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LAND

BIOSCOPIUM

Guidelines for mapping urban biodiversity in urban regeneration areas

T-FACTOR
PARTICIPATORY FUTURES
CO-CREATING CITIES THROUGH MEANWHILE SPACES

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/ABOUT THIS PUBLICATION

/ABOUT THIS PUBLICATION

Urban biodiversity is an oxymoron in today's cultural context, but biodiversity is a crucial aspect of our cities' environments, societies, economies, governance, and cultures.

Today's challenges related to climate change and the loss of biodiversity in the territories and green spaces of cities should be tackled with the awareness that designing with nature is a local, regional and global emergency. Cities are called upon to take the lead in promoting the conservation of biodiversity, but also its implementation in urban open spaces.

Researching the value of biodiversity in urban regeneration contexts is part of the theme of the use of the natural resources of our territory; it is necessary to consider the effects of social and economic impacts on our environment, and especially on the numerous species that populate it. It is, therefore, necessary to investigate the role of biodiversity with respect to its peculiarities and challenges in urban regeneration settings. Assessing the loss of biodiversity in urban settings is a topic included in the ESG (Environmental, Social, and Governance) dimensions that can highlight the limitations of ESG models and also suggest some solutions. Biodiversity degradation (biodiversity loss) creates risks (physical, transitional and liability) for all companies and sectors in different ways and over time.

European Biodiversity Strategies for 2030 [1] (2023) strongly marked a change in the European landscape on the issue of biodiversity. The European Union is directing planners, and decision makers towards strategies to be urgently included in urban and spatial regeneration plans with imminent, concrete and visible impacts by 2030. The EU Council emphasized the need to step up efforts to tackle the direct and indirect causes of biodiversity and natural resources loss. It reiterated the need

1. https://www.consilium.europa.eu/en/policies/biodiversity/#2030

to fully integrate biodiversity objectives into other sectors, such as agriculture, fisheries and forestry, and to ensure coherent implementation of EU measures in these areas. Hence, the need to map biodiversity in complex urban regeneration contexts raised in different urban contexts.

The guidelines for mapping urban biodiversity in urban regeneration areas collected in this report were created thanks to an experimental initiative - called Bioscopium - conducted within the T-Factor project from April 2023 to December 2023.

T-Factor[2] a Horizon 2020 research and innovation project funded by the European Commission with grant agreement n. 868887. It aimed to demonstrate the transformative potential of temporary uses as part of urban regeneration initiatives across six pilot projects in Europe, as critical assets for the city to establish more inclusive and sustainable regeneration processes.

2. | www.t-factor.eu

Photo credits: LAND

The Bioscopium initiative

Bioscopium was conceived as one of the initiatives developed by T-Factor for the pilot project of Milan at MIND - Milano Innovation District, by the researchers of Polifactory - Department of Design - Politecnico di Milano and LAND Italia, in collaboration with agronomists and wildlife experts of Studio TerraViva.

Bioscopium's ambition is to experiment with an innovative wildlife biodiversity mapping system to support developers, policymakers and other decision-makers involved in regeneration projects in knowing, preserving and implementing wildlife in areas under regeneration and during the regeneration process, as a crucial factor for environmental quality and human wellbeing.

More specifically, the project aims to test a system for exploring urban biodiversity in regeneration contexts to:

- understand the impact of the masterplan on the habitats present in the area during the regeneration period;
- inform and sensitize developers and public authorities on biodiversity issues;
- engage and activate citizens in biodiversity-related activities;
- implement biodiversity with strategic actions and green management guidelines.

In order to give decision-makers comprehensive information about the natural state of the area (both inside its borders and in relation to the surrounding territory), and to support experts engaged in monitoring tasks, Bioscopium envisions a mapping system that integrates distinct mapping actions:

- Mapping of the Ecological Network and Landscape indicators, from territorial to local scale, through the analysis of open source data and their visualization on digital maps through GIS software[3];
- Gathering and visualizing biodiversity observations with citizen science methods and tools for complementing the data collection, while activating and educating the

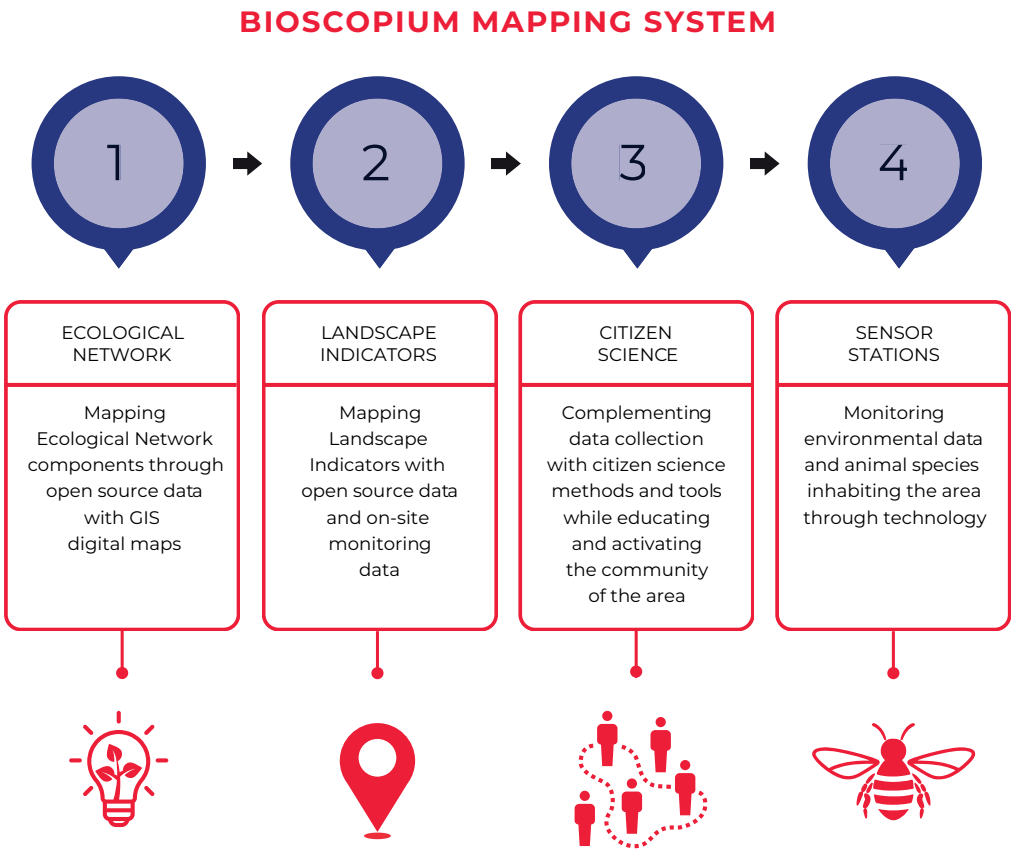
3. A Geographic Information System (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. GIS can show many different kinds of data on one map, such as streets, buildings, and vegetation. This enables people to more easily see, analyze and understand patterns and relationships (Source: *https://education.nationalgeographic.org/*).

<< Photo credits: Polifactory

community of the area;

- Monitoring with sensor stations for the collection of environmental data and the observation of faunal species inhabiting the area under regeneration.

Specifically, Bioscopium's sensor stations are inspired by the so-called Automated Multisensor Stations for Monitoring of species Diversity (AMMODs), which involve the integration of various technological components such as bioacoustic sensors, customized imaging systems, automated image analysis, DNA-barcoding, volatile organic compound analysis and discriminators to distinguish species on the basis of their intrinsic characteristics, such as movement and speed (see e.g. Wägele et al., 2022). More in depth, Bioscopium's sensor stations are designed in a modular way to be configured and personalized each time according to the biotope to be monitored, and to overcome the current limitations posed by the monitoring through human observations or the use of photo traps, or by weather stations alone (see section 1.4). Each module serves a specific function depending on the type of camera, sensor or actuator it is endowed with, and the class of



animals it intends to detect: insects, mammals, birds, fishes or amphibians. In general, each station aims to detect the number, type and variety of a specific class of animals present in the area over time, together with environmental data, such as soil moisture, water quality, air temperature, pressure and humidity.

Also, depending on the vastness and variety of the context to be monitored, the system can make use of a variable number of sensor stations, each one composed by different modules depending on the location where it is positioned and the classes of animals it is decided to monitor.

Based on the features of the Bioscopium mapping system and the implementation of the first prototype of the sensor stations, both of them experimented at MIND - Milano Innovation District, it was possible to extract some guidelines to be used by others in similar urban regeneration projects. Despite the Bioscopium system requiring further development and validation, we believe the experience at MIND allowed us to mature a good practice toward a new model for retrieving knowledge on urban biodiversity that, at the same time, facilitates engagement, education and action. The guidelines seek to disseminate the knowledge acquired by Bioscopium's experiments at MIND in order to further the conversation about urban biodiversity and establish it as a necessary component of any future urban development.

Purpose of the guidelines

The primary goal of setting guidelines is to give stakeholders of urban regeneration initiatives a workable approach and instruments that enable biodiversity mapping to become a routine and essential procedure for a just reconstruction, where the interests of people and the environment coexist.

Although key decision-makers will continue to play a crucial role in commissioning or initiating the mapping process, the guidelines are aimed at a wider range of actors who can independently and spontaneously carry out some complementary activities.

Further to this perspective, the potential target groups of these guidelines are the following:

- **Real estate developers** who may influence the masterplan's execution standards and biodiversity conservation;
- **Civil servants** capable of putting into practice suitable regulations targeted at strategic initiatives for the promotion of local biodiversity;
- **Specialists in biodiversity** (such as agronomists and animal conservationists) who are able to define, coordinate, carry out, and interpret mapping operations;
- **Professionals** with expertise in urban regeneration, as landscape architects and urban planners, who are able to identify and create plans of action for effectively managing and promoting the region's urban biodiversity;
- **Non-experts and citizens** who can help with data gathering, support citizen-science initiatives to promote biodiversity, and maintain natural areas, they can include neighborhood associations, local communities, and private citizens.

For each of these beneficiaries, specific **objectives** of the guidelines are:

1. **to raise awareness and knowledge of urban biodiversity**, through both scientific and popular contents, as a factor of environmental quality and human well-being, as well as marking its cultural and educational value for cities and their inhabitants;
2. **to provide some methodological steps** to be followed for mapping biodiversity in complex urban regeneration contexts, which consider the area under regeneration in relation with the wider Ecological Network;
3. **to exploit available open-source systems and resources** as the starting source of information on which to build biodiversity mapping strategies;
4. **to integrate the mapping work** performed by experts with tools and resources that help increment in both efficiency and frequency the mapping activities throughout the regeneration period;
5. **to facilitate the creation of an ecosystem of biodiversity-sensitive actors** that collaborate for the common purpose of

firstly knowing and then promoting local biodiversity;

6. **to suggest possible actions to be undertaken in order to preserve, protect or enrich the biodiversity** in the area under regeneration, in synergy with the wider urban context.

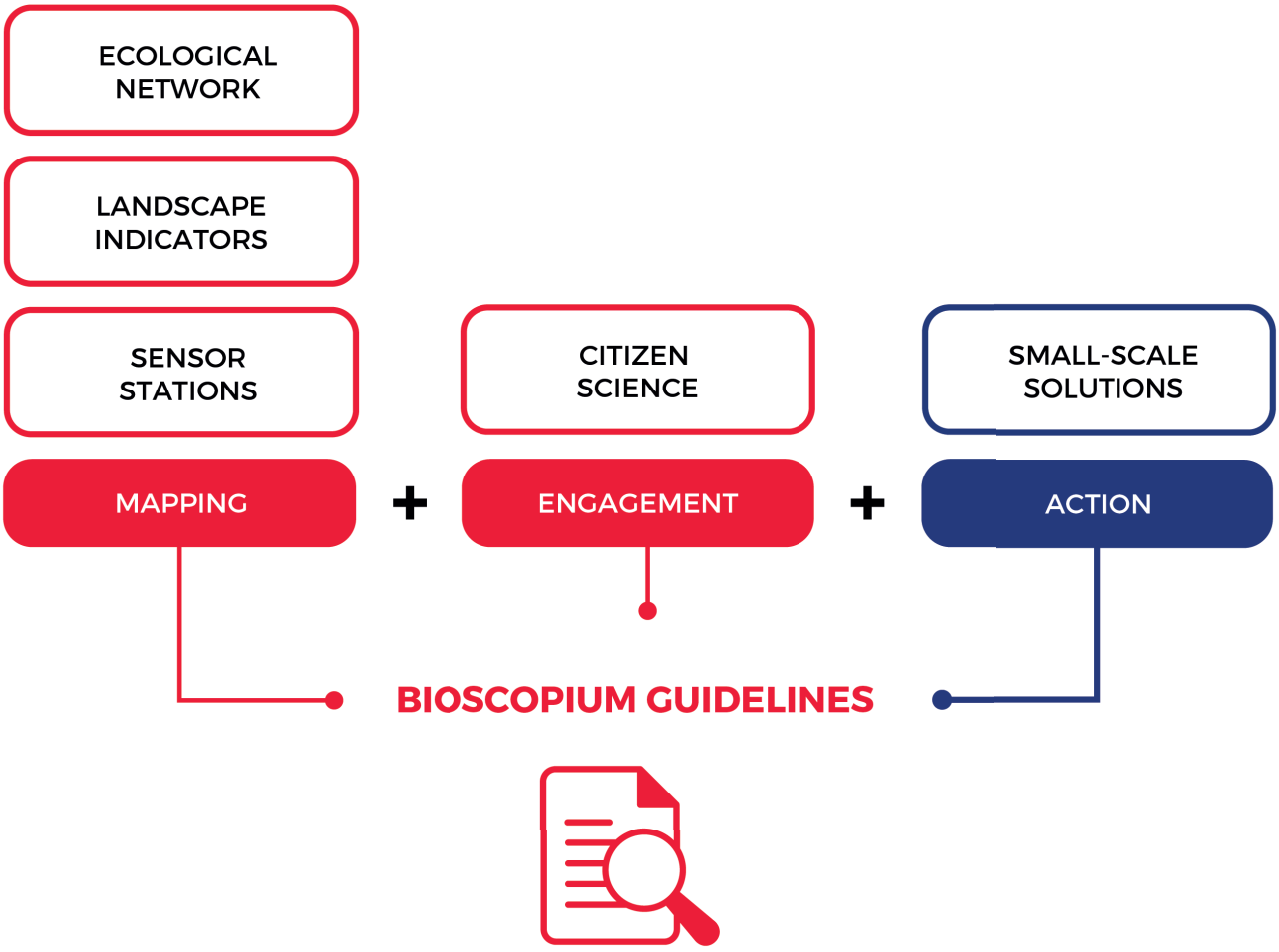
Photo credits: LAND

Structure of the guidelines

After an introduction discussing the function and significance of biodiversity in urban environments, and a glossary section which could provide definitions of important terminology on urban biodiversity, the guidelines are organized as follows:

1. **Mapping guidelines**, including guidelines for mapping the Ecological Network from territorial to local scale through the analysis of open source data, the involvement of wildlife experts and the use of sensor stations;
2. **Engagement guidelines**, for involving groups of non-experts in data collection, according to a citizen science approach, to complement what experts and the technology detect, while educating, at the same time, local stakeholders and communities;
3. **Action guidelines**, for identifying appropriate small-scale solutions to improve biodiversity in the regeneration context according to the results of the mapping and the engagement, which can be suggested to developers and decision-makers toward the development of a biodiversity-aware regeneration strategy.

Afterward, the case of T-Factor's milanese pilot project at MIND - Milano Innovation District is described, to exemplify how the guidelines can be applied to a real urban context under regeneration.


ECOLOGICAL NETWORK
LANDSCAPE INDICATORS
SENSOR STATIONS
CITIZEN SCIENCE
SMALL-SCALE SOLUTIONS
MAPPING
+
ENGAGEMENT
+
ACTION
BIOSCOPIUM GUIDELINES

/GLOSSARY

/BIODIVERSITY

The term biodiversity is defined by the Convention on Biological Diversity (CBD) as the ***"variability among living organisms from all sources including, inter alia, terrestrial, marine and aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species and between ecosystems***". Biodiversity is generally studied on three different levels, which correspond to three levels of organisation of the living world: that of genes, that of species and that of ecosystems (ISPRA[4]).

/BIOTOPES

In ecology, a biotope is defined as a limited area of an environment where plant and animal organisms of the same or different species live, together forming a biocenosis. The biotope is, therefore, the component of the ecosystem characterized by abiotic (non-living) factors, such as soil or substrate, with its physical and chemical characteristics (temperature, humidity, light and so on), but not considered separate from the biological component.

/ECOLOGICAL CORRIDORS

Landscape element that connects two or more patches of natural habitat. It serves as a habitat and channel for the movement of animals and spores and as an area through which genetic exchange between populations takes place *(Adapted from ISPRA)*.

/ECOLOGICAL NETWORK

The ecological network as an interconnected system of habitats, whose biodiversity must be safeguarded*, thus paying attention to potentially threatened animal and plant species*. The ecological networks are made by:

- ***Core areas****:* high nature areas that are already, or can be subject to a protection regime (parks or reserves);
- ***Buffer zones,*** or transition zones: zones located around high nature areas in order to ensure the necessary gradual establishment of habitats;
- ***Connecting strips (ecological corridors)****:* linear and continuous landscape structures that connect high nature areas and represent the key elements of ecological networks as they allow species mobility and genetic exchange, which is indispensable for maintaining biodiversity;
- ***Nodes and stepping stones/zones****:* areas of small surface that, due to their strategic position or composition, represent important elements of the landscape to support species in transit through an area, or host particular micro-environments in critical habitat situations *(e.g. small ponds in agricultural areas) (ISPRA).*

/ECOSYSTEMS

The totality of communities of animal and plant organisms and the environment in which they live and interact. Examples of ecosystems are a lake, a forest, a coral reef *(ISPRA)*.

/ECOSYSTEM SERVICES

According to the Millennium Ecosystem Assessment, they are the multiple benefits provided by ecosystems to humankind. Ecosystem services are set in four categories: supporting (such as nutrient cycling, soil formation and primary production); provisioning (such as the production of food, drinking water, materials or fuel); regulating (such as climate and tidal regulation, water purification, pollination and pest control), cultural values (including aesthetic, spiritual, educational and recreational). Relevant is the role of ecosystem services with respect to their connection to society *(MEA)*.

/GANGLIA

Ganglia are those natural units capable of constituting, in terms of size and internal articulation, ecosystem strongholds capable of self-sustaining themselves. They must be able to provide a habitat sufficient to maintain stable populations of the species of interest and allow differentiation of internal habitats so as to improve conditions for biodiversity. Ganglia can be primary and secondary depending on their function within the ecological network *(Adapted from ISPRA)*.

/HABITAT

Set of physical (e.g. light and temperature) and chemical (e.g. nutrient concentration) environmental conditions in which an organism grows and performs its vital functions. The set of organisms that inhabit a habitat is called a community *(ISPRA)*.

/MAPPING

Mapping is the act of representing information in maps. The map is a representation, usually on a flat surface, of the features of an area of the Earth, or a portion of the heavens, showing them in their respective forms, sizes and relationships according to some conventions of representation.

Specifically, ***urban biodiversity maps are a cartographic representation of any biodiversity data that have temporal and spatial units in relation to urban contexts***. The use of open-source data, from planning documents to citizen science, allows geo-reference information, surfaces and making evident spatial relationships that can represent the existing conditions of biodiversity in a place. Moreover, the collection of information and its systematization in cartography makes it possible to synthesize the complexity of urban biodiversity issues so as to make them comprehensible to all.

4. Italian Institute for Environmental Protection and Research - https://www.isprambiente.gov.it/

/GLOSSARY

/MONITORING

One of the ways in which ***environmental control*** is carried out is through monitoring, understood as the ***systematic verification*** of changes in a specific ***chemical, physical or equivalent parameter over time through repeated measurements and observations with appropriate frequency*** *(Adapted from ISPRA)*

/NODES

These are the ***areas of maximum naturalness and biodiversity, with the presence of one or more habitats and species of conservation interest at regional and supra-regional levels*** that must be conserved in order to maintain the viability of biological populations between the different nodes of the network *(Adapted from ISPRA)*.

/STEPPING STONES

In landscape ecology, ***they are small habitat patches***; they can be natural components in the ecological network of corridors at the territorial scale. An ecological corridor is defined as a strong connection between habitat patches.

/TARGET SPECIES

Species with characteristics that allow the identification of a range of spatial and functional requirements that encompass those of all other species in an area/ ecosystem to be placed under protection.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Inquadra il QR code e accedi al form online
Posiziona il tuo smartphone nella posizione designata
Segui le istruzioni del form per scattare e caricare una foto della specie di questo prato
Condividi i tuoi risultati rispondendo alle domande
Torna ad Herbula Wild Garden e confronta i tuoi risultati nel tempo
ALLINEA LO SMARTPHONE AI BORDI

1

/INTRODUCTION

/ INTRODUCTION

1.1 What is urban biodiversity and why it matters

The diversity of life on Earth, encompassing all its forms and interactions, is known as biodiversity. Biodiversity encompasses microorganisms, plants, animals, and the natural systems that uphold them, and it characterizes our natural richness, shaping the living environment that surrounds us, supporting ecological systems, and enriching our overall quality of life. The preservation of biodiversity is a crucial resource for the resilience of ecological systems and, consequently, for the advancement of human societies (Folke et al., 2016). To date, approximately 25% of species face global threats, posing a substantial risk to food security (IPBES, 2019), and requiring efforts to mitigate climate change, the availability of energy resources, and the condition of ecosystem services.

If biodiversity can be defined, in simple terms, as the diversity of life on Earth, the term urban biodiversity refers to the wild nature hosted by our cities.

Urban environments deserve to be considered and enhanced as habitats for wildlife, both flora and fauna, since they serve two primary functions (Dinetti, 2009):

- **Direct functions** involve contributing to the conservation of local biodiversity and protecting certain threatened species of conservation interest, which find a suitable habitat within urban settings. The conservation of nature in cities is thus beneficial for biodiversity in a narrow sense, given the often high levels of biodiversity found in urban environments compared to the surrounding rural areas.
- **Indirect functions** encompass raising awareness and fostering a proper perception among citizens, particularly

the youth, who reside in areas with depleted biodiversity, losing daily contact with nature.

Despite the scarcity of green spaces, cities serve as habitats for over 45,000 species, encompassing both native species, some typical of the surrounding areas, and others exclusive to urban environments. This diversity is attributed to the presence of varied biotopes (Sattler et al., 2011). Nonetheless, despite the remarkable biodiversity in urbanized environments, their conditions have a negative impact on nature as a whole (McKinney, 2002).

The presence and good condition of nature in cities is essential for the development of a sustainable quality of life and to increase people's awareness about it. Most people live in urban areas, and cities are the places where political decisions that affect the world's ecosystems are made. It is mainly in cities that people shape their perceptions of nature; thus, being in contact with nature in the place where people live and make decisions is essential to raise awareness of the importance of biodiversity globally.

For these reasons, the pressing importance of conserving biodiversity, coupled with the imperative to reintegrate nature into urban settings to create mutual advantages for both citizens and the environment, has turned cities into focal points for experimentation. Urban regeneration projects, in particular, because of their innovative and transformative nature, frequently serve as ideal platforms for these kinds of experiments (Gulsrud et al., 2018). They can vary from the implementation of strategies to conserve urban biodiversity, the restoration of habitats that bring target species back to the city (Obrist et al., 2013), and actions to improve people's affective and experiential connection with nature (Mayer and Frantz, 2004). Not to consider the benefits that direct contact with nature brings to people's well-being, as discussed in the next section.

1.2 Biodiversity and well-being

According to the World Health Organisation (WHO, 2023), rapid urbanization, land use change, land degradation, global trade and industrialisation have caused a profound and negative impact on nature worldwide. The ongoing depletion of natural resources is affecting environmental conditions and has a huge impact on climate change, vector-borne diseases and zoonoses, food safety, water supply, and pharmaceutical options. Also, it jeopardizes health, well-being and safety all around Europe. The importance of biodiversity for the daily lives of people and our planet was not only declared in the Convention on

Biological Diversity of Rio de Janeiro (1992), but more recently in the Kunming-Montreal Global Biodiversity Framework of COP15 and in the WEF 2022 BiodiverCities by 2030 report. According to the latest data collected by the European Centre for Environment and Health (WHO ECEH, 2023) and the United Nations Environment Programme (UNEP), it can be stated that it is necessary to redesign our urban spaces in a way that emphasizes the inescapable relationship between humans and nature, biodiversity and human well-being. Among the others:

- Nature and ecosystems provide important products such as water, energy, food and medicine as well as important services such as climate regulation, nutrient cycling, carbon storage, and oxygen production;
- Up to 1 million species are threatened with extinction – many within a few decades. The loss of biodiversity affects our life support systems (e.g. food systems), which in turn has an impact on health and well-being;
- Over 80% of the world's wastewater is discharged untreated into the natural environment;
- In the European Union (EU), 39% of the land was used for agriculture in 2018, while only about a quarter was classified as 'protected' in 2021, according to the OECD;

<< MIND Milano Innovation District - Herbula Wild garden
Photo credits: LAND

- Data from the European Environment Agency shows that agriculture, public water supply and tourism account for the largest share of water resource use. In Southern Europe, around 30% of the population live in areas under permanent water stress;
- Around two thirds of the EU's wetlands have been lost in the last century, with 85% of the remaining wetlands having an unfavorable conservation status.

Therefore, protecting nature and counteracting the loss of biodiversity and ecosystems, including in urban habitats, is a fundamental prerequisite for the health of future generations and is explicitly addressed by Sustainable Development Goals 14 and 15 on life below water and on land. Moreover, spending time in nature is associated with a lower risk of certain health conditions. Not to mention those studies that demonstrate that biodiverse environments, also called 'restorative environments', are particularly effective in enhancing psychological well-

being, reducing both physical and mental stress, eliciting positive emotions, and aiding in the replenishment of cognitive resources (Bellini et al., 2015; Hartig, 2004).

This means that investing in the transition to green and sustainable societies and economies represents an investment in health and cultural capital too. Here stands the strongest reason for mapping urban biodiversity: finding the balance between the well-being of people and the planet, as one depends on the other and *vice versa*. As mentioned above, urban regeneration contexts can be considered the ideal context and opportunity to experiment on the adoption of some good practices.

>> Photo credits: The meadoway - Community powered green spaces

1.3 Biodiversity and urban regeneration

It is not a secret that urbanization has had a devastating impact on the world's biodiversity: according to data collected and surveyed by FAO (the Food and Agriculture Organization of the United Nations) from 1990 to 2020, out of a total of 4.06 billion hectares (about 31% of the Earth's surface), some 186 million hectares of forests and woodlands have been destroyed, replaced by permanent urbanization installations, such as

infrastructure and buildings in the world's major megacities and metropolises.

The United Nations recently declared the 2020s the Decade for Ecosystem Restoration, calling on governments, institutions and citizens to rebuild degraded or destroyed natural habitats and conserve existing ones. Accordingly, as it can also be argued from the previous sections, international and national entities are formulating policies pertaining to urban biodiversity. Among the others, the Kunming-Montreal Global Biodiversity Framework (UN, 2022) guides the implementation of actions to revolutionize our relationship with biodiversity by 2030, advocating for local biodiversity policies that promote sustainable utilization and equitable sharing of its benefits, with a strong emphasis on awareness and education. Instead, the European Commission, through the New Biodiversity Strategy 2030 (EC, 2020), has urged cities with a population of at least 20,000 inhabitants to craft ambitious urban greening plans. These plans should encompass the creation of accessible and biodiversity-rich forests, parks and gardens, as well as the implementation of green roofs and walls in urban regeneration contexts.

In the contexts of urban regeneration, the design and management of biodiversity should also ensure short- and long-term soil regeneration processes. In this perspective, the European Union has promoted the Soil Strategy 2030, aimed at mitigating soil use by monitoring the health of the soil also with respect to components that create biodiversity. Accordingly, the transformation of disused/neglected urban areas has long since assumed a key role. In Italy, for example, 920 square kilometers of regenerable soil will be available in the national context over the next 27 years. The vision of the potential of urban regeneration, not only in real estate terms, but also at environmental, social and economic level was expressed in the National Report on Urban Regeneration (Unipol, 2023). However, the environmental and biodiversity dimension in these planning instruments is still weak and ancillary to the environmental sustainability challenges still facing the performance of the city's buildings and services.

