**spoke 5 : URBAN BIODIVERSITY**

| **Vision** |
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Living in harmony with nature in an urban context

| **Mission** |
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The mission of Spoke 5 are:

-Knowing and enhancing the environmental and biodiversity resources of the city

-Developing an integrated and sustainable planning of the cities of tomorrow;

-Ensuring resilience to functional biodiversity and promoting biological complexity;

-Developing models of management and enhancement of urban biodiversity also by communication and dissemiantion activities,

-Restoring and recovering degraded areas and improving the urban ecosystem;

| **Strategic Objectives** |
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The research framework of spoke 5 is aimed at investigating urban biodiversity, with a multidisciplinary and transdisciplinary approach. Specifically, the team of spoke 5 is developing strategies and guidelines to realize suitable solutions to restore and/or improve the functional components of urban biodiversity, to mitigate its main abiotic and biotic stress factors. This strategy will allow a multilevel characterization of ecosystem resources and define integrative design strategies to maximize the ecosystem services and the resilience of interventions through time.

The technological innovation of products and processes will sustain the realization of effective monitoring, evaluation and management of the interventions.

| **State-of-art analysis** |
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Urban areas cover about 3% of the global surface (7% in Italy); however, green areas occupy less than 10% of the overall urban surface. In 2007, for the first time in history, the global urban population exceeded the global rural population, and the world population has remained predominantly urban (UN, 2014). By 2050, 70% (6.3 billion people) of the global population will live in cities (UN, 2016).  Cities consume 75% of the world’s natural resources and account for more than 70% of global CO2 emissions. With 90% of the world’s urban areas situated on coastlines, cities are at high risk from some of the devastating impacts of climate change, such as rising sea levels and powerful coastal storms. For centuries, cities have helped foster some of mankind’s greatest ideas. It is no stretch of the imagination to believe that cities will now take the lead in addressing loss in biodiversity. Cities are on the frontlines of global climate change and need to lead in driving global action to mainstream biodiversity.

To increase the natural capital in urban areas is essential to improve, increase and protect its biodiversity.

Some critical aspects allow or prevent the implementation of this objective.

* Developing a stronger relationship between municipal governance plans and greening plans is necessary. In this regard, spoke 5 is conducting studies on the state-of-the-art of greening plans in Italy (18 green plans and strategies approved in provincial capital cities, three plans under development, out of 109 capital municipalities), on nature-based solutions (NbS) in the Mediterranean area, to formulate guidelines supporting public administrations in equipping themselves with suitable tools that operationally lead to improving, increasing and protecting biodiversity.
* Filling knowledge gaps on the effects of NbS in urban areas, especially regarding the interactions between species and the stresses to which the plant component is exposed, also considering climate change. In this regard, spoke 5 researchers have identified which plant species are more reliable to comply with water stress, and innovative monitoring strategies of interventions have been promoted, also based on remote sensing and biomolecular technologies.
* Citizens should be involved in co-planning and increasing knowledge related to biodiversity spaces. Spoke 5 has conducted experimental plants (in Milan, Florence, Rome and Campobasso) and a living lab to co-design biodiversity spaces.

Overall, the final purpose is to evaluate the most appropriate intervention strategies to restore biodiversity in the redeveloped areas and guarantee its persistence and succession over time.

**Mapping gaps and opportunities**

Urban ecology has become an important focus across the ecological and environmental sciences, but scientific and technological gaps remain to be addressed.

Among these:

- Identification of ecosystems best suited to the urban context.

- How do ecosystems evolve in cities, and how do they respond to anthropogenic effects?

- How can excessive stress factors such as pollution and the alteration of natural resources be removed to regenerate areas rich in biodiversity?

- How can green spaces be connected and ecological corridors be created that are compatible with urban development?

- What types of projects and management models work in an urban context?

