Project Database of ICP Forests
PROJECT DESCRIPTION

PROJECT INFORMATION

Project title:	**The role of soils in the vulnerability of Mediterranean forest to extreme droughts**
Project ID:	206
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Rationale

Over the next decades, European forests will be increasingly threatened by multiple dependent stressors such as drought, heat [1, 2], and new environmental conditions due to interacting natural and anthropogenic disturbances e.g., wind throw, insect outbreaks, fires and management [3, 4, 5, 6, 7, 8]. These unprecedented conditions [9], will make future forest management challenging [10, 11, 12, 13]. In fact, the increasing number of documented episodes of forest die-off associated with more frequent and increasingly severe droughts [2], suggests that many forest species worldwide are already challenged and unable to keep up with the rapid and severe abiotic changes.

These tendencies are particularly acute in the Mediterranean basin where the increasing intensity of droughts over the last decades has caused unprecedented rates of defoliation and mortality [14]. In the Mediterranean basin even tree species historically adapted to drought and widely distributed in the Mediterranean basin, such as holm oak (Quercus ilex L.) and cork oak (Quercus suber L.) or the black pine (Pinus nigra Arnold) are evidencing signs of vulnerability to climate change [16, 17, 18]. Hence, although these species are considered well adapted to drought conditions, reports on drought-related defoliation and mortality rates have increased in the Peninsula in recent decades (e.g. [14, 15]. Understanding the ecological and eco-physiological mechanisms that explain the vulnerability of these species is a first step towards designing management practices aiming to e.g. restore ecosystems or improve species adaptation under increasingly harsh climatic conditions.

Studies have mainly focused on plant physiological failures (e.g. [5,6]) and plant competition c (e.g., plant-plant resource competition [7]) as the ultimate causes of tree vigor loss and mortality in scenarios of climate-change (e.g. extreme droughts). However, a more holistic vision is needed to decipher the ecological mechanisms that allow for perturbation absorption and ecological stability. One of the current knowledge gaps in this regard is the role of soil (or the lack of it) as a potential factor that influences the sensitivity of trees to defoliation and death. Although soils are key to the overall ecosystem functioning as they regulate the supply of water and nutrients pools needed for primary production, very few studies could be found that link soil parameters to ecosystem health. In this context, a recent database analyses in US has highlighted the importance of taking soil properties into account to understand forest functioning and C uptake [19].

Hence, it is timely to deepen the role of soil as main providers of water and nutrients to plants. Understanding the role of soils as major controls of ecosystem health is important to

detect potential sources of forest vulnerability in the face of ongoing climatic changes. This knowledge is further important to develop new management strategies aimed at improving the adaptation of these emblematic and widely distributed species to warmer and drier conditions.

Objectives and hypotheses

We propose to investigate the historical trends of defoliation of emblematic Mediterranean forest species (e.g. Holm-oak, Cork-oak, Black pine) as a function of the trends in climate, past management and soil conditions. Our hypothesis is that the response to climate of these species is substantially determined by both local soil conditions and past management. Given that under a wide range of future climate scenarios water and nutrients will become the most limiting factors for forest survival in Europe, it is timely to test **the hypothesis that soil properties contribute to forest stability by shaping the physicochemical conditions of the edaphic matrix that enable water and nutrients uptake by plants.** Ultimately, we expect to gain important knowledge on how soils may improve the capacity of key Mediterranean tree species to withstand drought and hence, to adapt to climate change.

Methods

In our study, we will test how the Mediterranean forest vulnerability to climate extremes, (i.e. drought events) is explained by edaphic conditions, management and topography. Our case study will be geographically focused on the Iberian Peninsula/Spain and will consider three of the most dominant tree species: holm oak, cork oak and black pine. The extreme summer drought conditions to which Mediterranean ecosystems are subjected, accentuated by climate change in recent decades, make this bioclimatic zone a huge laboratory where to test the edaphic thresholds responsible for maintaining the functioning and health of our forests.

In order to track forest sensitivity and vulnerability to climate variability, we will use ICP time series of defoliation and mortality for the species of interest as well as satellite NDVI time series (code MOD13Q1), as these allow for an independent detection of forest decline (based on photosynthetic activity patterns) within the plots of interest. We will then obtain two independent measures of the historical stand performance (ICP defoliation and NDVI). We will then define thresholds of forest vulnerability to drought based on these historical trends and climatic factors (e.g. annual precipitation, SPEI) and resilience to extreme drought events following [15]. Variability on these historical trends and resilience to extreme droughts will then be explained using soil characteristics, climatic variables and land use using advanced regression methods.

Data of soil physicochemical characterization within the plots of interest will be obtained from ICP soil condition database. We expect to find strong signals of parameters such as texture or soil nutritional status

Climate variability will be incorporated to the analyses by means of two different databases. Temperature and precipitation time series will be obtained from the Spain02 v5 dataset (ref: https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/joc.4391) while climate extremes will be identify through the drought indices dataset for Spain (ref: https://www.mdpi.com/2306-5729/2/3/22/).

Finally, raster information on land use and topography for the plots of interest will be obtained from the SIOSE Database on land use in Spain and the Terrain and Slope Digital Model products provided by the National Center for Geographic Information of Spain (IGN; https://centrodedescargas.cnig.es/CentroDescargas/locale?request_locale=en).

Further data involved in the evaluations

This study will be further coupled also to parallel experiments and field monitoring activities in the framework of several projects lead by the PI of this project, Jorge Curiel Yuste (e.g. see Garcia Angulo et al. 2020)

- Vulnerability to Climate Change of Holm-oak forest: mechanisms and influence of management on ecosystem services, (VERONICA) CGL2013-42271-P
- El papel de las interacciones planta-microbiota en la resiliencia y colapso ante el Cambio climatico de encinares mediterraneos (IBERYCA) CGL2017-84723-P

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