PhD OFFER 2017 – University of Bordeaux – INRA Biogeco

Assessing ecological and economic consequences of species turnover in French forests / Evaluation écologique et économique des changements d'espèces forestières dans la forêt française

Advisors and working team

Advisors: Marta Benito Garzón. E-mail: marta.benito-garzon@inra.fr.
Annabel Porté E-mail : annabel.porte@u-bordeaux.fr
Place of work: UMR INRA 1202 Biogeco – University of Bordeaux, Pessac, France
Collaborations: Luc Doyen and Laurianne Mouysset – UMR CNRS 5113 Gretha, Pessac
Fabienne Benest – IGN, Division Inventaire Forestier, Caupian, Saint-Médard-en-Jalles, France.

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I- General framework

There is a broad consensus that modern climate change is having important effects on species distributions. However, there are contrasting opinions on how ecosystems will be reshuffled by a changing climate and how to design management practices that can mitigate its negative impacts if any (Pereira *et al.*, 2010; Donoghue & Edwards, 2014). The southernmost populations of temperate tree species in Western Europe are predicted to experience increasing mortality, reduced growth and reproductive rates under future warming, indicating that these species are likely to contract their current distribution in the coming decades and to leave empty spaces available for other species (Brodribb & Hill, 1999; Benito-Garzón *et al.*, 2013a). At the same time, Mediterranean species are expanding northwards as a consequence of climate change (Parmesan, 2006; Delzon *et al.*, 2013), with increasing dominance of broadleaf species following land use changes, in detriment of conifer trees more resistant to drought (Vayreda *et al.*, 2016).

The forecasted changes in species distributions and community composition would have important economic and societal consequences (Millar *et al.*, 2007; Hoegh-Guldberg *et al.*, 2008). If species composition was to change in the future, the future of those trees commercially relevant needs to be revisited. The management options considering the translocation of biological material to compensate for climate change are generally enclosed in the term assisted migration (Hoegh-Guldberg *et al.*, 2008; Schwartz *et al.*, 2012). This term encompasses different options that would lead to different climate-related risks and need to be considered separately. In forestry, assisted gene flow has been the most studied option (Aitken & Bemmels, 2016). In Europe, examples of translocation of populations do exit for commercial species (Benito-Garzón *et al.*, 2013b; Isaac-Renton *et al.*, 2014; Benito-Garzón & Fernandez-Manjarrés, 2015), but no attention has been paid to other species that will help to maintain ecosystems services in the future.

France, and the Nouvelle - Aquitaine region in particular, constitutes the ecotone between the temperate and Mediterranean biomes, and observations that Mediterranean trees like *Quercus suber* and *Quercus ilex* and submediterranean ones like *Quercus pubescens* are conquering northern areas do exist (Delzon *et al.*, 2013; Benest, 2015). If climate is favoring Mediterranean species or invasive ones in detrimental of more temperate species, ecosystem services and local economies would need to adapt.

Analyzing time series of species turnover in terms of abundance and individual tree growth over the last 35 years will give us the necessary information to relate the likely species turnover with changes in recent climate and help us to understand the main trends of forests composition in France for the coming years. The final goal of this PhD program is to understand tree turnover in the past to aid decision-making in forest adaptation by generating plausible bio-economic scenarios where the trade-off between maximizing economic return of forests and favoring other forest services is considered (Ay *et al.*, 2014). In particular, these scenarios can help understanding the ecological and economic benefits and drawbacks of changing species composition in those locations where the expected mortality of temperate tree species is high and the natural colonization of Mediterranean tree species is unlikely or too slow.

I- Objectives

The main goal of this PhD is to understand the temporal and spatial distribution of species and communities in France with a particular emphasis on the Nouvelle-Aquitaine region and the economic consequences of changing species (naturally or human-mediated – assisted species migration).

The PhD program is divided in three main research tasks:

1) Analysis of temporal series of species turnover (1980 -2015)

The ambition of this task is to understand tree community assembly in the past and anticipate the ecological communities of the future based in the relation between climate and competition of trees in the last 35 years. For doing so, this task will analyze historical changes of species composition taking advantage of ancient National Forest Inventory data collected in France covering a window time of 35 years (1980 to 2015). It will be developed in close collaboration with the IGN (National Forest Inventory Division; Bordeaux: Fabienne Benest).

