Chapter 1
Urban Services to Ecosystems: An Introduction

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Recent environmental and pandemic emergencies made us more aware that a deep change in our way of living is urgently needed. People are becoming increasingly conscious that substantial social, economic and environmental changes are necessary to reduce the planetary consequences of unsustainable development while acknowledging the failure of adopting pure technological solutions. The last decades of human history led to excessive pressure on natural and seminatural ecosystems

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but, at the same time, life expectancy and global demographic curve increased all over the world at unprecedented rates. People are urged to find new tools to effectively respond to the challenges that await us in this century: on the one hand, the fulfilment of the increasing demand for energy, food and drinking water and, on the other hand, the need to reduce waste and emissions all along the production chains and especially in the urban environment. There is no doubt that change and innovation, through the testing and advancement of new models, have been instrumental in human progress. In the *green city* of the future, digital technologies and the *Internet of things* will represent not only a fundamental management tool, but they will also help in the planning, design and implementation choices of green infrastructure.

In Europe, the concept of green infrastructure was coined in the context of territorial planning and responds to the specific aim of ensuring accessibility to a wide range of nature's contributions to people, through a strategically planned network of natural and seminatural areas, which interpenetrate widely the places where most people live their daily lives. However, the vast majority of people intend the relationship between nature and man as one way and the value of nature as instrumental (as a provider of benefits/services), masking human agency and broader values (Kenter 2018). Unidirectional expressions such as *ecosystem services* or *nature's contribution to people* attest humans' difficulty to abandon the anthropocentric perspective and to accept to be an integral part of ecosystems, *one* of the many species present on earth, whose pressure threatens the survival of *many* others. Giving space to nature in the places where we spend our daily lives can favour the transition to a more *ecocentric*, less utilitarian vision towards nature. Thus, green infrastructure becomes a structural element of *naturally developed* human societies that are capable of using resources responsibly and of preserving and ensuring as much space as possible to the nonhuman elements of ecosystems, with the awareness of being dependent on nature "objectively and subjectively" (Immler 1985).

The *green growth* has been proposed as a promising way to find a new balance between human needs and the exploitation of natural resources. In this context, any form of the multifaceted term *development* can only be *holistic*, thus including ecological and economic sustainability, fair distribution as well as the efficient and effective use of resources. However, making cities *green and healthy* goes far beyond simply reducing CO_2 emissions and pollutants through efficiency measures and energy savings or through sustainable urban transportation. These are fundamental mitigation strategies, but they might be not enough, unless accompanied by an increase in the vegetation cover of our cities.

We need to plan and design green infrastructure so that it is no longer at the service of the city (following the concept of ecosystem services) but that the *new city* is designed in harmony with natural ecosystems, with a complete paradigm shift. Urban green infrastructure can help reconnect society to nature leveraging on environmental awareness and informal education, thus playing a substantial role in improving the attitude of citizens towards natural and seminatural ecosystems. The challenge is to strategically expand urban green infrastructure and provide our societies, including the most vulnerable people, with a more liveable, healthier, safer and fairer environment.

This book wonders precisely what services the city can offer to nature, thanks to a multidisciplinary approach obtained by involving scientists and practitioners from different backgrounds: vegetation ecologists, architects, landscape architects, engineers and agronomists. All those who contributed to this book did so with the intent to test themselves, looking for a common dialogue and striving to recognise an intrinsic value to green infrastructure, well beyond the simple role of a (ecosystem) services provider. The green infrastructure referred to in this book includes urban and peri-urban spaces that humans deliver to other components of natural ecosystems, in order to establish mutually beneficial interactions and synergies.

The commitment of contributors to find a meeting point, on the one hand, led ecologists and vegetation scientists to overcome the idea of green infrastructure as a quasi-synonym of ecological network and, on the other hand, has pushed planners and designers to abandon conventional approaches based on population projections, built infrastructure and architectural objects, unable to meet the challenges and needs of the ecological and sustainable urban form and development.

Despite the effort to converge towards a common and shared idea of green infrastructure, the attentive reader will notice in this book diversity of approaches and writing styles, which to some extent demonstrates that the concepts of vegetation and habitats, as perceived by ecologists, are still far to be corroborated by those who design and build the spaces of our daily life. In fact, the attitude to perceive green infrastructure as a man-made artefact, designed to host vegetation but focused more on its services related to human perceptions and well-being, building energy efficiency, acoustic insulation and carbon fixation, is still the predominant one.

