Assessing the potential of European forests for climate change mitigation and biodiversity conservation

Outline:

Biodiversity conservation and climate change mitigation are globally considered the main targets of current environmental policies (European Commission 2021); and are now widely recognized as tightly interconnected (Pörtner et al 2021) as biodiversity is affected by climate change while contributing to its mitigation given its role in ecosystem functioning (Díaz et al. 2019)

Forests are of primary relevance for both these major environmental challenges. They host three-quarters of known terrestrial plant, fungi and animal species need forests as a part of their habitat (FAO & UN, 2020) and sink huge amounts of carbon from the atmosphere, with two-thirds of the global forest net sink was in temperate (47%) and boreal (21%) between 2001 and 2019 (Harris et al. 2021).

An in-depth knowledge of the relationships between biodiversity conservation and climate change mitigation is urgently needed to effectively design management strategies for European forests. Several studies tried to link forest biodiversity with one or multiple ecosystem functions (Ratcliffe et al. 2017) but mostly accounted only for tree diversity (Baeten et al. 2013); whereas, it is now widely accepted that forest biodiversity should encompass multiple taxonomic groups (Burrascano et al. 2018). Many studies addressing the biodiversity and ecosystem function topic in forests do not provide sound results since functions are vaguely defined and forest dynamics is not accounted for, as it was highlighted for instance for biodiversity/productivity relationship in a recent review (Sheil 2020). The use of a broad dataset that include information on field-sampled forest structure and management as well as on multi-taxon biodiversity would allow to overcome these limits and relate properly forest biodiversity and their function.

Forest carbon stocks are both indicators of forest developmental stage and of their role in storing carbon with positive outcomes for climate change mitigation.

Aim

The present project aims to assess the relationship between forest multi-taxon biodiversity and carbon stocks at the European scale, while accounting for the effect of different management strategies ranging from clearcut to conservation-oriented silviculture.

Ultimately, we aim at reconciling conservation and climate mitigation goals by informing conservation and forest management policies and actions on their outcomes for the two most relevant environmental changes of our times.

The specific aims are:

1. Assess the spatial variation of forest carbon stocks, multi-taxon diversity and their relationships at the continental scale.

We will use multi-taxon biodiversity data deriving from the harmonization of different datasets in Bottoms-Up database. Structural data will be elaborated for the assessment of deadwood and living biomass carbon pools. This information will be associated with high-resolution geospatial data related to soil carbon pool (FAO 2020).

The relationships between carbon stocks and the diversity of the joint and individual diversity of multiple taxonomic groups, will be modelled through GLMMs (Fig. 1) accounting for management strategies to understand which ones may favour both carbon and biodiversity accumulation at the continental spatial scale.

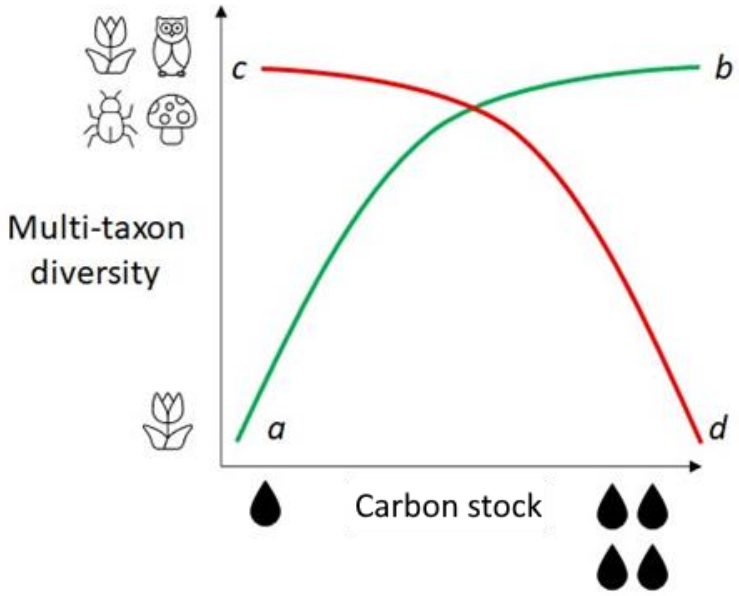

Fig. 1. - Different potential relationships between multi-taxon diversity and carbon stocks.

2. Identify species and functional groups related to different carbon stock ranges and management strategies.

Species distribution models (SDMs) will be performed under the supervision of Prof. Robert Muscarella, who is the main developer of the R package ENMeval that estimates optimal model complexity for Maxent ecological niche models.

We will regress presence data, or abundance data if harmonization processes will be feasible, for each species from the Bottoms-Up database with the SDM predictions (Fig. 2).