The student will perform a combined analysis of ordination techniques of community composition across spatial and temporal gradients (coenoclines) in combination with the niche breadth across time and space of each species across all the Nouvelle-Aquitaine region. Similar approaches have been proposed for analyzing spatial turnover of the species along environmental gradients (Urli *et al.*, 2014; Olthoff *et al.*, 2016). The methodological innovation relies on the analysis of the temporal niche of species using coenoclines based on abundance and fitness-related traits (growth, survival, tree diameter, and tree height) of species co-existing over time.

We expect to analyze the abundance and growth of 14 major trees in France (*Abies alba, Fraxinus excelsior, Fagus sylvatica, Larix decidua, Picea abies, Pinus halepensis, Pinus pinea, Pinus pinaster, Pinus sylvestris, Quercus petraea, Quercus robur, Quercus pubescens, Quercus ilex* and *Quercus suber*) from 1980 to 2015 across all the French National Forest Inventories plots sampled, with particular attention at the ecotone between Mediterranean and Temperate forests.

2) Exotic and invasive species assessment

One increasing debate on global biodiversity is taking place around the invasive species and whether climate change would boost or not their range expansions. Expected new climates with no-analogs in the past will likely promote new communities assemblages for all the biomes of the world (Benito-Garzón *et al.*, 2014). However, whether climate change is promoting the spread of invasive species in these new biological communities remains an open question (Willis *et al.*, 2010).

Several exotic species are increasing their presence in France and in particular in the Nouvelle-Aquitaine region, where signs of mediterraneization have being observed. For example *Quercus rubra* L., *Robinia pseudoacacia* L., *Prunus serotina* Ehrh., and *Acer negundo* L are species well represented in the Nouvelle-Aquitaine region and in France, and that are expected to increase invasion niches in some parts of their range (Camenen *et al.*, 2016).

In this task the student will study time invasion rates over the last 35 years based on the NFI plots of the most important tree exotic species existing in France: *Quercus rubra*, *Robinia pseudoacacia*, *Prunus serotina*, *Acer negundo*, and *Ailanthus altissima*.

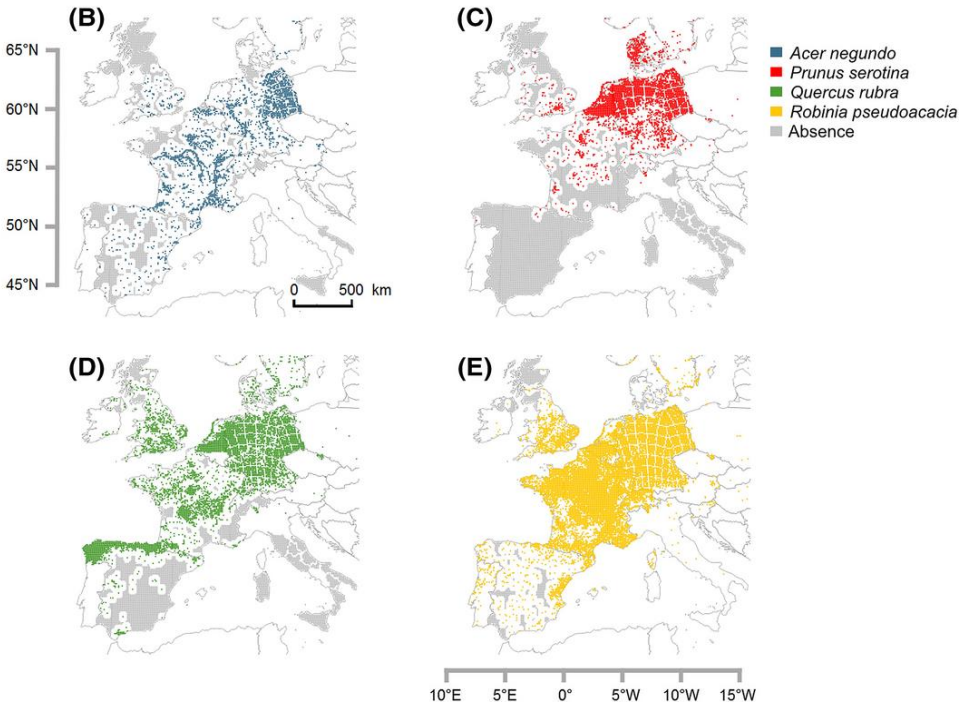

Figure 2. Current distribution of *Acer negundo* (B), *Prunus serotina* (C), *Quercus rubra* (D) and *Robinia pseudoacacia* (E) in Europe (from Camenen et al. 2016).

