Disentangling species mixture effects on individual-tree growth using Swiss National Forest Inventory data

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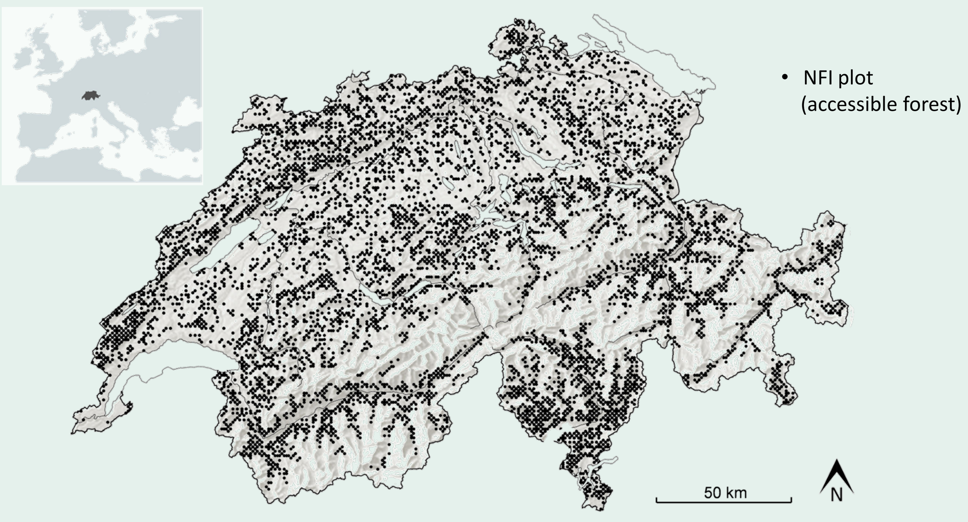
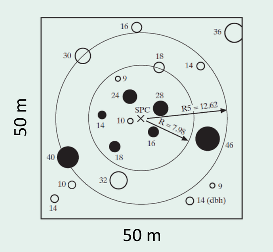
The Project SWISS-SPEMIXMOD

- Quantify the effects of species mixtures on tree growth along Switzerland's environmental gradients
- Prepare the knowledge for the use in forest scenario models for better predicting forest development in response to changes in climate and species composition

National Forest Inventory data



Sample plot



Distributed over a 1.4x1.4 km grid

Sample tree ≥ 12 cm dbh

● Sample tree (dbh)
○ No sample tree (dbh)

Surveys [1]

NFI 1: 1983-85
NFI 2: 1993-95
NFI 3: 2004-06
NFI 4: 2009-17

99 154 BAI values

Modelling method

- Climate-sensitive, species-specific nonlinear mixed-effects models for individual tree basal area increment (BAI) fitted on NFI data [2, 3]
- Site-dependent explanatory variables → temperature, moisture index, stand density, stand development, soil conditions, topography, management and nitrogen deposition

$$BAI = e^{b_1 \times (1-e^{b_2 \times DBH})} \times e^{b_3} + \epsilon \qquad b_3 = \beta_0 + \beta_1 V_1 + \cdots + \beta_i V_i + b_{plot}$$

b_1, b_2, b_3: coefficients to be estimated
ϵ: standard error
β_0: fixed intercept
$V_{1\text{-}i}$: explanatory variables
$\beta_{1\text{-}i}$: model coefficients estimated for the explanatory variables
b_{plot}: random intercept with NFI plots as grouping factor

- Exploration of different approaches for integrating mixing-effects into functions

