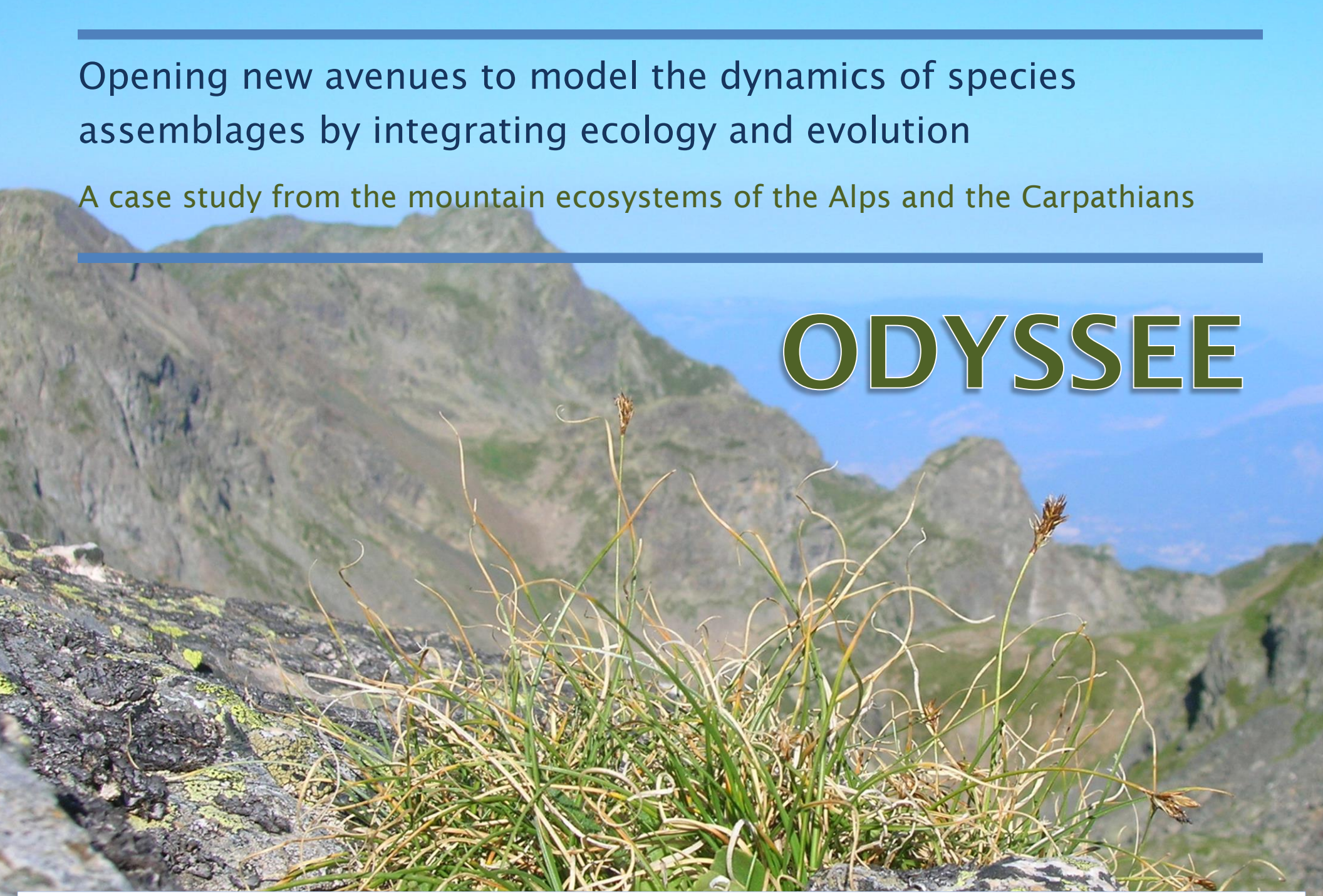
Opening new avenues to model the dynamics of species assemblages by integrating ecology and evolution

A case study from the mountain ecosystems of the Alps and the Carpathians

ODYSSEE



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ODYSSEE project brochure

Mountains remain one of the most extended natural environments in Europe and harbor extremely fragile ecosystems such as mountain pastures and meadows. ODYSSEE is a bilateral French-Romanian project that focused on the biogeography of mountain grasslands over Europe and addresses how different components of biodiversity respond to environmental changes. This brochure is targeted to a wide audience interested in mountain biodiversity and in global change related issues.

