The Role of the Minor Hydrographic System in Increasing the Ecological Network

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Patrizia Lombardi
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Post Un-Lock

From Territorial Vulnerabilities to Local Resilience

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Preface

This book is the first result of the "Post Un-Lock" research project, funded by the Interuniversity Department of Regional and Urban Studies and Planning (DIST) of the Politecnico di Torino, a three-year work involving the collaboration of a large number of researchers belonging not only to different departments and institutions but also to diverse disciplinary areas.

The research involves teams from the Department of Environmental, Land, and Infrastructure Engineering (DIATI) of the Politecnico di Torino (such as environmental and geomatics engineers), the Department of Mathematical Sciences "Giuseppe Luigi Lagrange" (experts in mathematical statistics), and the Department of Medical Sciences of the Università di Torino (researchers in the field of medical statistics and epidemiology), committed to reflecting on the territorialization of the pandemic and the effects of pollution on health in cities.

The Post Un-Lock research took shape in the last months of 2020, triggered by the scientific impulse of the international goals of sustainability and resilience in the perspective of the post-carbon city and the overcoming of environmental, economic, social and health crises. Scholars have collaborated and tested on case studies methodologies, approaches, and tools capable of re-imagining cities and regions to overcome vulnerabilities and to innovate the socio-ecological system on the basis of the ideal-typical model of Local Resilience Unit.

With this in mind, we would like to thank, in addition to the authors of the chapters and their collaborators: the partners of the research such as the Interdepartmental Centre Responsible Risk Resilience Centre (R3C), the SDG11LAB, the S3+Lab (Urban Sustainability and Security Laboratory for Social Challenges), the CED PPN (European Documentation Center on Natural Park Planning), the Living Lab and the PIC4SER of Politecnico di Torino. We would also like to thank the external supporting institutions such as IUGA of Grenoble, University of South Denmark, CMCC (Euro-Mediterranean Center on Climate Change), and the administrations involved in the case studies, whose suggestions provided crucial support for the outcomes of this publication. Other institutions and people we would like to thank are: Nicola Tollin, Professor with special responsibilities in Urban Resilience, UNESCO Chair at University of Southern Denmark (SDU), ITI,

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Chapter 3
The Role of the Minor Hydrographic System in Increasing the Ecological Network

Luigi La Riccia and Stefano Ferraris

Abstract This contribution describes the definition of the structure of the local ecological network. It was carried out as part of the support activities for the construction of the new urban plan of Mappano (Turin, Italy). The knowledge of the minor hydrographic system in Mappano allowed the construction of the structural map of the local ecological network, which contemplates the structural elements of the network (primary ecological network), the contiguous portions to the structural elements (areas with ecological functionality areas where it is a priority to intervene to increase ecological network), the areas of possible expansion of the network, i.e., areas with residual ecological functionality. However, there it is possible to carry out interventions useful for the protection of habitats and species of interest for conservation of biodiversity. Peripheral strips and connecting corridors, consisting of minor water canals, have therefore made it possible to better define the areas of possible expansion of the network: wetlands and marshes, in these relevant areas, represent stepping-stones of fundamental importance for rest and reproduction of many species and which need to be safeguarded in the design of the new local urban plan.

Keywords Local ecological network · Minor hydrological system · Mappano · Green and blue infrastructures · Ecosystem services

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3.1 Introduction: The Ecological Network for Planning at the Local Scale

Among the lessons that come to us from the health crisis from COVID-19 pandemic there is one, of fundamental importance, which concerns biodiversity. The destruction of natural habitats and the pursuit of increasingly intensive models of agriculture, breeding, and industry undermine the resources necessary for the well-being, health, and economy of human communities and at the same time expose us all to serious biological risks. The dramatic crisis of biodiversity today is therefore one of the greatest challenges that deserves attention even for health reasons (Hooper 2005). It is in this sense that the massive reaction to the pandemic crisis implemented by the European Union and largely represented by the "Next Generation EU" programme[1] should be read. This programme, confirming and adopting the sustainability of the Green Deal principles, demonstrates that the European Commission and the EU Member States, albeit through a difficult path of convergence, have at least in theory understood that it is really time to change and that the economic recovery must closely match environmental resilience and sustainability (PNRR, 2021).

