

PhD position in forest ecology

Title:	The role of wild boar and bryophytes in the network of forest interactions: implications for the coexistence of woody species
Main supervisor:	Philippe Balandier (Team FORHET)
Co-supervisor:	Anders Mårell (Team FONA)
Research unit:	Forest Ecosystem Research Unit (EFNO), Irstea
Graduate school:	549 – Santé, Sciences Biologiques et Chimie du Vivant (SSBCV) de l'Université d'Orléans
Scientific disciplines:	Ecology, Forest sciences
Keywords:	Bryophyte, Competition, Ecological filter, Facilitation, Forest renewal, Regeneration, Mixed forests, Oak, Pine, Wild boar

Abstract

Interest in the study of mixed forest stands is increasing both for managers and scientists because they are often more productive and less vulnerable to uncertainties than pure stands. However, the renewal and maintenance of mixed stands is a major challenge for managers because of the differences in autecology between tree species. To meet this challenge, managers need to understand the mechanisms and parameters that allow the coexistence of species. According to modern theory of species coexistence, coexistence is determined by (i) 'equalizing mechanisms' that reduce the relative difference in fitness between species, and (ii) 'stabilizing mechanisms' that increase the relative importance of intraspecific competition to interspecific competition. This thesis project will explore the coexistence of a pioneer species, Scots pine (*Pinus sylvestris*), and a post-pioneer species, sessile oak (*Quercus petraea*) in temperate lowland forest ecosystems. The objective is to study the different mechanisms that allow the coexistence of these two species by focusing on the unknown role of bryophytes and modulated by the disturbances of wild large ungulates and especially wild boar. In particular, the thesis aims at distinguishing between direct and indirect interactions within the undergrowth community (focusing on the triplet forest regeneration-bryophytes-wild boar) in order to evaluate the magnitude of the negative (competition) and positive (facilitation) interactions. The thesis will focus on two stages of forest renewal processes, germination of seeds and establishment of seedlings of our two target tree species. The thesis project benefits from the OPTMix long-term experimental site (<http://optmix.irstea.fr>), set up in the Orléans State Forest to study mixed sessile oak-Scots pine stands, with a control of wild large ungulates by selective fences.

Projet description

The work proposed in this thesis project contributes to the sustainable management of forests under the influence of climate change. The thesis project is part of the French National Plan for Forest and Wood 2016-2020, the French National Plan for Research, Development and Innovation 2025 of the forest-wood sector as well as the French National Biodiversity Strategy and the National Adaptation Plan to Climate Change in which mixed forest stands appear as a management measure to mitigate the impacts of climate change and for the preservation of biodiversity.

The interest in the study of mixed forest stands is growing among managers and scientists because they are considered to be more productive and less vulnerable to hazards than pure stands. However, renewing and maintaining mixed stands is a major challenge for forest managers. In general, the difficulty lies in creating and maintaining an appropriate environment (**environmental filter**) for all target tree species and preventing one species to become dominant over the others through the competition for resources (example of **competition by exploitation**), the increase of species specific pests (example of **apparent competition**) or the release of allelopathic substances (example of **competition by interference**).