- How can the risks to urban biodiversity be assessed?

| **Research & Innovation priorities** |
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**WP1** - Biodiversity and ecology aspects of urban forestry. The principal aim of this activity is to analyze the resource compartment of urban biodiversity, with specific regards to the primary producers to be used in urban forestry and Nature Based Solutions. An accurate transdisciplinary and transcalar research strategy will permit to address different topics, from the typological characterization of urban ecosystems and their plant species, up to the investigation of plant physiology and relationships with the soil to elaborate reliable management strategies of the realized urban green interventions while ensuring ecosystems (and related services) stability and promote the Italian forest/wood chain.

**WP2** - Urban soil biodiversity. The principal aim of this activity is the characterization of urban soil categories to define the most suitable restoration strategies to support efficient forestation actions. This will be achieved by investigating: i) the biodiversity and functions of the urban soil-associated microbiota (i.e., bacteria and fungi) and invertebrates and their changes in response to different structural, environmental, human and vegetational conditions/stressors; ii) the rhizosphere, to understand how to modulate and exploit plant-microbial interactions for optimizing the plant growth and persistence of urban NBS and other green infrastructures. Both these research contexts are based on the application of multiple analytical tools (mainly related to omics technologies) proper bioinformatics (e.g., AI-based) and predictive modelistic approaches able to improve soil ecosystem services and the overall urban environmental quality.

**WP3** - Urban forestry - an integrative and sustainable design. This activity aims at promoting urban biodiversity and climate actions, taking into account social inclusion, stakeholder engagement and shared governance approaches and ecological modeling (statistical and complex models). Open data repositories (e.g., earth observation and topographic databases) and a comprehensive review of international case-study applications at urban and regional scales will be used to develop intelligent systems (e.g., Machine Learning-based) for the modeling, simulation and prediction of innovative NBS and to provide scalable guidelines for planning reliable urban forestation processes, regeneration actions and to enhance the connections among urban, peri-urban and rural areas.

**WP4** - Impact of urban forestry on supporting and regulating ecosystem services (environmental level). The main objective is the creation of an integrative knowledge, analytical and modeling baseline to design permanent green infrastructures (e.g. NBS) to support ecosystem services and to mitigate climate and pollution atmospheric stressors in urban contexts. Specific attention is devoted to the air pollutants responsible for global warming and to a detailed analysis of morphological, physical, chemical and biological features of urban soils for assessing their vulnerability and resilience in response to the above mentioned stressors. Multidisciplinary monitoring actions and the analysis of national case studies, implemented through predictive models, will provide urban planner stakeholders with reliable decisional guidelines for the designing of NBS aimed at conserving biodiversity and ecosystem functioning and resilience.

**WP5** - Impact of urban forestry on supporting and regulating ecosystem services (biological level). The aim is the assessment of the effects of different NBS and urban biodiversity management strategies on plant and animal functional diversity and of its mediated ecosystem services (i.e., pollination, seed dispersal and pest control). A multidisciplinary and ecosystem multilevel approach, based on innovative technologies (e.g., DNA/RNA-based, smart sensors), will permit the development of efficient and scalable tools for monitoring the effectiveness of urban green restoration actions in shaping biodiversity and its functional interactions. Specific research on the environmental and biotic urban factors influencing plant reproduction, animal biodiversity, populations connectivity, functional traits and trophic interactions will be used to obtain suitable predictive and risk management models to provide the guidelines for the design and management of sustainable and resilient NBS in different urban contexts.

**WP6** - Environmental and ecological restoration. Activity 6 aims at finding and operating processes and strategies to increase the urban biodiversity and ecosystem services in critical areas such as polluted, abandoned or highly disturbed sites. Biotechnology-based approaches will be applied to design and evaluate the effects of bioremediation actions (i.e., phytoremediation and mycoremediation). At the same time, specific activities devoted to the restoration/support of the functional plant and animal biodiversity will be operated to increase urban habitat diversity and mitigate the main stress factors. The survey of short-term evolution and dynamics of such interventions through innovative approaches will permit the selection of the best technological and management strategies transferable in different urban contexts, representative of Mediterranean cities.