Since the 1970s, when the strong pressure of economic growth and demographic expansion of cities began to show in a concrete way, there was a need for mankind to find harmony with nature (United Nations Conference on the Human Environment, Stockholm Conference 1972): climate and global changes, land consumption, deforestation, intensive agriculture, pollution, and ecological fragmentation are contributory causes of the disappearance of biodiversity (UNEP, 1992) and the destruction of ecosystems which are accompanied by the degradation of ecosystem services. The main challenges perceived by people today, in terms of risk and impact, are environmental ones (World Economic Forum 2020).

The reduction of biodiversity damages the resilience of natural systems and favours the transmission of pathogens from animals to humans (zoonoses) (IUCN 2020, 2021). Many scientific data support that the emergence and re-emergence of zoonotic diseases are linked to the unnatural coexistence between wild animals and humans, as well as to the alterations of ecosystems and the subtraction of natural habitats from wild species due to uncontrolled urbanization (IPBES 2018; IPCC 2019).

The COVID-19 pandemic has highlighted the vulnerability to the reactions of nature and the poor ability to mitigate their impacts (preparedness), with serious damage to health, social cohesion, and socio-economic well-being. It is therefore all the more important to account for current and potential economic costs, through a correct quantification of ecosystem services, deriving from the degradation of natural assets: the positive externalities for biodiversity and ecosystems must certainly be valued. Urban green space networks, together with natural and semi-natural ecosystems around cities, allow urban areas to be more sustainable and tackle many challenges including air pollution, noise, heat waves, hydrogeological instability and

[1] https://europa.eu/next-generation-eu/index_en.

a better management of the water cycle, conservation of the resource through the strategy of green and blue infrastructures.

Therefore, since the seventies, urban planning practices demonstrated the potential of ecological network to contribute to challenges such as health, species protection, biodiversity protection, and climate change adaptation (Benedict and McMahon 2002). When understood as part of local ecological network, these and other emerging challenges and trends must be considered not just as obstacles to overcome but as important drivers for investing the future urban planning choices (La Riccia 2015, 2017).

The identification of the most suitable planning scale to trigger, starting from an ecosystemic vision, territorial policies aimed at the design of ecological networks is a question strictly connected to the definition of the concept of "local", which cannot univocally coincide, according to a common name widely used in urban planning, with only the municipal planning area (Selman 2006). The ecological network in fact refers to an open system of territorial relations between the different biological and landscape elements that constitute it and cannot, therefore, be enclosed and delimited within strictly defined administrative limits. Thus, involving variously localized portions of the territory, the ecological network interacts with multiple scales and territorial planning tools. The urban planning scale that comes closest to the methodological perspective outlined for an adequate planning and management of ecological networks therefore seems to coincide with that represented by municipal and park territorial planning, which today have a more direct operation and a higher capacity of integration.

Ecological networks can be framed among planning strategies including an articulated set of territorial actions aimed at mitigating the effects of environmental fragmentation of anthropogenic origin at all levels of ecological organization. The main objective of this type of planning is, therefore, the conservation of biological diversity and dynamic processes that allow the maintenance of vitality and functionality over long periods of biological populations and communities, ecosystems, and landscapes.

Being a set of territorial actions that refer to environmental sustainability policies, acknowledging EU and international guidelines, the priority given to nature conservation actions, beyond the intrinsic value attributed to biodiversity and the need for its protection, it implies a series of positive consequences also on a human level. These consequences can be of a social, cultural, aesthetic-perceptive nature, being the interventions, in general, aimed at improving the environmental quality and conserving resources, and their usability, for future generations.

To deal with the design of an ecological network, it is important to have a cognitive framework relating to the basic ecological and landscape disciplines inherent to this problem (Antrop 2001, 2004): the models of population structure and dynamics, the ecology of biotic communities, the ecology of the landscape, the study cultural and visual perceptive landscape, land uses, and conservation biology.

3.2 The Minor Hydrological System in Mappano

The current form of settlement of Mappano (Turin, Italy) reflects the nature of a territory whose use has been fundamentally agricultural for centuries, dotted with some large historic farmhouses. Over the centuries, in fact, exclusively agricultural activity has developed, with the creation of a complex system of irrigation and reclamation canals (to make land that is too humid and characterized by stagnant water usable) which has evolved over time, with a texture of minutely branched and mutually interconnected streams. On this territorial matrix, the recent urbanization and infrastructure of the twentieth century has superimposed itself in a disorderly form, creating significant hydraulic problems. In most of the territory, the aquifer is located a few metres from the ground level and is exposed to high vulnerability.

