**Spoke 4**

**Ecosystem functions, services, and solutions**

**1 Vision**

Monitoring, preserving, and restoring terrestrial ecosystems in the context of climate change

**Mission**

The mission of Spoke 4 are

* + Knowing and monitoring the environmental and biodiversity resources of the terrestrial ecosystems
  + Understanding the adaptation of terrestrial ecosystems to climate changes and their potential for mitigation
  + Adopting conservation plan of terrestrial ecosystems to achieve international targets
  + Applying restoration protocols and assessment plans using Nature based Solutions approaches

**2. Strategic Aims**

The objective of Spoke 4 is to develop concrete, replicable and transferable solutions to achieve the objectives set by the EU Biodiversity Strategy for 2030. Through a multidisciplinary approach, Spoke 4 identifies effective strategies to reduce anthropogenic pressure on ecosystems, species and populations, also by supporting and developing biobanks, favoring the creation and aggregation of protected areas and green infrastructures and identifying technological and management solutions capable of generating environmental, social and economic value. Spoke 4 also addresses emerging issues closely linked to human well-being such as forest conditions and regeneration of degraded areas and the identification of Nature-based Solutions (NbS) capable of mitigating socio-environmental problems (pollution, environmental disasters and global warming). Spoke 4 contributes to achieving the climate-related objectives of the PNRR.

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**3. Analisi dello Stato dell'Arte**

Terrestrial ecosystems cover a large area in Italy, with huge diversity from the Alpine regions to the most southern and arid regions. Unfortunately, the pressure on terrestrial ecosystems is extremely high, especially in the Mediterranean areas. Thus, the role and the ecosystem services that those ecosystems provide are threatened, and a number of actions need to be taken based on scientific knowledge.

* Mappatura delle lacune e delle opportunità.

The EU Biodiversity Strategy and the EU Nature Restoration Law are clear commitments to propose interventions to reduce pressure on ecosystems of particular value and/or particularly under stress or at risk and encourage actions to reverse the curve of biodiversity loss and restore degraded terrestrial ecosystems, through infrastructure creation operations green infrastructures, Nature-based Solutions and encouraging the establishment of new protected areas.

**4. Priorità di Ricerca e Innovazione**

* Descrizione le principali linee tematiche di ricerca divisi in WP e tast

Spoke 4, structured into 5 Activities, has the general objective of providing digital tools, data, models, and advanced statistical methods for monitoring biodiversity and ecosystem functions at a national level and within protected areas to support landscape planning and local actions aimed at restoring, conserving, adapting and enhancing ecosystem functions and services in terrestrial ecosystems. Long-term landscape planning accounts for the impacts of Climate Change and focuses on the adaptation potential of ecosystems and increasing the mitigation potential at the national level. Finally, Spoke 4 is designed to advance in providing information-enabling services for circular and low-carbon economies, such as net carbon emission certificates, economic quantification of ecosystem services, production chains, environmental insurance, and Payment for Ecosystem Services.

Activity 4.1 “Advanced systems for monitoring, studying and managing biodiversity, its organization, and the related ecosystem functions and services in relation to natural and anthropic impacts” provides a common environment for NBFC where data are collected, stored, and processed in a shared digital platform. The NBFC Digital Platform includes four Thematic Areas on Biodiversity, with n. 4 dedicated to collecting data, monitoring, and analyzing through dedicated models and tools of the nexus between Biodiversity and Biodiversity Ecosystem Function (BEF). This is used to monitor biodiversity and ecosystem functions and simulate the impacts of climate change and other anthropogenic stressors.

Biodiversity loss and climate change are intrinsically linked. Climate change affects the distribution of species and habitats as well as ecosystem functions and services. At the same time, the relationship between biodiversity and ecosystem functions gives biodiversity a powerful role in climate change adaptation and mitigation.

Activity 4.2, “Adaptation and Mitigation of Terrestrial Ecosystems to Climate Change, including Ecological Responses and Future Forecast Scenarios,” addresses both above issues by providing robust models for the development of climate change adaptation strategies at the landscape scale and scientific information on the potential of ecosystem adaptive management to improve resilience to climate change.

Activity 4.3 focuses on conserving biodiversity in protected areas, leveraging the potential of intraspecific genetic variability, and providing models and statistical approaches to predict changes in biodiversity and ecosystem processes.

Activity 4.4 “Scenarios of Area-based conservation planning and management” specifically addresses issues at landscape and national scale, providing information on i) how to strengthen the network of Natura 2000 sites and protected areas, ii) multi-sectorial landscape planning in a biodiversity-inclusive perspective and iii) narratives and pathways specifically addressing the biodiversity issues of use for the elaboration adaptation strategies at a national level.