3) Evaluation of the socio-economic consequences of changing species composition

Adapting forests to climate change requires a decision framework in which a major set of parameters depends on the species, populations, seed resources, land use, etc. (Guo & Costello, 2013). In particular, the economic consequences of tree translocation rely on the choice of target species and populations and on the ecosystem services that are attended (production of timber and non-timber products, recreational and cultural value, etc.). Translocation options are based however on the comparison between local versus foreign origins of seed sources of economically important trees, but not on considering a local species turnover towards less productive trees in terms of timber production. For example, Temperate species are more productive than Mediterranean ones but they might also underlie a higher extinction risk from climate change, at least at the ecotone between Mediterranean and Temperate biomes. Adapting forests to the future might hence seek for a compromise between maximizing both ecosystem productivity and ecosystem resistance.

Understanding the ecological and economic consequences of changing tree species composition is urgent to propose innovative management options to optimize forests to future climate change. We propose to quantitatively evaluate these changes in species composition by the generation of bio-economic scenarios that link the choice of species and/or populations with the economic utility of a given region. The analysis will be based on what happened in French forests during the last 35 years, to finally assess a trade-off between economic and ecological values for the future. Econometric models will be manipulated with scenarios of climate change and changes in tree growth to predict the potential consequences of climate change on the economic returns of forests (Ay et al., 2014; Mouysset, 2014) and to infer costs and benefits of changing species composition.

This task will be developed in collaboration with the GRETHA group for Theoretical and Applied economics (University of Bordeaux; Luc Doyen and Lauriane Mouysset)

II- Working program

This is multidisciplinary research program, that will accomplish three different tasks for which the student will need to collaborate with ecophysiologists, economists and integrate the results in an ambitious modeling framework with a final focus to give educate responses to optimize forests health under climate change.

III- Databases

The basis of this PhD program is to give a multidisciplinary understanding of forests coupling large databases. For doing so, several databases regarding forests, land use and economics will be used:

1) **French National Forest Inventory:** Ancient (1980 and 1990 campaigns) and new (yearly campaigns from 2005 to 2015) National Forest Inventory campaigns covering all the French territory from 1960 to 2015. 1990 campaign has already been homogenized to match with the new methodology used by the NFI in the newly campaigns. Some work on the harmonization of the data from 1980 is expected to be done during this PhD program.
2) **Climate Data:** Downscaled CRU yearly data from 1900 to 2014; IPCC climate grid data for future scenarios
3) **AGRESTE – TERUTI – LUCAS:** Land Use/Cover Area frame statistical survey. In 2014, the French Ministry of Agriculture coupled the TERUTI and LUCAS databases to annually estimate variation in land uses: agricultural, natural or urban.

IV- Supervision and place of work

This PhD is co-funded by the Idex Junior Chair of the University of Bordeaux and the Aquitaine Region. The PhD will be developed at the University of Bordeaux (INRA – BIOGECO. Advisors: Marta Benito Garzón and Annabel Porté, both researchers at INRA BIOGECO), with strong collaborations with the GRETHA (Theoretical and Applied Economics group; CNRS – University of Bordeaux. Luc Doyen, researcher at CNRS) and the IGN (National Forest Inventory, Caupian. Head of the NFI – Ecology division: Fabienne Benest).

V- Required profile

- Good skills in data analysis, statistics and spatial analysis
- Good knowledge of R
- Experience in the management of large databases
- Knowledge of community ecology / spatial ecology
- Capacity to work in a multidisciplinary and international team
- Basic knowledge of French
- Good knowledge of English

VI- References

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