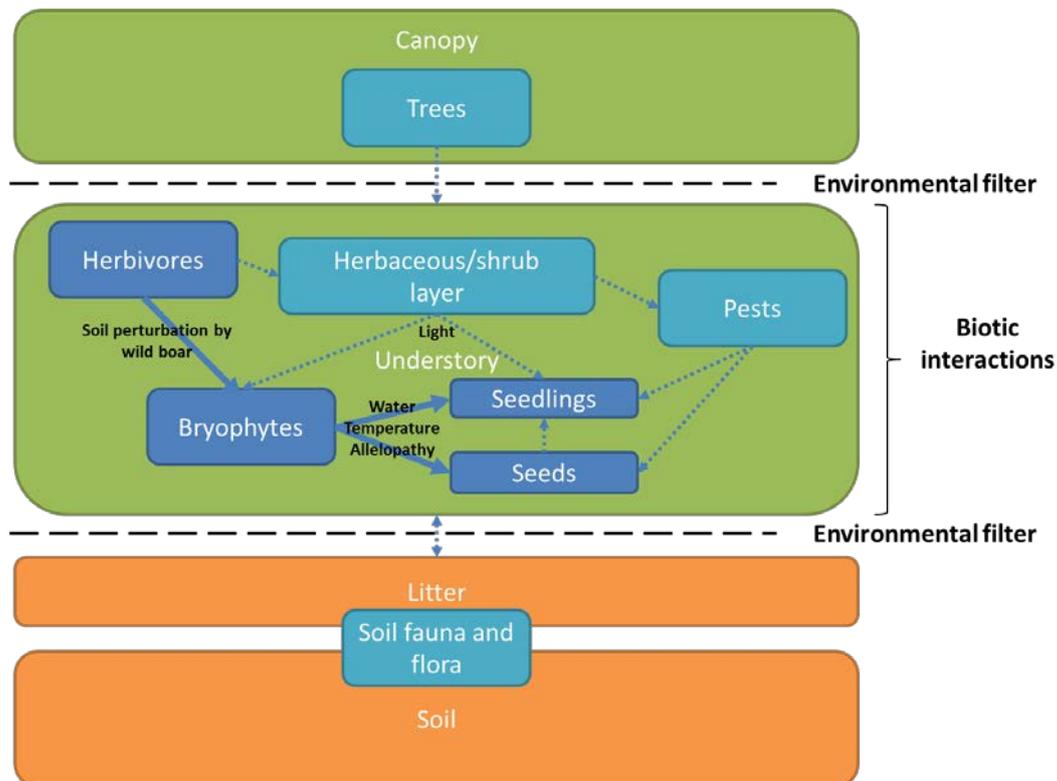


Figure 1. Conceptual scheme of the undergrowth community studied by the thesis project. We consider the abiotic environment constrained by the stationary conditions of the soil and the tree stand as external environmental filters to the study system. The experimental part of the thesis will focus on the role of bryophytes (solid arrows) for seed germination (part 1) and establishment of young seedlings (part 2) through the modification and sharing resources such as water and light (competition by exploitation or direct facilitation). The thesis will also study the direct effect of wild boar soil disturbance on the abundance and composition of bryophyte communities (part 3, solid line) and its indirect effect on seed germination and seedling establishment (indirect facilitation). The other biotic interactions (dashed arrows) of the study system will be taken into account in a modeling approach (part 4).

Objective of the thesis

The thesis project aims from a fundamental point of view to deepen our knowledge on the role of bryophytes and wild boar in the dynamics of temperate forest ecosystems, particularly in the context of the renewal of mixed forests. In particular, are bryophytes competitors or facilitators in relation to the coexistence of woody species? How does wild boar soil disturbance change the patterns of interactions between bryophytes and tree seedlings?

From an applied point of view, the thesis aims at studying the constraints related to the renewal of mixed forest. In particular, what are the abiotic and biotic conditions that favor the establishment of a regeneration composed of several species?

Material and methods

The thesis will rely on the OPTMix (Oak Pine Tree Mixture, <http://optmix.irstea.fr>) experimental research facility installed 5 years ago in the forest of Orleans by Irstea (UR EFNO). This experimental facility comprises 33 plots corresponding to three repetitions with a cross-factorial design combining stand composition (mixture vs. monospecific), stand density (low vs. medium) and presence/absence of large wild ungulates (Korboulewsky et al., 2015).

The thesis project is divided into four parts. The first part consists of studying the effect of bryophytes on the germination of oak and pine seeds, based on controlled pot experiments. The second part aims to study the effect of bryophytes on the establishment of young pine and oak seedlings. The student will use a trait-functional approach to differentiate the mechanisms by which bryophytes influence seed germination and seedling establishment. Part 3 focuses on the effects of wild boar disturbance on the abundance and species composition of the muscular field layer. Parts 2 and 3 will be carried out *in situ* on the OPTMix experimental research facility. Finally, part 4 will mobilize the measurements from the first three components, previous studies and the bibliography, in order to model the interactions among species. This model will make it possible to draw conclusions about the possibility of the coexistence of the two woody species (oak and pine) within a forest stand by explicitly integrating the role of bryophytes and the disturbance by a large ungulate, wild boar.

Candidate profile

The candidate should possess a Master 2 thesis or equivalent in ecology, with a particular interest in forest ecology and networks of ecological interactions. Ideally, we are looking for a candidate with a mixed profile with competences both in community ecology and ecological modeling.

Working environment

The thesis will be carried out at Irstea Nogent-sur-Vernisson (Loiret) in the Research Unit EFNO (Forest Ecosystems). The student will be part of the scientific community working on the OPTMix experimental research facility and will benefit from internal collaborations with colleagues with complementary skills including bryophyte ecology, functional biodiversity, effects of wild ungulates on forest regeneration, forest dynamics, and modeling of coexistence within communities.