Inventive actions are, therefore, needed that seek to integrate urban biodiversity into concrete regeneration operations. The significance of urban biodiversity projects lies in the provision of a range of ecosystem services, such as urban-rural soil regeneration, climate regulation, air and water purification, pollination, and aesthetic benefits planning for cities. Thus, environmental protection and the design of ecological corridors and green infrastructure (European Commission, 2018) are increasingly considered priority actions in urban regeneration strategies across Europe. Moreover, green corridors, which are interconnected strips of green spaces linking urban areas with natural habitats, have become popular in European cities as a nature-based solution[5] to promote urban biodiversity.

As declared by most regional landscape plans and green papers (at least in the European context), the design of biodiverse habitats and ecosystems in urban regeneration contexts should also include the careful selection of plant species such as native plants and wildlife-friendly plants in private and public gardens. These small but necessary design actions will contribute to the sustenance and maintenance of local urban biodiversity, as native plants are adapted to local conditions and provide food and habitat for local wildlife, also considering that they have minimal water requirements compared to allochthonous and alien species (EU, 2020).

Certain cities are exploring innovative green placemaking strategies, particularly in the context of regeneration initiatives. One noteworthy example is the Natural Park of Lama Balice in Bari, Italy (Tarsitano et al., 2021), where cultural and social interventions, such as sensory labyrinths, vegetable gardens, and natural architectures, have been employed to restore biodiversity. These interventions aim to enhance citizens' quality of life while upholding principles of sustainability and social participation. Similarly, the Tempelhofer Feld Initiative in Berlin, Germany, has transformed a former airport area into a space dedicated to biodiversity recreation and protection. The city has implemented a maintenance plan for the area, fostering cooperation with citizens.

5. Nature-based solutions encompass measures aimed at safeguarding, preserving, restoring, and sustainably utilizing natural or altered terrestrial, freshwater, coastal, and marine ecosystems. These actions are designed to tackle challenges that span social, economic, and environmental dimensions, as articulated in the Fifth session of the United Nations Environment Assembly (UNEA-5, 2022).

>> Biodiversity Corridor Montrèal - Canada, Photo credits: LAND

>> Lama Balice Park in Bari, Italy, Photo credits: Italian Botanical heritage

These endeavors exemplify actions bridging humans and biodiversity. But to establish a better balance between the two, humans firstly need to know what biodiversity is present (or should, or could be present) in a certain urban area, that is to perform biodiversity mapping and monitoring. And here comes the work of experts that, with more or less support from available technologies, are called to provide urban planners and real estate developers with such knowledge. This is not an easy task, and the often scarce awareness of decision-makers, together with the even more scarce availability of resources, and the limitations of existing methods and tools, frequently make biodiversity mapping and monitoring a sporadic and optional practice. The Bioscopium system, together with the guidelines collected in this document, try to overcome some of these limitations, which are summarized in the next section.


MIND

1.4 Mapping and technology limitations

Biodiversity mapping, or censusing and monitoring, is a procedure normally led by ecology experts, which is time-consuming and highly complex, and for these reasons, is often not carried out in fragmented urban areas.

A partial and time-limited mapping of areas is sometimes preferred over the proper execution of field observations due to the time and expenses involved in gathering data and the lack of necessary expertise.

To facilitate data collection, and to avoid experts spending a lot of time on field for the sake of direct observations, several tools and techniques have been developed for wildlife mapping and monitoring, also including the support of amateurs and non-experts.

The most common and diffused is probably image capture through photo traps, which is a powerful tool for estimates of population densities, body sizes, and behavior. For small mammals, Littlewood et al. (2021) attached a camera to a baited tunnel, a method that can replace live-trapping typically used for monitoring of rodents. Other applications have been invented, for example, to discover and count pest insects attracted by pheromone traps, yellow pans or bucket traps.

However, photo trapping is endowed with some limitations that do not allow for an extensive and systematic application. They include limited camera coverage (resulting in decreased probability of detection), the possibility to detect species only above a certain body size, and the need for human intervention in both maintenance (replacing batteries, downloading data, repositioning the device), as well as identification, counting, and classification of images.

<< MIND Milano Innovation District - Herbula Wild Garden, Photo credits: LAND

These constraints, in addition to the often limited availability of open-source data on the conditions of ecosystems in the surveyed areas, turn biodiversity mapping and monitoring into

a sporadic action, mainly conducted for satisfying mandatory regulatory standards rather than a genuine interest in the sort of the environment. As a consequence, this results in the limited access to monitoring data records, especially when carried out by property developers or private entities, which further increases the fragmentation of information and the difficulties in lowering the efforts for conducting such actions.

Today, mapping by means of image capture and recognition with autonomous systems for species detection[6] represents the most promising way to reduce human effort and is becoming more and more technologically advanced. Standards related to data collection protocols (such as type of camera used, positioning, species nomenclature) have been proposed that allow the comparison of data from different projects (Forrester et al., 2016).

These technologies combined with participatory practices, such as those proposed by citizen science, could improve data collection results and reduce human effort (Liu et al., 2024, Velasquez-Camacho et al., 2024).

In our vision, integrating data collection (performed by experts with the support of advanced data capturing technologies, such as the Bioscopium sensor stations) and open-source image recognition systems, together with citizen involvement by means of citizen science, can make biodiversity mapping and monitoring a more accessible, continuous and participatory practice. We believe this strategy could compensate for the time, costs and limitations of expert work alone, while at the same time activating communities, raising awareness, and supporting data standardization, digitisation and openness, toward a more continuous, systematic and extended mapping and monitoring at urban level.

6. See e.g. Wildlife Insights (*www.wildlifeinsights.org*) or Bat Conservation Trust (*https://www.bats.org.uk/*)

1.5 Working together with local organisations and experts while leveraging on citizen science

As mentioned above, mapping urban biodiversity in areas under regeneration in the way suggested by these guidelines entails the involvement and participation of several actors from the urban ecosystem. We strongly believe that, to make urban biodiversity a priority in the future regeneration agendas, it will be increasingly important to make it a common affair, starting from making it easier to perform and access (as proposed by the Bioscopium initiative), and then pushing local stakeholders, experts and citizens working together toward a shared purpose. To do so, each one should cover a specific role and function in the mapping process suggested as follows, starting from that of *biodiversity steward*, i.e. the individual, group or organization that acts as promoter of the biodiversity mapping and is responsible for bringing the issue to the attention of decision-makers, as well as finding and organizing the resources needed for data collection and its subsequent use.

In the context of urban regeneration, this role should ideally be covered by the developer or local authorities, but if not triggered by them it could eventually be appointed to other local actors such as:

- stakeholders of the area under regeneration (e.g. companies sensitive to the issue);
- environmental associations, activists, networks of nature experts based in the urban context;
- cultural associations, youth associations, etc., operating in proximity to the regeneration area;
- local public institutions operating close or in connection to the area under regeneration;
- organized groups of citizens living nearby, etc...

Of course, decision-makers of the area will keep on playing their

decisional role by authorizing the mapping, providing access to the area and to data already available, as well as participating in defining the solutions to be implemented in support of biodiversity.

While the above-mentioned actors, if not playing the steward role, could be involved in the mapping process with other roles and tasks, which could span from supporting the work of experts (which will remain fundamental) by providing data about the territory, developing and organizing engagement activities, or implementing actions and solutions for preserving and improving biodiversity as those described in the dedicated sections of these guidelines.

>> Mapping Biodiveristy with citizen at MIND - Milan Innovation District. Photo credits: Polifactory

A further discourse should then be devoted to cooperation with local communities or individual citizens. Their role in the mapping could be defined as 'active beneficiaries'. In fact, building on the EU Biodiversity Strategy for 2030, it is suggested to make citizens play an active role in the mapping process, and not only make them take advantage of the benefits brought about by direct contact with nature in the city. This active role can include their involvement in the implementation of strategies to promote biodiversity in private spaces, and participatory practices in data collection and monitoring of urban green spaces through citizen science and educational programmes.

Citizen science, indeed, is a research methodology conducted with the participation of the general public, amateur/non-professional researchers in ecology, biology and conservation sciences. In urban regeneration contexts, citizen science activities can contribute substantially to urban biodiversity analysis and monitoring practices. For this reason, an entire section of the guidelines is dedicated to the engagement of non-experts in mapping activities, and citizen science represents the key approach for making this happen.

<< Biodiversity mapping with citizens at MIND - Milano Innovation District. Photo credits: LAND

2

/MAPPING GUIDELINES

/ MAPPING GUIDELINES

In this section, you can find guidelines for mapping the Ecological Network of the area under regeneration at different scales, from the territorial landscape in which it is located to the specific regeneration site.

The purpose is to better frame the relations of the area with the larger urban environment and to identify the traits and potentials of biodiversity that need to be preserved or enhanced.

In the real world, biodiversity conservation, management and improvement initiatives depend heavily on mapping and tracking the current state and trends of wildlife populations.

This entails keeping an eye on modifications to the population size, habitat quality, and other crucial markers of the health and survival of wildlife.

Moreover, opportunities for biodiversity conservation and improvement can be identified by analysis with maps, which provide tangible evidence for policy considerations too.

Applying these guidelines you will be able to

- ***acquire knowledge*** on the conditions of green and open spaces in the surveyed areas;
- ***assess the vulnerability conditions*** of habitats (at territorial/ urban scale) and biotopes (at regeneration site scale);
- ***learning the factual condition*** of plant and animal species in the regeneration area;
- ***monitoring fauna*** through sensors and citizen engagement.

To do so, it is suggested to combine several types of data, scales and views, some of them already available and accessible

through open-source databases or to be retrieved from previous studies conducted in the area; some others to be collected from scratch, involving ecology experts and/or using photo traps, sensory stations or other existing technologies.

Therefore, the following steps are suggested:

1. **Consulting** planning documents and mining open-source data;
2. **Analyzing** the urban ecosystem through Ecological Network and Landscape Vulnerability Indicators;
3. **Classifying** habitats and biotopes in the regeneration area with open-source data;
4. **Extrapolating** knowledge on invasive and endangered species;
5. **Integrating** open and existing data with on field observations.

/GUIDELINES

Consulting planning documents and mining open-source data

A key initial step in mapping biodiversity consists of analyzing the conditions of biodiversity in the area that is undergoing regeneration. A preliminary investigation (*screening*) that collects and evaluates pertinent data on habitats and ecological networks surrounding the targeted area is recommended.
To do so, reviewing planning documents is the first step in recognizing the circumstances of biodiversity in areas ranging from regional to local. In fact, urban planning documents describe the features of urban environments from the local to the territorial scale. In particular, it would be suitable to consult:

- Regional Landscape Plans;
- Urban Landscape Plans;

- Green Plans and directories;
- Biodiversity Conservation Plan;
- Regional and Local Environmental Monitoring Plans;
- Ecosystem services assessment Plan.

Planning documents are useful tools for comprehending the intricacy of the environment and the relationships between plant, animal, and human species that contribute to biodiversity, particularly when they are close to urban regeneration sites.
It is also feasible to establish different dimensional scales for interpreting the landscape and its biodiversity components – namely the Ecological Network - through urban planning and regulatory documents: the territorial (regional/metropolitan), urban, neighborhood, and project scales.

This cross-scales approach suggests that knowledge of the planning documents to assess the spatial and environmental conditions of habitats (in the territorial dimension) and biotopes (in the local dimension) could facilitate the data mining action.

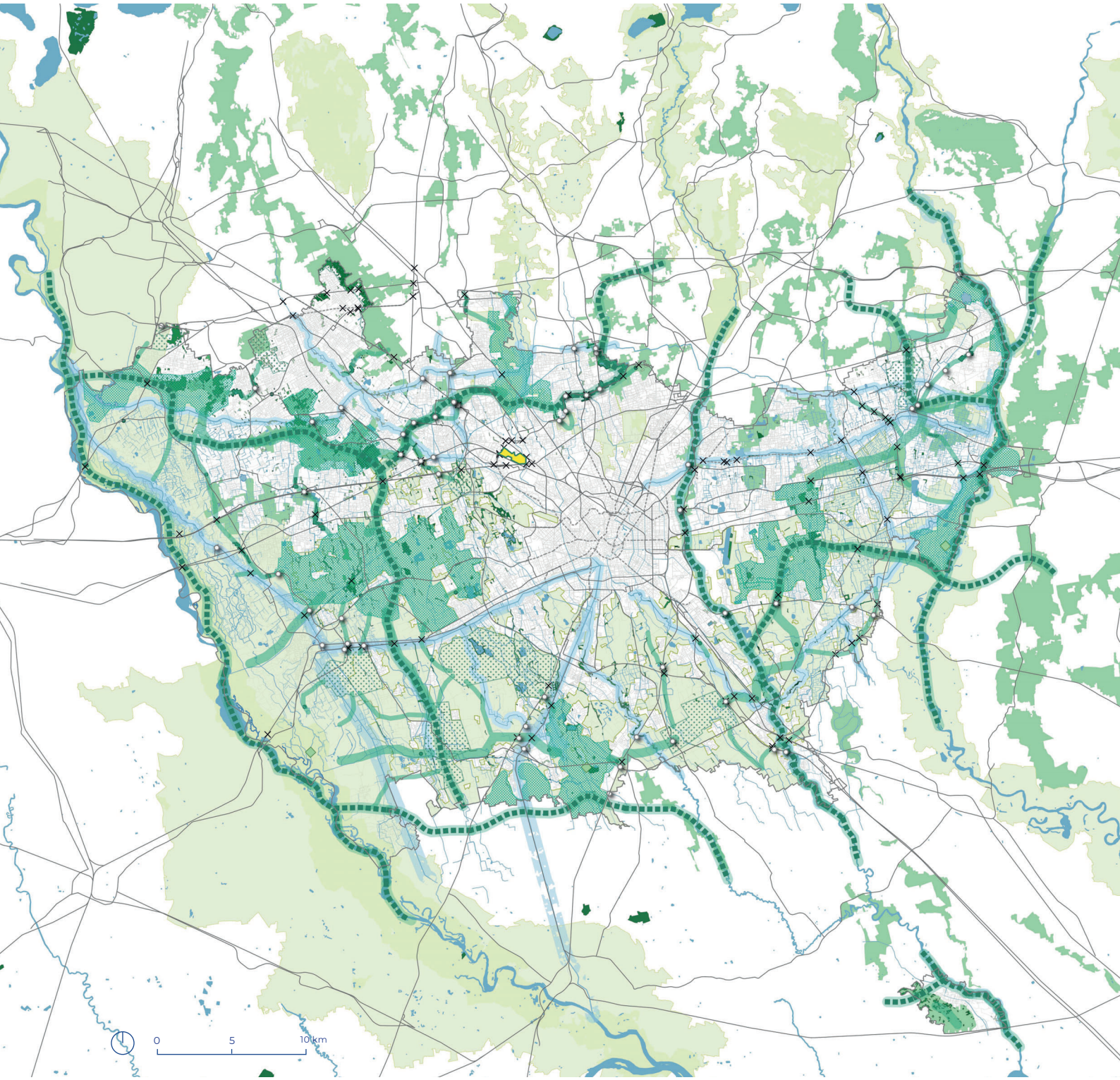
Specifically, the analysis of planning documents could allow the preliminary assessment of landscape vulnerabilities and networks around the project areas, according to an inter-scalar.

To supplement these documents, it is possible to include a cartographic information research with open-source data sets to support the Ecological Networks mapping at different scales.

By using maps, it would be possible to design strategic interventions such as rethinking the length of the Ecological Network, the width of its ecological corridors, and the urban areas where the green infrastructure can be spread. In particular, at the large dimension, Ecological Network maps aim to represent the urban regeneration areas as *stepping stones* in the metropolitan re-connection of the area. At the medium scale, maps identify the *landscape components* of the municipal territory: e.g green areas, barelands and open spaces where green infrastructure can capillary infill inside the urban settlement. At the small scale, Ecological Network maps could guide spatial transformations envisaged by the administrative urban and landscape plans, which are based on the development of the historical, geographical, morphological structure of the city.

Milan metropolitan ecological network

Credits: Elaboration by LAND from Rete Ecologica Regionale and Piano Territoriale Metropolitano database.



>> Milan municipal ecological network

Credits: LAND's elaboration from Metropolitan Ecological Network plans and database, DUSAF 2023 Land Use Regione Lombardia Database. Comune di Milano Geoportale SIT database.


TANGENZIALE NORD DI MILANO
BIOSCOPIUM
Novate M.
AUTOSTRADA TORINO-TRIESTE
Nirone
Stephenson
Legend
MIND_area
MIND BIOTOPES
Tree line
Forest belt
Complex forest strip
Simple forest belt
Urban park - Mediterranean hill
Tree-lined square
Arboreal meadow
Meadow
Roadside flowerbed
Perimeter channel
Purification basin
LAND USE
Water bodies
Water node
Water course
Canal
Water bodies
Topographic database - vegetation
Tree
Non-vegetated areas
Agricultural areas
Unused grasslands
Urban parks
Green areas
Wood
Topographic database - infrastructures
Railway stations
Main roads and motorways
Buildings
Roads
Railway

Analyzing the urban ecosystem through Ecological Networks and Landscape Vulnerability Indicators

Mapping landscape features and Ecological Networks is based on the research of *primary ecological corridors* that are detectable at both the local and broad spatial scales. The objective of the mapping is to map existing Ecological Networks in order to qualify the current condition of flora and fauna.

By identifying obstacles and *nodes of the Ecological Network*, maps foster the visualization of possible connections among the green areas of the site under regeneration and its surroundings.

Buildings, highways, trains, and roads are a few examples of the landscape features that work in a linear or diffuse way to provide barriers with little to no bio permeability, or appropriateness.

Thus, by using open source data from local geoportals and consulting the spatial and local plans and documents, cartographic analysis could be replicated and scaled up to the project site.

More in details, the Ecological Network maps can be used operationally in three different spatial dimensions:

- *Large dimension*: framing Regional/Metropolitan Ecological Network around the area under regeneration;
- *Medium dimension*: framing Urban/Municipal Ecological Network neighboring the area under regeneration;
- *Small dimension*: framing the area under regeneration linked to the Ecological Network nodes, edges and borders.

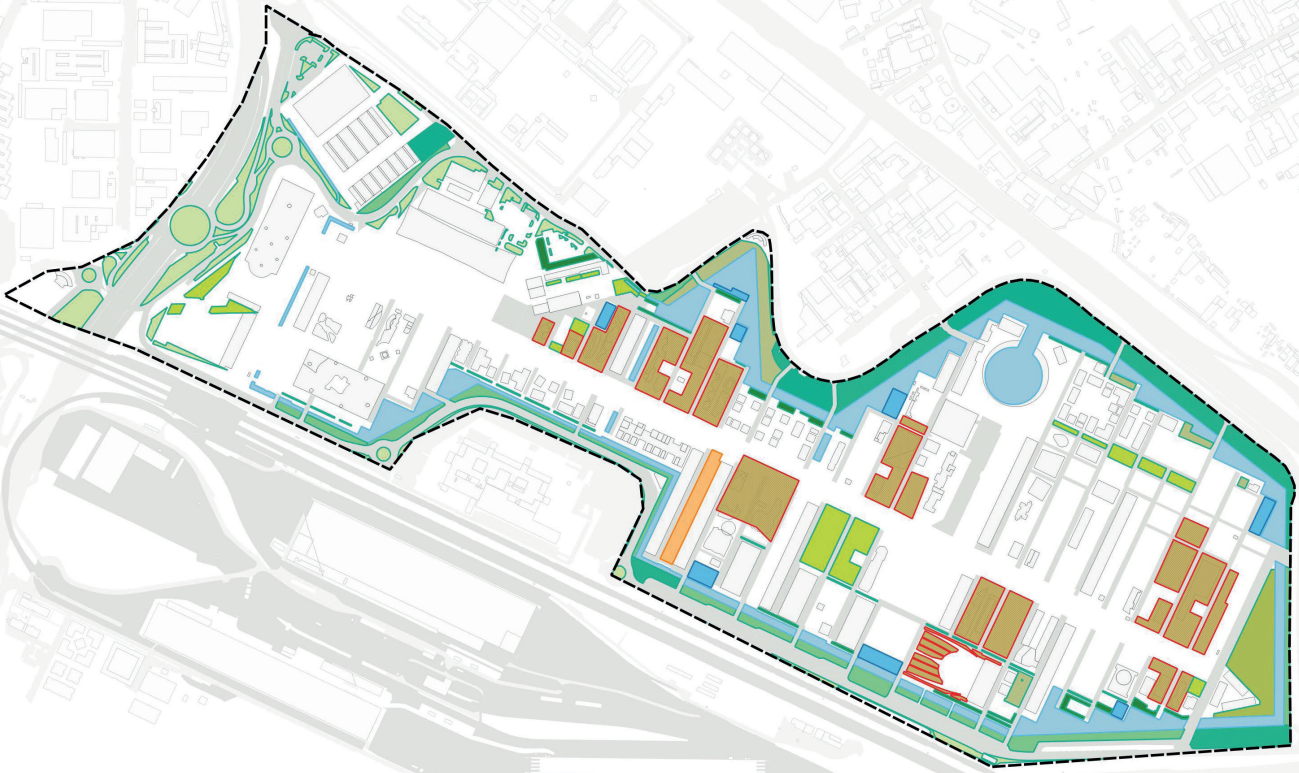
Mapping Landscape Vulnerability Indicators[7] includes strategic actions to map landscape and wildlife indicators in urban regeneration areas, to assess local biodiversity criticalities and potentialities.

The aim of Landscape Indicators is to *measure the degree of*

7. Tool for measuring and reporting the values of environmental and physical condition of a space, useful for monitoring the impact of strategic and design interventions in the urban context.

Biotopes classification at MIND

Credits: DUASAF 2023 Regione Lombardia. Elaboration by Studio TerraViva and LAND



- Tree line
- Forest patch
- Complex forest belt
- Simple forest belt
- Urban Park
- Tree square
- Tree meadow
- Street flowerbeds
- Meadow
- Urban Park - Hortus
- Phyto-purification basin
- Perimeter channel

0 500 m 1 km

Municipal scale

vulnerability of green areas in regeneration areas and, above all, to *measure how suitable areas* are to host new target species for the promotion of biodiversity.

In urban regeneration contexts, Landscape Indicators mapping could be conducted with open-source data in GIS systems through the support of experts in landscape ecology and wildlife science.

Nonetheless, the following tools could be used to perform the ecological study utilizing maps:

- open-source software like Guido toolbox or GIS systems (JRC, 2023);
- available data from national and international geoportal databases;
- open-source data from the spatial, landscape, and urban planning of the area under regeneration;
- comparative analysis of soils using satellite imagery;
- local surveys in the area under regeneration.

8. A thematic map showing spatial features of one or more small areas in relation to a larger area. It is usually used for indicating particular features in the small areas about which information is to be obtained.

However, it is necessary to have access to an updated dataset of territorial and urban Land Use classification data in order to carry out the geographical analysis.

Operationally, Landscape indexes[8] can be set across the same three spatial dimensions mentioned above.

More in depth, the open-source indicators to map biodiversity conditions in urban regeneration contexts could be classified as:

Landscape Fragmentation Index. The index can be mapped at both the medium and small scales, assessing the progressive reduction of natural and semi-natural environments and an increase in their isolation. It is mainly generated from the urban expansion phenomena, implemented in more or less sustainable forms, from the development of the infrastructure network aimed at improving the connection of urbanized areas through linear works (ISPRA, 2021). Data resource to support mapping actions are:

<< Landscape Fragmentation Index. Credits: DUSAF 2023 Regione Lombardia database. Elaboration by Studio TerraViva and LAND

- *Corine LandCover Dataset*: CORINE Land Cover (CLC) product offers a pan-European land cover and land use

inventory with 44 thematic classes of grounds;

- *ESA Land Use maps*: Land Use classification set on Sentinel-2 resources;
- *Land Use / Cover frame Statistical Survey* from Eurostat database;

Wildlife Suitability Index is a useful tool to assess the efficiency of ecosystems to host potential new animal species. It is an analysis conducted at the small scale. Specifically, the Wildlife Suitability Indicator allows objective feedback to be given to the assessments made regarding the efficiency in the provision of ecosystem services.

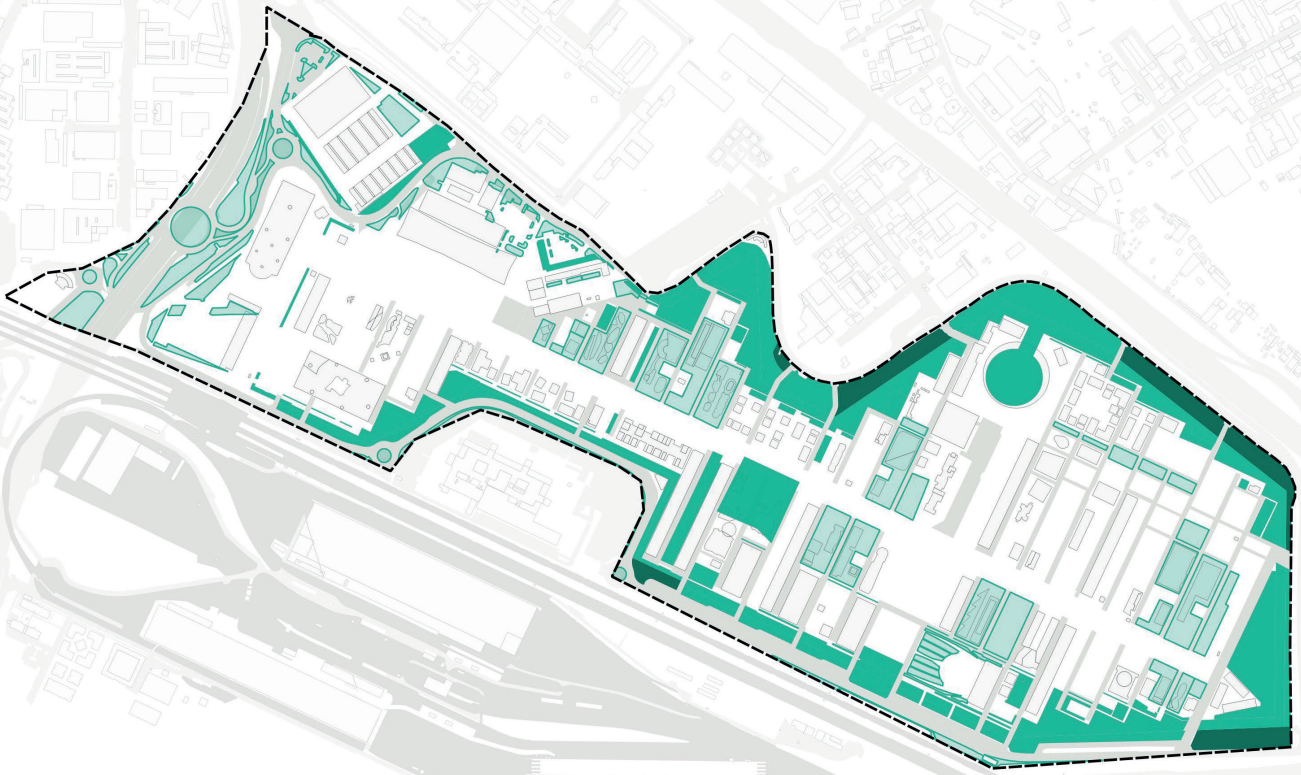
We suggest to analyse the index on three information bases:

1. Biotopes extension and orientation in the area under regeneration;
2. faunal data collected on field by experts;
3. faunal observations from iNaturalist and photo-trapping data on site.

In a synthetic value analysis, the collected faunal data can be represented according to an indicator with a three-value scale:

- *Low wildlife suitability* (value 1): no fauna data found for the biotope type, or ubiquitous and synanthropic species found.
- *Medium wildlife suitability* (value 2): for the biotope type, species with a high distribution but more stringent ecological requirements than in the previous class found.
- *Low fauna suitability* (value 3): demanding and/or rare species found for the biotope type.

These studies can be used to inform decisions about the allocation of maintenance resources, the implementation of corrective measures, the preservation of particular green areas within the Ecological Network, and the creation of new biotopes. On the other hand, this research could lead to the development of strategic actions towards biodiversity conservation and development at urban scale. Moreover, the Ecological Networks maps can be supported by Landscape Indicators to qualitative and quantitative measure the impacts of human and non-human influences in the dynamic system of landscape.