The area is not crossed by main natural waterways, so there are no relevant elements of the fluvial dynamics characteristic of large waterways. As part of the drafting of the new local urban plan of Mappano, a very accurate campaign of land surveys was carried out aimed at representing the system of canals and ditches in the various functional and critical aspects. The articulated system of irrigation canals, the vast agricultural area innervated by them, the large development of rows of trees still present, and the stretches of water, probable residues of mining activities of the past, constitute a real network of significant size (see Fig. 3.1), so much so as to be an important piece of the ecological network on a territorial scale, as well as a qualification element from a landscape point of view.

Some problems from a hydraulic point of view are evident: the ecosystem and hydrogeological issue connected to the Stura di Lanzo Torrent is actually relevant for the flows that cross Mappano. The surface water system has promoted a historical productive function in the Mappano area, giving rise between the nineteenth century and the first half of the twentieth century to laundry activity. It still finds its present in some active industrial laundries.

Today, the drinking water catchment wells, located mainly to the north of the town, are strategic, especially if related to the issue of hydrogeological risk (see, for example, the intense atmospheric events that occurred in 2019) and require special attention to areas at risk of flooding. If we focus our attention on the system of surface waters coming from the Stura river, we can point out in particular the Bealera Nuova (with its spillway), the San Giorgio Canal, and the foothill spillway channel protecting Leinì-Settimo (the so-called Scolmatore Ovest), which are already the subject of coordinated interventions in relation to the hydrogeological safety of the territory.

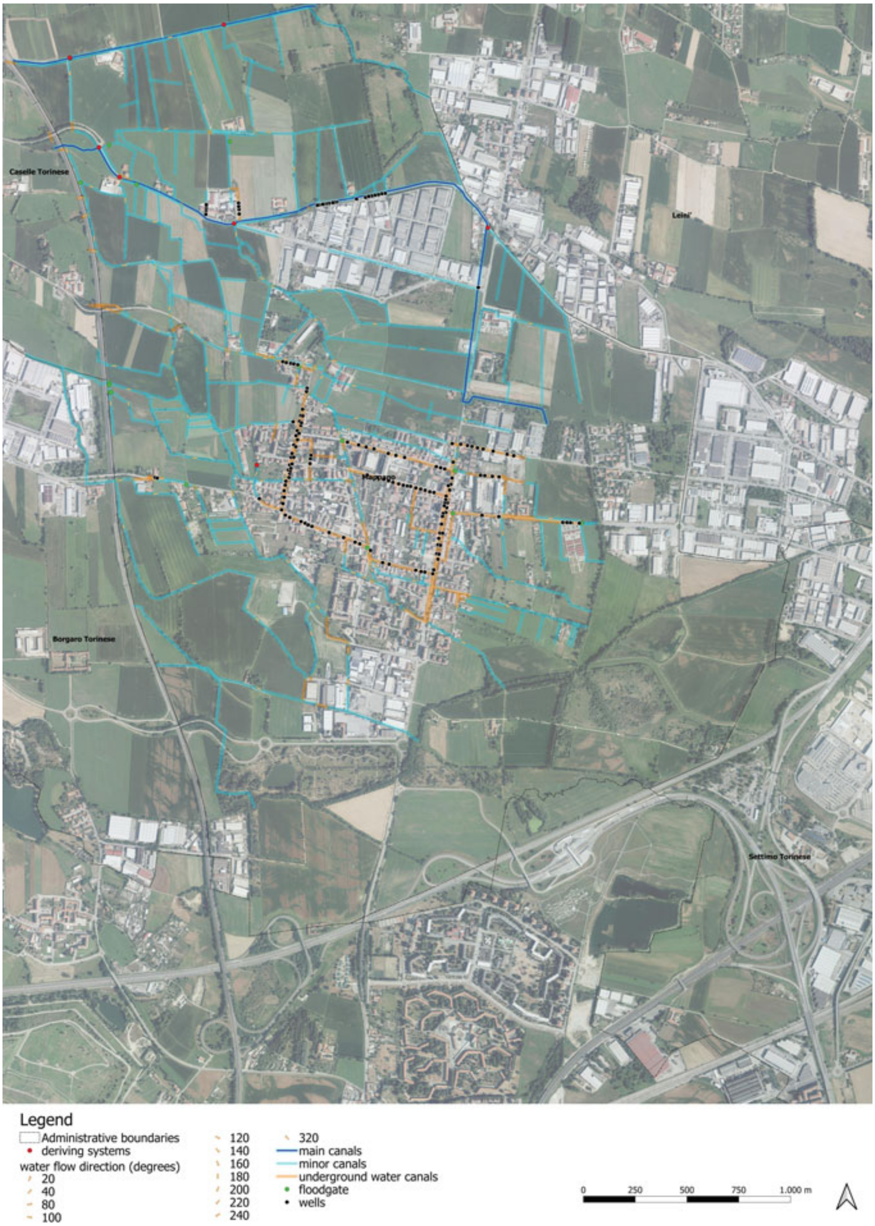

Fig. 3.1 Minor hydrographic system of canals in Mappano area (*Source* La Riccia, SDG11Lab)