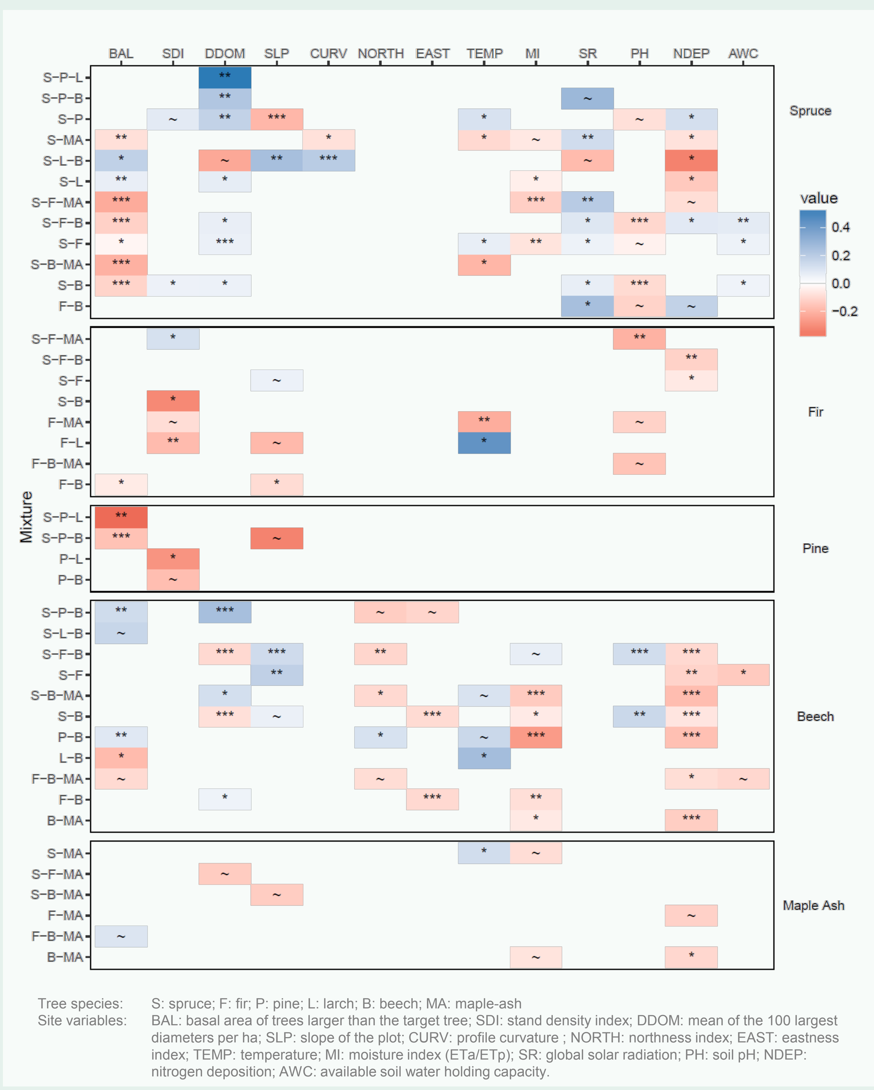
Complementarity is modulated by multiple factors

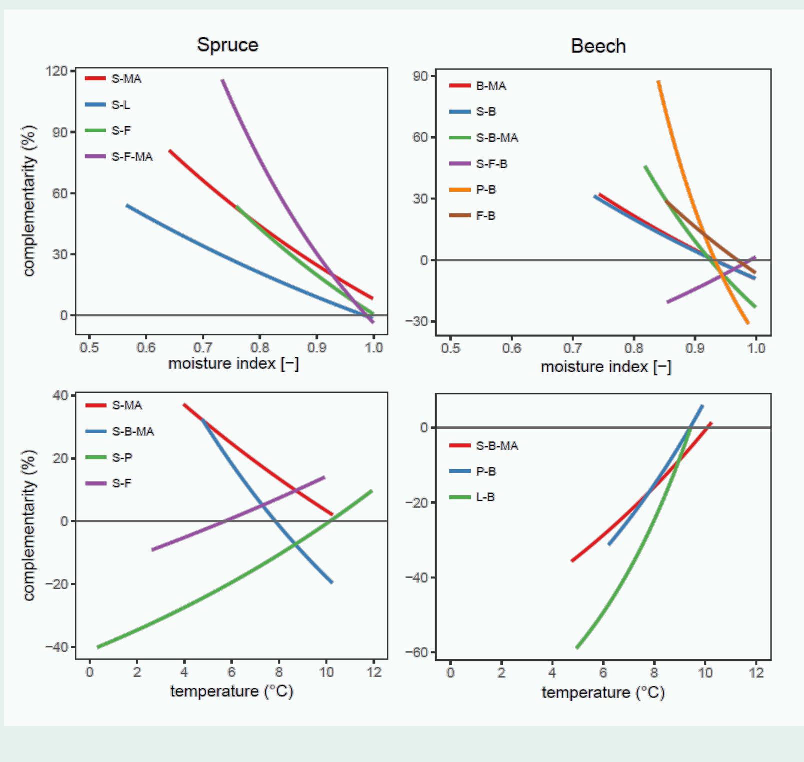
How does individual tree growth complementarity vary with climate, stand properties and site conditions for the main tree species growing in central European forests?

Mixing effects → categorical variables + interactions with site-dependent variables

Complementarity[4] → effect of species mixture on growth (%) $\dfrac{BAI_{MIX} - BAI_{MONO}}{BAI_{MONO}} \times 100$

Estimates of the interactions between site conditions and mixture variables





Complementarity effects vary strongly with climatic, stand, soil and site conditions