Local Scale: MIND

Wildlife Suitability Index. Resource reference from DUSAF 2023 Regione Lombardia database. Credits: Studio TerraViva and LAND

- Low wildlife suitability (value 1)
- Medium wildlife suitability (value 2)
- Medium wildlife suitability (value 3)

0 500 m 1 km

Classifying habitats and biotopes in the regeneration area with open-source data

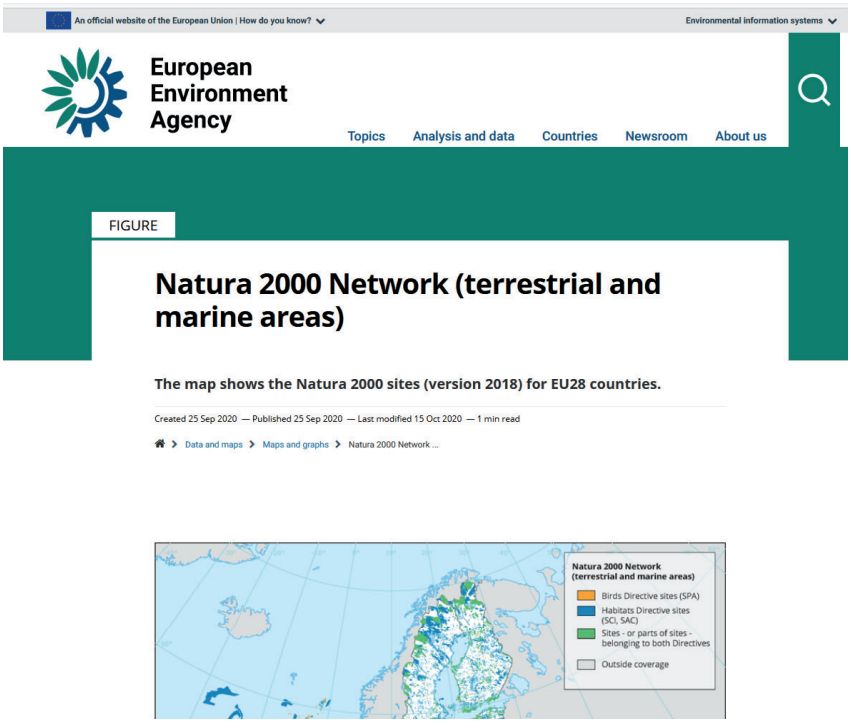
In this context, the tools validated from the European Union for biodiversity conservation and improvement are:

- **JRC Biodiversity Platform**: a data – resource platform for mapping and assessing the ecosystem services in European contexts. According to the action 5 of EU Biodiversity Strategy, it is required to Member States to map and assess ecosystems and their services. As a response, the Joint Research Centre developed a series of maps of ecosystem services. All the data are available in *GIS – Geographic Information system format*.
- **Natura 2000 (MASE, 2009)**: an Ecological Network tool to map habitats that European policy frameworks and directories identified as vulnerable and, therefore, in need of conservation. Specifically, the Natura 2000 network is a map visualization tool which identifies: *Sites of Community Interest (SIC), Special Zones of Conservation (ZSC)*, and also includes *Special Protection Areas* for the protection of bird life. It provides a classification of spaces and areas, from the territorial to the urban scale, enabling the identification of landscape-sensitive, protected areas in conservation processes. Moreover, the tool allows to identify timelines and temporal processes of changes. *Natura 2000* network map recognizes the ecological and ecosystem importance of these practices. Agricultural areas, for example, are linked to numerous animal and plant species that are now rare and threatened and whose survival requires the continuation and enhancement of traditional activities, such as grazing or non-intensive agriculture.
- **EUNIS geoportal of the European Environmental Agency**: an open-source information system that collects information on nature and its peculiarities. Through this website it is possible to map, classify, and retrieve specific information on habitats, their geo-morphological and biodiversity

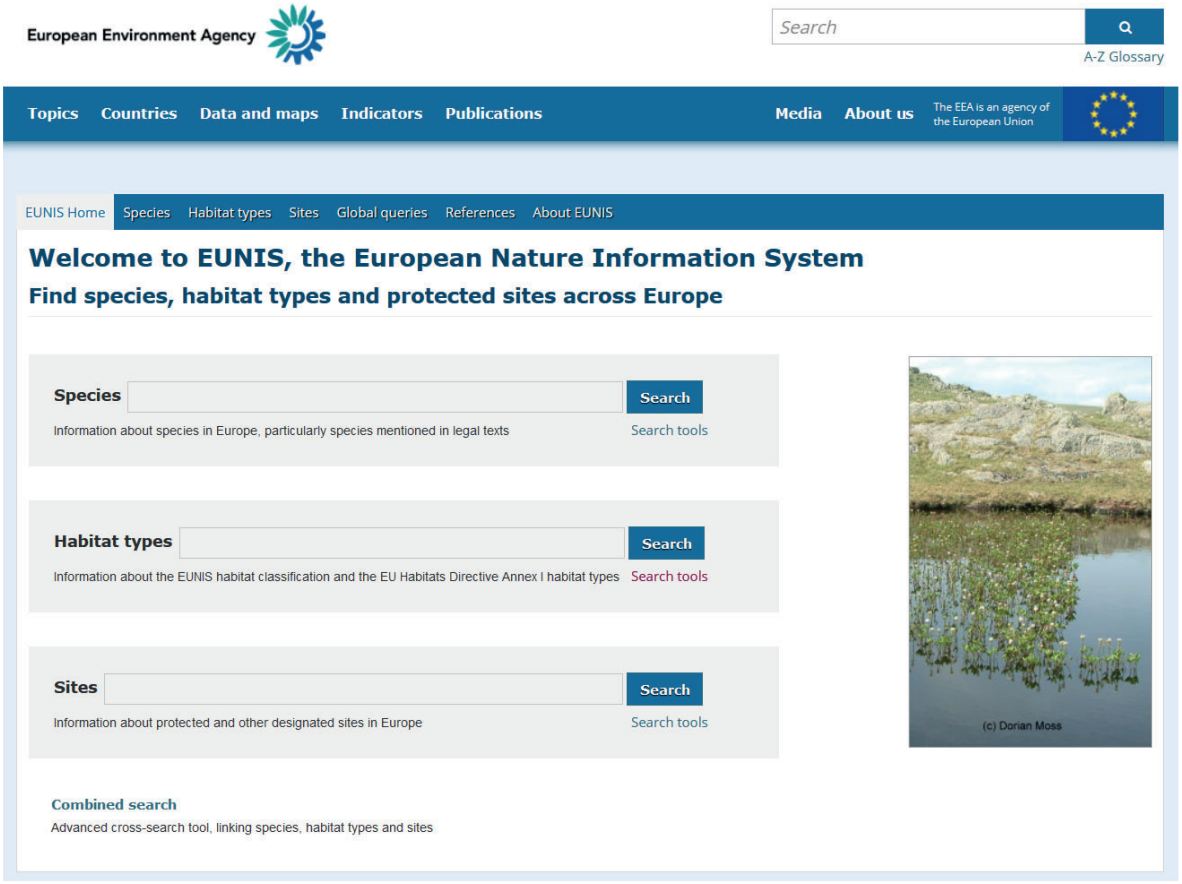
characteristics, and their conservation status. It is a quick and effective tool for gathering scientifically certified and internationally validated information. This mapping tool also makes it possible to quickly observe which areas and which species are in a state of conservation and which are allochthonous to the original environment.

- **Corine Biotopes Map of the European Environmental Agency**: an EU inventory of major nature sites. The Corine biotopes project enhanced reliable and accessible information about vulnerable ecosystems, habitats, and species. It was used to guide environmental policy in the European Community including the planning of the Habitats Directive. The scope of the Biotopes database was later extended to include countries of Central and Eastern Europe.

All the platforms and dataset are valuable tools for mapping the geographic location and environmental parameters of habitats and biotopes that are either within or adjacent to the project area. Moreover, it is possible to involve landscape ecology experts in this mapping process to confirm the reliability and efficacy of data received and collated in maps, with regard to the geographical and environmental aspects of the context under investigation.



>> Natura 2000 European Environment Agency. Credits: EEA Natura 200 Network.



Extrapolating knowledge on invasive and endangered species

Protecting local wildlife and indigenous species is critical for preserving ecological balance and biodiversity. This is crucial for ensuring animal survival, maintaining healthy ecosystems, and promoting biodiversity.

Consulting existing studies on urban biodiversity is fundamental to understand which species should be preserved and which should be contained or removed at local level, as well as which species are considered indicators of good environmental quality, in order to avoid implementing interventions that could disrupt the balance of the area under regeneration.

For this aim, a comparison with environmental evaluations already conducted in the area under regeneration or the surrounding areas, as mandated by local regulations or by the

developer on its own initiative, is also significant.

Specifically, in order to develop this study, data from Protecting local wildlife and indigenous species is critical for preserving ecological balance and biodiversity. This is crucial for ensuring animal survival, maintaining healthy ecosystems, and promoting biodiversity.

Consulting existing studies on urban biodiversity is fundamental to understand which species should be preserved and which should be contained or removed at local level, as well as which species are considered indicators of good environmental quality, in order to avoid implementing interventions that could disrupt the balance of the area under regeneration.

For this aim, a comparison with environmental evaluations already conducted in the area under regeneration or the surrounding areas, as mandated by local regulations or by the developer on its own initiative, is also significant.

Specifically, in order to develop this study, data from Environmental Monitoring Plans conducted by landscape ecology or fauna experts must be analyzed. This comparative analysis would allow the collection of sensitive data on the local fauna population as well as the ecological sensitivity of the urban regions surrounding and within the project site.

If no Environmental Monitoring Plans are available, it is suggested to involve experienced experts in landscape ecology, agronomy, wildlife, botany, or biology to conduct field observations.

<< European Nature Information system. Credits: EUNIS

>> Site visit with ecology experts at MIND. Photo credits: LAND

Integrating open and existing data with field observations

In addition to the previous points, mapping urban biodiversity means monitoring the health of green city spaces through the number and variety of species (both plants and animals) present.

To foster this detection, data available through open sources are often not full and thorough at the project scale. This is why it is critical to enhance this knowledge with monitoring data obtained from specifically designed field observations.

Mapping, surveying and sampling techniques and methodologies are many and are chosen on the basis of the object of the **mapping** (plants, insects, mammals...), the **objectives** (measuring the quality of agricultural environments, mitigation of impacts of new infrastructures, etc.) and the **context/habitat**. Based on this operational framework, it should be defined:

- the *extension* of the mapping;
- the *specific areas* where to carry out the observations within the site under regeneration;
- the *timing* of the intervention.

Ideally, observations should be repeated several times a year (at least once per season), for several years in succession, depending on the length of the regeneration process.

In order to carry out this field work, the contribution of expert faunists and ecologists who possess the expertise to perform field analyses is essential, especially in urban contexts that are often subject to sudden processes of change and transformation.

The Bioscopium system envisages a mapping approach that makes use of technology to support and integrate the field work carried out by experts. We have prototyped dedicated sensor

stations to such an extent (see our Case Study below), but there are many existing technologies(starting from photo traps, which can be considered the most accessible and easy-to-use tool) and platforms that can serve this scope too.

If the objects of the mapping are plant species, recognition apps like PlantNet can be very useful (and can also be used by non-experts and for citizen engagement purposes). For animal species, according to their class, you can find, as follows, some suggestions that we have applied to the development of Bioscopium sensor stations.

Detection of Polyommatus icarus at MIND. Photo credits: Polifactory

Insects:

Given the scale and behavior of these animals, the use of traditional photo traps is not effective, since their proximity and motion sensor cannot detect such small and quick subjects, and the camera cannot focus on subjects in such a quick motion too. We suggest opting for cameras that allow macro photography and setting the shots in timelapse mode. As an example, we opted for video shots of 4 seconds every 30 seconds. Also, we recommend positioning the camera within or next to a flower meadow and to place some attractors in front of the camera lens. Unless you want to attract specific species like butterflies, which may require the use of specific attractors such as pheromones, you can use natural products like apple slices, honey, pollen or simply water. Pay attention to place attractors on a surface that is not in direct contact with the soil, to avoid them being overrun by ants. Overnight, you can put a small light source to attract nocturnal insects.

You will need to leave the camera on field for several hours and possibly repeat the operations for a few days, adapting the positioning and the use of attractors according to the results obtained.

To analyze the images of insects obtained with this strategy you can then exploit a dedicated image recognition platform like Picture Insect. To supplement the data collected through cameras, it is also useful to organize citizen science activities as suggested in the following section of these guidelines.

>> Detection of Graphosoma lineatum at MIND.
Photo credits: Polifactory

Birds:

For monitoring birds, traditional photo traps currently represent a high-performance tool, and there are smart nests and feeders already available on the market, such as Bird Buddy[9] or The Peep Show[10]. Smart nests are particularly useful for observing the behavior of nesting specimens (useful for example for target species), rather than detecting different species. As an alternative, traditional photo traps can be placed in proximity of classic bird feeders and programmed in timelapse, or opting for the traditional capture mode triggered by embedded proximity sensors, depending on where they are positioned. In fact, in this case, it is important to position the camera on a tree branch free from leaves that could spark the camera shots every time they sway in the wind. As attractors, besides bird feed, you could opt for sound recalls, especially when the mapping focuses on specific species only. Also in this case, to analyze the images of birds detected and identify their species, you can exploit a dedicated image recognition platform like Merlin Bird ID. Participatory data collection is possible too, but more complex to perform, as birdwatchers teach us, with the exception of the more diffused species that populate our cities.

9. https://mybirdbuddy.com/

10. https://www.thepeepshow.com/

>> Detection of Anas platyrhynchos at MIND. Photo credits: Polifactory

>> Detection of Casmerodius albus Linnaeus at MIND.
Photo credits: Polifactory

Mammals:

For this class of animals too, traditional photo traps are a fairly effective tool, especially for capturing images overnight, when the probability to detect these kinds of animals is higher. In this case, our recommendation is to implement a positioning protocol capable of covering different areas in order to intercept transit corridors. Obviously, the best spots are represented by wild areas inside the site under regeneration or in the close surroundings, which are not or poorly disturbed by human presence.

For this reason, in order to properly develop the protocol and identify effective spots where to position the cameras, it will be necessary to carry out an exploration in advance (or a participatory scouting activity), better if involving an expert, who could eventually detect traces of animals, thus making the positioning more effective.

Once suitable locations have been identified, the installation of devices can be carried out and the data collection initiated, together with maintenance and repositioning activities. For a complete overview of the fauna present in the area, the protocol should ideally cover the four seasons. For mammals, attractors mainly consist of feed, to be distributed in front of the cameras. The choice of what feed to use depends on the purpose of the mapping, and it is advisable to seek the opinion of an expert, so as not to alter the ecosystem balance.

To analyze the images of mammals detected, the best image recognition platform in our opinion is iNaturalist. Participatory data collection is possible too, but more complex to perform since mammals tend to escape from human presence.

>> Detection with photo traps of Vulpes vulpes at MIND. Photo credits: Polifactory

Reptiles, amphibians and fishes:

For what concerns the mapping of these classes of animals we recommend the involvement of experts since, in our opinion, in an urban environment, it is more difficult to perform and, because of their habitat and behavior, the use of traditional photo traps is quite reductive.

Just think that, although reptiles account for almost a third of the known terrestrial vertebrate species on Earth, the first map showing the distribution and density of every reptile species in the world has been completed only in 2017 by a team of 39 scientists led by Uri Roll of the Ben Gurion University of the Negev, in Israel[11].

Moreover, for what concerns fishes, the use of electronic devices in an aquatic environment presents several complications. In this case, it could be interesting to opt for underwater cameras programmed in timelapse mode, if the water conditions allow for good visibility.

Nonetheless, also these classes of animals can be included in citizen science activities and, in addition to iNaturalist, there exist several dedicated applications that you can exploit to identify the different species, such as HerpMapper for reptiles and amphibians, and MyCatch for fishes.

11. It is published in the journal Nature Ecology & Evolution.

3

/ENGAGEMENT GUIDELINES

/ENGAGEMENT GUIDELINES

In this section, you can find guidelines for engaging people in mapping urban biodiversity, in order to integrate data from open-source databases, biodiversity monitoring documents and field observations, eventually making use of technology, as suggested in the previous section.

But the purpose here is not only to exploit the power of collectivity to gather a meaningful amount and variety of data. It is to raise awareness on the topic and educate people to the relevance and benefits of urban biodiversity while supporting data gathering.

To do so, some efforts must be put into the development and organization of activities that at the same time can attract, inform, train and motivate people in observing, knowing, and preserving the biodiversity that surrounds them.

Such activities, due to their nature, fall within the scope of so-called citizen science, which, according to the EU-Citizen. Science platform, is defined as

> *"...any activity that involves the public in scientific research and thus has the potential to bring together science, policy makers, and society as a whole in an impactful way. Through citizen science, all people can participate in many stages of the scientific process, from the design of the research question, to data collection and volunteer mapping, data interpretation and analysis, and to publication and dissemination of results."*

In our case, we refer to the most common approach to citizen science, which consists of an open call to volunteers to take part in data collection; but be aware that, as specified by the ECSA -

European Citizen Science Association (Haklay et al., 2020) talking about citizen science can entail a much broader spectrum of research actions, in many different fields, including but not limited to natural sciences and environmental monitoring.

Also, the roles of the participants can vary, from covering small tasks that require little engagement to contributing more extensively to the research, but an active engagement that requires participants' cognitive attention should be preferred to limited or passive interactions. In any case, as recommended by the ECSA, the purpose of the project and their role in research must be communicated clearly and openly with participants.

Despite many kinds of activities that can fall under the hat of citizen science, the following guidelines aim at supporting the design of citizen science initiatives for documenting urban biodiversity, especially when data from open sources and planning documents are not sufficient, and the collection of differentiated and scientifically validated information from a citizens' group can significantly fill the gap.

By citizens' group we consider all the possible variables in terms of age, size, origin and composition, with the only constraint of being able to download, access and interact with a citizen science app, such as iNaturalist, which we chose for our experimentations in the T-Factor project. Other kinds of engagement activities can then be foreseen to involve those not included in the data collection (such as primary school kids or impaired people), who can contribute, for example, in the design and maintenance of biodiverse green spaces, as highlighted in the following section.

>> Citizen science activities at Herbula Wild Garden aimed at mapping animal biodiversity and monitoring plant biodiversity in flower meadows.
Photo credits: Polifactory.

Define who to involve and motivate them.

In order to involve people in data collection about urban biodiversity, we firstly recommend to define very sharply the citizens' group you want to address, rather than opting for a large and generic call for participants, which will require massive communication efforts with no guarantee you will obtain the expected feedback. Actually, addressing already existing groups and communities (for example a class of students from high school or a community neighborhood) might represent the best strategy. Once defined who to involve, you will need to find a way to attract and motivate them. Of course, you can focus on people that are already sensitive to the topic, but if your purpose is also to raise awareness and educate, some more efforts will be required. For example, you could organize 'biodiversity tours' with some local experts, or other kinds of entertainment events that bring people closer to the topic while having fun. Or you could opt for small incentives in exchange for participation. As you can read in the Case Study below, to such an extent we created an initiative called Biodiversity Ambassador Program and we decided to address company employees working in the area under regeneration, offering 10 coffees to all the participants achieving the goal set for data collection.

Choose a focus for data collection.

Another important aspect to define before engaging people is what you want them to focus on during data collection. This clearly depends on the gaps you want to fill in your data collection, but also on what is feasible by your citizens' group. Do you want them to focus on both plants and animals? Are there specific species you would like to detect and monitor? What is the area you want them to cover? For how long? What citizen science app better serves your purpose? These are the questions you need to answer to be able to provide your volunteers with all the information they need for a right and relevant contribution to the research. To do so, you will probably need the support of experts who know the area and its characteristics, as well as the species who eventually deserve particular attention (see section 2.4 and 2.5).

/GUIDELINES

Assign specific tasks and instruct participants.

Choosing the focus for data collection is not only important to make citizens' contribution relevant and coherent with your research, but also to assign them specific and bounded tasks they can easily accomplish. We suggest assigning a few tasks in a specific period of time and to organize one or more sessions to explain in detail to participants what the tasks consist of, instruct them on the use of the citizen science app you have chosen and illustrate to them the area to investigate. For example, within our Biodiversity Ambassador Program we asked participants to upload at least 5 verified observations of animals detected inside the boundaries of the area under regeneration over a period of two months. To explain to them what to do, we organized one session of 1 hour in the area, during which we accompanied them in downloading the iNaturalist app and uploading a sample observation.

The use of a citizen science app will allow you to monitor the activity and behavior of your volunteers, and to eventually intervene by correcting your strategy, in progress or organizing further instruction sessions.

Clean data collected and integrate them with other sources.

At the end of the period set for participants to collect data, it is time to analyze them and compare/integrate these results with what gathered from other sources (see Mapping guidelines above).

To do so, you will need the support of experts, but before sharing data with them it is fundamental to clean them up from wrong and useless information.

Our suggestion is to consider only those observations that are both verifiable, i.e. accompanied by a picture and/or sound; verified, i.e. validated by the community of experts provided by the app (for example, we considered only observations validated by at least two experts from the iNaturalist community); and reporting complete information in terms of genre and species.

To conclude, in agreement with citizen science principles (ECSA, 2015), participants should be informed about the outcomes of the research they contributed to, either by publishing results in an open access format, or by organizing a dedicated moment of presentation or showcase, which could also represent the occasion for engaging those who could not take part in the activity. For example, you could involve local artists in order to represent both visual and quantitative data in an appealing way and set-up a dedicated exhibition open to the city.

As mentioned above, within an urban regeneration project it is important to raise awareness and engage on the topic of biodiversity not only for mapping purposes, but also to educate people on knowing and approaching it. We believe that closing the distance between citizens and urban nature, first of all by making people learn how to interact with it, will push everybody to contribute more actively to initiatives such as those described before, or to simply take better care of the environment.

Waiting for this to happen, we suggest as follows some guidelines to concretely design biodiverse green spaces, after having mapped and analyzed the status of biodiversity in the area under regeneration thanks to the activities recommended so far.

<< Setting up biodiversity monitoring panels inside Herbula Wild Garden for citizen science activities. Photo credits: Polifactory

4

/ACTION GUIDELINES TO DESIGN BIODIVERSE GREEN SPACES

/ACTION GUIDELINES TO DESIGN BIODIVERSE GREEN SPACES

The elaboration of strategies for the management and promotion of urban biodiversity brings many benefits and allows action to be taken against the dynamics of declining species populations and the degradation of ecosystems. It is a complex process though, that requires the participation of experts from various disciplines and allows the ambition of environmental protection and urban biodiversity to be translated into a concrete plan of action. The goals to be achieved must be geared towards making cities and the ecosystems they constitute more liveable and resilient spaces for people, animals and plants through the dissemination of integrated nature-based actions, carefully accompanied by good ecological management practices. The purpose of these guidelines is to orient and inform decision-makers and professionals involved on the main steps, providing specific actions to be followed in order to develop a strategy for the management and promotion of urban biodiversity.

Specifically, the actions to design green areas that could foster the habitability of local biodiversity, in urban regeneration contexts, should follow prerequisites emerging from the the mapping suggested above, and follow the guidelines below:

/GUIDELINES

Matching the spatial dimension of green spaces with the environment in which they are located: large green spaces tend to promote and maintain high biodiversity, as they usually contain more ecological niches and offer more resources than smaller areas. Species diversity tends to decline rapidly when green spaces are smaller than 4 hectares, while larger areas can harbor the most sensitive and intolerant species of the urban environment. In fragmented environments such as cities, ecological networks and connectivity favor the maintenance of greater biodiversity.

The disposition and proximity of green spaces to ecological corridors are crucial for maintaining biodiversity, enhancing ecosystem services, and providing spatial opportunities for regenerative urban strategies. Connections between different green spaces and habitats facilitate the migration of plants and animals, particularly between large green areas. The permeability of these ecological links for wildlife is determined by their traits and degree of naturalness. If the planned interventions cannot be placed in continuity with the existing green spaces due to incompatibility with greening measures (e.g., underground utilities, underground car parks), the nature-based solutions should be planned and designed to improve habitat connectivity on site (e.g., green walls, green roofs, biodiverse gardens).

Selecting native plants to attract wildlife: native plants sustain the wildlife with whom they have co-evolved and, if carefully chosen, can help to restore ecosystems' natural food and trophic chains by increasing the presence of insects or the development of wildlife-friendly fruits. In an urban context, plant species must meet numerous criteria, including ecological, biological, aesthetic, and ease of maintenance.This is why it is critical to examine ahead of time the list of adaptable and forbidden species as outlined in municipal and regional plans.

>> Herbula Flower meadow designed to attract wildlife and preserve local biodiversity.
Photo credits: LAND

Designing spaces based on the needs of target species: the incorporation of specific physical or biological components into the landscape design of the ecosystems can considerably benefit local wildlife. The intervention could include plants that are necessary for an animal's life cycle.

>> Mowing the Herbula meadow before sowing 'Flowered Desert' mix by Comagricola Green Europe.
Photo credits: LAND

Ecological and sustainable management of green areas: maintenance of green areas can have a significant impact on their ability to deliver ecosystem services and biodiversity. It is typically quite a demanding task intended at keeping areas within particular functional and aesthetic parameters. In recent years, new strategies for the ecological management of urban green spaces have arisen, and they are no longer viewed as just ornaments, but as actual multifunctional habitats and ecosystems. To ensure the multifunctionality of these green infrastructures by maximizing their capacity to support biodiversity, ecological

management of green spaces is based on differentiated and rational maintenance of areas according to their intensity of use, function, visibility, and composition, minimizing interventions and disturbances, and reducing the use of pesticides to the minimum.

Communicating the value of biodiversity actions: enhancing the ecological value of green spaces and increasing biodiversity provide several advantages and services to the community. The general public is becoming more aware of environmental sustainability, however, the need of ecological design and green space management is not always clear to non-experts. A low-maintenance lawn, for example, may appear 'untidy' to some people, but by effectively communicating the value of upkeep, everyone may realize the true worth of this measure. It is thus critical to effectively explain the value of actions and measures performed in pursuit of the aims of ecological improvement and biodiversity promotion over time, to highlight the benefits of lowering pesticide use, and to highlight native flora.

>> Addressing guidelines and actions to improve Biodiversity at MIND. Photo credits: LAND

These are some of the actions that can be applied to design green spaces in the city and more specifically in areas under regeneration, to offer value and significance to temporary landscapes and processes in relation to the temporal thresholds of nature in cities. To support this goal, the T-Factor project has sown the seeds of experiences and efforts that can be replicated in other contexts and that will certainly reveal new tactics and practices for the renaturalization of urban regeneration contexts.

5

/FUTURE DEVELOPMENTS

/FUTURE DEVELOPMENTS

As stated in the beginning of this report, the Bioscopium mapping system is still at an experimental stage, which requires further validation. Accordingly, our experiments at MIND, which allowed us to develop these guidelines, must be considered just an initial step in the elaboration and spreading of a biodiversity mapping practice for urban areas under regeneration.

Thus, the guidelines here collected represent a work in progress that, as the system will be further tested, will see the release of one or more updated versions.

Moreover, at MIND, it was not possible to prototype and test all the features of the Bioscopium system as envisioned by the project, especially for what concerns the implementation of technological components.

Among the others, future developments could consist of:

- the integration of a solar panel and a wi-fi connection in the sensor stations to minimize the human intervention;
- the implementation of modules specifically designed for the detection of birds and water animals, including sound attractors;
- the implementation of a digital platform for the integration and automatic visualization of the data collected from the stations, which exploits image recognition solutions (e.g. Wildlife Insights by Google);
- the integration into the digital platform of a reporting feature of problems encountered in the natural areas of the regeneration site (e.g. dry vegetation, litter in the forest, presence of pests, swarms gone mad...) in citizen care mode;
- the development of biodiversity mapping on pollinator

species and bio-indicators of air- soil quality in urban landscape with AI tools;

- the construction of an analytical model that could map local animal biodiversity flows against urban mobility space syntaxes with AI mapping systems;
- the implementation of mapping guidelines with biodiversity index to account the amount of species diversity in specific green urban areas with remote sensing tools (in addition to open source data).

In terms of participation and engagement, the last point could be particularly relevant for expanding citizen science activities from data collection to the active proposal of community actions aimed at solving, in a bottom-up perspective, some of the reported problems (e.g. a citizens' group could take charge of recovering or maintaining an abandoned green space).

As follows, the experimentations done so far of the Bioscopium mapping system in the context of MIND in Milan is presented in detail, to give the readers a practical application of the guidelines previously illustrated, and show with a concrete example the benefits of mapping biodiversity in areas under regeneration.

