PROJECT INFORMATION

Project title:	**Forests under stress: understanding how species interact and adjust to climate change**
Project ID:	134
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PROJECT DESCRIPTION

Research background

Droughts are expected to set in more rapidly, last longer and be more intense with global warming (Trenberth et al., 2014). Because of rising concern associated with the recent drought-induced reductions in forest growth and survival (e.g. Allen et al., 2015), mitigation processes buffering the vulnerability of forests to drought has become a major research frontier in ecology and ecophysiology (e.g. Limousin et al., 2013; Grossiord et al., 2017a). Yet, while knowledge on fine-grained physiological responses to drought is continuously progressing and contributing to improved predictions (e.g. McDowell et al., 2013), the vast majority of empirical studies and climate-vegetation models do not account for community-level processes that could mediate drought impacts on trees.

Over the last three decades, findings in community ecology have led to the widespread agreement that species diversity plays a critical role in plant performance (Hooper et al., 2005), including reducing their susceptibility to drought (Isbell et al., 2015). Forests represent some of the richest biological areas on Earth, with more than two thirds being “mixed” ecosystems (i.e., where at least two tree species interact in a given forest community). As such, one might also expect tree species diversity to be a critical factor shaping drought impacts on forests and to become increasingly significant with the exacerbation of drought events in the future. However, despite extensive evidence of the importance of tree species diversity for

multiple forest ecosystem functions (e.g. Jactel & Brockerhoff, 2007; Morin et al., 2011), the role of tree species diversity on forest responses to drought has been excluded from earlier research.

Aims and Objectives

The aim of this project is to use large-scale observations derived from the ICP-Forests data to detect how tree species interactions and tree species diversity modify drought impacts in forests. More specifically, we plan to:

1. Use a water balance model to estimate drought stress conditions over the last 30 years across Europe at a fine precision scale.

2. Derive the growth responses and crown conditions of trees from ICP-Forest Lv. I and II plot data across European forests during years characterized by severe droughts and/or heat waves.

3. Determine how tree species composition, tree species diversity and edaphic conditions interact and alter the physiological responses of trees to warming and drought.

Significance and Innovation

1. This work will be the first observational study to generate a large-scale analysis of the role of tree species diversity on drought impacts in forests.

2. This approach will reconcile previous work on species interaction effects usually conducted at the ecosystem-scale and enable us to build a new conceptual framework of tree species diversity effects during climate extremes.

3. This work will provide site-specific predictors of tree diversity effects on drought and warming resistance for management recommendations.

Methodology Description

The overall workflow can be described in the following major steps:

- **Compiling climate and edaphic data from two large European databases and estimating drought conditions across Europe over the last 30 years using a forest water balance model.** We will extract daily climate data from the Agri4Cast (http://mars.jrc.ec.europa.eu/mars) and Eusoils (www.eusoils.jrc.ec.europe.eu) databases and estimate daily soil drought conditions using the BILJOU Model (Granier et al., 1999).
- **Deriving tree physiology, biodiversity and edaphic measures from ICP-Forests Lv. I and II plot data.** The physiological measures include the visual assessment of crown condition (Lv. I and II), the growth and yield (Lv. II), the tree vitality (Lv. II) and the phenological observations (Lv. II). The biodiversity measures will enable us to plot-level diversity (species richness, Shannon index), structural diversity (LAI, DBH and height) and functional diversity (e.g. leaf nitrogen). The edaphic measures will be used to characterize plot-level soil characteristics.
- **Analyze the inter-link between biodiversity and edaphic measures, and tree physiological responses to drought and warming.** Using statistical approaches, we will determine how across European forests tree species diversity modulates drought impacts on tree, and how edaphic conditions interact with tree diversity to alter these impacts.

Justification for requesting Lv. I and II plot data

To analyze the impact of tree diversity drought impacts in forests, we would like to request the Lv. I and II plot data from ICP-Forests for the following reasons:

1. The ICP-Forests is a comprehensive forest-monitoring network distributed across all major forest types in Europe. Therefore the high representativeness of the ICP-Forests plots satisfies our need for a large-scale assessment of tree diversity effects.

2. The size of Lv I, but also Lv II plots are ideal for comparing with the outputs from the forest water balance model.

3. As we require tree physiological data and ground vegetation data such as species composition/abundance, tree characteristics such as DBH/tree height and edaphic

parameters, the ICP-Forest plots, particularly the Lv. II plots are ideal for our objectives.

Expected outcomes

- In-depth and large-scale understanding of the role of tree species diversity and forest composition on drought impacts.
- New tree species diversity framework for future empirical studies and model implementations.
- Predictors of drought impacts in European forests for future climate-smart managements practices.

Research background of the PI and other supports to this project

The PI, Dr. C Grossiord, is a specialist in characterizing tree acclimation to warming and drought conditions and assessing the role of species interactions on forest ecosystem functioning. Her previous projects include (i) field-based experiments to measure ranges of acclimation responses to long-term drying and warming (e.g. Grossiord et al., 2017a, b, c), (ii) field-based and global analyses of the role of species interactions of forest drought resistance (e.g. Grossiord et al., 2013, 2014a, b), and (iii) continental-scale forest water balance modeling (Grossiord et al., 2014b). Overall, the applicant expertise spans on a broad range of experimental approaches, measurement techniques and modeling methods that will be particularly useful in this project. Besides, this research will be conducted as part of a Swiss-funded project (Ambizione Career Grant, Swiss National Science Foundation) in close collaboration with lead scientists in ecosystem ecology and climate change science, such as Dr. A. Gessler, Dr. M. Schaub, Dr. A. Rigling (WSL, Switzerland), Dr. N. McDowell (PNNL, USA), Dr. X. Morin (CNRS, France) and Dr. D. Bonal (INRA, France). This will ensure Grossiord & colleagues deliver expected outcomes within the timeframe of this project.

Timeline (beginning and end of the project): Jul 2018 – Feb 2021

Year	Months	Activity
2018	Jul-Dec	Compiling the daily climate and soil data from Agri4Cast and Eusoils databases.
2019	Jan-Jun	Obtaining drought estimation across Europe using the forest water balance model.
2019	Jul-Dec	Compiling the ICP-Forests plot data (physiology, biodiversity, edaphic conditions) for selected drought years.
2020	Jan-Jul	Statistical analyses
2020	Apr	Presentation of the first results at the Annual meeting of the European Geosciences Union (EGU)
2020	Aug	Presentation of the first results at the Annual meeting of the Ecological Society of America (ESA)
2020	Sep-Dec	Preparing manuscripts
2021	Jan-Feb	Submitting manuscripts

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