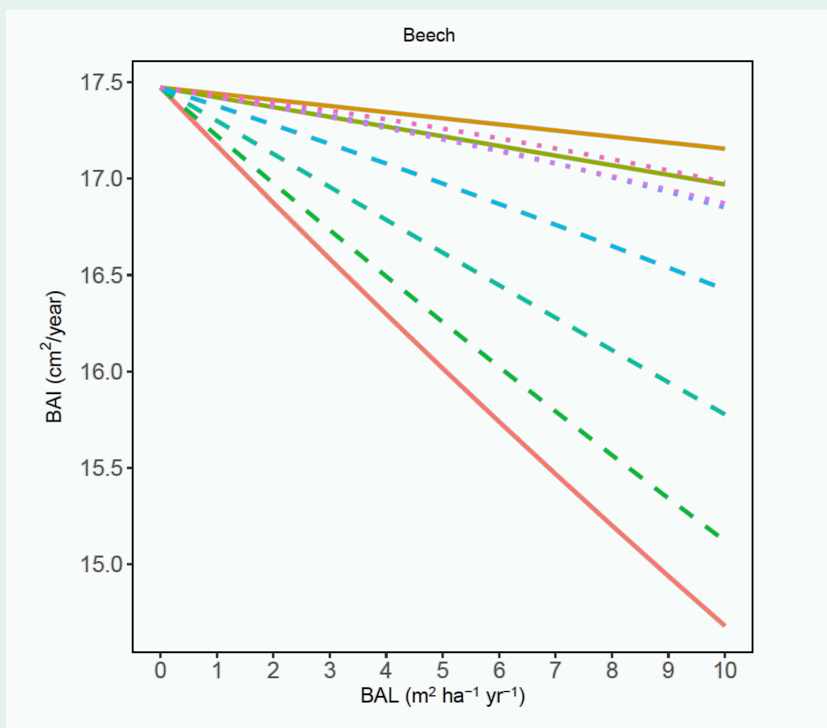
Different or opposite complementarity-resource availability trends depending on species associations

Mina et al. 2017. Multiple factors modulate tree growth complementarity in central European mixed forests. J Ecol.

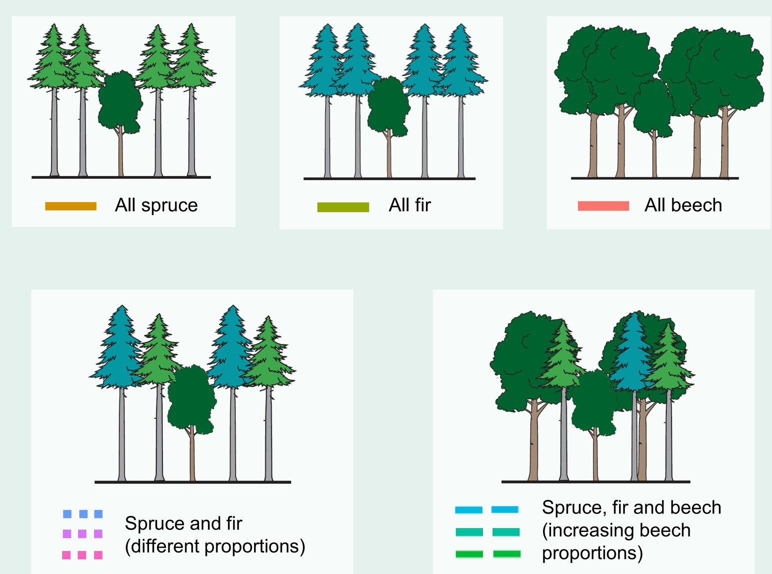
Species interactions can be symmetric and asymmetric

- How to disentangle the different modes of intra- and inter-specific competition and integrate them in individual tree growth models?
- Are species interactions in spruce-fir-beech forests more associated with size-symmetric (belowground) or size-asymmetric (aboveground) competition?

Mixing effects → continuous indices
BA_{SS}: species-specific basal area (size-symmetric)
BAL_{SS}: species-specific basal area of larger trees (size-asymmetric)



Composition of larger competitors



Species-specific indices can be integrated in individual tree models to express the different modes of competition among species in mixed forests

Competitive interactions for spruce and fir are more relevant on the size-symmetric component

Beech is a strong self-competitor for both aboveground and belowground resources and it generally benefits from the admixture with spruce and fir in temperate Central European mixed forests

Mina et al. in prep. The symmetry of competition in Norway spruce, silver fir and European beech mixed forests.

Conclusions

- Mixing effects can be successfully integrated in individual tree growth models but variability due to site-dependent factors, climate, stand conditions and species associations must be taken into account
- The symmetry of competition should be considered when modelling intra- and inter-specific interactions

REFERENCES: [1] Swiss National Forest Inventory. http://www.lfi.ch/. Swiss Federal Institute WSL, Birmensdorf, Switzerland. [2] Thürig et al. 2005. Evaluation of the growth function of an empirical forest scenario model. For Ecol Man 204, 51-66. [3] Rohner et al. in revision. Predicting growth of central European tree species - a modeling approach based on forest inventory data. Eur J For Res. [4] Forrester 2014. The spatial and temporal dynamics of species interactions in mixed-species forests: From pattern to process. For Ecol Man. Drawings of trees modified from Börner, Bellassen and Luyssaert 2010. Forest Management Cartoons. MPI-BGC Germany and LSCE France.

EUMIXFOR Cost Action

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