ODYSSEE addresses how biodiversity across trophic levels is shaped by history and response to climate. Long-term climatic influences, such as the Pleistocene Glaciations, severely affected ecosystems at large scales. European mountains have been particularly affected due to the high altitudes that had not allowed important components of biodiversity to survive. On the other hand, at local scales, factors such as land use, microclimate heterogeneity due to local topography greatly influenced the changes in composition of organisms. Local topography is a particular feature of mountain areas that could shape the plant distributions by driving the snow regimes or especially by allowing species to find local refuges. We equipped the surveyed sites with data loggers that allow accurate recording of light and temperature at local scales.

The ODYSSEE field work. Various sampling have been conducted such as soil sampling for DNA barcoding, climatic loggers installation and soil mesofauna sampling.

"In my opinion, the strongest point of our study is represented by its multi-trophic approach: integrating the plants - soil microflora - soil mesofauna networks into one framework is a step forward towards a new generation of models that explain and predict the patterns of biodiversity and ecosystem functioning at large biogeographical scale. All these would not have been possible without the joint efforts of the researchers from all partner laboratories that covered a wide range of expertise in biology."

Dr. Mihai Pușcaș (project coordinator, UBB)

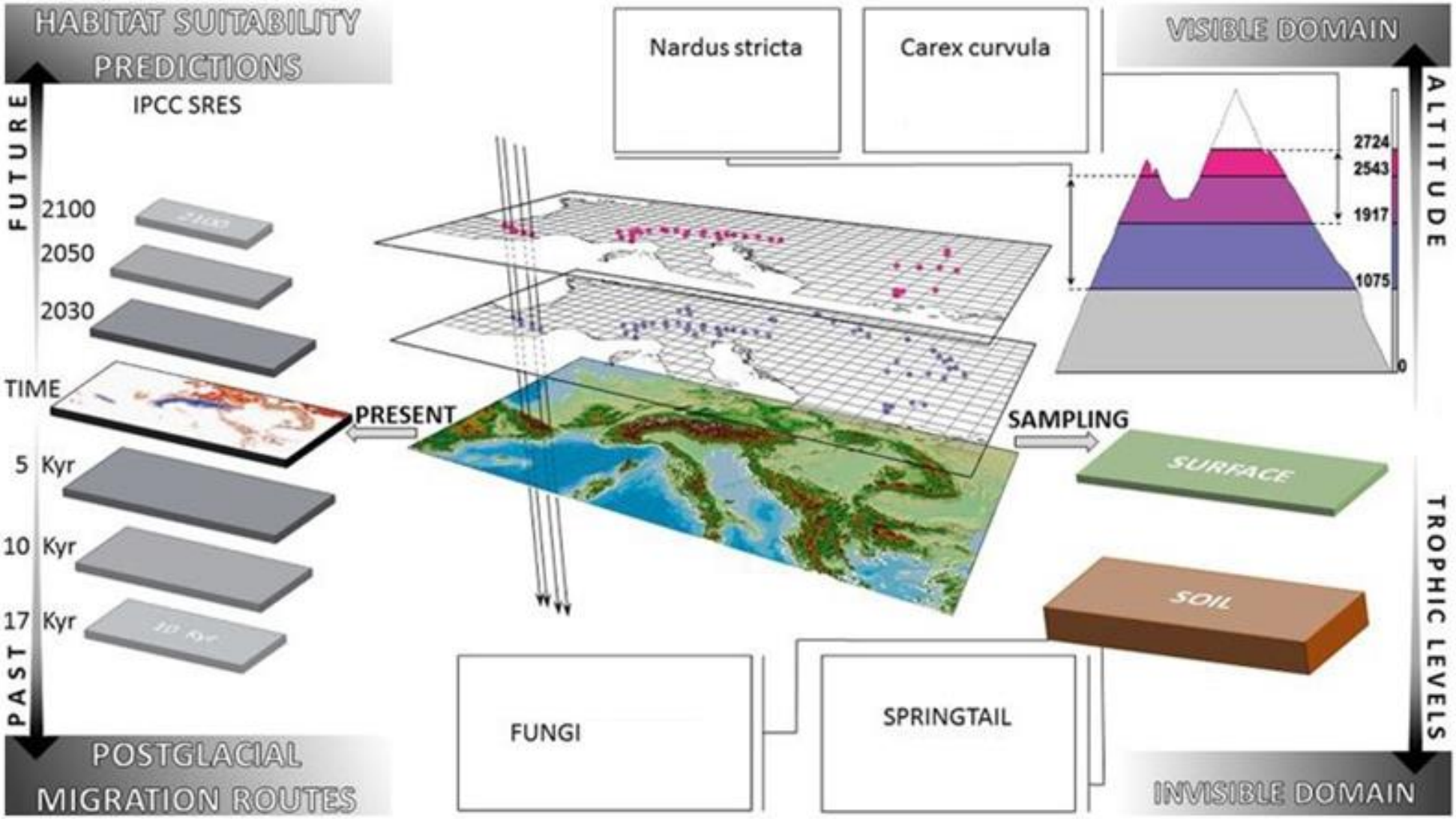
High mountains of Europe form a 'sky island' system, where the relationships between the island structures and evolution is particularly interesting. Despite the large extension of the grassland ecosystems in this 'sky island' system, these relationships remain virtually unknown for many important species, drivers of ecosystems. ODYSSEE scientists investigate the discrepancies among populations of two keystone graminoids across the major mountain areas. Many of the geographic ranges pertaining to the European Alpine System are highly important biogeographically and might be considered as hot spots of biodiversity. Certainly in some regions, favorable climate persisted over long period of times and so they became refugial areas.