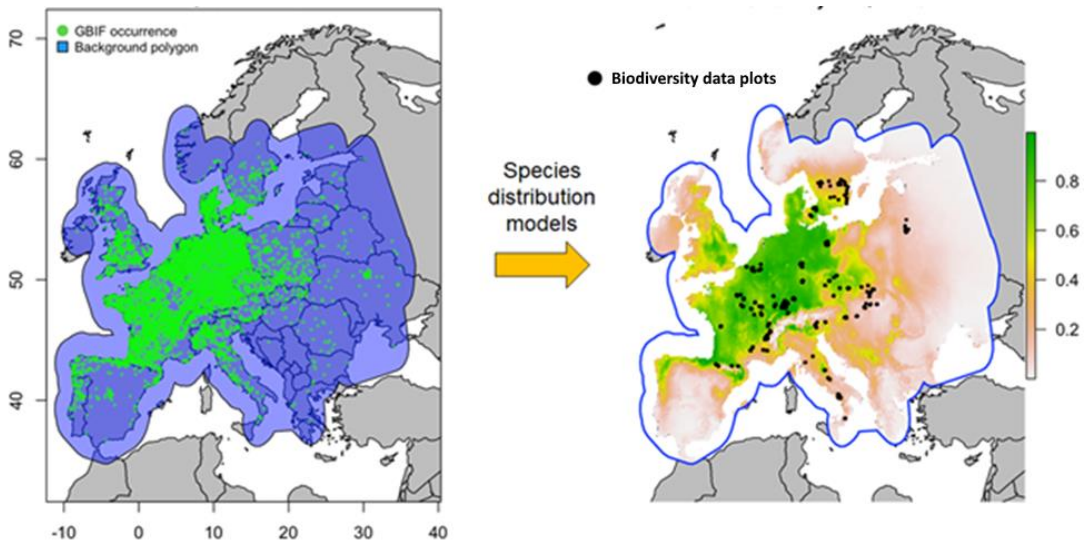

Fig. 2. (Left) Occurrence records obtained from GBIF and the geographic extent for an example study species. (Right) Example of output from a species distribution model (habitat suitability) for a sample species with points showing locations of Bottoms-Up biodiversity data plots.

The residual variation will be compared with the distribution of management strategies and carbon stocks ranges through mixed effect models. We predict that both management and environmental conditions will affect species distributions by altering the presence of species as compared to the predicted occurrence derived from the SDMs (Fig. 3).

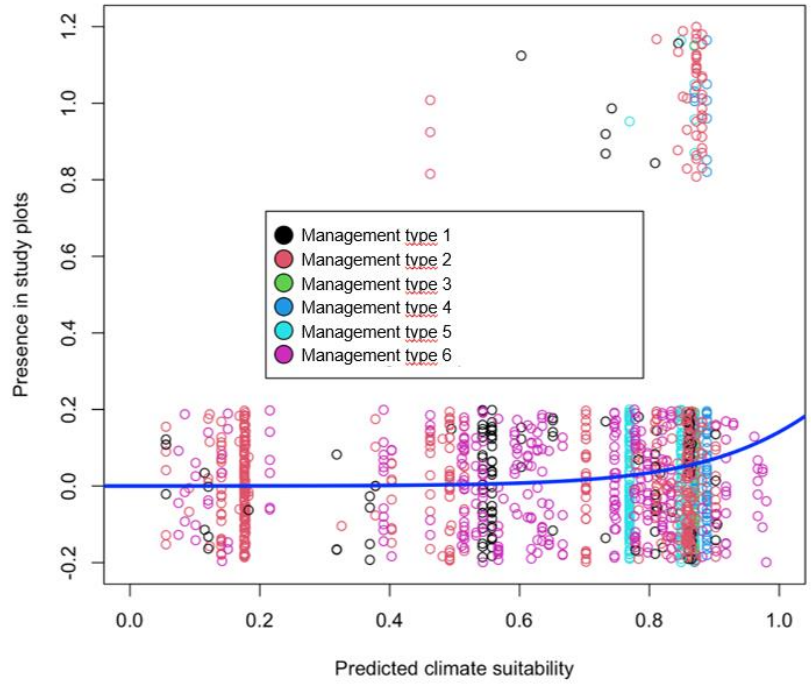

Fig. 3. Hypothetical plot showing presence of a target species in study plots against predicted climate suitability as modelled by the SDM.

By associating this variation to species functional and phylogenetic features it will be possible to have a mechanistic understanding of the effects of different management strategies on several ecosystem components. We will test if species grouped through phylogenetic or functional relatedness show the same response to the chosen environmental drivers.

Project outcome

The present project will contribute to the definition of management strategies to jointly pursue biodiversity conservation and carbon storage in European forests. Specifically, results will inform on which general silvicultural strategies and fine-scale practices enhance the sustainability of forest management as defined in the EU Taxonomy Regulation (EU 2020/852) to address the goals of the European Green Deal policy areas "Sustainable Industry" and "Biodiversity". The outcomes of the project will have implications for environmental policies and actions ranging from the EU Renewable Energy Directive and EU Emission Trading System by informing on forest role in carbon accumulation, to the EU Biodiversity Strategy for 2030 by "improving forest health and resilience" through the enhancement of forest biodiversity.

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Please note that if the outline changes substantially (more than 1 aim is revised substantially), or co-author(s) are added to the above lists the governing board should re-vote on the project.

Further opt-in authors:
According to the BOTTOMS-UP Bylaws any member of the BOTTOMS-UP Consortium can declare his/her interest to become opt-in author. The first author is required to preliminarily accept one such offer from each dataset that represents at least 2% of the data in the analysis. It is upon the discretion of the first author whether to accept any opt-in offer beyond this requirement. Persons interested in opt-in authorship can be nominated until …. with e-mail to the first author (and cc: to the BOTTOMS-UP Governing Board), explaining which dataset(s) they represent and preferentially also how they could contribute. Note however that such a nomination only means the option to become co-author. In the end only those persons will be retained as actual co-authors who have made a significant intellectual contribution to the paper during the course of its preparation (in accordance with BOTTOMS-UP Bylaws and compliance to ethics in academy).

Data to be used: All the taxonomic information at the species level from all the datasets in the BOTTOMS-UP platfrom.

Please detail which datasets will be used, also reporting specific subsetting procedures if needed.

Time line:
Deadline for permission of data usage from custodians: May 2022
Extraction of data from BOTTOMS-UP: May 2022

Data preparation and analysis: September 2022
Raw results to be sent to the wider author team: December 2022
Writing up of the paper (including preparation/optimization of figures): February 2023
Feedback round of co-authors to MS: April 2023
Submission: May 2023

Confirmation:
I confirm that I will adhere to the BOTTOMS-UP Bylaws.

Date
4 May 2022

Signature

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