The 26 contributions (excluding the present introductory chapter) of this book are organised in alphabetical order around three thematic pillars, i.e. (a) *green infrastructure, urban ecology and vegetation science*; (b) *planning and implementation of green infrastructure*; and (c) *nature-based solutions and innovative design approaches*.

1.1 Green Infrastructure, Urban Ecology and Vegetation Science

Ecological principles, including vegetation science and soil science, can help in designing, establishing, managing and monitoring green infrastructure (GI) at different spatial scales (Pickett and Cadenasso 2008): from transnational ecological networks down to the small scale of urban green roofs and private gardens, enabling their ecological function as stepping stones for biodiversity and metacommunity dynamics in urban districts (Cameron et al. 2012). From a landscape ecology perspective, in fact, GI can be defined as (Benedict and McMahon 2002, p. 12):

> an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations

In particular, the urban GI (UGI) is characterised by multifunctional patches, corridors and the urban matrix yet connected to the natural and seminatural ecological network (Ahern 2007; Pauleit et al. 2019) in a green-grey continuum (Davies et al. 2006).

Considering green infrastructure in terms of habitats, i.e. in an ecological perspective, may provide some advantages. Living organisms organise themselves in relation to each other, building webs where the single individual development largely depends on its neighbours. The advantage of considering communities, instead of single species, when dealing with the planning, design and managing of UGI, is due to the fact that inside a community the species are more or less adapted to the same conditions, namely, soil and climate, which are the most limiting abiotic factors for plant growth. Similar pedoclimatic conditions, which can hinder the healthy development of many cultivated plants, can be found in urban areas, where ecomimicry can be pursued to inspire the urban plantings (Nash et al. 2019). Cultivated ornamental plants are resource-consuming: they require several inputs such as irrigation, fertilisation and knowledge for successful effect, briefly costs, that municipalities are hardly willing to face in any situation (Hoyle et al. 2019). At the opposite side of the table, there are the many spontaneous urban plant communities, thriving without any specific intervention unless the disturbance due to irregular mowing. In turn, plant communities host wild animals (e.g. birds, insects) and provide beauty (Aloisio et al. 2020). Seminatural plant communities adapted to harsh conditions can be an ideal model to reconstruct habitats within the man-made landscape. Moreover, thinking in terms of *systems* more than *individuals*, when planning UGI, creates dynamic communities where living organisms may coexist and the eventual failure of one species will not represent a miscarriage at the urbanite's eye (Southon et al. 2018).

The works of this section concern the many facets inspired by nature-based solutions and lead to similar key results. For instance, authors pointed out the important role played by the experimental research focused on the composition and the dynamics of natural plant communities that may be mimicked to implement GI (Chaps. 3, 6, 8 and 10). The function of GI in improving the interconnection among habitats suitable for different living beings, such as soil biota, vascular plants, mosses, nesting birds or arthropods, is highlighted (Chap. 2). Functional traits and phylogenetic diversity of plant species contribute to fulfil ecosystem services in urban areas, more efficiently than monospecific plantings (Chap. 4). Urban soil is a habitat and sustains life, mitigating climate, pollution and flash flooding; its important chemical and physical properties interact with the complexity of urban ecosystems, offering opportunities for biodiversity in green infrastructure design, implementation and monitoring (Chap. 11). The study of the urban matrices (water, soil, air) can be pursued through the monitoring of all the organisms living there and, through this study, the use of the nature-based solutions is enabled and the habitat analogues are defined (Chap. 7). The need for a deep reconsideration of the methods and the finalities of applied ecological research and monitoring activities and the tight connection between the degree of naturalness, human health and ecosystem functioning are highlighted, too (Chaps. 5 and 9).

1.2 Planning and Implementation of Green Infrastructure

> Green Infrastructure can be broadly defined as a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings. More specifically GI, being a spatial structure providing benefits from nature to people, aims to enhance nature's ability to deliver multiple valuable ecosystem goods and services, such as clean air or water. (European Commission 2013, p. 7)

Planners consider GI a part of the design skeleton, drawn on maps (thus on land) to cover territories, to create continuous connections, physical but also with relapses on cultural and social life. The main principle is about the protection and enhancement of natural processes, necessarily integrated through planning and development of spaces and lands. For this reason, GI works as opposite to grey infrastructure, which usually focuses on one goal at a time (vs. multifunctional).