3.3 The Value of Minor Waterways for the Construction of Local Ecological Network and Green and Blue Infrastructures

The waterways, even minor ones, have a very high value for the local ecological network: the water flow constitutes a natural line of continuity; the banks of the waterways and the lateral bands also present intrinsic impediments (topographical and related to flood events) for the construction of buildings and works of various kinds; for these reasons, it is along the waterways that, even in heavily man-made areas, residual elements of naturalness are more easily found. Moreover, these are particular elements of naturalness, endowed with specific ecosystemic characteristics (hygrophilous and aquatic facies, sheltered environments with high slopes, very often not representative of the surrounding areas), necessary but not sufficient to express the multiple needs of an ecological network. It is a complex category within which it is possible to distinguish further cases:

Main ecological river corridors or similar to be strengthened and/or rebuilt for multiple purposes. It is the set of main waterways that can form the backbone for multi-purpose (ecological and fruitful) redevelopment projects of a certain breadth;

Minor watercourses of significant ecological value (ichthyofauna, aquatic life in general, naturalistic requalification of the bank vegetation) or belonging to complex or development-relevant minor water systems, for which a priority policy of maintenance and enhancement can be proposed of biological resources.

If we consider the ecological reticularity of the territory, we understand that, in the case of Mappano, it rests on this very dense network of minor waterways and therefore represents the backbone of this fragile system of residual habitats, precisely because this territory is predominantly agricultural.

The construction of an ecological reticularity derives from a functional approach that not only guarantees the protection of ecosystems but also their efficiency and, therefore, the possibility of fulfilling their ecosystem functions and related ecosystem services, a vital aspect of the anthropic use of natural resources. The objectives of the elaborations carried out are: (1) to analyse the state of naturalness and biological diversity at different scales (from wide area to local scale); (2) to prioritize the pursuit of ecological coherence in spatial action; (3) to protect areas relevant to the conservation of ecosystems from the effects of potential impacts from external human activities; (4) to restore degraded ecosystems; (5) to promote the sustainable use of natural resources, compatible with the protection of biodiversity and naturalness.

The map in Fig. 3.2 shows the network of minor waterways superimposed on the structure of the local ecological network: it is the result of the combination of two methodologies (Voghera and La Riccia, 2016): ARPA (Piedmont Region, 2015) and ENEA (LGRE, Metropolitan City of Turin, 2014–2016). The ARPA methodology (DGR no. 52-1979 of 31/07/2015), which identifies the elements of the ecological network on the basis of faunistic and vegetation indicators and modelling tools in order to identify the areas of ecological value and ecologically permeable areas of the territory. The reference framework of indicators is based on the Piedmont

Land Cover (level IV) and the respective classification according to the EUNIS system (EEA, 2007). This classification allows a score to be applied to the following systemic classes (mammals, avifauna, invertebrates), which is based on a species-habitat affinity analysis. To this is added an analysis of the vegetation aspects on the basis of four indicators (distance from the climax, naturalness, degree of floristic biodiversity, conservation importance), resulting in areas of ecological value for vegetation. Ecological Value Areas (AVEs) are then identified. The ENEA methodology identifies the ecological function (Voghera et al. 2020) of the territory, starting from the different types of land use on a Piedmont Land Cover basis (level IV) and the criteria for assessment, defining five key indicators for evaluating the ecological status: naturalness, conservation relevance, extroversion, fragility, and irreversibility. The integration of the results of the two methodologies results in the map of the structurability of the ecological network. This map shows the systems constituting the local ecological network (REL) consisting of three main elements: (1) structural elements of the network (primary ecological network), i.e., areas of high and moderate ecological functionality as well as areas hosting point conservation emergencies, i.e., of significant naturalness and relevance for biodiversity conservation; (2) portions contiguous to the structural elements (buffer 50 m), i.e., the areas with residual ecological functionality in which it is a priority to intervene to increase the functionality of the primary ecological network and for which to implement protection measures to maintain the primary ecological network; (3) areas of possible expansion of the network, i.e., the areas with residual ecological functionality, but on which it is possible to implement interventions useful for the protection of habitats and species of interest for the conservation of biodiversity.