Activity 4.5 “Conceptual framework and methodological tools of Nature-Based Solution and Restoration Ecology” capitalizes on the results of the other activities and provides methods for the choice and implementation of NbS for active post-fire restoration, endangered riparian stands, areas damaged by anthropogenic pressure or extreme events and polluted sites as well as enhancing specific ecosystem services.

**5. Impatti Previsti**

**Impatto Scientifico:**

Through the use of different techniques, including genomic ones, data analysis, and modeling supported by HPC, we aim to offer a new perspective on the management and conservation of terrestrial ecosystems, native and endemic species of the Italian peninsula, and key/sentinel species of Mediterranean ecosystems.

By improving our knowledge of the evolutionary and adaptive processes of natural populations, our results will produce new and valuable data useful for evaluating the vitality, uniqueness and irreplaceability of populations of wild animals and plants, in particular those species whose demographic dynamics or gene pools have been seriously and negatively influenced by more or less recent anthropic impacts.

New methodologies for restoration of terrestrial ecosystems will be released. Implementation of a new restoration strategy based on the valorization of biodiversity, as a fundamental element of NbS, through new approaches integrated with complementary technologies for a higher impact on the various types of degradation present on a national scale

Computerization of processes. Extension of the application of NbS in an IT-based operating environment through the development of ICT products capable of promoting more efficient solutions to the different situations of environmental degradation present in different geographical and biodiversity conditions.

**Impatto economico**:

Energy production from woody biomass, agroforestry systems, and industries for extracting molecules or value-added products. Evaluation of ecosystem services provided by the natural and semi-natural ecosystems studied, both as regulatory services (carbon absorption, water production and purification and soil protection, air and soil depollution) and as cultural-recreational services and landscape improvement. Training of a new generation of experts in Biodiversity management and valorisation.

* **Impatto sociale**: Miglioramento della qualità della vita, equità e inclusione.

Useful information is provided to increase the territory's resilience to anthropic and natural pressures, as well as through support for higher education and the technical skills of public administration employees.

Increased supply and accessibility of enabling information for the circular and low-carbon intensity economy, such as net carbon emission certificates, economic quantification of ecosystem services, environmental insurance, and payment for ecosystem services.

We will also contribute to surveying, evaluating and promoting the varied range of ecosystem services that protected areas, through their biodiversity and the spatial heterogeneity that distinguishes them, can offer to communities and territories, not just those most easily susceptible to recognition economic as they are tangible (e.g. certified organic agri-food production in protected areas), but also those less easily tangible (e.g., carbon sequestration, regulation of water flows, biogeochemical cycles, decomposition and recovery of organic waste, regeneration of raw materials, genetic resources, functions of asylum and shelter for offspring) and finally the socio-cultural ones which are by their nature intangible, supporting cultural/cognitive development (e.g. scientific information, maturation of a historical and identity consciousness, the formation of landscape, aesthetic, recreational and socio-symbolic values).

* **Impatto ambientale**: Contributi a sostenibilità e resilienza.

We will predict the adaptation and mitigation capabilities of representative Mediterranean and temperate ecosystems within the expected climate change scenarios, providing suitability maps of the main ecosystems and terrestrial communities in Italy. This will support the implementation of adaptation strategies and adaptation plans and improve biodiversity resilience to climate change impacts.

Area-based conservation of biological diversity represents the most effective method to halt its decline, but at the same time, it is one of the main challenges of the coming decades, both in terms of scientific research and application. Removing areas from economic exploitation or reducing its intensity requires careful planning to make conservation compatible with social and economic development. The coherence of the actions developed within Spoke 4 with the reference regulatory framework and the development of strategies capable of influencing the behavior of political decision-makers at different levels will allow the action undertaken to generate a more lasting value on an economic, social, and environmental level.

**6. Collaborazioni e Stakeholder**

The BEF Platform will involve the production and industrial sectors in its implementation and in the services it can offer.

In the first case, ensuring access to large quantities of data on biodiversity, ecosystems, and ecosystem functions, classifiable as "big data" is an epochal challenge for research, industry,

and the service sector. In this context, SMEs, Spin-offs in the ICT sector, and large innovative companies will be involved in

the development and implementation of the NBFC Digital Platform, who will participate in the identification of solutions relating to the semantics of information, virtual search environments, advanced machine learning and deep learning, real-time monitoring, etc.

In the second case, the platform's data and services will also be accessible to SMEs so that further services can be developed to manage and monitor private natural areas. The information provided by the NBFC Digital Platform will also be of interest to insurance companies or for the activation of services relating to payment for ecosystem services, for example, particularly relevant for agricultural areas that fall within protected areas.