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CASE STUDY

/BIOSCOPIUM AT MIND

/ CASE STUDY: BIOSCOPIUM AT MIND

1 | T-Factor at MIND

The paradox of urban regeneration is often evident in our cityscapes. Unfinished neighborhoods, brand-new buildings standing empty, soulless districts, and dynamics of displacement often labeled as 'gentrification' have been leaving scars in our cities. At the time of multiple crises and uncertainties, the paradox of urban regeneration risks becoming the more tangible evidence of structural failures in the ways we equip cities for the future. Therefore the way we make cities must be rethought deeply.

New urban regeneration models and tools are needed to keep pace with complexity, rapid change, and emerging needs in our communities.

Urban regeneration is not only about cities' hardware such as buildings and infrastructure; it is a fundamental reboot of the urban software - the social, economic and cultural fabric that makes cities thrive, persist and mitigate against present and future shared risks.

T-Factor's mission is to boost innovative approaches to unleash more inclusive, sustainable and vibrant temporary uses in six regeneration areas in Europe. In Milan, Italy, the chosen area under regeneration was MIND - Milano Innovation District. Positioned as Italy's first innovation district dedicated to life sciences, MIND is situated on the ground of Expo 2015. The regeneration journey for this area commenced in 2017 and is slated for completion by 2031.

Within the MIND pilot project, three missions were delineated to address the overarching challenge of crafting a new identity

for the area centered on nature, health, and well-being. In particular, one of them focused specifically on enhancing well-being through green practices and open-air activities, with the aim of positioning MIND as a hub for conscious, healthy, and sustainable lifestyles. To fulfill this mission, the main intervention was a temporary garden-laboratory called Herbula Wild Garden. This garden was open to the local community from the end of 2022 and aimed at teaching people about the benefits of urban biodiversity. The partners of T-Factor involved in this initiative were Polifactory, LAND and PlusValue. They engaged the local developer, Lendlease, as main partner on the ground to facilitate, promote and maintain the green installations. Other key stakeholders involved were the public authority owning the area, Arexpo, and the third sector organization running social and cultural activities in the district, Fondazione Triulza.

Herbula was dedicated to the cultivation of indigenous herbs and flowers, fostering local biodiversity and the smart use of its products, across three different areas:

- an area with planters, dedicated to the cultivation of aromatic and officinal herbs available to those interested in using them for culinary or herbal preparations;
- an experimental area, dedicated to educational research and botanical experiments, especially devoted to the cultivation of edible native species that can be processed and transformed into everyday products;
- a flowery meadow, dedicated to spontaneous vegetation capable of attracting pollinators and other useful insects.

The variety of spaces enabled the implementation of several initiatives around the topic of urban biodiversity.

Following the experience gathered around Herbula, the Bioscopium initiative was conceived to map biodiversity, engage local communities, and finally experiment with some small-scale temporary actions. The expected outcome was raising awareness on biodiversity in the area.

The first prototype of the Bioscopium system was implemented and tested at MIND from April to December 2023. To conduct this experiment, most of the guidelines outlined in this report were followed.

2 Bioscopium: mapping biodiversity at MIND

Bioscopium was envisioned with the goal of creating a new system for exploring urban biodiversity in regeneration contexts, providing decision-makers with a tool for understanding the impact of the regeneration process in the area, while also assisting experts in charge of mapping and monitoring tasks, by involving citizens and other local actors in biodiversity-related activities.

To accomplish this goal, the Bioscopium system combines the analysis of the Ecological Network and related Landscape Quality Indicators at various scales through open source data, the monitoring of environmental data and faunal species through sensor stations, and citizen science activities for integrating data collection.

The T-Factor pilot project at MIND - Milano Innovation District allowed us to test the following aspects of the Bioscopium mapping system:

- **The Ecological Network of MIND** was mapped at three investigation scales: the Milan Metropolitan City territory, the Milan Municipal City, and the MIND District. The cartographic analysis was generated with reliable open source data coming from: Lombardy Regional Land Information System (SIT), Regional Landscape Plans, Metropolitan Territorial Database (PTM), Land Use Municipality of Milan (DUSAF 2023). The data were later visualized through digital maps thanks to GIS software. Particular attention was paid to the temporality of data. This analysis was carried out by landscape and planning experts from LAND Italia.
- **Landscape Fragmentation and Wildlife Suitability Indicators** at the territorial scale and in MIND areas were processed through the use of:
    - Open source data (regional and municipal geoportal of Lombardy and Milan);

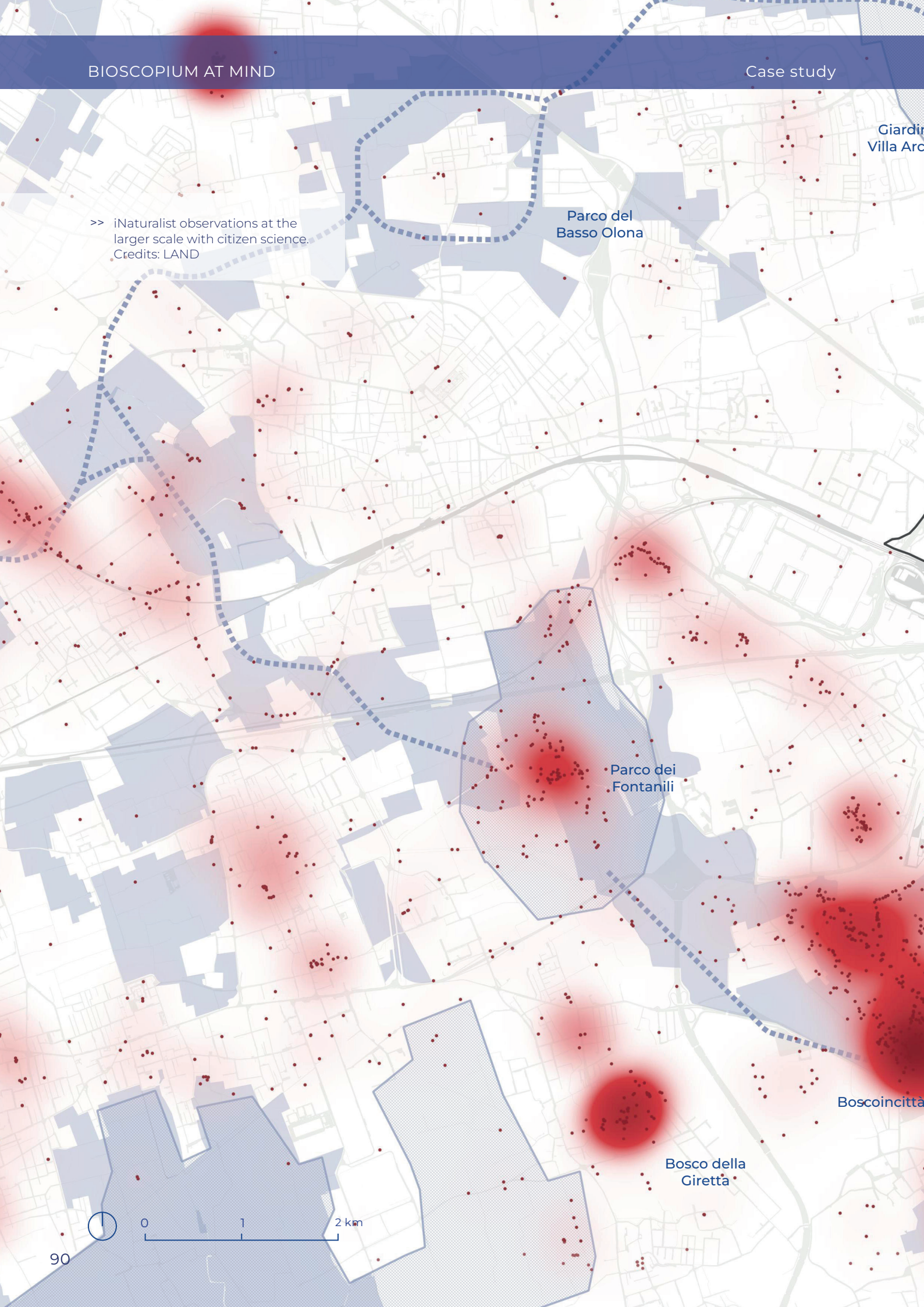
- On-site monitoring data from 2020 to 2023 for environmental monitoring plans commissioned (PMA - Piano di Monitoraggio Ambientale) by Arexpo to Studio TerraViva;
- Data collected through on-site faunal observations from 2021 to 2023 in the PMA (Piano di Monitoraggio Ambientale) of AREXPO;
- Data gathered through citizen science activities on the iNaturalist app;
- Data collected through photo traps in 2023.

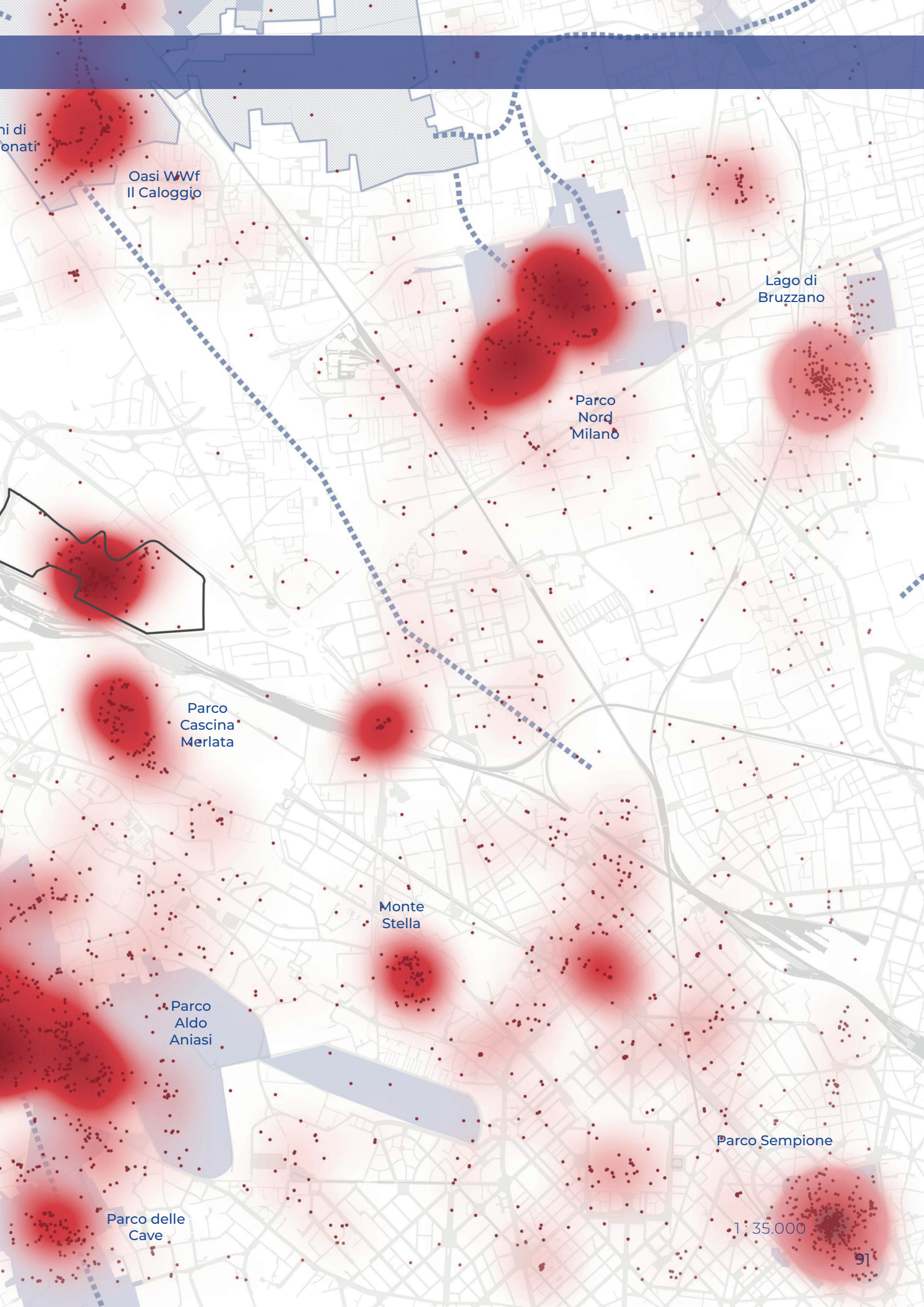
The indicators were studied and outlined by Studio TerraViva's experts, who have been conducting analytical investigations and environmental monitoring at MIND since 2018. The digital tools used were GIS (Geographic Information System) and Guidos Toolbox.

- **Mapping of the local fauna through photo traps** available on the market and the prototype of two sensor stations specifically designed for detecting the presence of mammals and insects in connection to some environmental data. These activities were carried out by design researchers from Polifactory - Politecnico di Milano with the support of fauna experts from Studio TerraViva during the phase of data analysis.
- **Biodiversity mapping with the local community** through the citizen science app iNaturalist and photographic documentation of landscape development with custom-built wooden panels in the temporary space of Herbula Wild Garden.

All of these actions and their related outcomes will be thoroughly discussed in the sections that follow. Finally, some solutions to improve urban biodiversity at MIND based on the results of the experiment are presented to support decision-makers and real estate developers in setting strategies and guidelines for making MIND a biodiversity-aware urban environment.

>> iNaturalist observations at the larger scale with citizen science. Credits: LAND

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3 Mapping MIND Ecological Network: from urban plans to open-source data

Milan and its metropolitan area are currently facing a particularly dynamic phase of transition, underlining the city's tremendous appeal. Many regeneration initiatives have lately begun and will continue to begin, helping to rethink the urban and metropolitan structure and balance.

In the coming future, MIND will play an important role in the urban regeneration process thanks to the collaboration with another large regeneration effort - AdP Scali Ferroviari - that will determine an essential reorganization of the city with metropolitan-scale implications.

All of these regeneration sites are undergoing metamorphosis and radical changes in the urban landscape representing, at the same time, relevant and potential spaces to improve the Ecological Network and promote biodiversity development.

In the case of MIND, the analysis of the Ecological Network was carried out at three research scales, ranging from the whole Milan Metropolitan City to the borders of the MIND district in order to detect the potential spaces for biodiversity improvement within the urban framework:

- Large scale = Metropolitan Ecological Network (1:180.000)
- Meso-scale = Municipal Ecological Network (1:35.000)
- Local scale = MIND Ecological Network (1:10.000)

The map at metropolitan scale aimed to verify the role of MIND as a potential stepping stone in the broad metropolitan area, since MIND's new masterplan fits as an intermediate geographical point between the Regional and theMunicipal Ecological Network. Its proximity to primary ecological corridors supported by rivers (Olona River), and minor watercourses with characteristics of ecological importance (Lura creek, Villoresi Secondary Canal, Northwest Scolmatore Canal) makes MIND's

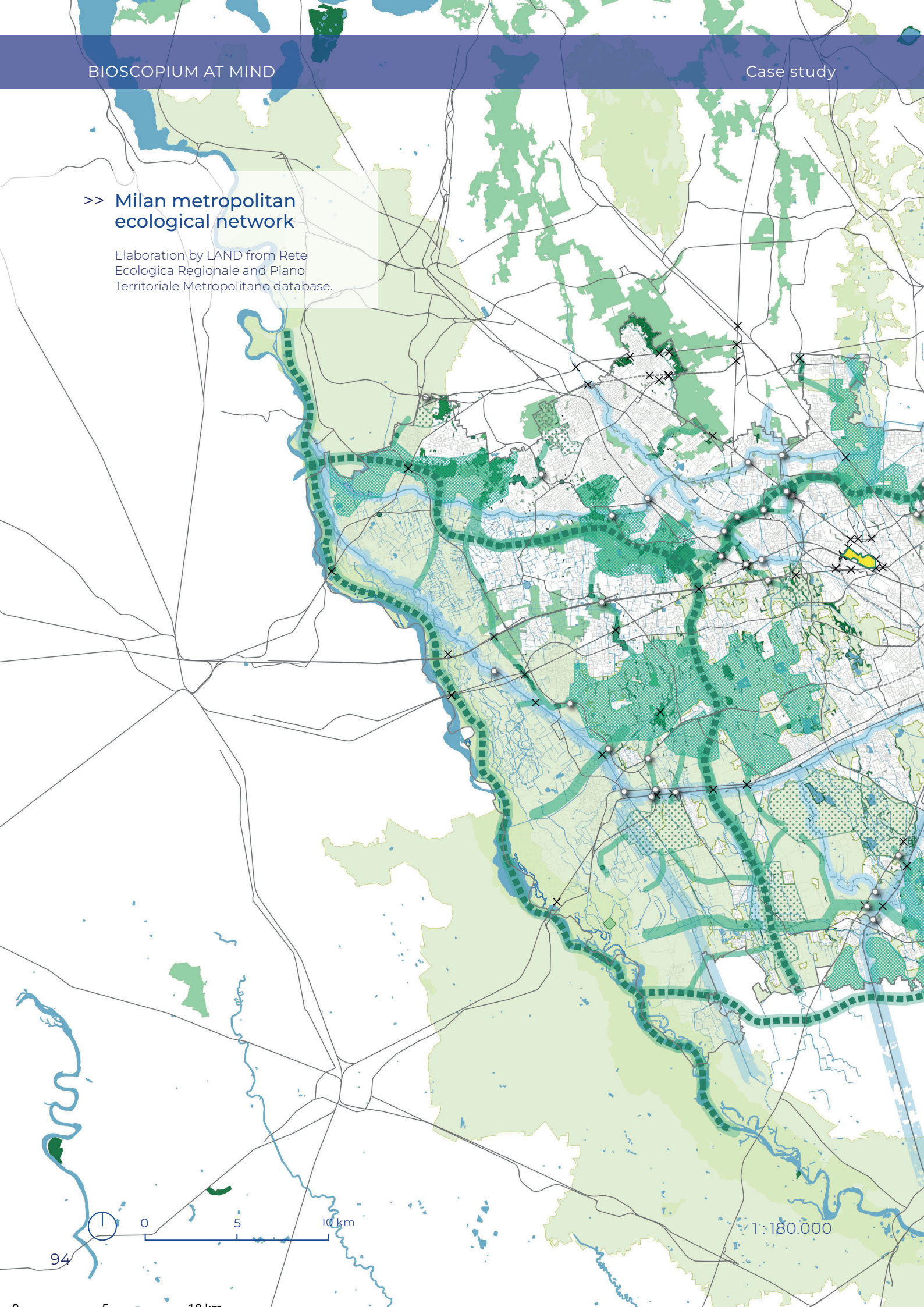
urban regeneration area strategic for the enhancement of urban ecosystem services integrated with the Metropolitan Ecological Network.

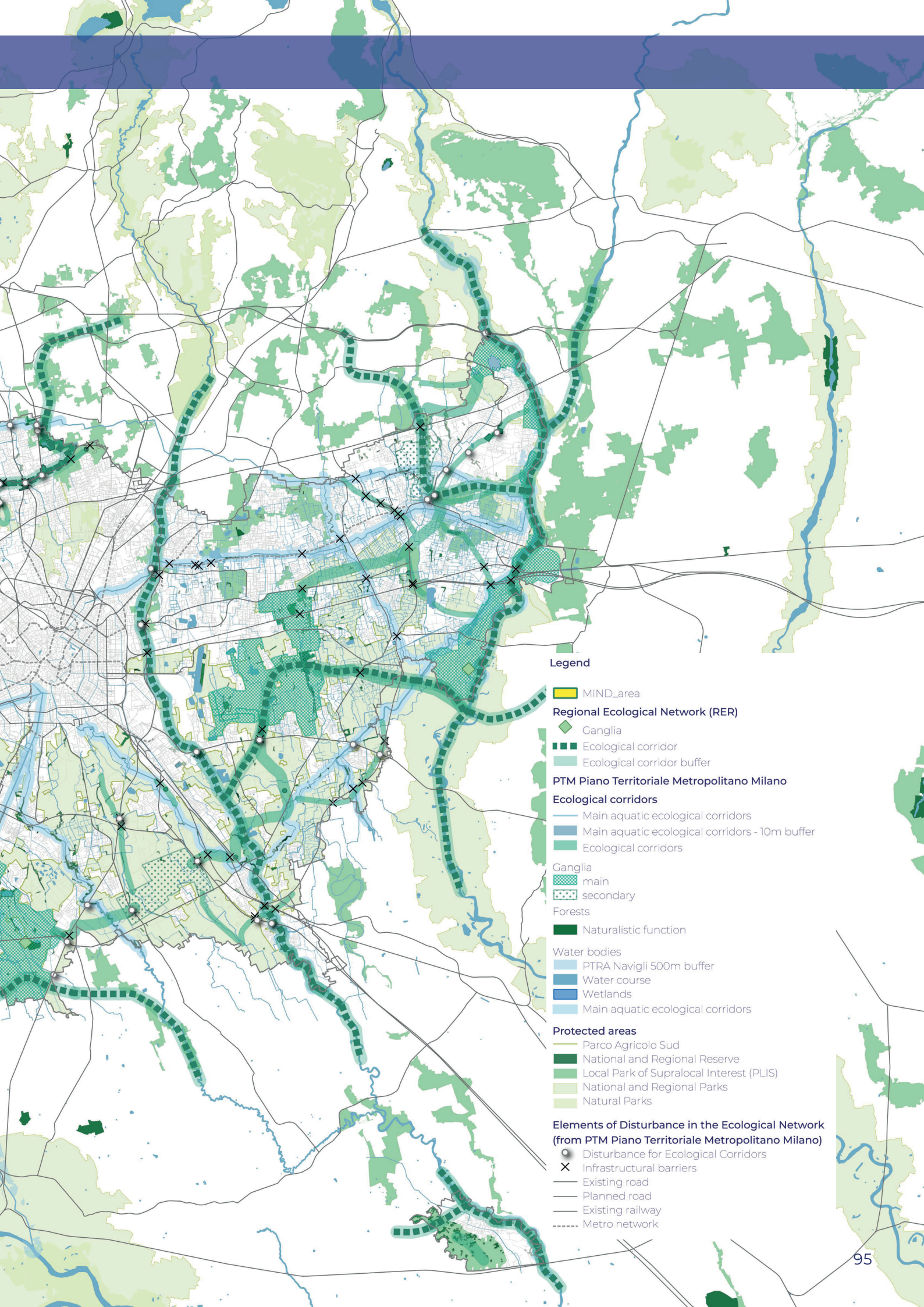
The meso-scale map allowed us to identify the landscape components of the municipal territory of Milan. The Ecological Network at the city scale is an indispensable frame of reference for guiding the transformations envisaged by the Milan 2030 Piano di Governo del Territorio (PGT), which is based on the development of the historical, geographical, morphological structure of the city through cartography.

Finally, our study focused on MIND at the local level as a peri-urban area within the Municipal Ecological Network. The objective is to implement ecological consolidation by first enhancing biodiversity at the local level through monitoring and mapping of existing flora and fauna. This will contribute to the development of a sustainable ecosystem.

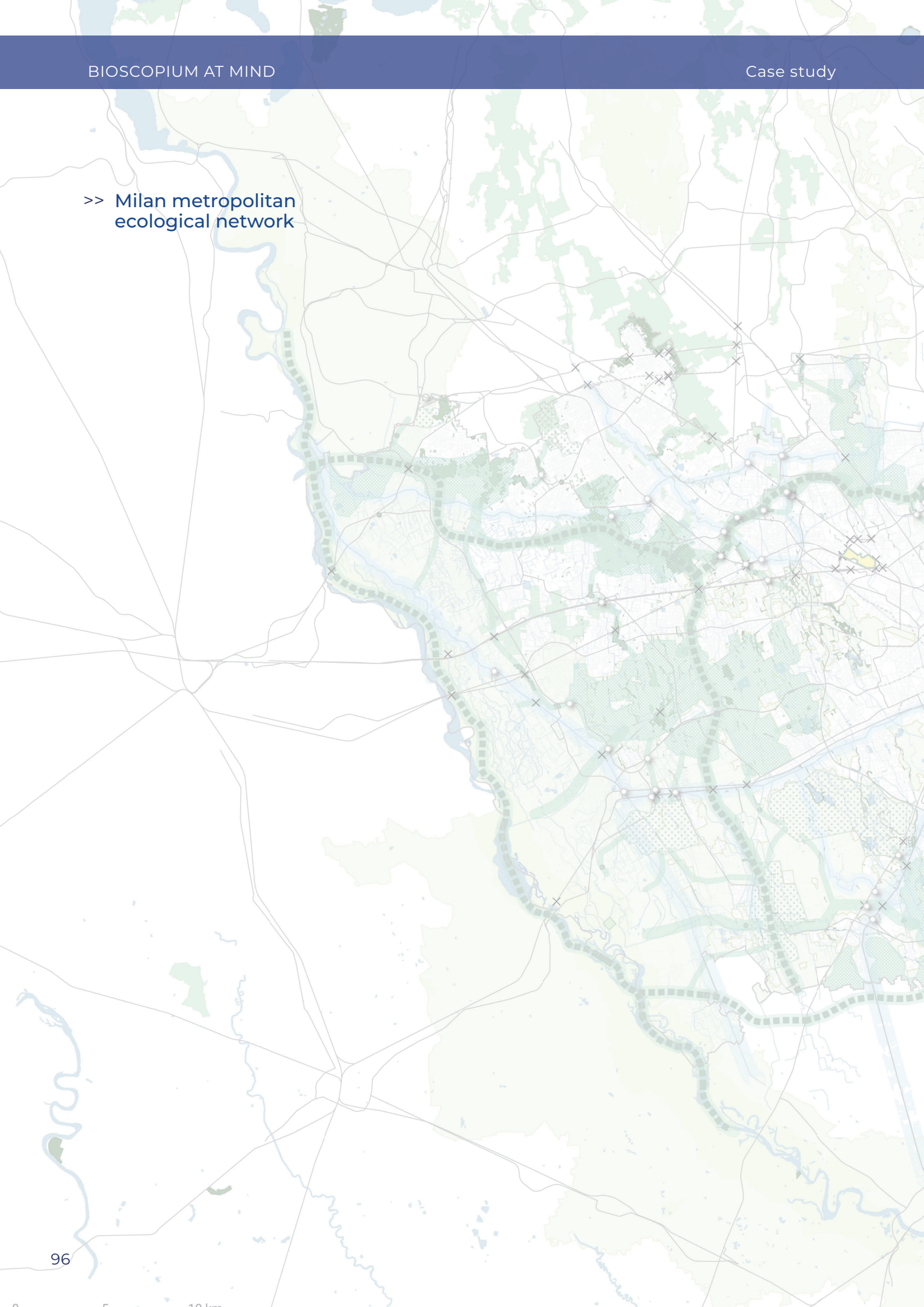
>> Milan metropolitan ecological network

Elaboration by LAND from Rete Ecologica Regionale and Piano Territoriale Metropolitano database.




Legend
MIND_area
Regional Ecological Network (RER)
Ganglia
Ecological corridor
Ecological corridor buffer
PTM Piano Territoriale Metropolitano Milano
Ecological corridors
Main aquatic ecological corridors
Main aquatic ecological corridors - 10m buffer
Ecological corridors
Ganglia
main
secondary
Forests
Naturalistic function
Water bodies
PTRA Navigli 500m buffer
Water course
Wetlands
Main aquatic ecological corridors
Protected areas
Parco Agricolo Sud
National and Regional Reserve
Local Park of Supralocal Interest (PLIS)
National and Regional Parks
Natural Parks
Elements of Disturbance in the Ecological Network
(from PTM Piano Territoriale Metropolitano Milano)
Disturbance for Ecological Corridors
Infrastructural barriers
Existing road
Planned road
Existing railway
Metro network

>> Milan metropolitan ecological network



Starting from the regional and metropolitan dimension of the city, the Ecological Network in Milan is well analyzed by 2 types of Plans:

- *The Regional Ecological Network* (Rete Ecologica Regionale - RER): recognised as a priority infrastructure of the Regional Territorial Plan, it is a planning supporting tool for planners, ecologists and landscapers.
- *The Milan Metropolitan Territorial Plan* (Piano Territoriale Metropolitano Milano - PTM): it is the general territorial planning and coordination tool of the Metropolitan City of Milan, in line with the orientations expressed in the Strategic Territorial Plan.

In the case of Milan, the Metropolitan Ecological Network map shows an interconnected system of habitats, whose biodiversity must be safeguarded, thus paying attention to potentially threatened animal and plant species. Moreover, maps of Habitats and Natura 2000 reveal the presence of important parks in the metropolitan area of the city:

- Parco Agricolo Sud and Nord: protected natural areas around Milan, particularly important for the biodiversity they conserve and protect. The agricultural vocation of these areas makes it possible to make the landscapes productive while at the same time protecting the habitats they contain;
- Parco Adda Nord: river, agricultural and forest park;
- Parco delle Groane: urban belt and forest park;
- Parco Lombardo della Valle del Ticino: river, agricultural and forest park.