3.4 Discussion

The analyses carried out on the Mappano territory highlight several vulnerabilities from different points of view: firstly, the intensive use of resources must be considered, in particular land consumption due to settlement sprawl phenomena, with the modification of the dynamics of minor canals and water use; secondly, from the hydrological point of view, a scarcity of hydrological functions can be noted, with the presence of artificial water sources and distributions, the reduction of surface, ground and underground water supply.

Consequently, the sensitivity of the water ecosystem to climate change. Hydraulic works on the river network have led to morphological change, river silt dynamics and management, and lowering of the riverbed.

According to CICES classification (v. 5.1),[2] it is possible to select some specific ecosystem services considered important from the point of view of the minor hydrographic system in relation with local ecological network (Table 3.1).

[2] https://cices.eu/content/uploads/sites/8/2018/03/Finalised-V5.1_18032018.xlsx.

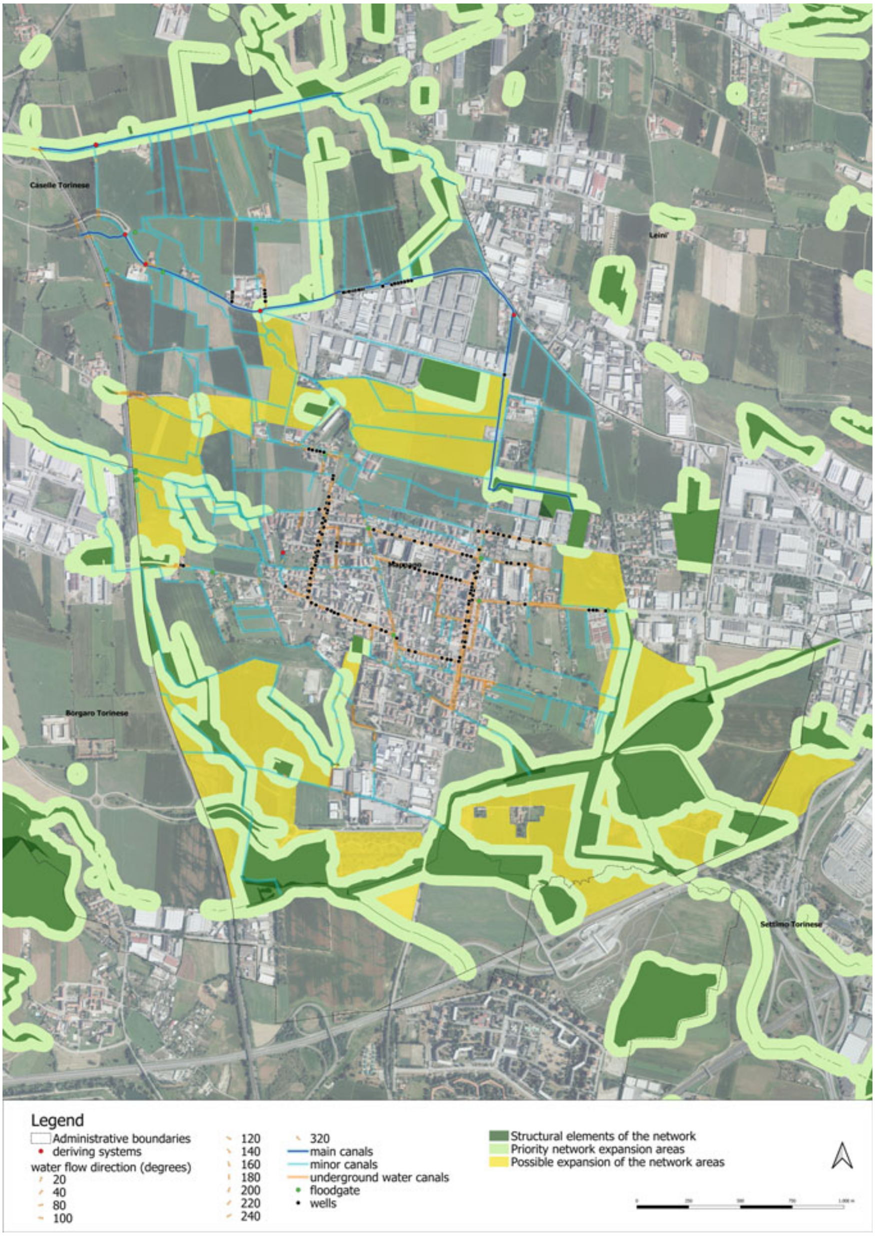

Fig. 3.2 Relation between the minor hydrographic system of canals and the structure of local ecological network in Mappano (*Source* La Riccia, SDG11Lab)