Another key point addressed by the ODYSSEE project was the unknown diversity, particularly the diversity of organisms in the soil. Hidden aspects of diversity that were studied within the project were the microbial diversity and soil communities of springtails (Collembola). The Collembola fauna of the European mountains as a whole is unexplored, especially if we consider the surveys in the Carpathians and the Balkans. ODYSSEE aims at shedding light on the distribution of microbial diversity and springtails in relation to the major biogeographical regions and climate regimes.Exploring the relationships between the visible and hidden parts of biodiversity is a new frontier for ecology.

In this project, two contrasting grasslands have been sampled at biogeographic scale. The siliceous climacic grasslands of the alpine zone, dominated by *Carex curvula*, and the anthropogenic pastures of the subalpine zone, dominated by *Nardus stricta* were sampled across the Alps, Carpathians, Pyrenees, Balkans, Sudetes and the Hercynian Massifs of Central Europe. Different components of biodiversity have been studied including phenotypic and genetic diversity of the dominant plant species in the ecosystems, taxonomic and functional diversity of plant species assemblages and soil molecular diversity using DNA metabarcoding, for microflora (fungi) and mesofauna (*Collembola*).

A diversity of tools and methods are used to characterise the multifaceted components of the biodiversity of mountain grasslands:

- Satellite imagery to map mountain grasslands at the European scale and to track interannual variations in snowcover and productivity
- Environmental DNA to characterise the hidden diversity of soil fungi and soil invertebrate
- Genome-scan fingerprinting methods to unravel the genetic diversity of populations of the dominant plants
- Mega-phylogenetic trees of mountain plants to assess the relatedness of plant communities
- Models of species assemblages operating at multitrophic levels



Conceptual model of how sampling design of the ODYSSEE project addressed the different facets of biodiversity

Generated from three years of integrated research across the whole range the European Alpine System, ODYSSEE aims to cover highly relevant topics of biogeography in the era of big data. Due to the networking effort of the project partners, the mountains of Europe are now examined by means of key ecosystem components in relation to precisely measured changes in microclimate. A major challenge of the coming years will be to maintain the biodiversity of the most fragile ecosystems. Therefore, an unprecedented sampling design at a continental scale will help track changes in biodiversity hotspots of the most important high elevation ecosystems. Using highly developed tools to quantify richness of organisms, such as soil DNA metabarcoding, a big dataset stands as a base to understand the invisible components of ecosystems and their functioning, while soil diversity will no longer be hidden. Newly implemented tools such as modeling approaches will assess the testimony of plant lineages and predict species distribution shifts in response to a range of scenarios of global change.

The results of the ODYSSEE project provide policy makers a framework to understand the conservation role of the European Union mountain grassland habitats, with a special focus on the patrimonial values of soils.

Current conservation efforts will need to adapt to the changing needs of the organisms living in such a remarkable mountain ecosystems.

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