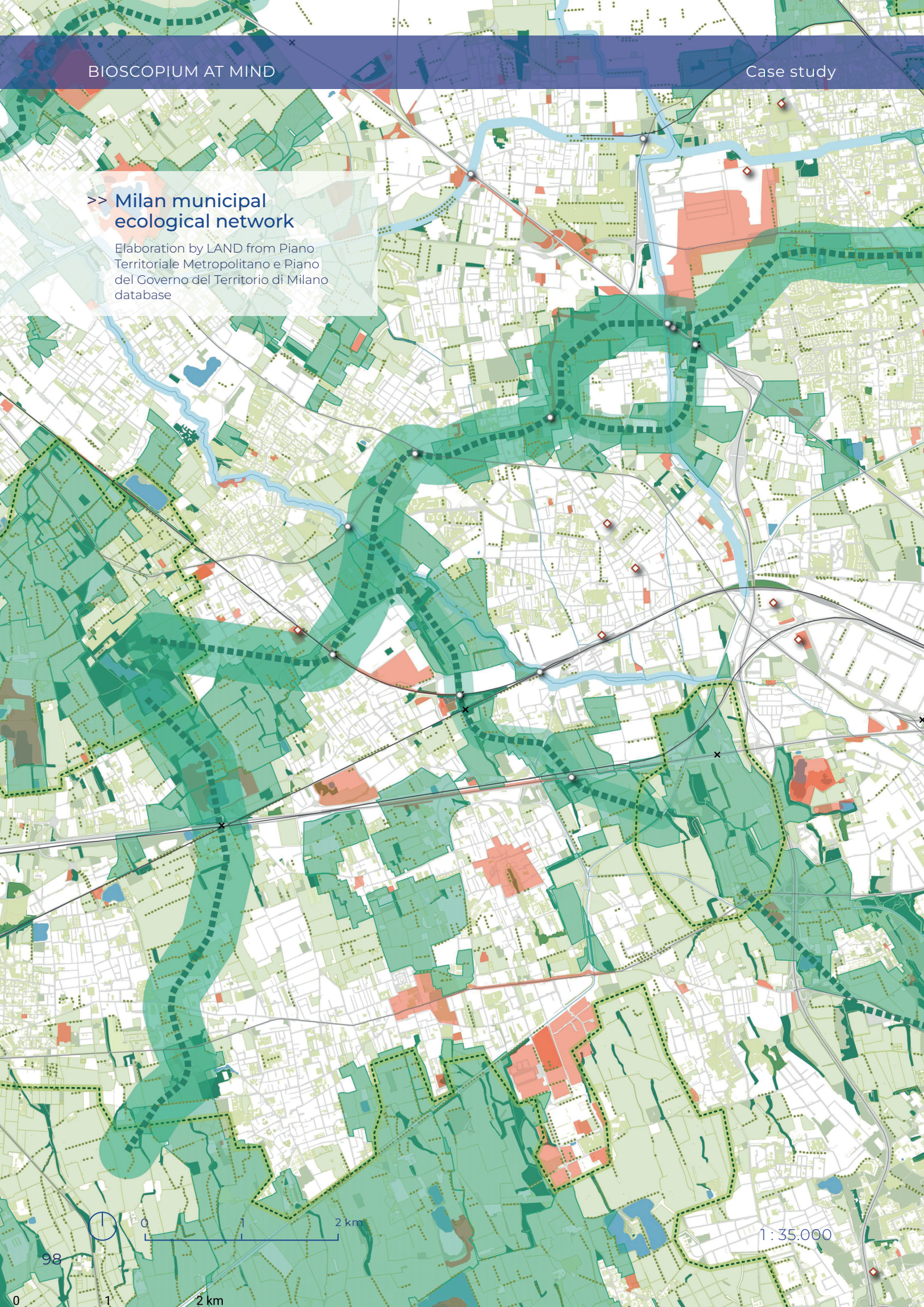
Despite the high level of urbanization, the area includes 17 local parks of supra-municipal interest (PLIS), for a total of around 9.355 hectares.

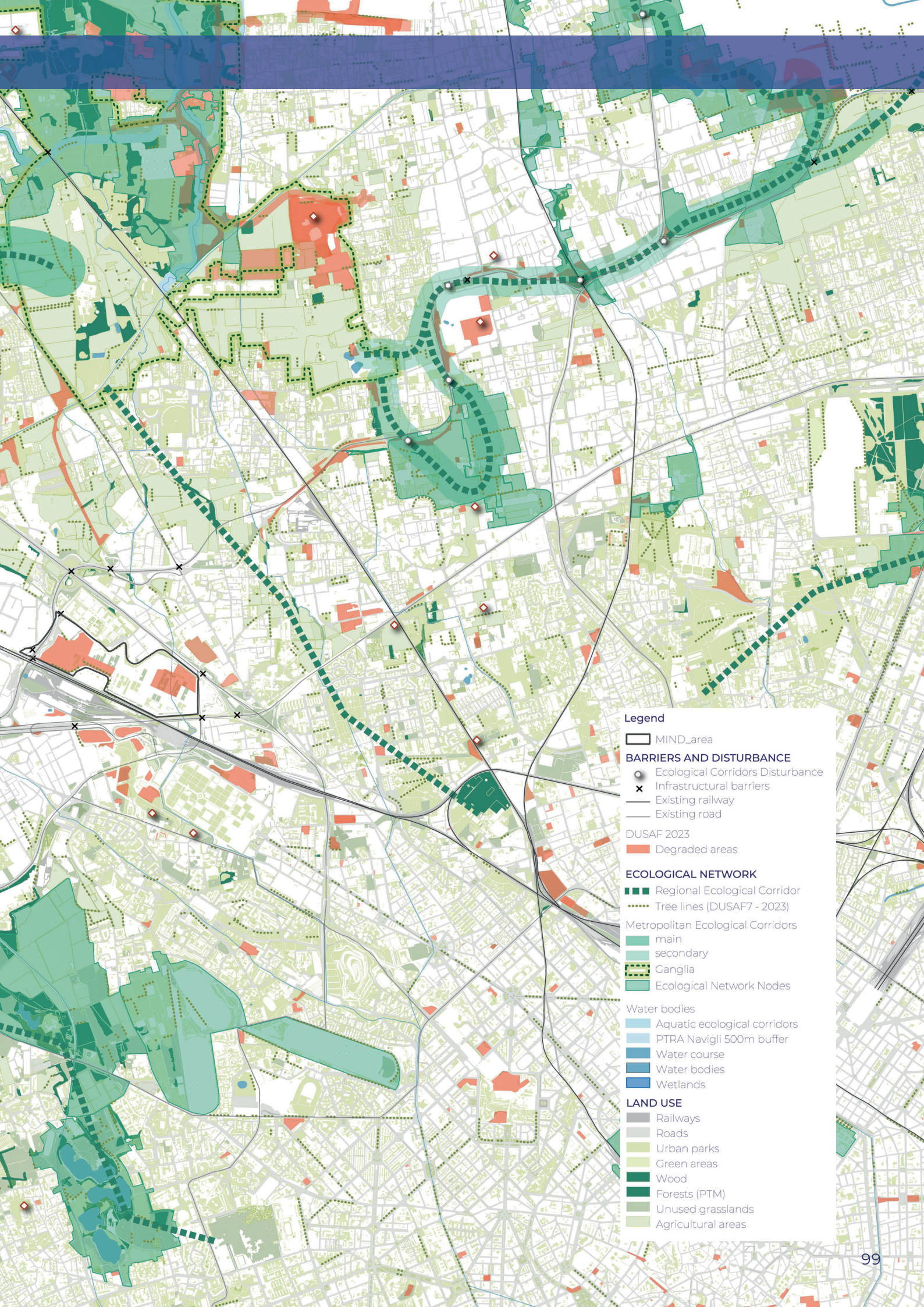
These maps allowed us to have an overview of the ecological condition of the territory where MIND is located; additionally, owing to planning documents and statements, MIND is not only an urban redevelopment area, but it is also a potential ecological hotspot because of its proximity to regional parks whose ecological values are underlined by planning documents with european assessment.

Therefore, being MIND a large area under transformation, surrounded by a great natural and cultural heritage, it could become an opportunity to bring ecological and biodiversity values back to the center of the contemporary planning debate.

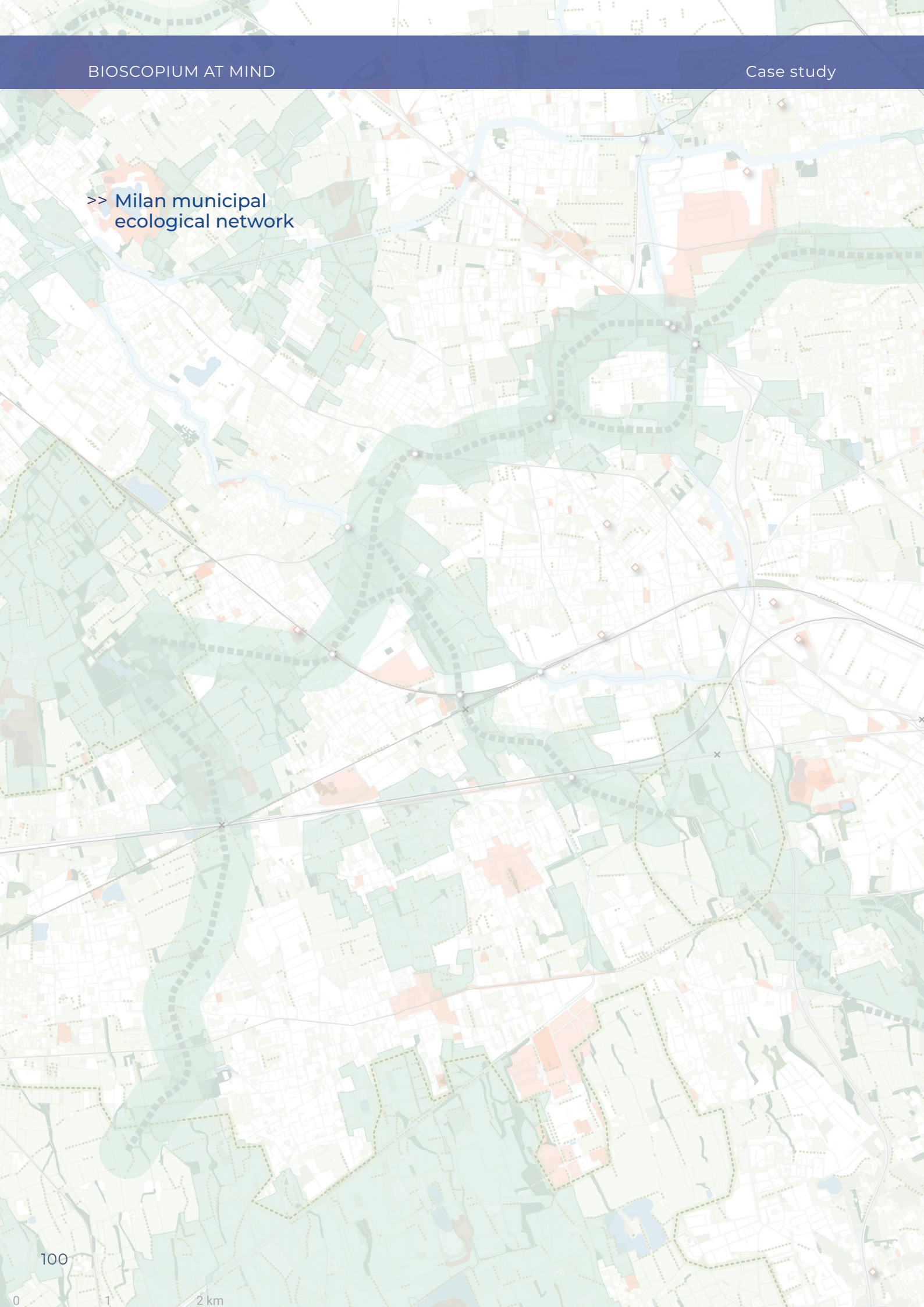
>> Milan municipal ecological network

Elaboration by LAND from Piano Territoriale Metropolitano e Piano del Governo del Territorio di Milano database




Legend
MIND_area
BARRIERS AND DISTURBANCE
Ecological Corridors Disturbance
Infrastructural barriers
Existing railway
Existing road
DUSAF 2023
Degraded areas
ECOLOGICAL NETWORK
Regional Ecological Corridor
Tree lines (DUSAF7 - 2023)
Metropolitan Ecological Corridors
main
secondary
Ganglia
Ecological Network Nodes
Water bodies
Aquatic ecological corridors
PTRA Navigli 500m buffer
Water course
Water bodies
Wetlands
LAND USE
Railways
Roads
Urban parks
Green areas
Wood
Forests (PTM)
Unused grasslands
Agricultural areas

>> Milan municipal ecological network



When data and information provided by territorial plans are not sufficient to map green and available regions to foster biodiversity, a change of scale is necessary, by shifting city size in maps. It is an action that enables a more detailed reconstruction of the green areas and their connection into the Municipal Ecological Network.

In Milan, the map of the **Municipal Ecological Network** is a planning tool aimed to:

- supply the Territorial Government Plan (PGT) with an integrated framework of current naturalistic sensitivity and ecosystem fragility for the evaluation of strengths and weaknesses, opportunities and threats in the territory;
- provide municipal and intermunicipal implementation planning with an organic framework of naturalistic and ecosystem restrictions, as well as possibilities to discover environmentally friendly measures;
- bring indications to carry out possible strategies to implement the local environmental value.

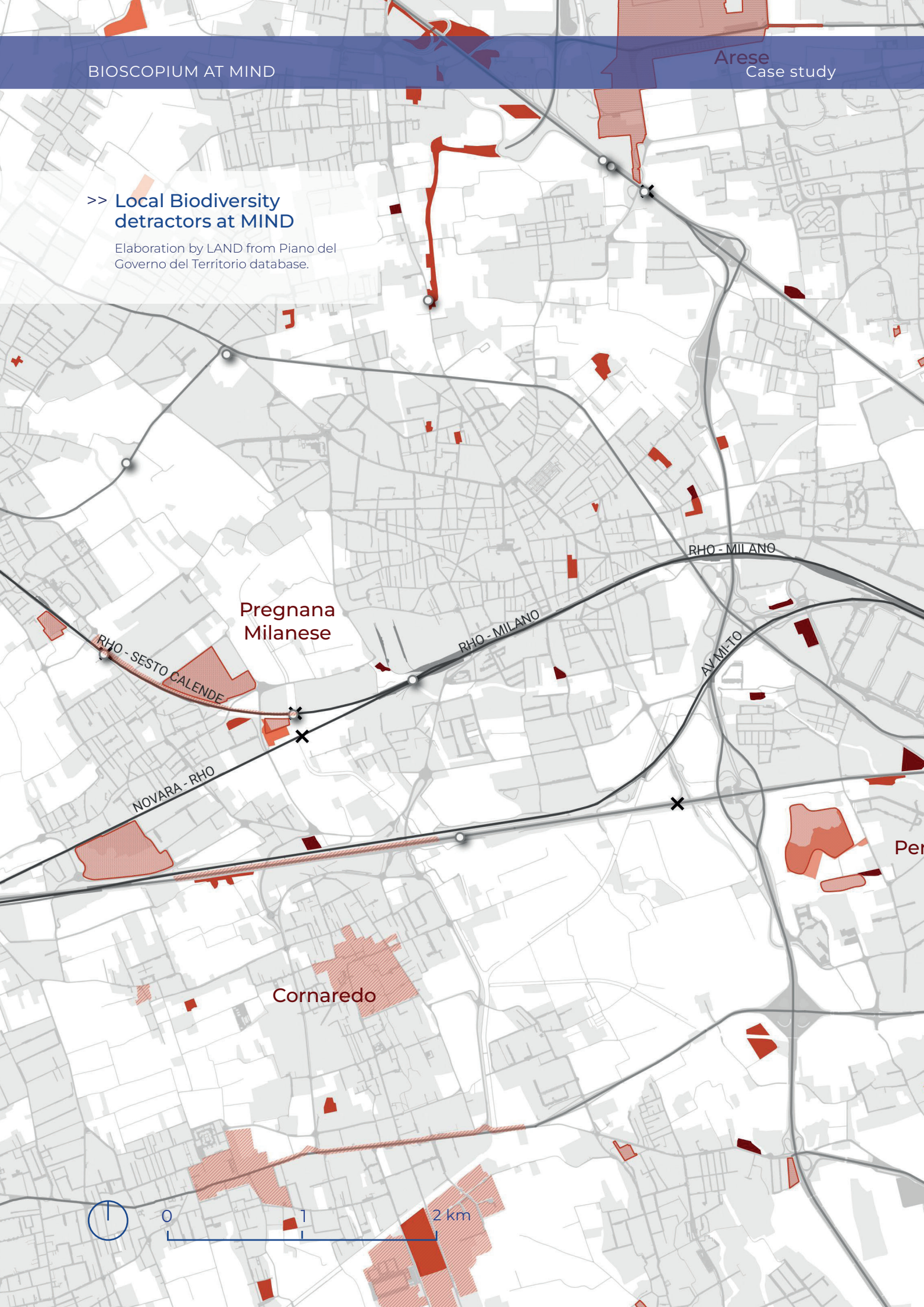
To summarize, the Milan Municipal Ecological Network represents a system of suitably green areas rich in natural elements (nodes) and connecting territorial strips with good vegetation equipment (ecological corridors).

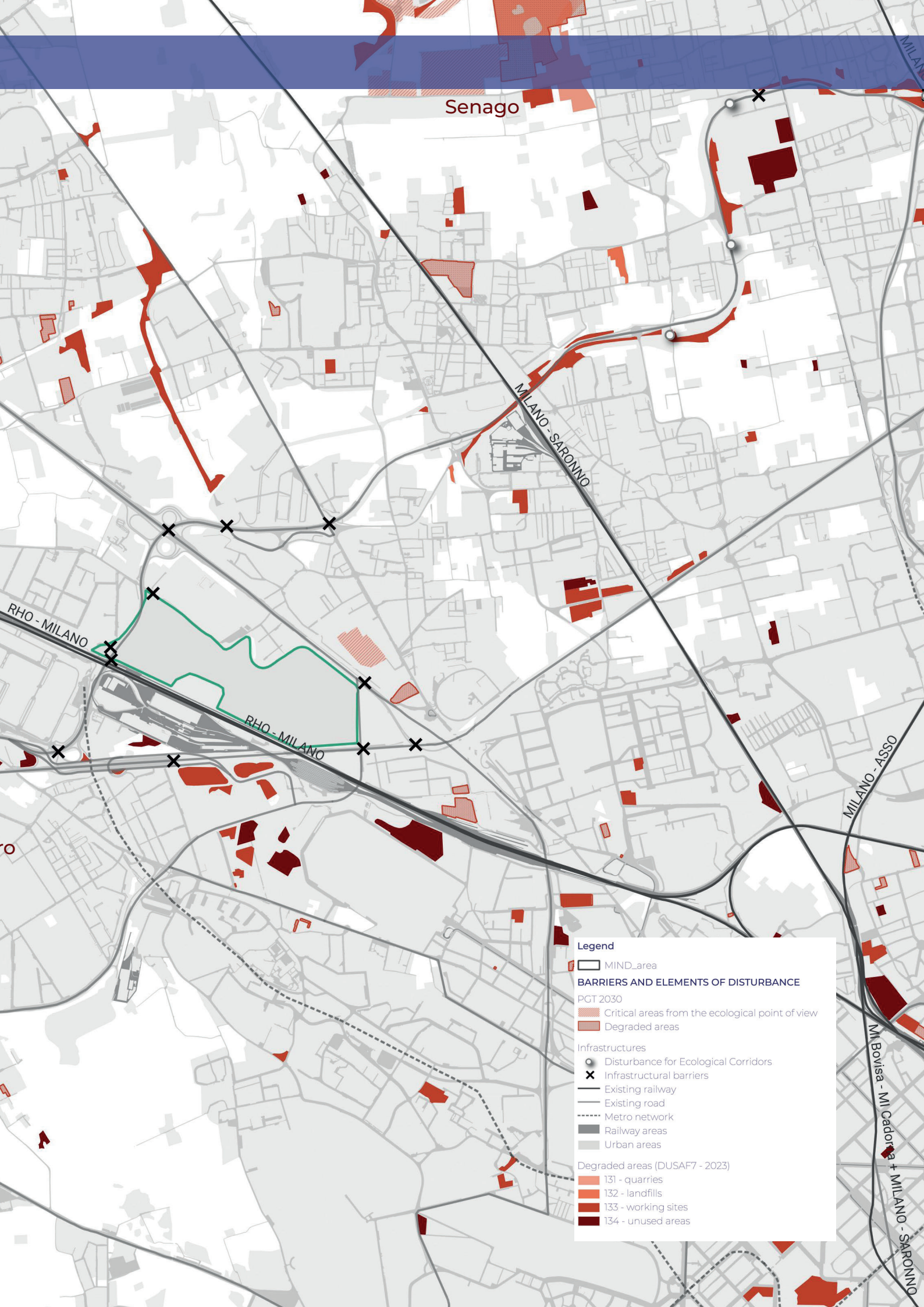
According to this plan, MIND is presented as an area of urban regeneration whose innovative design emphasizes specific themes such as:

- *the morphological quality* of the entire MIND intervention, on built and green urban surfaces. The quality is related to the whole built environment proposed in the masterplan intervention, which must be in balance with the natural environment;
- *the urban ecosystem* obtained through the maximization of ecological connectivity, the planting of new trees and the creation of diversified habitats that encourage biodiversity,in relation to the environmental and naturalistic conditions of the context in which it is inserted (nodes of the regional and municipal ecological network);
- *the landscape fragility* of the project and the environmental system, which has considerable ecological values, but offers limits of many kinds due to the presence of motorways, railroads, canals, power lines, and subterranean utilities. MIND is a highly vulnerable and critical urban regeneration area considering the infrastructural barriers surrounding it.

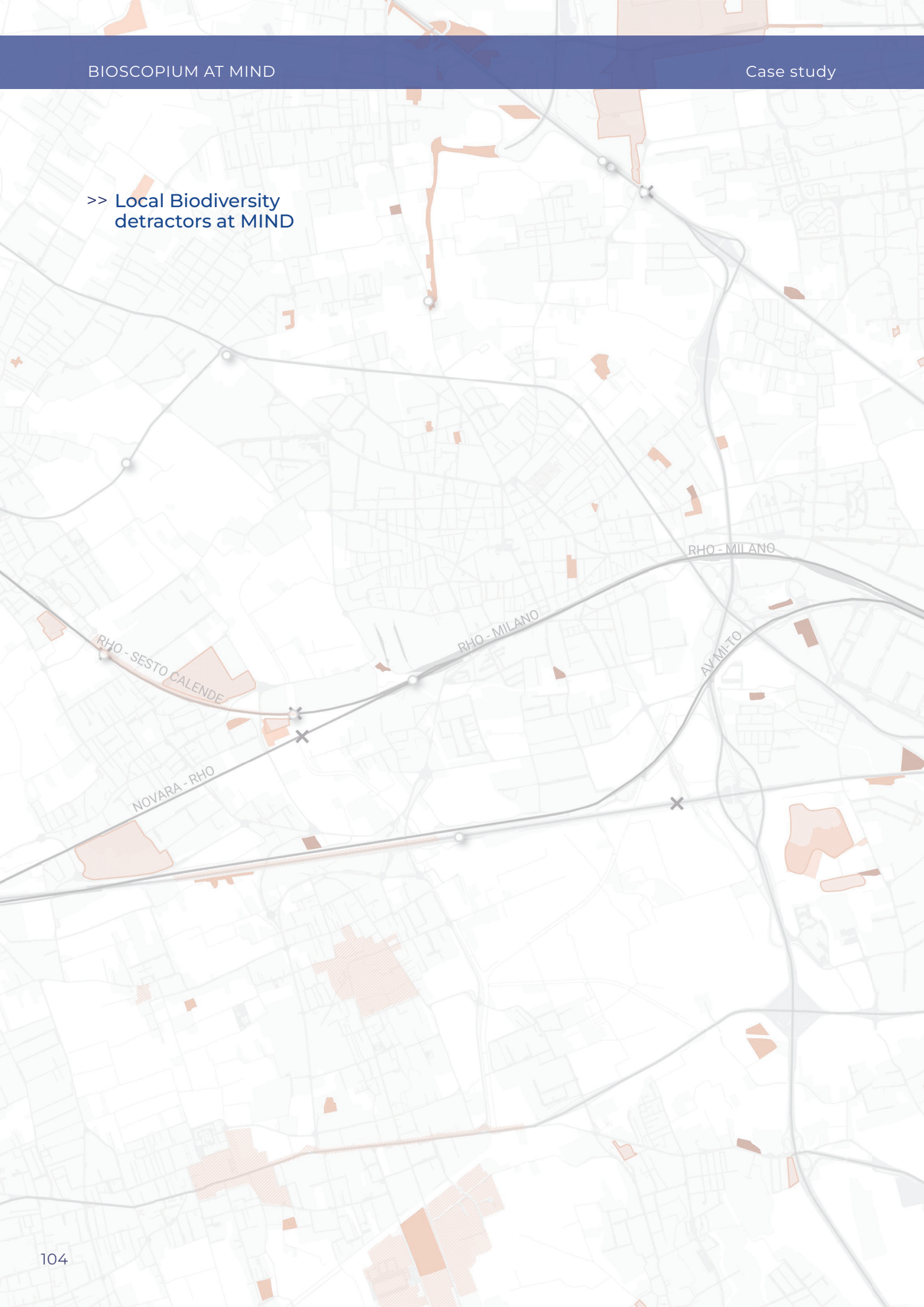
>> Local Biodiversity detractors at MIND

Elaboration by LAND from Piano del Governo del Territorio database.




Senago
MILANO - SARONNO
RHO - MILANO
RHO - MILANO
MILANO - ASSO
M.Bovisa - MI Cadorna + MILANO - SARONNO
Legend
MIND_area
BARRIERS AND ELEMENTS OF DISTURBANCE
PGT 2030
Critical areas from the ecological point of view
Degraded areas
Infrastructures
Disturbance for Ecological Corridors
Infrastructural barriers
Existing railway
Existing road
Metro network
Railway areas
Urban areas
Degraded areas (DUSAF7 - 2023)
131 - quarries
132 - landfills
133 - working sites
134 - unused areas

>> Local Biodiversity detractors at MIND



In order to reinforce the meaning and the relevance of Municipal Ecological Networks, as green infrastructure to set the spatial continuity in the fragmented urban fabric of Milan, it is important to cross-reference this map with those of the detractors of biodiversity that exist in the area surrounding the MIND case study.

The Local Biodiversity detractor map around MIND, depicts the main infrastructural nodes and barriers that hinder the passage of ecological components - fauna and flora - from the external border of MIND inwards.

In addition to the infrastructure system, disturbance elements for biodiversity development include degraded areas such as quarries, landfills, working sites and unused areas, extracted from open source land use data. Also, in the process of elaborating the Milan 2030 PGT, a mapping of the most environmentally critical/sensitive zones or areas that represent an opportunity for the environmental connection/reconnection of various parts of the territory was implemented. Therefore, from this map it can be deduced that MIND is not the only area of interest for an urban transformation that could include biodiversity as a pillar of innovation, but like the former EXPO area, other areas also have the potential to strengthen the continuity of the local Ecological Network.

The greatest challenge in terms of landscape planning is to successfully add ecological value to our cities' existing developed and open places. In fact, mapping the Ecological Network is a difficult task that requires the assistance and technical support of experts.

The work of mapping the MIND Ecological Network is the result of a collaborative effort by experts of Studio TerraViva and LAND. The MIND Ecological Network can be represented by mapping green areas and the vegetation that gravitates around the site: this consists of tree and shrub belts inside and outside MIND. However, these elements are not sufficient to identify the quality of MIND's local Ecological Network, which is functional and consistent with the objectives of the Metropolitan and Municipal Ecological Network Plans analyzed above.

During the Bioscopium testing process, it was required to create a technique for mapping MIND green areas and open spaces in order to represent the level of vulnerability of the environment, beginning with its state of the art. The technique was to map MIND's green areas using remote sensing mapping in GIS and crossing information with field surveys conducted by agronomists of Studio TerraViva. This research was conducted prior to the qualification of the ecological services that this location can provide throughout time.