GI tries to progress multifunctional targets, enabling the same land system to perform different functions. Planners should aim to improve ecosystem services and goods through nature and environment, improving climate change adaptation and mitigation and thus biodiversity. Planning GI means also to provide and enhance processes in a sustainable and resource-efficient way, especially where spaces are limited. GI is part of the ecological network, be it complex or formed by isolated patches of urban nature, and may significantly contribute to local environmental values. Urban GI may interact and interfere at multiple scales, connecting urban and/or rural areas, being inside or outside protected areas. GI is planned to offer different advantages to human society: food, clean air and water, climate regulation, flood management, recreation and more, especially in urban areas, where most of the people in the world live nowadays (Ahern 2007).

Ecosystems are the matrix of biodiversity, so ecological systems *are* diverse: foodscape is a feasible way to create an integrated system of ecological networks, with local food production as an optimal strategy for recovering abandoned areas. In the wider and more complex meaning of GI, water plays a major role, both in the stormwater regulation and in the vulnerability management, through mitigation of a large number of processes like the urban heat island effect. Drainage systems play a key role here, avoiding flooding risks and ultimately contributing to sustainability (Ahern 2007).

According to some authors, GI as a concept is not coming "out of nowhere" (Wright 2011), but it describes a nonlinear evolution very far from being completed. More recently, innovative planning techniques have been implemented with GIS-based solutions to make places more resilient (Meerow and Newell 2017), offering a new methodology to set and control GI design in complex urban systems, where the Green Infrastructure Spatial Planning (GISP) model has been introduced, a GIS-based multi-criteria approach that integrates six benefits: (1) stormwater management, (2) social vulnerability, (3) green space, (4) air quality, (5) urban heat island mitigation and (6) landscape connectivity.

Green infrastructure is a very wide and, at the same time, precise topic: in the twenty-first-century society, it is no more possible to think of a planning strategy that does not adequately consider the role of GI, in any possible scenario.

This section contains a range of readings illustrating a wide spectrum of GI options and scenarios. Starting with food and agriculture (first group of contributions), an interesting glimpse to GI comes from the Japanese experience in treating farmland (Chap. 12) over a vast area surrounding Tokyo, while the Italian region of Trentino shows how to integrate landscape resources and foodscapes from an ecological network perspective (Chap. 15). Both chapters show great examples on how to contribute to GI, especially in urban and peri-urban areas.

The section includes three chapters with specific focuses on treating GI as *land driven* (second group of contributions): Antalya is one of the sceneries used to describe how to restore and preserve ecological corridors and permeability (Chap. 13), thanks to a set of GI used as a backbone for a wider territorial system; Chap. 14 emphasises the need to focus on multifunctional ecological network to develop framework for landscape and spatial planning, presenting an Italian case study; and Chap. 20 shows the possible links between planning and nature conservation strategies through the example of the Collserola Protection Plan in Barcelona.

A third group of contributions deals with water courses and in particular with water resources management in urban areas in Italy (Chap. 16), geological risk and land restoration throughout Europe (Chap. 17) and opportunities for urban revitalisation in the United Kingdom (Chap. 18) and along the Danube in Eastern Europe (Chap. 19).

All chapters underline that the holistic approach is the best way to keep several actors involved on the same page: public bodies and authorities at different levels, citizens and stakeholders.

1.3 Nature-Based Solutions and Innovative Design Approaches

As cities expand and urban population soars, competition for space from various land uses has become more intense, resulting in green space and nature being squeezed out of many urban areas and marginalised by practitioners and decision-makers.

Growing population density and related urban sprawl have made it harder to justify urban nature, for too long regarded only as an aesthetic nicety rather than a fundamental component of our urban built environment. This attitude has proved hugely detrimental for both people and the environment, with many unsustainably urbanised areas falling apart, due to the effects of climate change and the increasing environmental and socio-economic challenges.

