PAPER PROJECT

Preliminary title: **Assessing the functional vulnerability of epiphytic communities across Europe in the face of climate change**

Target journals: Journal of Ecology, Ecology, Journal of Biogeography

Aims

The number of species and the functions they play within ecosystems are declining worldwide due to global change drivers such as climate change and land transformation. This **biodiversity loss** negatively affects both ecosystem's function and stability, and human well-being. Under this context, it is expected that both species and functions will be lost in response to future climate change scenarios. In order to better quantify the impact of climate change on biodiversity, **functional redundancy** of biological communities has been identified as a key component for maintaining ecosystem stability by preventing the loss of ecosystem functions with species loss. In other words, analysing functional redundancy could help us to unveil the effect of a potential loss of species on the functional structure of the communities and, in turn, on the ecosystems' functioning and stability. The **main objective** of this paper is to assess the functional vulnerability of lichen and bryophyte epiphytic communities across Europe under different climate change scenarios. In particular, we aim to assess whether the loss of species according to their sensitivity to climatic changes would impact the functional structure of the communities under different climate change scenarios for 2040 and 2070.

To achieve our main objective, we will calculate the CVorg metric that quantifies the functional vulnerability of biological communities. To do that, we will use the dataset of lichen and bryophyte occurrences across Europe provided by the COST Action leader. The main 6 steps to be carried out are described below:

1. **Data wrangling:** We will check the matrices of lichen and bryophyte occurrences, and we will correct some issues related to duplicates, species synonyms, spatial coordinates and missing species.
2. **Functional traits:** To characterize the functional structure of each community, we will select a suite of functional traits related to water balance, nutrient acquisition and reproduction. For 534 lichen species present across the gradient, we will retrieve bibliographic information for three qualitative traits: growth form, photobiont type and reproductive structure (Nimis and Martellos 2021, Smith et al. 2009).
3. **Climatic variables:** Climatic information at the site (n=67) and plot levels (n=1004) will be retrieved from the high-resolution climate dataset CHELSA (Karger et al. 2017). Nineteen

bioclimatic variables will be obtained for current and future climatic conditions. For the future climate change scenarios, we will retrieve information for two time periods (2011-2040 and 2041-2070) and three scenarios (ssp126, ssp370 and ssp585). Based on principal components analyses (PCAs), Pearson correlations and ecological meaning we will select a suite of climatic variables.

4. **Fourth corner analysis:** We will calculate a ranking of species loss based on the intrinsic species response to environmental conditions (Galland et al. 2020). To that end, we aim to conduct a fourth corner analysis (family binomial) to predict the probability of appearance of each epiphytic species in every site considering their distributional and climatic ranges, and their functional traits.
5. **Functional vulnerability (CVorg):** We will calculate the functional vulnerability of each community to species loss under the current climatic conditions and for different future climate change scenarios (Galland et al. 2020). CVorg quantifies the variation of the functional richness of each community as species are sequentially removed (following the species loss ranking – step 4).
6. **CVorgs comparisons:** We will analyze how the functional vulnerability of epiphytic communities varies according to different time periods, habitat types, climate change scenarios and species extinction risk thresholds.

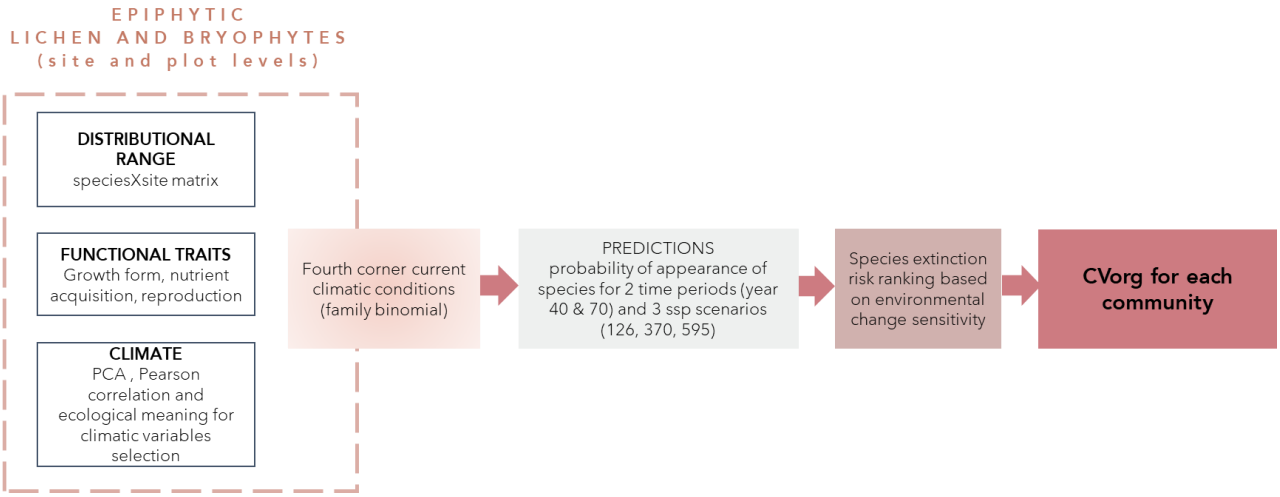

Figure 1. Pipeline conducted for evaluating the functional vulnerability of lichen and bryophyte communities (epiphytes) across European forests.

We expect the functional vulnerability of epiphytic communities to have a diverse range of responses to different climate change scenarios. In this sense, while some communities may face an increased functional vulnerability, others may maintain it constant or even improve it. In fact the functional richness of the community may or may not be maintained by the core species, with a differential effect on the taxonomic and functional diversity of these communities.

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: **Pilar Hurtado Aragüés, Paolo Giordani, Renato Benesperi, Juri Nascimbene**

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:

- Do you need data for specific regions, forest categories or silvicultural regimes?

We will use the whole dataset of epiphytic lichens and bryophytes for all regions, forest categories and silvicultural regimes

- Will you use both datasets allowing for stand and plot-level aggregation of multi-taxon data or only one of these two?

We will use both datasets, for stand and plot-level aggregation

- For which taxonomic group do you need data? Please refer to the attached list of taxonomic groups TAXA.xlsx

Lichens and bryophytes

- Do you need data on standing trees (including snags, standing dead trees and stumps)?

Yes

- Do you need data on lying deadwood?

No

Time line:

Deadline for permission of data usage from custodians: 01/06/2022
Extraction of data from BOTTOMS-UP: 01/07/2022
Data preparation and analysis: 01/07/2021-30/09/2022
*Raw results to be sent to the wider author team: 0*1/10/2022
Workshop with the wider author team: 15/10/2022
Writing up of the paper (including preparation/optimization of figures): 01/01/2023
Feedback round of co-authors to MS: 01/02/2023
Submission: 01/03/2023

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

Date: 25/04/2022

Signature: Pilar Hurtado Aragüés