4 Landscape vulnerability Indicators

Thanks to the contribution of Studio TerraViva experts and LAND architects and researchers, it was possible to set landscape vulnerability Indicators to assess the environmental and biodiversity condition of the green and open spaces at MIND.

The mapping was carried out using regional and local data extracted from open-source geoportals and modeled in GIS. The methodological process followed the scaling down methodology described in the previous section.

In order to assess landscape vulnerability, experts mapped the following indicators and levels of information:

1. Biotopes Analysis at MIND;
2. Types of prevalent ecosystem services in the biotopes of MIND (to map the ecosystem services that are relevant in the research areas, i.e.regulating services, provisioning and cultural services);
3. Landscape Fragmentation Indicators (to analyze the degree of fragmentation and isolation of green areas around and within MIND, through inter-scalar mapping);
4. Wildlife Suitability Index (to map the absence or presence of biodiversity in the area and its possible implementation in favor of the local fauna and flora);
5. Functionality of green areas at MIND.

For each biotope classification, information is given on the type of ecosystem service and the level of expected service provision.

The Landscape Fragmentation Indicator was then evaluated at both the municipal and local scales, assessing the progressive reduction in the surface area of natural and semi-natural environments, and their increased isolation.

Afterward, the Wildlife Suitability Index was calculated, as a useful tool to assess the efficiency of ecosystems to potentially

host new animal species. Finally, the relationship between eachbiotope and its context was investigated.

According to the approach specified in the general guidelines, the analysis of the local network within MIND was relevant in defining the survey region, which included the Biotopes Analysis.

The term biotope is used to define a set of one or more spatially contiguous and interconnected habitats (also referred to as environmental units), located in a precise space and separated from the surrounding areas by discontinuities such as barriers or urbanized areas. Occasionally, biotopes may also include non-vegetated parts.

The open sources utilized to determine the biotopes were:

- census carried out by Arexpo as part of the Environmental Monitoring Plan (PMA) for the MIND area;
- census of green areas carried out by LAND;
- photo-interpretation based on the most recent photos using GIS.

For each biotope, an attribute table structured according to specific information was populated based on the local census carried out by Arexpo, the census of green spaces at MIND set by LAND in 2023, the ecosystem services classification and shape area dimension.

Biotopes analysis of MIND. Credits: Elaboration by LAND from Studio TerraViva's data from 2018 to 2023

Therefore, the biotopes were classified according to the ecosystem services classes used in the monitoring carried out by Arexpo: regulation services, cultural services, regulation and cultural services.

Specifically at MIND, the presence of watercourses within the biotopes (Torrente Guisa, Canale Viviani) was not considered an interruption in the continuity of the green network at the locale scale;on the contrary the perimeter channel and the phytodepuration tanks were considered independent biotopes and, therefore, relevant spaces for the regulation of the urban ecosystem.

Based on the biotopes classification map, the ecosystem services assessment was possible thanks to the on-site surveys developed by Studio TerraViva in 2018, 2022, and 2023.

For each biotope, the prevailing ecosystem service was identified between:

- regulation of ecological processes, climate mitigation, and environmental health. This service finds its best instrument in biodiversity, which thus becomes an indicator of biotope resilience and efficiency. In the case of aquatic biotopes, this is expressed as an improvement in water quality, exercised through the complex floristic and faunal communities they host;
- aesthetic service, translated in this context as the beauty and enjoyment of the landscape. Biotopes are judged on their pleasantness, aesthetic value, usability and the appeal to local tradition, which some biotopes perform. A further element is the mitigation function of external impacts (e.g. noise).

The outcomes of the monitoring of ecosystem services carried out for Arexpo under the PMA are reported. In particular, emphasis has been placed on the assessment of the efficiency of the delivery of the ecosystem services. Data on outcomes for the years 2021, 2022 and 2023 are reported. These data make it possible to give a "temporal perspective" to the analysis of the Ecological Network, assessing how the individual

v v Type of Ecosystem Services prevalent associated with each biotope at MIND.
Credits: Elaboration by LAND from Studio TerraViva's data from 2018 to 2023

biotopes that make it up have undergone their quality over time (e.g. maintenance work, drought, etc.). The diagrams show the degree of efficiency of the prevailing ecosystem service, classified in: aesthetic, regulation, or both.

Aesthetic
Aesthetic and Regulation
Regulation

0 500 m 1 km

Municipal scale

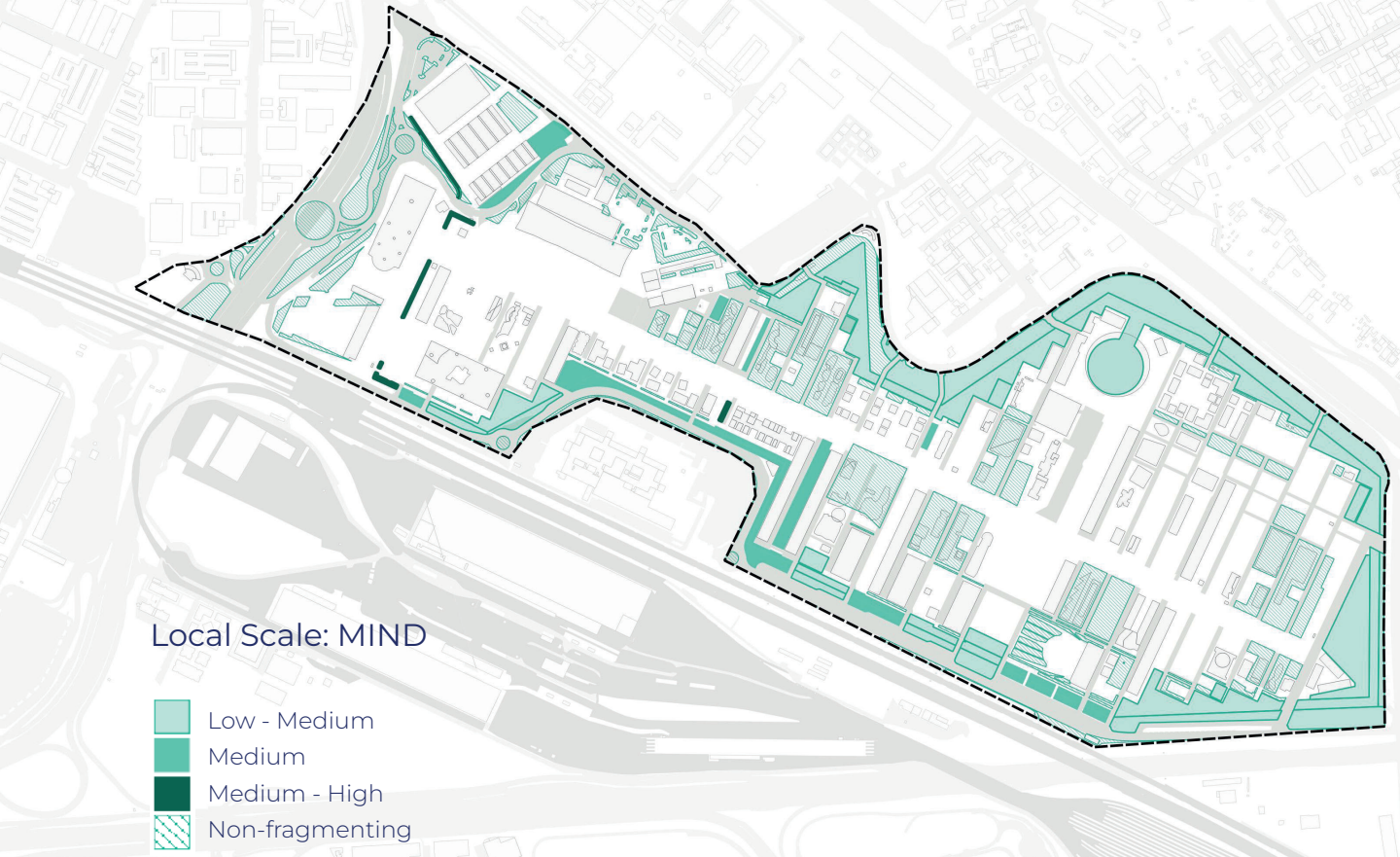
v
v Biotope isolation map at MND.
Credits: Elaboration by LAND from Studio TerraViva's data from 2023 survey

<< Landscape Fragmentation map at the larger scale.
Credits: Elaboration by LAND from Studio TerraViva's 2023 survey

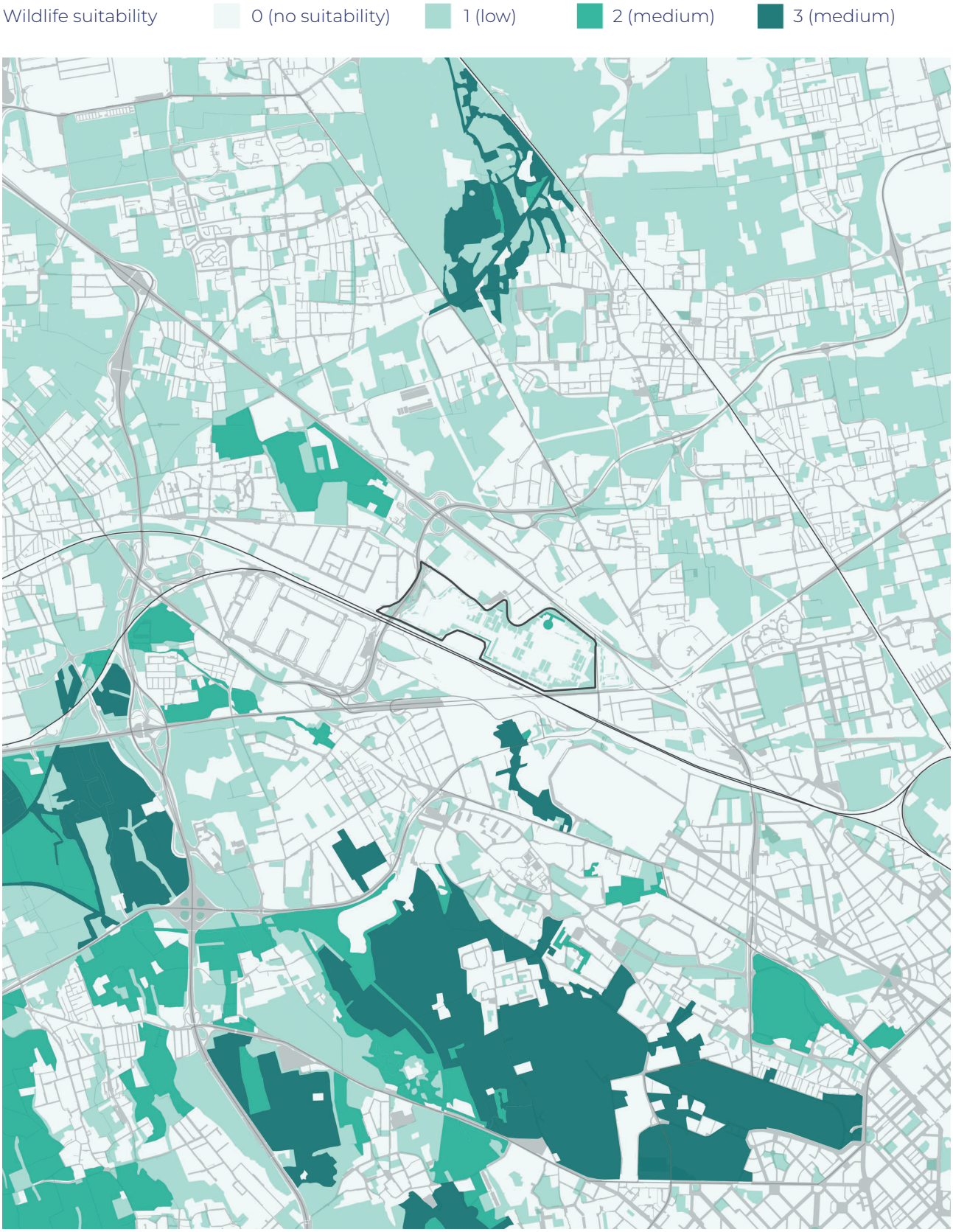
The analysis of Landscape Fragmentation and biotope isolation (or connectivity) of the elements that compose the MIND Ecological Network was then carried out using the Guidos Toolbox software developed by the JRC of the European Commission.

The Guidos Toolbox software offers a comprehensive set of analyses and indicators for the evaluation of Ecological Networks. In the present case, the evaluation of the indicator "Foreground area density - Average for five-class patches" (FAD-APP-5) was deemed useful. The peculiarity of this indicator is to be multiscalar, i.e. to be evaluated at different spatial scales, with the aim of reading the relationship of each resource element with its surrounding context. In other words, the indicator provides the level of fragmentation/isolation of each resource tile in relation to the surrounding context.

Large and well-connected tiles obtain high indicator values. Small and isolated tiles on the contrary return the lowest values.



Municipal scale



<< Wildlife Suitability index at the local scale of MIND.
Credits: Elaboration by LAND from Studio TerraViva's 2023 survey

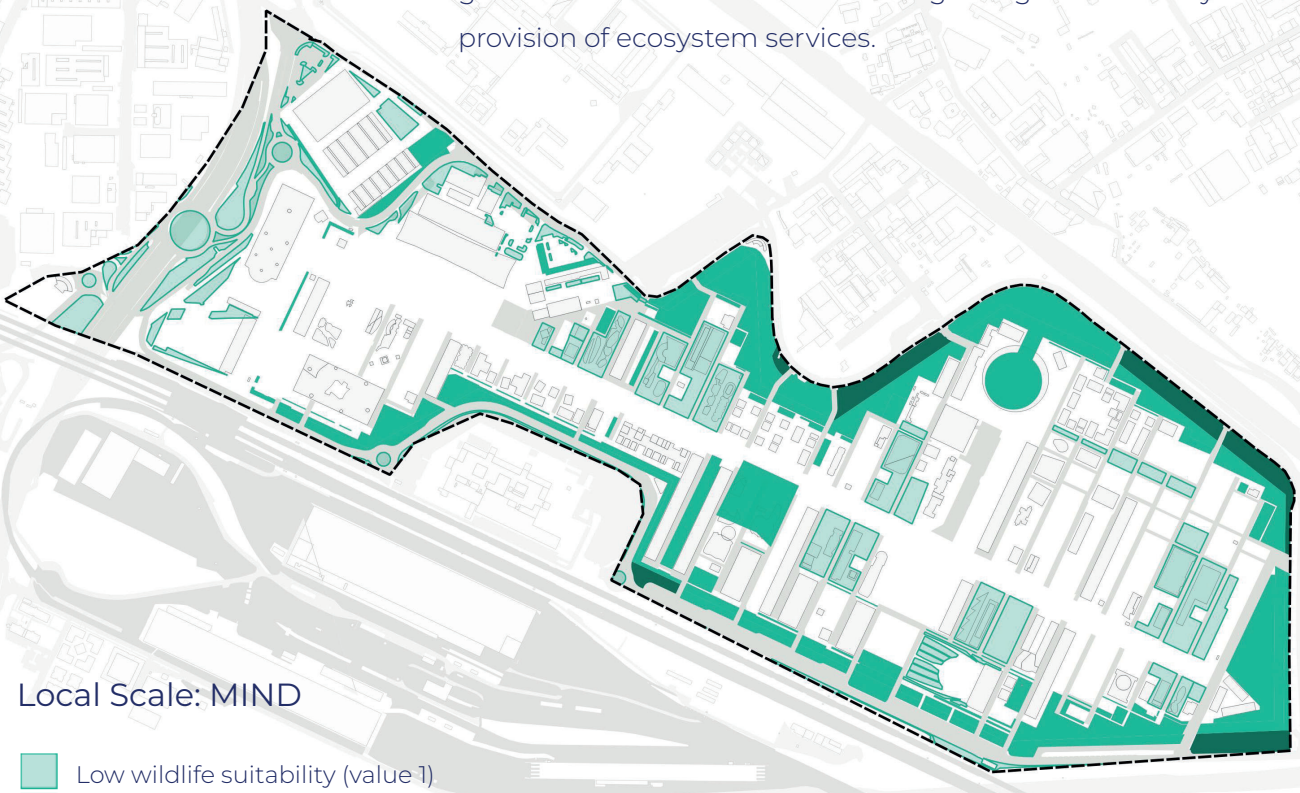
<< Wildlife Suitability Indicator at larger scale.
Credits: Elaboration by LAND from Studio TerraViva's 2023 survey

Moreover, for each type of biotope, a Wildlife Suitability Indicator was reported, constructed from all the wildlife data collected in the area since 2020 (the wildlife monitoring carried out for the PMA before and after EXPO2015, wildlife observations from iNaturalist and data collected through photo trapping).

The wildlife data were represented according to an indicator with a three-value scale:

- Low fauna suitability (value 1): no fauna data were found for the biotope type, or ubiquitous and synanthropic species were found;
- Medium wildlife suitability (value 2): for the biotope type, species with a high distribution but more stringent ecological requirements than in the previous class were found;
- Medium fauna suitability (value 3): demanding and/or rare species were found for the biotope type.

The Wildlife Suitability Indicator allows objective feedback to be given to the assessments made regarding the efficiency in the provision of ecosystem services.



Local Scale: MIND

Low wildlife suitability (value 1)
Medium wildlife suitability (value 2)
Medium wildlife suitability (value 3)

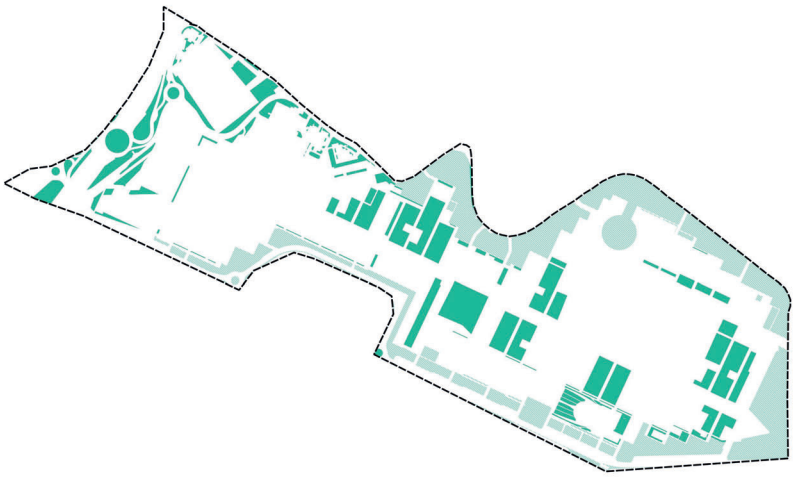
0 500 m 1 km

As part of the AREXPO Environmental Monitoring Plans (PMA - Piano di Monitoraggio Ambientale), a map of the functionality of the Ecological Network was compiled, by means of a symbolic representation of the functional structures found within the area (corridors, barriers, ganglia, nodes, etc.).

For each biotope, it was made explicit whether or not each biotope participates in the most relevant ecological structures. In particular, it was highlighted whether they belong to the following functional structures:

- Continuous ecological corridors;
- Discontinuous ecological corridors (stepping stones);
- Connections outside the MIND area;
- Ecological ganglia;
- Ecological nodes.

>> Discontinuous ecological corridors (stepping stones)



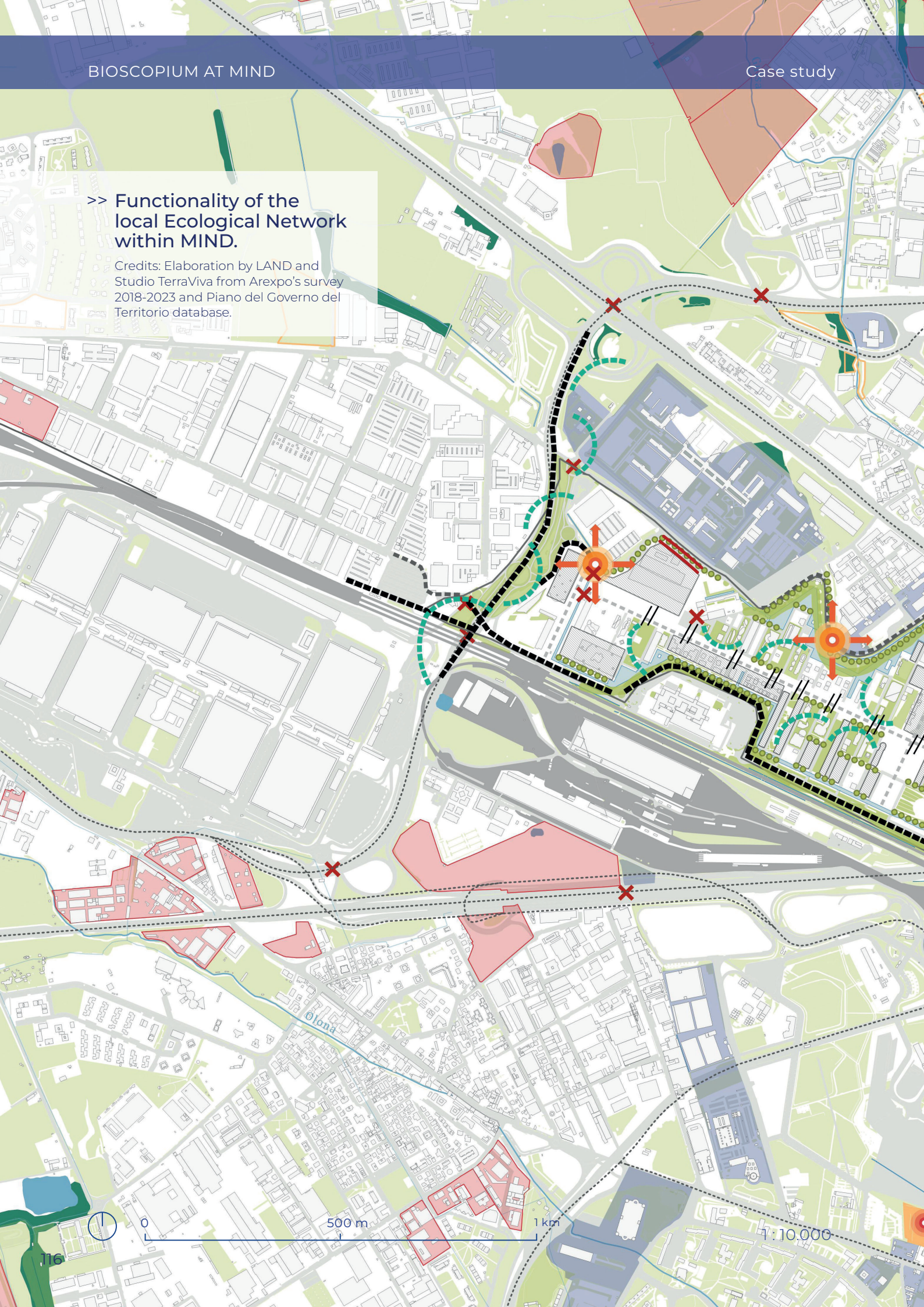
>> Ecological ganglia

>> Ecological nodes

All these indices and indicators converge in a synthesis map that aims to define the ecological functionality of MIND's green areas. Moreover, MIND Ecological Network Functionality aims to suggest possible strategic actions to increase the ecological value of areas through the development of local biodiversity. The map was designed with the contribution of the experts of Studio TerraViva.

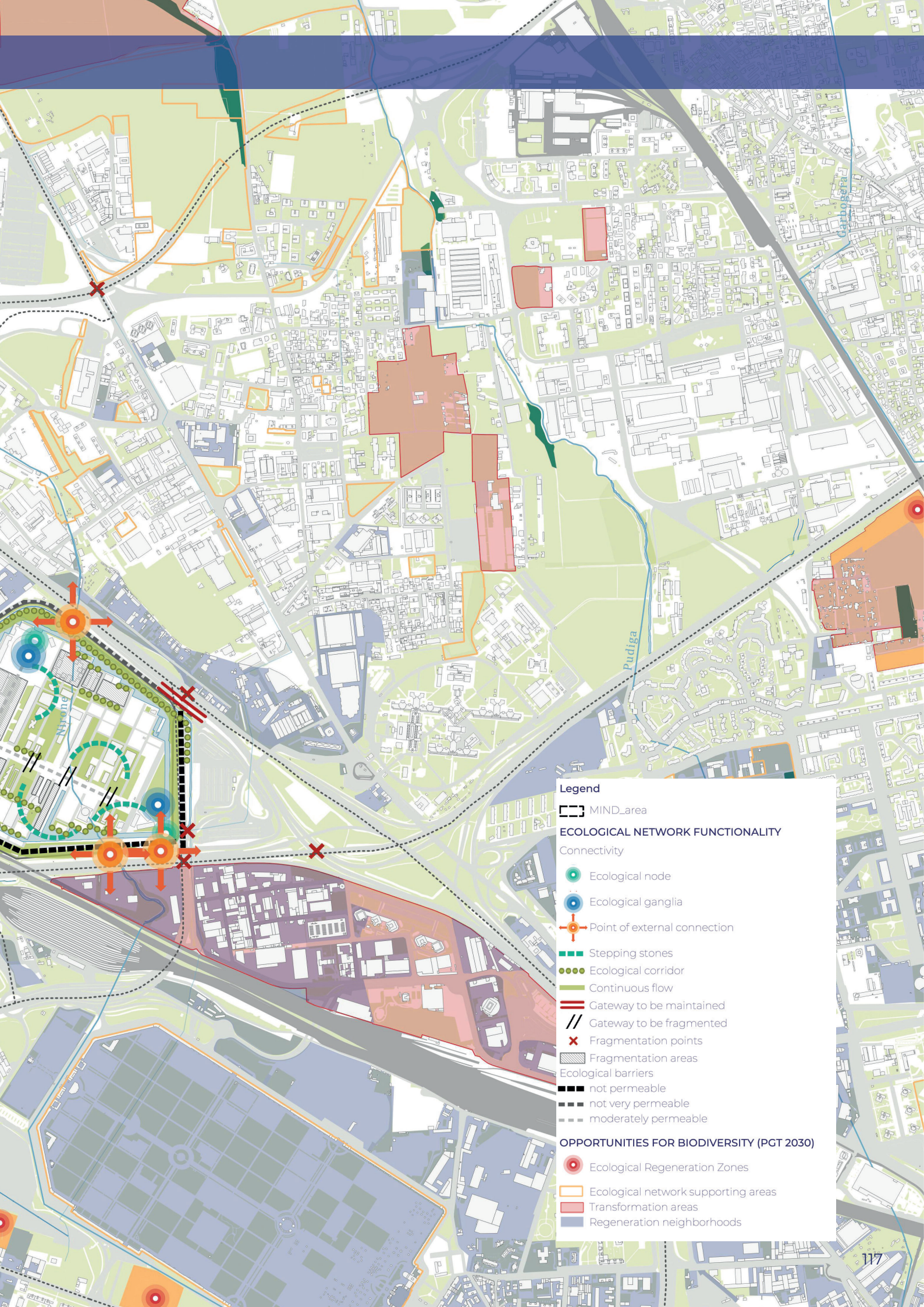
^^
<< Functionality of existing ecological network elements at MIND: corridors, ganglia and nodes. Credits: Elaboration by LAND from Studio TerraViva's 2023 report and survey

The map is made up of connectivity structure layers, i.e. the identification of all points of connection of structural elements (nodes and ecological ganglia), and also points of disconnection or separation. They are considered as strategic points for ecological connection (ecological crossings). The most prominent element is represented by what is referred to as the 'continuous flow': a complete ring along the outer perimeter. This band is made up of elongated forest and aquatic resource tiles. Less structured and effective is the connection inside the area and between the internal and external areas. Internally, the connection relies on very simplified resource tiles. The opportunities are linked, above all, to the enhancement of the two 'compartments' of the district, currently divided by the Decumano road, today an ecological barrier, along which eight potential connection points have been identified, defined as gateways to be defragmented. In this sense, the regeneration project should result in the insertion of new, higher quality resource tiles and the overcoming of the ecological barrier of the Decumano.



>> Functionality of the local Ecological Network within MIND.

Credits: Elaboration by LAND and Studio TerraViva from Arexpo's survey 2018-2023 and Piano del Governo del Territorio database.


