

REMIX



Resilience of mixed beech- Scots pine forests to climate change

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Context — Numerous recent studies have documented the ecological benefits and values provided by mixed-species stands in temperate forests. However, the effects of these mixtures are expected to change with corresponding changes to environmental conditions and gradients of resource supply.

Objectives — Our main goal was to increase our understanding of the differences in growth, structure and functioning of trees in mixed vs. pure forests using a well replicated study at the European level. In particular, we asked (i) how does productivity of mixed-stands differ from that of pure stands, (ii) how does crown morphology differ in mixed and pure stands, and (iii), to what degree do both (i) and (ii) depend on the site characteristics?

Approach — We studied the growth of Scots pine (*Pinus sylvestris* L.) and European beech (*Fagus sylvatica* L.) in mixed versus pure stands on 32 triplets (pure pine-mixed-pure beech) located along a productivity gradient through Europe, reaching from Sweden to Bulgaria and from Spain to Ukraine. We installed a triplet in the Northern Vosges; we cored 20 dominant trees per plot and species and pooled our data with the rest of the European network. Additionally, we used terrestrial laser scanning (TLS) to obtain high-detail 3-D description of crowns in a subsample of four sites covering the mixture's distribution area (from Spain to Sweden).

Key results —

- A unique network was established consisting of triplets of Scots pine (*Pinus sylvestris* L.) and European beech (*Fagus sylvatica* L.) across Europe. The network consists of 32 triplets, 96 plots, 7555 trees and 4695 core samples. These data contribute to our understanding of mixed stand dynamics.
- In mixture standing volume (+12 %), stand density (+20 %), basal area growth (+12 %), and stand volume growth (+8 %) were higher than the weighted mean of the neighbouring pure stands.
- Our findings confirm that species mixing can stabilize productivity at the community level, whereas there is a neutral or negative effect on stability at the population and individual tree levels.

- Crowns in mixed stands were wider and lower-reaching than those in pure stands. Innovative TLS metrics revealed site effects not captured by traditional metrics.
- There was an overall positive effect of mixing on light absorption.
- Overyielding in mixed stands did not show any relationship with site index and climatic variables.
- However, the magnitude of mixing effect in crown structure differences increased in the two sites with higher productivity and heterogeneity over monocultures increases with water availability.

Main conclusions including key points of discussion — The unique empirical network built has demonstrated the higher stand productivity and forest structural changes in mixtures compared to monocultures. Using a combination of techniques, from classical dendrology to remote sensing and modeling, we have been able to highlight the importance of considering both site conditions and spatial scale when analyzing mixtures. Some of the next necessary steps which will be tackled partially with the project REFORM include considering the effect of forest management, and thinning in particular, in the overall differences between mixtures and monocultures.

Perspectives — The strong European network built during the COST action EuMixFor (and supported financially by the Labex for the French team) has been recently funded through the participation in the ERA-net European project “REFORM” (French team funded by ANR and led by H. Jactel, INRA Bordeaux). In this project we will analyze the combined effect of species diversity, density and drought on growth and on crown characteristics.

Valorisation —

Publications

Barbeito, I., Dassot, M., Bayer, D., Collet, C., et al. 2017. Terrestrial laser scanning reveals differences in crown structure of *Fagus sylvatica* in mixed vs. pure European forests. *Forest Ecology and Management* 405: 385-390.

Heym, M., Ruiz-Peinado, R., del Rio, M., Bielak, M., Forrester, D., Dirnberger, G., Barbeito, I. et al. 2017. EuMIXFOR empirical forest mensuration and ring width data from pure and mixed stands of Scots pine (*Pinus sylvestris* L.) and European beech (*Fagus sylvatica* L.) through Europe. *Annals of Forest Science* 74: 63.

Forrester, D.I., Ammer, C., Anninghofer, P. Barbeito, I. et al. Effects of crown architecture and stand structure on light absorption in mixed and monospecific *Fagus sylvatica* and *Pinus sylvestris* forests along a productivity and climate gradient through Europe. *Journal of Ecology*, 2017.

Forrester, D.I., Ammer, C., Anninghofer, P. , Avdagic, A., Barbeito, I. et al. Predicting the spatial and temporal dynamics of species interactions in *Fagus sylvatica* and *Pinus sylvestris* forests across Europe, *Forest Ecology and Management*, 2017, 405, 112

Del Rio, M., Pretzsch, H., Ruiz-Peinado, R., Ampoorter, E., Anninghofer, P., Barbeito, I. et al. 2016. Species interactions increase the temporal stability of community productivity in *Pinus sylvestris*–*Fagus sylvatica* mixtures across Europe. *Journal of Ecology*

Pretzsch, H., del Rio, M., Schutze, G., Ammer, C., Avdagic, A., Barbeito, I. et al. 2016. Mixing of Scots pine (*Pinus sylvestris* L.) and European beech (*Fagus sylvatica* L.) enhances structural heterogeneity, and the effect increases with water availability. *Forest Ecology and Management* 373/ 149-166.

Pretzsch, H., del Rio, M., Ammer, C., Avdagic, A., Barbeito, I et al. 2015. Growth and yield of mixed versus pure stands of Scots pine (*Pinus sylvestris* L.) and European beech (*Fagus sylvatica* L.) analysed along a productivity gradient through Europe. *European Journal of Forest Research* 134: 927-947.

Presentations

Terrestrial laser scanning reveals higher structural complexity of broadleaved species in mixed European forests. Ignacio Barbeito*, Mathieu Dassot, Leona J. Griebisch, Francois Ningre, Catherine Collet, Patrick Vallet. Presented at Silvilaser 2017, October 10-12, Blacksburg, VA, USA.

La productivité du site influence l'occupation de l'espace des houppiers de Fagus sylvatica entre peuplements purs vs. mélangés le long d'un gradient européen. 6ième édition de l'atelier T-Lidar pour la

communauté francophone. Utilisation de nuage de points à haute densité pour l'écologie forestière. INRA d'Avignon, France - L'Université de Sherbrooke, Québec. 23 – November 2016.

Canopy space filling in Mixed vs. pure stands of European beech and Scots pine. Ignacio Barbeito*, Mathieu Dassot, Catherine Collet, François Ningre. Presented at 10th IUFRO Beech Symposium, September 1-5, 2015. Kastamonu, Turkey.

Croissance et occupation de l'espace par la canopée de hêtre-pin sylvestre en peuplements purs vs. mélangés le long d'un gradient européen. Ignacio Barbeito, Catherine Collet, Mathieu Dassot, François Ningre, Myriam Legay, Alexandre Piboule. Presented at Les forêts mélangées : quel état des connaissances scientifiques? Nogent-sur-Vernisson, 8-9 June 2015.