**WP7** capitalizes on the results of the other activities and aims at providing innovative models and tools for the management of urban biodiversity. This will be developed through a participative approach involving researchers, territorial institutions, industrial stakeholders and citizens. Technology innovations (e.g., smart/high-tech sensors, smart DNA-based tools), big data and artificial intelligence-based systems, and socio-economic investigations (also based on citizen science-based projects) will be validated and tested to design reliable strategies for the long-term management of sustainable and effective urban NBS.

| **Expected Impacts** |
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**Scientific impact:** The research of spoke 5 will have an effect on the territory in terms of protection and safeguarding of natural resources, environmental requalification and risk prevention (e.g. spread of invasive species, phytosanitary or veterinary outbreaks, etc.).

**Economic Impact**: Spoke 5 activities are expected to generate economic impacts in different contexts, among which:

* **Increased Property Values**: The property value of infrastructures and patches close to well-maintained and biodiverse green spaces, are typically higher due to their higher desirability.
* **Energy Savings**: a well-designed and managed plant and NbS displacement provides natural cooling through shade and evapotranspiration, thus reducing energy consumption for air conditioning in summer months.
* **Tourism and Recreation**: Urban green spaces attract more visitors and support local businesses like cafes, bike rentals, and tour services, boosting the local economy.
* **Job Creation**: The planting, monitoring and maintenance of urban forests and their inhabitants create employment opportunities in many sectors (e.g., architecture, arboriculture, environmental monitoring)
* **Reduced Healthcare Costs**: The health benefits of urban green spaces significantly contribute to lower medical expenses, as residents experience with a lower incidence pollution-related and stress-induced illnesses.

**Social impacts**: Spoke 5 activities are expected to generate improvements of wellbeing, equity and social inclusion through different actions, such as:

* **Improvement of urban greening actions**: this provides a calming environment, reducing stress and anxiety. Actions devoted to guaranteeing access to green spaces are also fundamental to promote physical activity and reduce the incidence and emergence of non communicable diseases in citizens.
* **Promotion of community cohesion**: Urban parks, tree-lines and other kinds of NbS create shared spaces that foster social interactions, improving community bonds and reducing social isolation.
* **Enhancement of Aesthetic and Recreational areas**: NbS, if properly designed and managed can improve the visual appeal of cities and provide spaces for leisure, which can enhance citizens’ wellbeing.
* **Improvement of educational opportunities:** Urban NbS can serve as stages for implementing environmental education activities and events, teaching residents about the value of biodiversity and the importance of its conservation and sustainable management.
* **Environmental impact**: The research of spoke 5 will have an impact on the territory in terms of protection and safeguarding of natural resources, environmental requalification and risk prevention (spread of invasive species, phytosanitary risks, etc.).
* **Air Quality Improvement**: Trees absorb organic and inorganic pollutants. , reducing CO2 and releasing oxygen, improving urban air quality.
* **Climate Regulation**: Urban forests reduce the urban heat island effect by providing shade and releasing water vapor. They also sequester carbon, mitigating climate change impacts.
* **Stormwater Management**: Tree canopies reduce runoff by intercepting rainfall, and root systems promote water infiltration, minimizing flooding risks.
* **Biodiversity Support**: Urban green areas provide habitats for various species, supporting local ecosystems and enhancing biodiversity.
* **Noise Reduction**: Dense tree cover acts as a natural barrier, reducing urban noise pollution.

| **Collaborations and Stakeholders** |
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Spoke 5 has activated the following collaborations:

* Collaboration with the Command for Forestry, Environmental, and Agri-food Units (CUFAA);
* Collaboration with nurserymen and nursery associations (e.g., Assoflora);
* Collaboration with the National Association of Italian Municipalities (ANCI);
* Synergies with urban regeneration and reforestation projects (e.g., Forestami, Fondazione Futuro delle Città, Alberitalia, ParcoItalia);
* International collaboration with BOLD - Canadian Centre.
* International collaboration with FAO