Darbogna
Pudiga
Nirone
Legend
MIND_area
ECOLOGICAL NETWORK FUNCTIONALITY
Connectivity
Ecological node
Ecological ganglia
Point of external connection
Stepping stones
Ecological corridor
Continuous flow
Gateway to be maintained
Gateway to be fragmented
Fragmentation points
Fragmentation areas
Ecological barriers
not permeable
not very permeable
moderately permeable
OPPORTUNITIES FOR BIODIVERSITY (PGT 2030)
Ecological Regeneration Zones
Ecological network supporting areas
Transformation areas
Regeneration neighborhoods

5 Mapping local fauna with photo traps and sensor stations

5.1 Exploration with photo traps

Since September 2022, the team of researchers from Polifactory-Politecnico di Milano involved several urban biodiversity experts from local associations, such as Progetto Natura Onlus and the WWF oasis in Bollate, in a series of on-site inspections and visits of the MIND area with the aim of understanding whether the area could be of interest for environmental mapping and monitoring activities.

These activities resulted in an overview of the environmental conditions of the area under regeneration that, together with the monitoring reports conducted by Studio TerraViva for Arexpo and the work done by LAND, helped the T-Factor local coalition in targeting the activities described below.

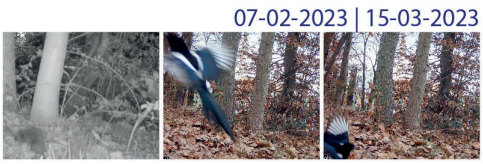
As a first action, from October 2022 to March 2023, photo traps were placed in five specific areas of the site. This activity aimed to collect preliminary photographic data on the local fauna, enabling a more in-depth assessment of the existing biodiversity.

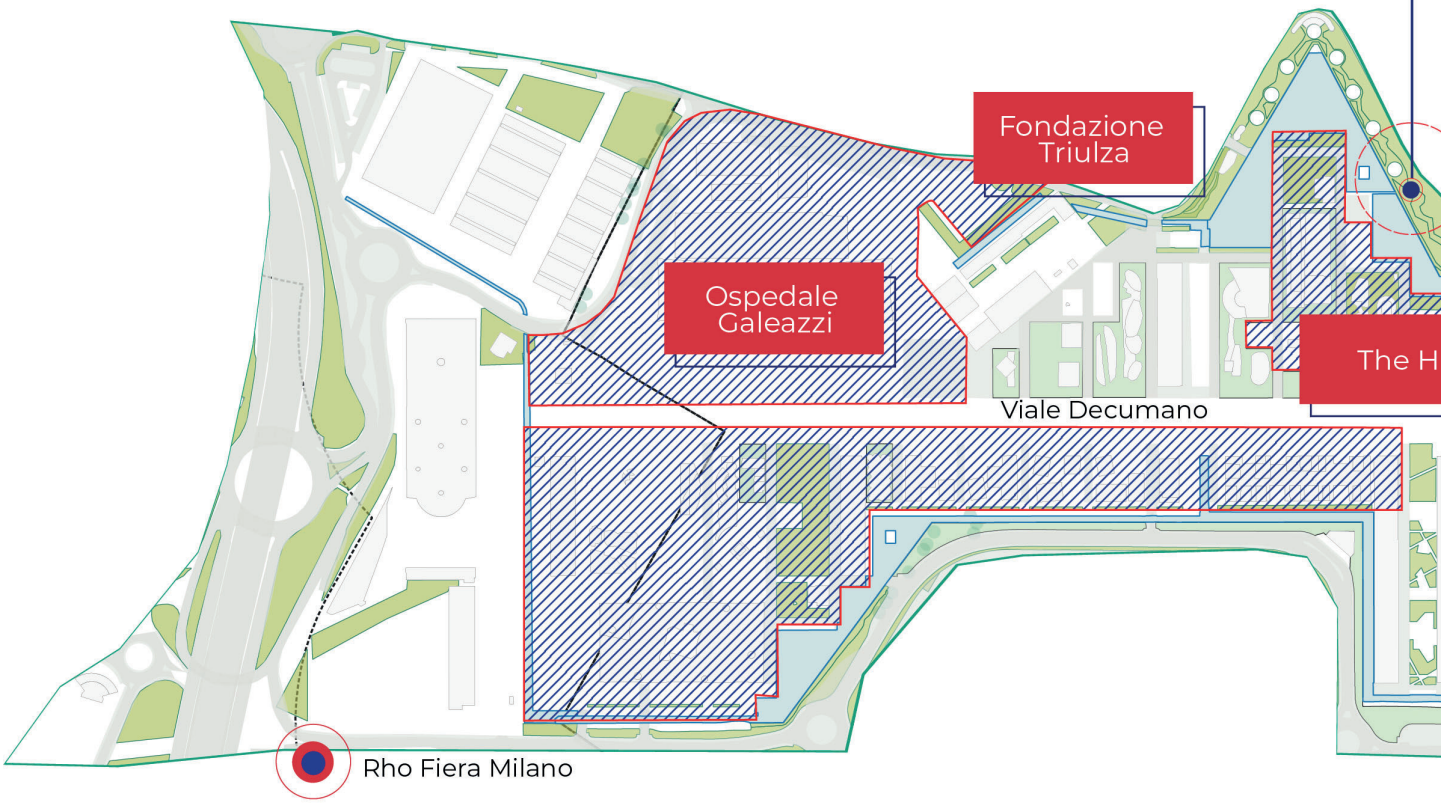
It also helped the researchers to recognize the limitations of this type of monitoring and to provide initial design ideas for the development of Bioscopium, and specifically the sensor stations, with the ambition to overcome the limitations of 'traditional' photo trapping.

>> Detection with photo trap of Sciurus carolinensis at MIND. Photo credits: Polifactory

⩛ Inspection of MIND perimeter canals July 2022. Photo credits: Polifactory

>> Photo traps positioning map at MIND and first results. Credits: Polifactory





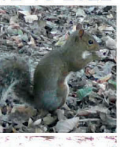
Phototrap

Railway and public Station

Active construction sites 2023-2024

Possible place-making implementation for the implementation of Biodiversity

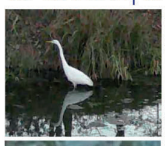
12-10-2022

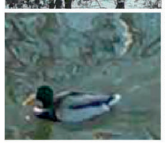


07-02-2023 | 15-03-2023

8-11-2022 | 3-12-2022

03-12-2022 | 07-02-2023





5.2 Design and setup of the sensor stations

After investigating existing ways of mapping biodiversity and biodiversity-focused initiatives around Europe, design researchers hypothesized a model that could simultaneously facilitate mapping for experts, make it accessible and implementable by non-experts, and involve citizens. With these premises, the idea of designing open-source sensorized stations made with low-cost digital fabrication and sensing technologies was born.

More specifically, thanks to preliminary studies, design researchers identified the need to develop, prototype and test a modular system of sensor stations, or advanced photo-traps, that in addition to audio and video data could collect a set of environmental data to be correlated with the images.

The system developed for the mapping tests at MIND was designed both in terms of hardware and software as an open-source modular system. However, despite the system being based on four types of sensor stations, each one dedicated to a different class of animals, because of time and budget constraints, it was possible to prototype and test only two stations at the MIND area: the mammal station and the insect station.

>> Details of the mammal station. Photo credits: Polifactory

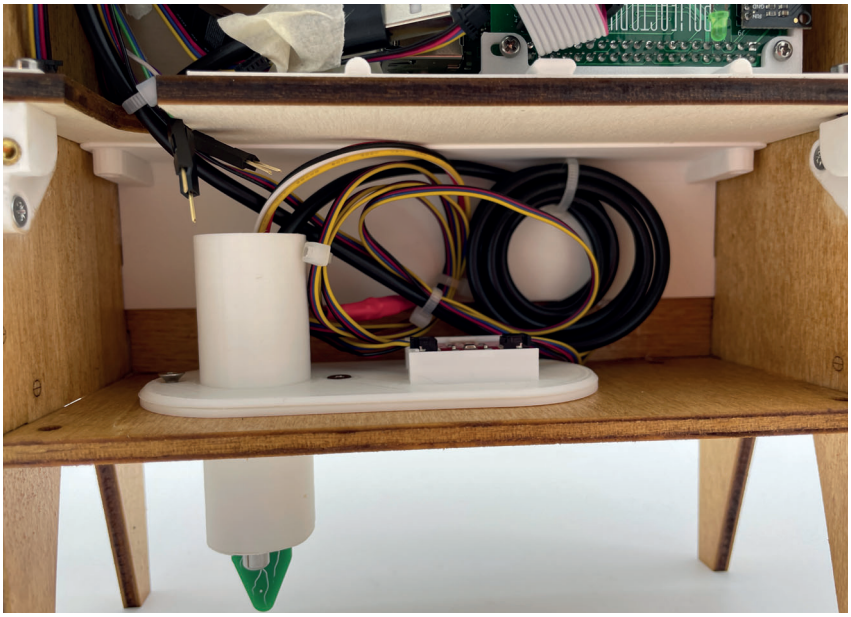
^^ Prototype of the mammal station.
Photo credits: Polifactory

	/INSECT STATION	/MAMMAL STATION
	The station was positioned at Herbula Wild Garden flowery meadow to record the passage of insects (butterflies or other pollinators).	The station was positioned in the forest ring along the outer perimeter to record the passage of small mammals and birds.
BASIC REQUIREMENTS	· stand-alone power supply (powerbank) · system for outdoor use · data collection · macro camera (set in timelapse mode) · lighting	· stand-alone power supply (powerbank) · system for outdoor use · data collection · camera with day and night mode · proximity sensor
ATTRACTORS	· Honey · apples	· Seeds · apples · sardines
DATA COLLECTED	· video with audio · location · date · time · soil moisture · temperature · pressure	· video with audio · location · date · time · soil moisture · temperature · pressure

Each prototyped station was composed of five modules that correspond to specific functional blocks:

1. the microprocessor, i.e. the 'computer' that runs the program, with its own power supply system;
2. the audio recorder and speaker module that records audio and can emit sounds;
3. the lighting module that contains LEDs that light up at dusk and are used to attract nocturnal insects in front of the camera (this module was not active in the mammal station);
4. the module of environmental sensors that measures pressure, temperature and humidity (but could also integrate other sensors);
5. two different photo and video modules to respond to the two different monitoring scales:
    a. *The model A* (for insects) embeds a programmable daytime macros camera and is positioned inclined towards a limbo at the center of which is a small tank of water or honey (working as attractors), and a twilight sensor used to activate the LEDs in the lighting module;
    b. *The model B* (for mammals) embeds two cameras (one with a fixed focus and one with autofocus) for night and daytime that are activated when the proximity sensor detects some movements; it also integrates a twilight sensor to switch from day to night mode.

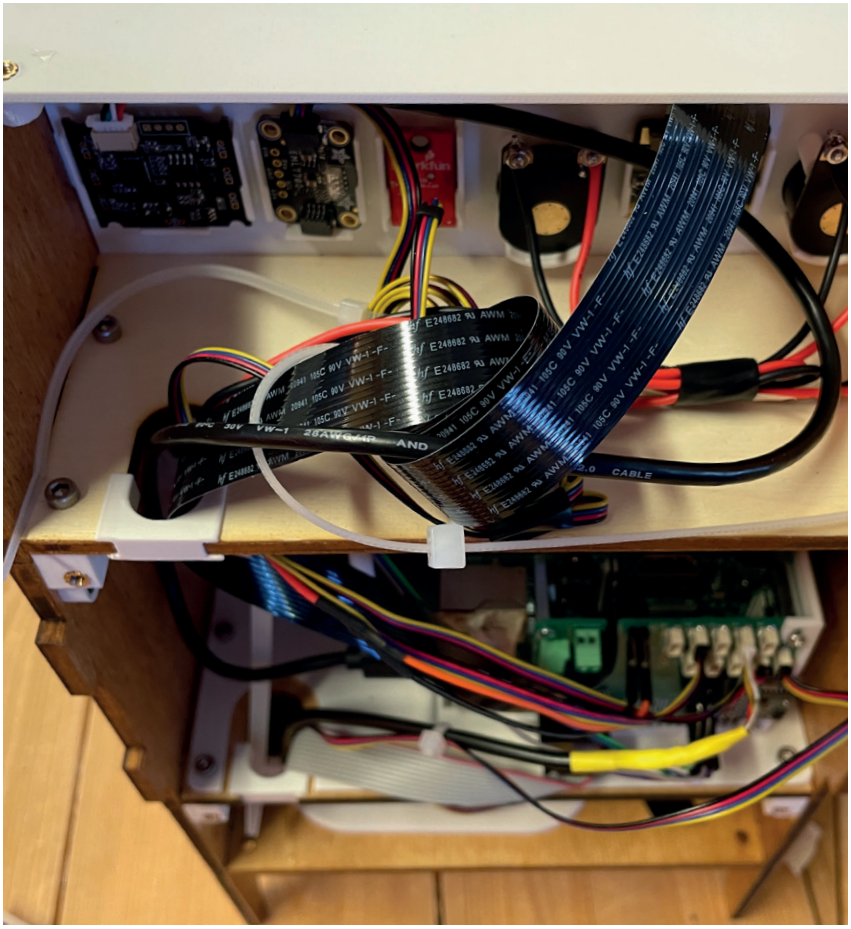
>> Making of the mammal station. Photo credits: Polifactory



The system was designed to be extended to several (and different) functional blocks and is programmable, thus allowing it to be adapted, also at software level, to different mapping requirements (e.g. emitting sound calls to be used as attractors for birds).

The containing structure, which protects all the electronic components, is also modular. For the first prototypes, each module was made of wood using laser-cut technology to be easily disassembled. It consists of a front face that differs according to the functions it integrates and allows sensors and actuators to be positioned facing outwards. The side faces allow the bases of the different modules to be stacked, also supporting the rear closure that is common to all the modules to allow an easy opening for data transfer and power bank recharging. The roof is made of mirrored PMMA so as to be as inconspicuous as possible in context.

Inside each station, the electronic components and wiring are held in place by 3D-printed PLA casings, different for each functional block.



>> Details of the making of: sensor positioning. Photo credits: Polifactory

>> Detail of the insect station: actractor part. Photo credits: Polifactory

The stations tested at MIND were programmed to shoot short videos. The insect station integrated a timelapse program that triggered the camera for 30 seconds every minute. In the case of the mammal station the two cameras were triggered by movements in front of them, thanks to the activation of a proximity sensor, also operating in night mode thanks to infrared.

A LED light source was placed in the insect station, which was activated thanks to a twilight sensor only during night hours to attract insects and give visibility to the camera.

Both stations recorded environmental data (soil moisture, temperature, pressure) on a daily basis, including date and time of the detection.

5.2.1 Fauna mapping through sensor stations at MIND

As mentioned before, the mapping protocol that was tested at MIND involved a series of preliminary activities to get to know the area, assess its status, and discuss the development of the sensor stations with experts.

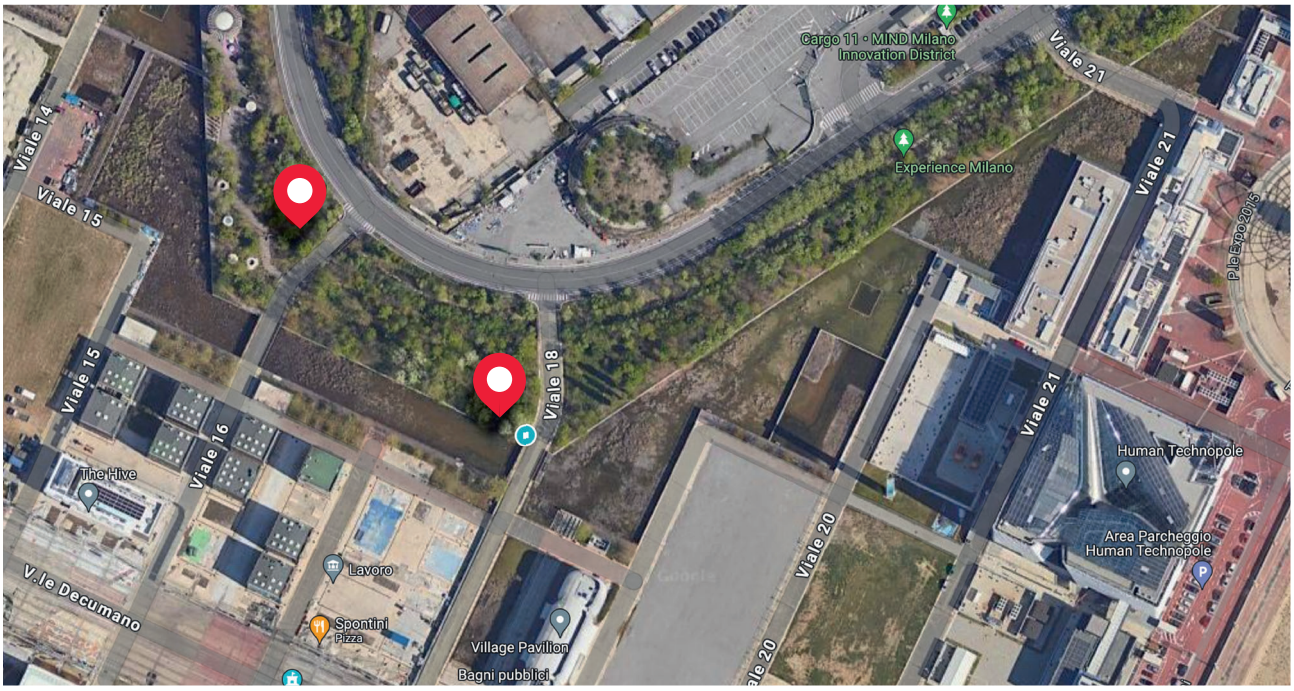
After an initial design phase of the sensor stations, the team met with Studio TerraViva experts to define the correct mapping protocol (locations, times and object of mapping) to be implemented and the attractors to be integrated in the stations according to the fauna present in the area.

We have learned that mapping biodiversity means monitoring the health of the territory through the number of species (plant and animal) present and several other environmental information. Typically, observations are repeated several times a year, for several years in succession.

The techniques and methodologies for mapping, surveying and sampling are many and are chosen on the basis of the object of the mapping (plants, insects, mammals, etc.), the objectives (measuring the quality of agricultural environments, mitigating the impact of new infrastructure, etc.) and the specific context/ habitat.

Thanks to the preliminary activities mentioned above, we were able to identify four types of biotopes within the MIND area: forest (e.g. outer ring), aquatic (canals); urban park, and urban green (meadows, ponds...). Among them, the outer forest (not yet affected by construction sites) and the flowery meadows turned out to be the most interesting scenarios for mapping tests.

Mammal station positioning map
Source: Google Maps



Insect station positioning map
Source: Google Maps

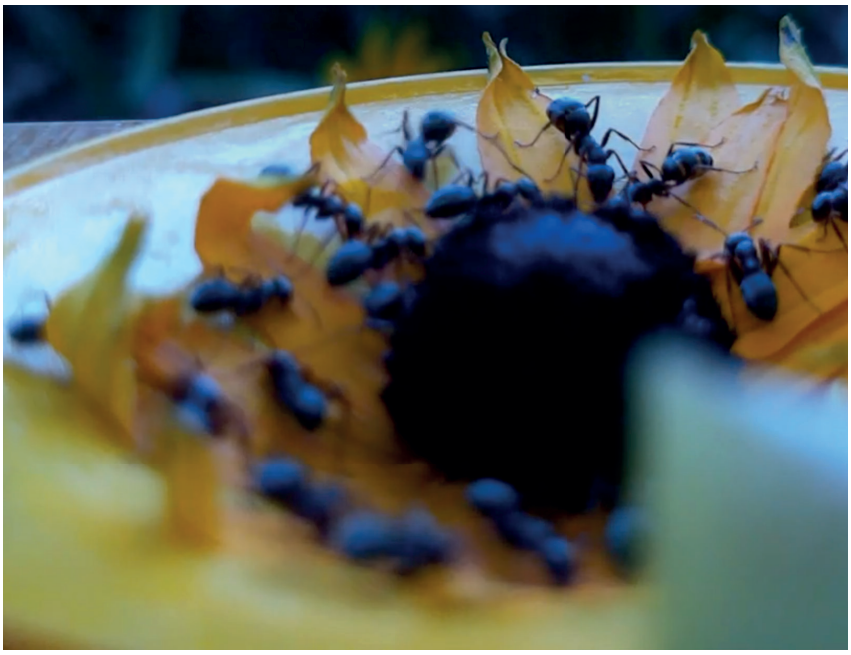
After several inspections of the area and once traces of animal presence (thanks to photo trapping) were identified, the installation of the stations was carried out.

Taking into account the deadlines of the T-Factor project and the periods with the highest probability of animal presence, we identified July (between the 17th and 27th) and September 2023 (between the 19th and 22nd) as the two ideal installation periods.

>> Positioning of the mammal station at the outer forest ring. Photo credits: Polifactory

>> Positioning of the insect station in the flowery meadow. Photo credits: Polifactory

>> Image capture of the insect station. Photo credits: Polifactory



>> Image capture of the insect station. Photo credits: Polifactory

As time is a key component in a regeneration context, a crucial aspect of the mapping was the definition of the timing of data collection: mapping and monitoring biodiversity at different points in time during the regeneration process allowed us to understand the impact of implemented interventions, inform stakeholders and suggest actions for protection or restoration.

5.2.2 Data analysis and visualization

Once placed onsite, the sensor stations started to collect the following data:

1. A *series of short videos*, stored on the SD memory embedded in each station with related meta-data (i.e., timestamp);
2. *Several data files* (string type, format JSON) stored on the station's micro-processor that merged measurements from all sensors, recorded once every two tenths of a second.

Once collected, these raw data had to be further processed before being analyzed in the following stages. The main goal was to understand whether these data could offer a novel and reliable information source in biodiversity mapping and monitoring, thus making Bioscopium a valuable tool for mapping processes.

Design researchers organized a data validation session, involving Studio TerraViva experts.

For the session, the raw data were pre-processed and visualized through the following steps:

- *Sensors data downsampling and cleaning*

  The preparation work started from the sensor data. The high recording frequency, initially set for the sensors, had created files of noticeable size (ten thousands data points). The resulting files could not be easily read or edited by most software. To address this issue, the files were reduced in size by the power of ten through a Shell script, resulting in a file of a few thousand data points.

  Data cleaning was also necessary for correctly formatting data, especially when errors occurred (e.g., due to some battery faults). Although these errors were only a few, they could create outliers affecting the final visualization. For

this reason, they were approximated to their closest value through a 'find and replace' text editor function. Once cleaned, the JSON file could be converted into a CSV/tabular format for the next steps.

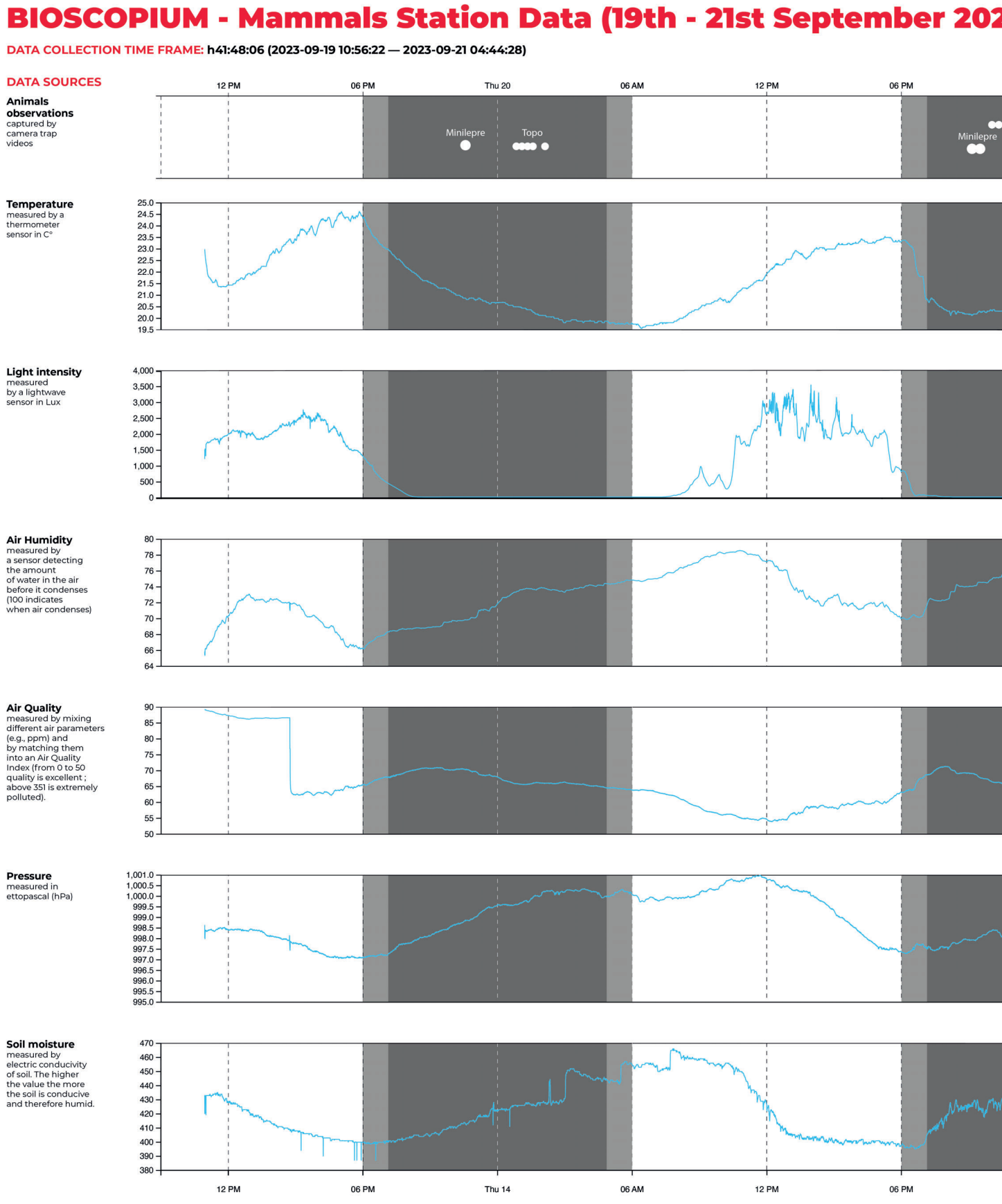
- *Sensor data visualization*

  Once the data file was reduced to a manageable size and cleaned up, it could be rendered into data visualizations through a dedicated software. The web application RAWGraphs 2.0 (https://app.rawgraphs.io/) was chosen, primarily because it is an open-source option that could render the data immediately in the browser. This feature allows users to switch between different visualization types and quickly change parameters in the browser, thus allowing a fast assessment of the final results. The line graph was the visualization type chosen to display the sensor data as a variating quantity over time.

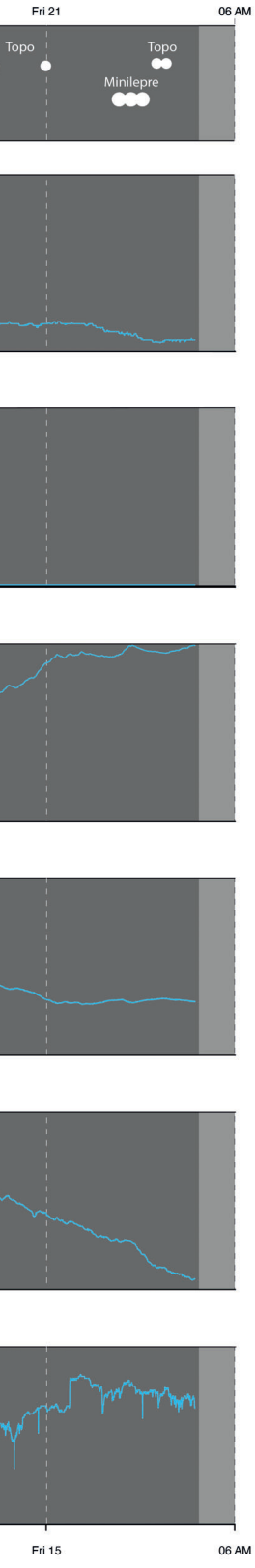
- *Pairing sensor data with photo traps pictures into the final layout*

  To conclude, sensor data were integrated with observations from photo trap pictures. In the final layout, all line graphs were stacked and aligned vertically on their x-axis (constituting the data time frame) to consent to a better comparison of how data changed at different times of the day and night. Using the timestamps of photo trap videos, it was then possible to locate observations on the timeline for each animal's appearance, approximately when this was recorded.

One of the visualizations used for the data validation session with Studio TerraViva.