Table 3.1 Selection of ecosystem services (ES) important from the point of view of minor hydrographic system and landscape in Mappano

	Supporting	Regulating	Provisioning	Cultural
ES responding to vulnerabilities	Maintaining population and habitat (including gene pool protection)	Surface water filtration by ecosystems Regulating of the chemical condition of freshwater by living processes Hydrological cycle and water flow regulation (including flood control and shores protection)	Surface water for drinking with minor or no treatments Ground and subsurface water for drinking Surface water use for non-drinking purposes Grassland biomass: cultivated terrestrial plants (including fungi, algae) for nutritional purposes	Spirituality and religion, cultural diversity, inspiring creativity and art Cultural heritage, sense of belonging, social relations Environmental education Mental and physical health, well-being, leisure, recreation and ecotourism, aesthetic service Existence and legacy value Noise attenuation, visual screening Increased urban landscape value
Other ES supporting resilience		Bio-remediation by micro-organisms, algae, plants, and animals Filtration / sequestration / storage/ accumulation by micro-organisms, algae, plants, and animals	Grassland biomass: fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials) Reared Animals link to agricultural sector preservation (existing farming animals) Fibres and other materials from reared animals for direct use or processing (excluding genetic materials)	

Ecosystem services, adequately assessed, must be preserved and increased in order to support green and blue infrastructures, to respond to vulnerabilities and support territorial resilience. In these terms, it is important to maintain the naturalness of water ecosystems, including riparian areas and vegetation, wetlands and meadows, and connecting them with the agri-ecosystem elements.

The idea is to strengthen the water network as a structural element of Mappano landscape, improving and guarantee river functionality. The re-naturalization of minor waterways could increase the ecosystem services responding to vulnerabilities, specifically supporting and regulation ones (increasing water ecosystem multifunctionality and diversity), also using environmental engineering techniques.

3.5 Conclusion

An ecological network project that aims to interact effectively with the other networks that make up the territory (settlement and infrastructural) must adopt a series of elements that are part of a complex territorial reality. The main biodiversity reservoirs are given by the areas in which the natural environment has characteristics of high extension, of differentiation of the habitats, of continuity between the ecosystem units. Areas of this type (comparable to large, basically continuous "core areas") are still present but are basically disappearing due to the strong anthropogenic presence.

Minor waterways, including ponds and small lakes, low-level streams, streams, ditches and springs, are the most numerous freshwater environments globally, are fundamental to the biodiversity of freshwater, and are increasingly recognized for their role in sustaining ecosystem services (Giudice et al. 2023). Despite this, minor waters remain the least studied part of the water environment and are largely excluded from water management planning. We identify research priorities to support better protection of small waters and recommend policy actions needed to better integrate small waters into watershed and landscape management. Key requirements are identifying reliable monitoring programmes for minor waterways, developing effective measures to protect biodiversity and the ecosystem services they provide, and ensuring that regulators take full account of this critical part of the water environment.

The margins of natural matrices can be sharp or, as often happens, frayed. In the event that contiguous portions to the structural elements are in direct contact with the more anthropized territories but still incorporates significant presences of natural and water units, these can play significant basic roles of support for possible recolonization of the anthropized territory by species of interest.

With a view to reconstructing a functional ecological network, it is necessary to distinguish the units capable of constituting, in terms of size and articulation, an ecosystemic cornerstone capable of self-sustaining, from the connecting elements whose role is above all to favour biotic movements on the territory. Within highly anthropized areas, these cornerstones take on the configuration of real functional nodes, whose spatial definition depends on the connection objectives and the current natural presences.

In order to be able to speak of an "ecological node", it is necessary that a sufficient quantity of spatially close natural elements overall exceed a certain dimensional threshold, so that a "critical mass" is built up, capable of providing sufficient habitats for maintaining stable populations of species of interest, as well as allowing a differentiation of internal habitats capable of improving conditions for biodiversity purposes. To complete the primary nodes, other areas can be identified (areas of possible network expansion) to which an ecological function with the role of steppingstone can be attributed. Strengthening the natural capital present on the territory, even outside the main network, also the establishment of an intermediate steppingstone could support point where the connections would be too long.

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