More information

- **MÅRELL Anders** (Co-supervisor) – team leader FONA anders.marell@irstea.fr - 02 38 95 04 53
- **BALANDIER Philippe** (Main supervisor) – team leader FORHET philippe.balandier@irstea.fr – 02 38 95 03 51

References

- Allesina, S., Si, T., 2012. Stability criteria for complex ecosystems. *Nature* 483, 205.
- Balandier P., Collet C., Miller J.H., Reynolds P.E., Zedacker S.M., 2006. Designing forest vegetation management strategies based on the mechanisms and dynamics of crop tree competition by neighbouring vegetation. *Forestry* 79, 3-27.
- Barbier, S., Gosselin, F., Balandier, P., 2008. Influence of tree species on understory vegetation diversity and mechanisms involved--A critical review for temperate and boreal forests. *For Ecol Manag* 254, 1-15.
- Barrios-Garcia, M.N., Ballari, S., 2012. Impact of wild boar (*Sus scrofa*) in its introduced and native range: a review. *Biol Invasions* 14, 2283-2300.
- Chesson, P., 2000. Mechanisms of maintenance of species diversity. *Annual Review of Ecology and Systematics*, 31, 343-366.
- During, H.J., Tooren, B.F.V., 1990. Bryophyte interactions with other plants. *Bot J Linn Soc* 104, 79-98.
- Gaudio, N., Balandier, P., Perret, S., Ginisty, C., 2011a. Growth of understorey Scots pine (*Pinus sylvestris* L.) saplings in response to light in mixed temperate forest. *Forestry* 84, 187-195.
- Gosselin, M., Fourcin, D., Dumas, Y., Goselin, F., Korboulewsky, N., Toïgo, M., Vallet, P., 2017. Influence of forest tree species composition on bryophytic diversity in mixed and pure pine (*Pinus sylvestris* L.) and oak (*Quercus petraea* (Matt.) Liebl.) stands. *Forest Ecology and Management* 406:318-329.
- HilleRisLambers, J., Adler, P.B., Harpole, W.S., Levine, J.M., Mayfield, M.M., 2012. Rethinking Community Assembly through the Lens of Coexistence Theory. In: Futuyma DJ ed. *Annual Review of Ecology, Evolution, and Systematics* 43, 227-248.
- Korboulewsky, N., Pérot, T., Balandier, P., Ballon, P., Barrier, R., Boscardin, Y., Emmanuelle, D.-R., Dumas, Y., Ginisty, C., Gosselin, M., Hamard, J.-P., Laurent, L., Mårell, A., NDiaye, A., Perret, S., Rocquencourt, A., Seigner, V., Vallet, P., 2015. OPTMix: Dispositif expérimental de suivi à long terme du fonctionnement de la forêt mélangée. *Rendez-vous techniques* 47, 60-70.
- Kraft, N.J.B., Adler, P.B., Godoy, O., James, E.C., Fuller, S., Levine, J.M., 2015. Community assembly, coexistence and the environmental filtering metaphor. *Funct Ecol* 29, 592-599.
- Laurent, L., Mårell, A., Korboulewsky, N., Saïd, S., Balandier, P., 2017. How does disturbance affect the intensity and importance of plant competition along resource gradients? *For Ecol Manag* 391, 239-245. doi:<http://dx.doi.org/10.1016/j.foreco.2017.02.003>
- Lett, S., Nilsson, M.-C., Wardle, D.A., Dorrepaal, E., 2017. Bryophyte traits explain climate-warming effects on tree seedling establishment. *J Ecol* 105, 496-506. doi:10.1111/1365-2745.12688
- Marialigeti, S., Nemeth, B., Tinya, F., Odor, P., 2009. The effects of stand structure on ground-floor bryophyte assemblages in temperate mixed forests. *Biodiversity and Conservation* 18, 2223-2241.
- Soudzilovskaia, N.A., Graae, B.J., Douma, J.C., Grau, O., Milbau, A., Shevtsova, A., Wolters, L., Cornelissen, J.H.C., 2011. How do bryophytes govern generative recruitment of vascular plants? *New Phytol* 190, 1019-1031. doi:10.1111/j.1469-8137.2011.03644.x
- Weiher, E., Freund, D., Bunton, T., Stefanski, A., Lee, T., Bentivenga, S., 2011. Advances, challenges and a developing synthesis of ecological community assembly theory. *Philosophical Transactions of the Royal Society B-Biological Sciences* 366, 2403-2413.