Project Title: Identification of priority sites for the conservation of terrestrial animal and plant diversity to meet European and CBD 2030 targets

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Rationale

The European Commission has adopted a new Biodiversity Strategy for 2030 as a core component of the European Green Deal, and the development of the post-2020 goals of the Convention on Biological Diversity (CBD) is ongoing. The EU and its member states will soon be bound to environmental commitments at the continental and global levels, including the expansion of coverage of the Natura 2000 network of protected areas from the current 18% to 30%. We identified three major challenges that need to be overcome in order to achieve this goal:
- the EU and the CBD focus on different biodiversity elements: priority habitats and species (EU), or sites of particular importance for biodiversity (CBD);
- accounting for projected biodiversity change is paramount to avoid failure;
- most data relate to only one level of biodiversity (species), but information on other levels (e.g. habitat, ecosystems) has to be accounted for when assessing progress towards goals.

We aim to build on recent advancements in eco- and bio-informatics to identify priority sites to expand the coverage of Natura 2000 to 30% of the land, synergistically contributing to the achievement of the EU and CBD goals. Sites will also maximise the immediate protection and future persistence of biodiversity under global change, and we will assess their broad representativeness across levels of biodiversity and their currency.

We will use a mix of large databases on the occurrence of habitats and species, remote sensing data and other environmental digital cartography to identify sites hosting priority species and potential sites of particular importance for biodiversity (using the Key Biodiversity Areas methodology). We will then apply optimization methods to identify, among these sites, the set that would best complement the existing Natura 2000 network to reach 30% coverage. This approach will maximise the representation of all habitats and species, selecting sites with minimal projected climate change and good network connectivity. These sites represent synergistic priorities for conservation in the EU. We will then focus on Italian sites to improve the resolution of, and better define, the identified potential priority areas considering also underrepresented biodiversity (e.g., arthropods and plants). Then, we will assess the ecosystem integrity of these new priority areas by merging remote sensing and field vegetation data and will finally compare biodiversity between potential priority sites and selected control sites.

Activities:

- **Mapping the synergistic priority sites at the national scale and identify the ecological corridors with Artificial Intelligence:** We will use the data collected in the database of terrestrial arthropods and plants, together with fine-scale occurrence data to apply conservation criteria at the national scale, within a 10x10 km grid. We will build Joint Species Distribution Models (JSDMs) for the Italian species with available data. Notably, we will build distribution models for underrepresented taxa, i.e. terrestrial arthropods and plants, for which little is known about the distribution, population size and habitat preferences. A strong limitation in the use of point data of arthropods and plants is the unequal spatial sampling. Indeed, some areas could have been sampled more densely than others. To deal with this problem, we will use ascertained presence data and perform a spatial thinning of species occurrences to develop models of potential species assemblage distributions. We will predict current species distributions by considering several environmental factors, such as climate, land use etc. (Table 1), depending on the group's ecology and data structure (e.g., sampling density), following the approaches described in

Calabrese et al. (2014), Del Toro et al. (2019), Biber et al. (2020) Di Musciano et al. (2020). Within the identified KBA cells aggregating the occurrences data of several taxa, we will then identify the synergistic priority sites to potentially expand the protected area network at the Italian scale. We will estimate species richness and rarity (Leroy et al. 2013) in small cells of up to 1 ha resolution. We will assume that suitable new areas should have low human population densities and low street density. We will consider the population density grid (people/km^2) (EEA) as well as the street density estimated from GLOBIO to filter out areas not suitable for conservation. Subsequently, we will remove artificial surfaces by rasterizing Corine Land Cover polygons with codes starting by 1 ("Artificial surfaces"). We will obtain a map showing potential areas with low economic and social costs. After that, we will partition these areas into spatial clusters from 5 to 50 km2 adopting the k-mean algorithm (K-Means Clustering), based on the spatial coordinates. Using the data on biodiversity (suitability areas, species occurrences, richness and rarity), connectivity and shape of the patches we will perform an optimization analysis to identify the best suitable clusters to expand the Italian protected areas and meet European and CBD 2030 targets.

- Assessing ecosystem integrity: Changes in vegetation structure (McGarigal 2014) and composition will be analysed to quantify landscape dynamics with special emphasis on forest fragmentation (Riitters et al. 2002). Vegetation and dynamics will be described by remote sensing-based products based on NDVI-EVI (Table 1) - such as GTCD. Several methods for describing ecosystem functionality, based on vegetation maps and remote sensing data, will be used for grasslands (see Primi et al. 2016), wetlands and dune ecosystems using Copernicus Sentinel-2 imagery. Specifically, time series of forest canopy density for the last 20-30 years will be used as a proxy for describing unmanaged (rewilding space) versus harvested forests (wood production space). We will also collect all the information (e.g., Sabatini et al. 2021; research papers, park reports) concerning primary forests (sensu FAO 2015) in Italy (e.g., Sabatini et al. 2020; research papers, park reports); the structural attributes (e.g., roughness) and other characters (e.g., topography, remoteness) of the old-growth forest network database will be used in GIS environment by means of machine learning algorithms to discover the currently unknown primary forest in Italy. This information and analysis will allow for the improvement of a continuous index of vegetation and more specifically forest integrity as determined by the degree of anthropogenic modification (Grantham et al. 2020). Data collection to cross-check the results obtained by remote data will focus on the environmental strata in each of the three biogeographic regions. We will identify 5 sites per stratum for plant surveys (55 sites total).

- Assess climate change threat on synergistic priority sites and comparison of biodiversity between priority sites and control sites. Once synergistic priority sites will be identified under current conditions, we will test their stability and persistence in the future overlapping them with layers of climate change for 2050 and 2070 (Table 1). Moreover, we will also assess the threat by modelling future distribution for underrepresented taxa, i.e. (terrestrial arthropods and plants). We will use the Joint Species Distribution Models for the Italian species with available data, using the approach described above. We will predict species distributions under future scenarios by considering different representative concentration pathways for climate change (Table 1). We will also include, where available, the dispersal ability of the investigated taxa following the approach proposed by Di Musciano et al. (2020).

Finally, we will subset Italian priority sites and for each environmental stratum (Task 2.3) we will sample an equal number of random control sites (unprotected) using matching algorithms. We will then compare coverage and abundances of underrepresented species modelled distributions and level of ecosystem integrity between priority sites and control sites with a regression (generalized linear mixed or similar) model, including the effects of environmental covariates, to provide the first quantification of umbrella effects across species and ecosystems.