability (0.4 = poor to 1 = very rich).



Predicted relative radial growth as a function of light availability (Model 6).



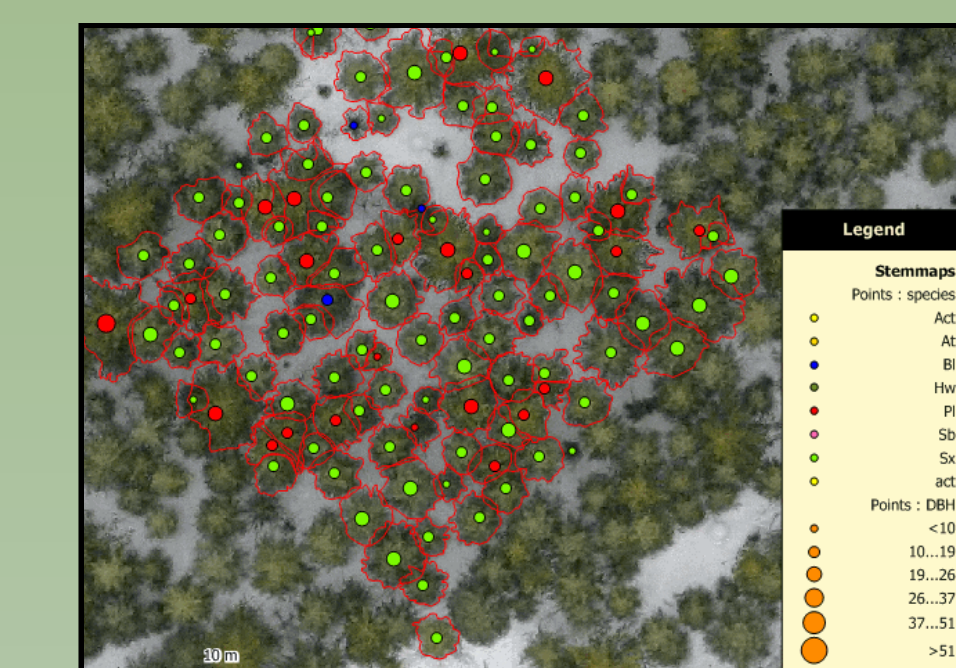
Predicted relative decline in radial growth as a function of neighbourhood competition index (NCI). Predictions generated by Model 6 for four levels of soil nutrient availability (0.4 = poor to 1 = very rich).

Functional forms and results of model comparison ( $\Delta AICc$ ) for alternative hypotheses predicting the effect of soil nutrient availability on competitive interactions among lodgepole pine, interior spruce, and subalpine fir with aspen included as a neighbour.