23)



The data validation session involved one expert from Studio TerraViva and three design researchers from Polifactory-Politecnico di Milano and was organized on October 4th, 2023. During the two-hour session researchers showed the expert both the photo trap videos and observations gathered by the participants involved in the Biodiversity Ambassador Program on iNaturalist platform.

The expert was guided through the visualizations and left free to read and comment on them. He expressed his view on the insights data suggested, their potential use, and limitations in biodiversity mapping and monitoring.

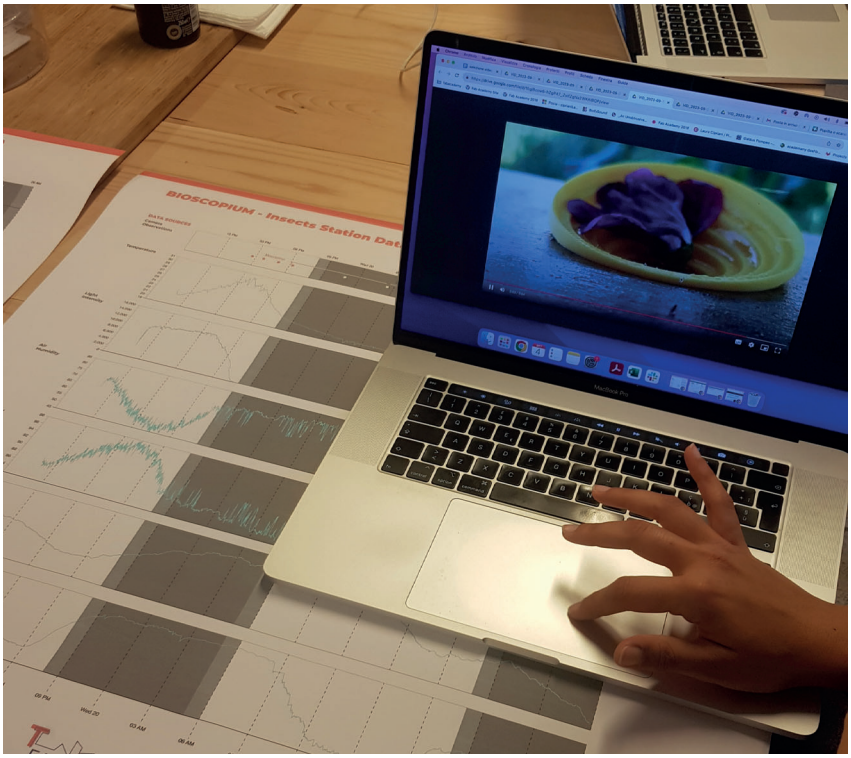
The most meaningful insights for the further development of Bioscopium were the following:

- The possibility of comparing photo traps observations with changes in temperature and light during the day was the most interesting aspect for the expert. Combining and comparing these particular data enables further considerations of the monitored environment and its overall environmental quality. In particular, low light levels (mostly evident in the visualization at night) indicate little anthropic disturbance, implying that the monitored environment may be a suitable 'wildlife corridor' for certain mammals.
- On the contrary, air quality was deemed the least interesting parameter because it was the least influential on animals' needs and behaviors. Admittedly, the only use of this data could regard the quantity of pollen, as this may indicate the presence of pollinators (although pollen quality would also need monitoring since pollinators are highly selective in this sense).
- The time frame during which data was collected (about 40 hours for each monitoring period) was considered insufficient for a more comprehensive picture. For example, the expert pointed out that air pressure over such a short time frame could not give relevant insights.
- Rather than general biodiversity monitoring, displaying all these sensors' data together could be highly relevant

for the scientific study of a specific *taxa*. The visualizations might enable researchers to relate photo traps observations (i.e., the presence of some animals in the monitored environment) with other environmental parameters, thus formulating hypotheses and further research questions (e.g., why a given species had appeared at night?).

>> Data validation session with Studio TerraViva.

>> Data validation session with Studio TerraViva.



6 Mapping biodiversity through citizen science

To involve citizens in biodiversity mapping at MIND, we created a specific initiative called Biodiversity Ambassador Programme. Considering the state of the art of the MIND area at the time of our experimentation, which was mainly inhabited by the employees of the companies residing in the district, we decided to involve them in our Program, to carry out field work to map local biodiversity (making use of the iNaturalist app), and to monitor the evolutionary state of the landscape under regeneration through photographic reporting. The Ambassadors were asked to carry out 2 tasks during a two-month-long trial period, in exchange for 10 coffees at the temporary café close to the Herbula Wild Garden.

>> Biodiversity Ambassador programme training. Photo credits: LAND

vv Biodiversity Ambassador programme training. Photo credits: LAND

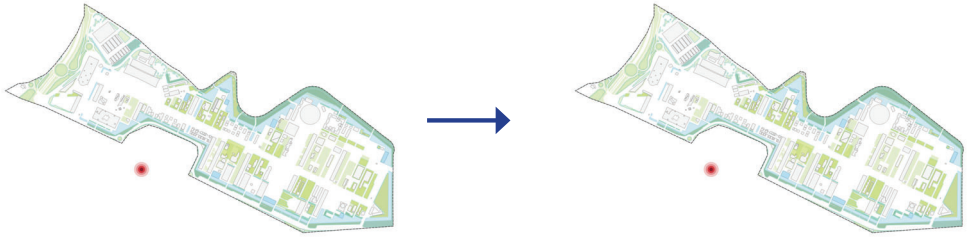

ATTIVA LA TUA CURIOSITÀ!
Osserva da vicino il prato fiorito e scopri la biodiversità di MIND
Contribuisci anche tu alla mappatura della biodiversità seguendo le istruzioni qui di seguito
Inquadra il QR code e accedi al form online
Posiziona il tuo smartphone nella posizione designata
Segui le istruzioni del form per scattare e caricare una foto sulla specie di questo prato
Condividi i tuoi risultati rispondendo alle domande
Torna su Iwobila Wild Garden e confronta i tuoi risultati nel tempo

The tasks consisted of:

- Task 1: Download the iNaturalist app and join the 'Herbula Wild Garden' project, take pictures of at least 5 wild species observed in the area during the set period and upload them by entering geolocation data. Then, recognize the species observed following the suggestions of the community.
- Task 2: Scan QR codes present on the informative panels located in the Herbula Wild Garden, follow instructions to take pictures of the flowery meadow, and then share them by answering questions in the dedicated online form. Return to Herbula at least 2 times and repeat the task to compare results over time.

To engage and train participants, experts from the T-Factor team organized an on-site meeting throughout the Herbula Wild Garden areas, during which a guided mini-tour and simulation of mapping was conducted using the chosen citizen science app. Seven companies responded to the call to action with a total of 22 employees; 10 participated in the training, and 12 completed the tasks.

All the data collected contributed to build a dataset, strengthened by previous mapping activities done by experts and through photo traps and sensor stations.



Timeline of wildlife observations collected at MIND during T-Factor project. Credits: LAND

For the purpose of our study, we considered only verified observations submitted in the period 2020-2023 (corresponding to the T-Factor project duration) in order to have a broader understanding of the interactions between the citizens engaged in the project activities and the activation of meanwhile uses in the MIND area.

Then, in order to better understand the contribution of citizen science activities around the area of MIND during the T-Factor project, we filtered and classified user-submitted wildlife observations from iNaturalist for each season, from Autumn 2022 to Autumn 2023.

The aim of this analysis was to better understand the evolution over seasons of both public space frequentation and citizen engagement with respect to biodiversity and urban wildlife. From the timeline of faunistic observation inside MIND we can highlight a peak in wildlife observation during Autumn 2023 being the season with the highest number of observations.

In this map, we visualized all the verified observations present on iNaturalist and georeferenced in the MIND area, including those uploaded by the participants in the Ambassador Program.

2021 2022 2023

T-Factor End

6.1 Landscape evolution with human visual recognition at Herbula Wild Garden

While the Herbula Wild Garden layout was conceived and designed by LAND's landscape architects, most of the seeding and planting activities were done through participatory activities with different groups of beneficiaries of the garden, providing opportunities to learn, and disseminate knowledge of urban biodiversity thanks to first-hand experience.

Among the 3 areas that composed the Herbula Wild Garden, the flowery meadow was dedicated to spontaneous vegetation capable of attracting pollinators and other useful insects to improve urban biodiversity. The plants in the meadow were all spontaneous and native species of the Lombardy region, mixing perennials and annuals to allow the garden to change its appearance over time and according to the season.

Through the Biodiversity Ambassadors Program (task 2), MIND employees were involved in monitoring the evolutionary state of the flowery meadow.

However, the experimentation was carried out over too short a period of time to bring interesting evidence for monitoring urban biodiversity. The experimental application in more frequented areas, over the course of two years of observation, could provide qualitatively more significant evidence.

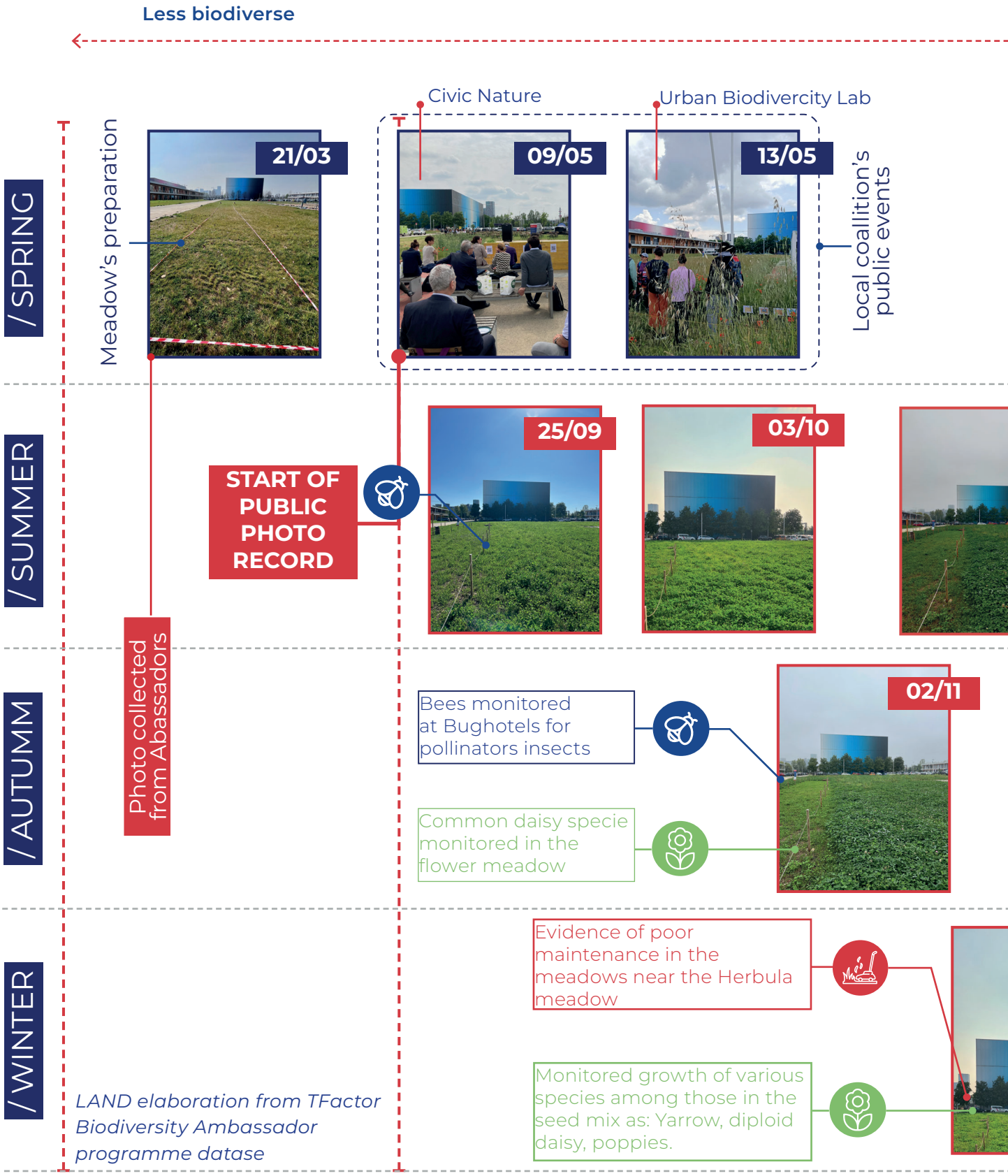
Despite the human visual recognition exercise that revealed how the issue of biodiversity and the nature-city relationship is a point of attention for the people living in the district, the visibility of panels in the garden did not always favor qualitatively and quantitatively interesting results. It would have been necessary to change the position of the panels more

often depending on the temporary local fluxes and green area changes.

Moreover, the experimentation with informative panels could have been probed in other landscapes at MIND. Other panels, in other places, could have explained how to improve biodiversity with citizen science daily actions.

Herbula Wild Garden - landscape evolution at macro-scale, with citizen science approach and human visual recognition.

Photo credits: LAND.



More biodiverse

01/12

END OF PHOTO RECORD

General observations

1. Experiment yielded significant results with respect to the involvement of MIND's tenants within the Ambassador programme: 20 amabssadors, 159 observations from September to December 2023.

2. Limit of the experiment found in the position of the trigger panel. Scarcely frequented area with poor ecosystem quality. The fringe position of this panel did not allow visibility of it and did not arouse curiosity in MIND users.

Visual categories

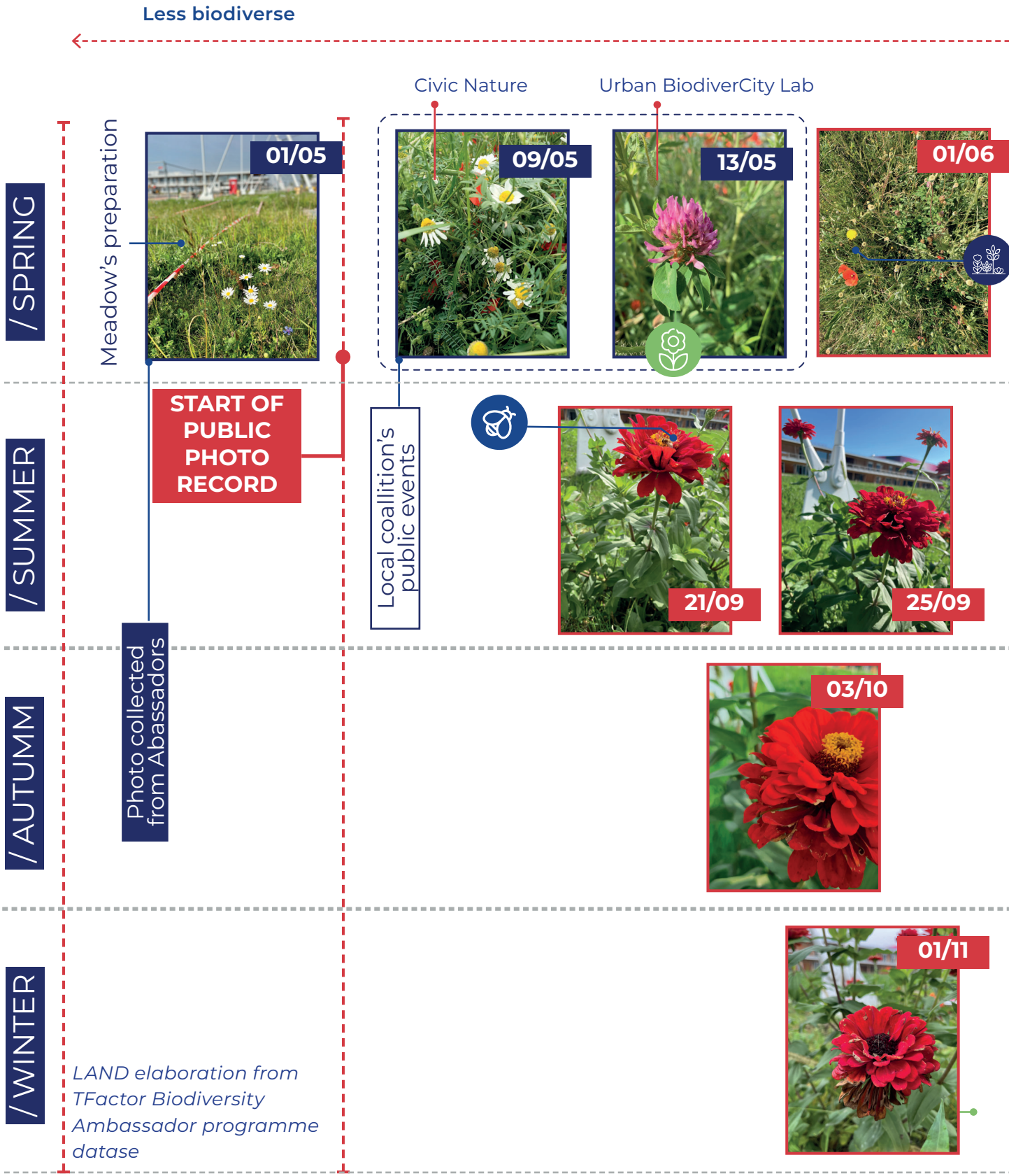
- Variety of species
- Blooming/ flowering
- Presence of target species
- Lawn care

Conclusions:

The experimentation, although carried out over too short a period of time, yielded interesting evidence for monitoring urban biodiversity. The experimental application in more frequented areas, over the course of two years of observation, could provide qualitatively more significant evidence.

Herbula Wild Garden - landscape evolution at micro-scale with citizen science approach and human visual recognition.

Photo credits: LAND.



More biodiverse

01/12

END OF PHOTO RECORD

General observations

1 Collected photoes from MIND Biodiversity Ambassadors. With the support of micro panel in the flower meadows, the observations of pollinating insect species were possible; nevertheless there are few results to qualify them meaningfully. Observations could be supported supplemented with those collected by sensors.

2 The observations collected at the micro scale are more numerous than those collected at the macro scale because it is located in a position of greater visibility and public passage. It is next to Food Hub Court.

Visual categories

- Variety of species
- Blooming/ flowering
- Presence of target species
- Lawn care

Conclusions:

The experimentation, although carried out over too short a period of time, yielded interesting evidence for monitoring urban biodiversity at micro-scale. However, experimentation is not fully complete in order to monitor target species scientifically.

7 Strategies and legacy to manage biodiversity at MIND

7.1 Results of biodiversity mapping at MIND

Mapping activities conducted at MIND were crucial to define which areas have potential for biodiversity promotion and development of nature-based solutions.

According to Studio TerraViva experts, the approach proposed by Bioscopium needs some refinement, as all data collection methods have flaws (expert monitoring was too infrequent, iNaturalist has limitations based on user knowledge, and photo trapping requires continuous intervention in order to yield results in quantity), but their various strengths have contributed to an absolutely remarkable total of observations (around two hundred data), with sufficient information to be able to direct possible conservation or protection measures for certain species. In fact, thanks to data collected experts were able to identify:

- **Species with a high index of faunistic suitability**, such as the great spotted woodpecker, a species increasingly accustomed to the presence of man, but still with needs linked to green areas with medium-large trees. The photo traps detected the presence of foxes and dormice, animals that are widespread in Italy, but strongly linked to the absence of anthropic disturbance. Their presence, and even more so their sightings, give the impression of naturalness, as these species are usually not present in big cities. Finally, the presence of some rare dragonflies is associated with uncommon habitats in the surroundings of the area under consideration.
- **Species with a high degree of faunal degradation**. In highly anthropized contexts such as the one under consideration, it is not surprising to find allochthonous, invasive and sometimes harmful species. In recent years, there has often been talk of the threat that the American

grey squirrel poses to the native red squirrel. The sylvilago, or mini hare, has for decades led the wild rabbit to disappear from the countryside, replacing it altogether. And the presence of rats is often linked to environments with a high anthropic impact. This is also the case with other *taxa*, such as Cacyreus marshalli, a South African butterfly that arrived in Italy through the trade in geraniums on which it feeds, or with Popillia japonica, a beetle whose presence is harmful to many ornamental plant species.

- **Species with a high index of faunal suitability that are not yet present**. The presence of some species with a high aesthetic impact can be assumed or hoped for, as the presence of similar species or suitable habitats suggests their possible presence, or even nesting. This is the nuthatch, an expanding species, which in some European cities is typical of urban parks: its ecology is linked to environments similar to those of the great spotted woodpecker. In addition, the nuthatch is a frequent visitor to winter canteens, so its presence can be actively promoted through the installation of feeders, which are also suitable for many other species. A second species, less likely but of even greater imagery and visual impact, is the kingfisher. This species, which has been sighted less than three kilometers south of the area, requires water all year round for its feeding habits, and a ballast for nesting, both of which are present within the area. Moreover, observations in areas with medium to high anthropic impact are increasingly frequent, so its presence remains desirable and plausible to date.

>> Detection with photo trap of Sciurus carolinensis at MIND. Photo credits: Polifactory

>> Detection with photo-trap of Erinaceus europaeus at MIND. Photo credits: Polifactory

>> Detection with photo traps of Vulpes vulpes at MIND. Photo credits: Polifactory

Overall, on a local scale, according to Studio TerraViva, the mapping represented an upgrade in defining the structure of biotopes, and thus their functionality in relation to the efficiency of ecosystem service provision. The more refined the survey, the more significant and reliable is the judgment drawn from it: in this case, the continuation of wildlife mapping is recommended, especially with citizen science activities, which require little use of specialized personnel.

The Ecological Network has a direct impact on the fauna structure, so connections become fundamental and strategic structural elements. From this point of view, the arrangement of the Ecological Network at MIND appears efficient on the

basis of the fauna observations collected, as some species that are certainly rare in a strongly urbanized context are present, therefore coming from the most distant areas.

Moreover, being able to exemplify the effectiveness of certain ecosystem services through the presence of an animal species could be a very interesting communicative tool, to foster the knowledge of local ecology and refine future governance strategies toward the sustainable management of green areas.

On the other hand, Studio TerraViva experts consider the faunal analysis within the Mind area difficult to export to a wider area. Nonetheless, the widespread presence of ecological barriers, which on the whole make the provision of ecosystem services less efficient in the great eco mosaic of the north Milan area, does not exclude that the same area presents appreciable green infrastructures, and, in certain respects, the interesting faunal presences detected at MIND can be traced back to a certain level of connection to the vast area.

For what concerns the specific configuration of the biotopes within MIND, the main connecting axis is the blue-green outer ring formed by the perimeter canal and the forest biotopes that accompany it. This continuous corridor also represents the axis on which the connection points with the external environment, represented by the inlet and outlet of the watercourses are inserted. In contrast, connectivity towards the interior of the area appears limited and discontinuous. Initiatives such as Herbula Wild Garden, aimed at the temporary enhancement of one of these 'internal' biotopes, may have a positive impact by inserting environments of greater complexity also within the area and mitigate a weak point in the system.

The map represents the construction areas at MIND planned for 2023-2024. Future place-making actions in the area should take into account this plan and the mapping results described before, as well as related spatial and temporal variables. Specifically, there may be possible scenarios for the implementation of biodiversity through the design of temporary

spaces that could include:

- Tree rows and bio-diverse shrub belts;
- Flowery meadows;
- Wildlife gardens.

These are strategies and small actions that can be implemented through the collaboration and involvement of citizens following the T-Factor project experience and the consultancy of landscape and ecology experts.

They are temporary nature-based actions characterized by a high diversity of plant species, appropriately selected to promote the wildlife, and the presence of insects, birds and mammals. They are also adaptable solutions on the roofs of buildings if appropriately designed in the tank. Moreover, they represent an opportunity to disseminate the pedagogical and educational value of biodiversity in urban contexts, and to prosecute mapping and monitoring practices in a (more or less) participatory way.

Following these strategies, MIND could become, over time, an important connection point and qualify as a stepping stone in the system of ecological connections in the north-west of Milan. A tile with functions not only of connectivity, but with connotations of environmental resource and, therefore, source of biodiversity.

>> Nature-based solutions place-making to regreen and implement local biodiversity at MIND.
Credits: Elaboration by LAND.

Legend

Railway and public stations

Active construction sites 2023-2024

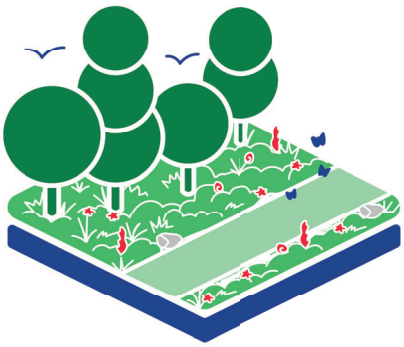
Possible place-making for the implementation of Biodiversity


Fondazione Triulza
The Hive
Biomed Cluster
Viale Decumano
Viale Decumano
Herubla Wild Garden
Mediterranean Hill
Merlata - MIND

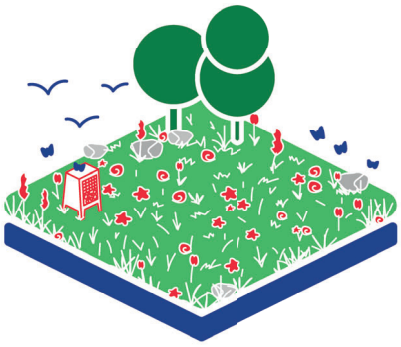
Nature-based solutions place-making to regreen and implement local biodiversity at MIND.

Credits: Elaboration by LAND.

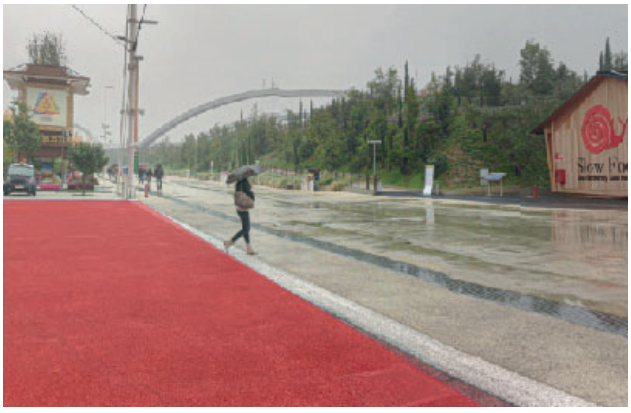
Tree rows and biodiverse shrub belts



Flowery Meadow



Wildlife Garden



Boosting Urban Biodiversity in meanwhile spaces at MIND

Credits: Elaboration by LAND.

Biotopes

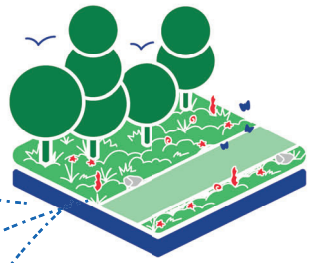
Nature-Based Solutions

Tree meadow

Regularly mown grassland

Urban area

Tree rows and bio-diverse shrub belts



Flowery Meadow

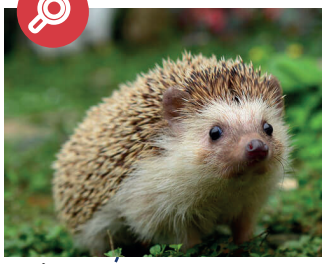
Wildlife Garden

Species selected from photo traps

Presence selected from Biodiversity Ambassador programme

Target Species

Vulpes vulpes



Erinaceus europaeus

Anax imperator

Apis mellifera

Corvus cornix

Pica pica

Sylvilagus floridanus

Lychaena phleas

Lasiommata megera

7.2 Legacy of Bioscopium: beyond T-Factor

Biodiversity loss is among the crucial challenges of urban agendas. Ecosystem degradation and lack of biological diversity make urban green areas most vulnerable to climate change and pests; as a consequence, they become less efficient in delivering ecosystem services to regulate the environment, thus human wellbeing. The introduction of wilderness principles to design new green areas and to manage existing ones requires a cultural shift. The design and monitoring of urban landscape must be addressed with multidisciplinary approaches and with open processes able to adapt to the uncertainty of societal and climate changes.

Bioscopium seeks to outline such an approach and developed a prototype of multilevel and multidisciplinary collaboration. The application at MIND demonstrated its potential and weaknesses.

On the one hand, the integration of citizen science and expert studies provided tangible guidelines easily replicable in other contexts to map biodiversity and define management strategies in a collaborative and accessible way. On the other hand, the governance structure of the pilot deeply influenced the methodology and its outcomes. Although at MIND a productive dialogue with key stakeholders has been established, the dynamic development of the masterplan did not allow the definition of a legacy roadmap, nor a tangible intervention plan in the field of biodiversity and green management within the timeframe of the T-Factor project.

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