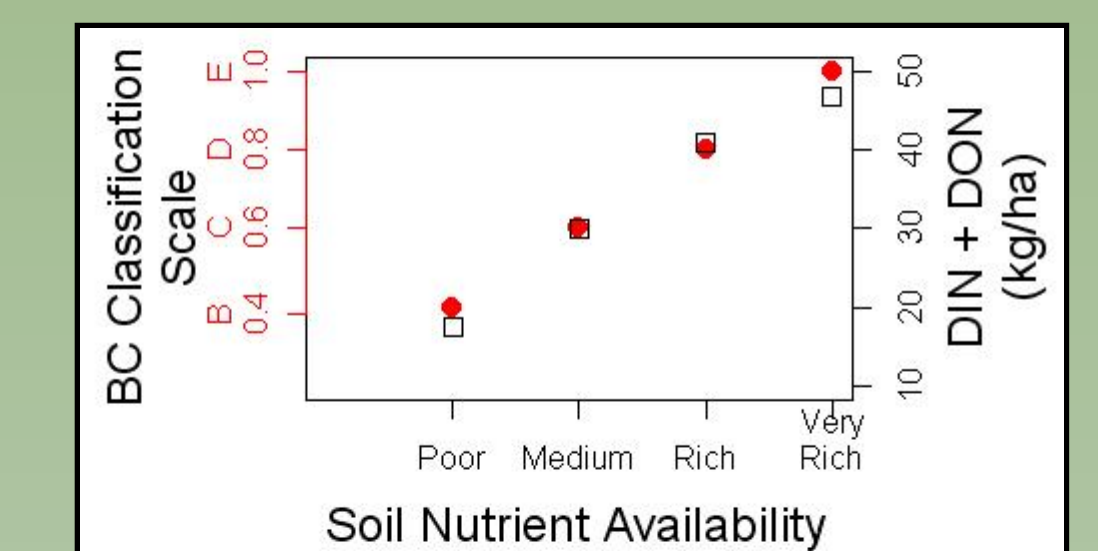
Model #	Functional form	Parameters	Biological interpretation/ Hypothesis tested	Pine	Spruce	Fir
1 (Null Model)	MaxGrowth $\times$ Light <sup>D</sup> $\times e^{-0.5 \times (\ln(\text{DBH}/X_o)/X_b)^2}$ $\times e^{-C \times \text{NCI}}$	MaxGrowth: maximum potential radial growth (mm) D: shape of the light effect Xb: width of growth peak Xo: DBH at which peak growth occurs C: shape of the crowding effect	<b>Growth is affected size, light, and neighbourhood crowding</b>	174	404	124
2	(MaxGrowth + b $\times$ SNA) $\times$ Light <sup>D</sup> $\times e^{-0.5 \times (\ln(\text{DBH}/X_o)/X_b)^2}$ $\times e^{-C \times \text{NCI}}$	Neighbourhood competition index NCI: $\sum \lambda \times (\text{DBH}^2 / \sqrt{\text{Distance}})$ $\lambda$ : adjusts the competitive effect of each species group b: scales how SNA affects maximum growth	<b>Soil nutrients affect the maximum growth rate</b>	12	54	7
3	MaxGrowth $\times$ Light <sup>D</sup> $\times$ SNA <sup>a</sup> $\times e^{-0.5 \times (\ln(\text{DBH}/X_o)/X_b)^2}$ $\times e^{-C \times \text{NCI}}$	a: changes the extent to which SNA affects the light-growth relationship	<b>Soil nutrients affect the light-growth relationship</b>	119	258	94
4	MaxGrowth $\times$ Light <sup>D</sup> $\times e^{-0.5 \times (\ln(\text{DBH}/X_o)/X_b)^2}$ $\times e^{-C \times \text{NCI} \times \text{SNA}^o}$	o: changes the extent to which SNA affects the crowding-growth relationship	<b>Soil nutrients affect the crowding-growth relationship</b>	29	84	4
5	(MaxGrowth + b $\times$ SNA) $\times$ Light <sup>D</sup> $\times$ SNA <sup>a</sup> $\times e^{-0.5 \times (\ln(\text{DBH}/X_o)/X_b)^2}$ $\times e^{-C \times \text{NCI}}$		<b>Soil nutrients affect the maximum growth rate and the light-growth relationship</b>	14	21	0
6	(MaxGrowth + b $\times$ SNA) $\times$ Light <sup>D</sup> $\times e^{-0.5 \times (\ln(\text{DBH}/X_o)/X_b)^2}$ $\times e^{-C \times \text{NCI} \times \text{SNA}^o}$		<b>Soil nutrients affect the maximum growth rate and the crowding-growth relationship</b>	0	0	1

## RESULTS

- Overall the highest support (lowest  $\Delta AICc$ ) was for model 6 where soil nutrient availability affected the maximum growth rate and the crowding-growth relationship.
- Maximum potential growth rate increased with increasing soil nutrient availability. The strongest increase was seen for spruce and weakest for fir.
- Crowding, a reflection of below-ground competition, had a stronger negative effect on tree growth as soil nutrient availability declined. The predicted growth decrease was especially strong for subalpine fir.
- There was little evidence to support an effect of soil nutrient availability on the light-growth relationship (above-ground competition).



Example stem-plot



Soil nutrient availability classification compared to measured dissolved inorganic and organic nitrogen (5 week in situ incubation; Kranabetter et al. 2007)

## CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Maximum potential growth rates increase and below-ground competitive effects decrease with soil nutrient availability. The magnitude of these effects varies by tree species. Careful matching of tree species composition and abundance by soil nutrient availability can optimize individual tree and stand-level growth.

### LITERATURE CITED

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