The cornerstones of the development of the evolved paradigm of green infrastructure (GI) – in today's formulation – are in particular to be traced back to the

theories and practices of visionary designers, Frederick Law Olmsted (1822–1903) and Ian McHarg (1920–2001), in the United States, and Ebenezer Howard (1850–1928) and Leberecht Migge (1881–1935), in Europe. It is well known that the work carried out by the Anglo-Saxon masters was inspired by the many long-term benefits of GI, the effectiveness of which is still evident today. The implementation of a new master plan (2001) of the Emerald Necklace parks and wetland system – covering the Charles and Muddy river corridors and the Fens areas of Boston – is still underway according to Olmsted's *green blue infrastructur*e approach (1860) to reduce flood risks, restore natural areas and integrate biodiversity into the urban built environment. Leberecht Migge's multifunctional open space system for the Hufeisensiedlung in Berlin (1925–1931) still stands today as a morphological element structuring the fascinating horseshoe settlement, designed from the model of English garden cities. The neighbourhood still maintains its green infrastructure and, in particular, the pre-existing forest and wetlands to serve the city's resident population and suburban ecosystem.

After a century, urban areas are at the centre of the debate on sustainable development in the age of the Anthropocene. Everywhere, with varying degrees of success, green agendas are experienced, increasingly proving able to respond to the many challenges. The importance of the deep aesthetic value of the urban *nature* is known, but the appreciation of the many, though less obvious, ecological, environmental, social and economic benefits provided by urban biodiversity is less widespread. Trees mitigate the local climate and, together with shrub and herbaceous vegetation, absorb excess nutrients and reduce the flow of urban stormwater. Community gardens primarily use underutilised public spaces, i.e. in addition to producing food and plants, provide meeting places and promote social interaction. In the vegetated public spaces of urban areas, pollinators help to maintain biodiversity, ensuring essential life support services. Green roofs reduce rainwater runoff, increase natural habitat and regulate indoor temperatures, saving energy. In addition to the environmental benefits of nature-based solutions, the potential health and well-being benefits directly linked to them, such as increased life expectancy and better mental and psychological health, are also relevant.

Designing urban green infrastructure implies considering it a critical infrastructure, i.e. an equivalent associated with city energy, water, waste, transport and communication infrastructure. Practitioners consequently need to draw deeply from research findings, monitor GI multifunctional qualities and disseminate the wide-reaching benefits of nature-based solutions in a way that all people can understand. Design should be about what green infrastructure can deliver in terms of quality of life, seeking to create healthier, more socially cohesive and biodiverse urban environments, deeply drawing from research findings, lauding its multifunctional qualities and continuing to communicate its wide-reaching economic, social and environmental benefits in a way that influences decision-makers, politicians and public (Armour 2017).

The contributions included in this section testify to a paradigm shift towards approaches which are more respectful of the natural requirements and *wild* living beings (Chap. 27), take more carefully into account biodiversity and communities'

functioning and their benefits (Chaps. 21, 22, 23 and 25), carefully consider health and well-being (Chaps. 22 and 26) and aim at better connecting urbanites with the natural and cultural history of the cities where they live (Chap. 24).

1.4 Concluding Remarks

As the array of definitions reported by Mell (2010) testifies, the term GI does not have a unique meaning, and it changes semantic connotation according to the field of application. However, either from biodiversity conservation or from urban planning and design perspective, the urban green infrastructure (UGI) has a common intent: to make the city more comfortable and liveable while *connecting* people with nature. If, in addition, to fulfil this function, UGI is also beautiful, all the better. One certainly cannot disapprove of those who intend to combine *utile dulci*. The strength of GI is, in fact, its multifunctionality based on the holistic approach adopted when perceiving, planning and designing it.

How UGI should be implemented? Should the use of exotic species be prohibited by law? Of course, in the case of the invasive ones, this has already been achieved in many countries, although other ones (like *Cenchrus/Pennisetum* spp.) are still widely used in Southern European cities despite their well-known invasive attitudes. However, the sustainability of urban greenery cannot and must not go through prohibitions and restrictions.

Perhaps we should first educate people about the *values of sustainability*. We need to realise how useless and unjust it is to think only of human well-being, as if cities were not part of natural ecosystems. An idea of a less energy-demanding society, more respectful of natural dynamics, is already making its way. It is the hope of those who wrote this book that, in the near future, the yellowing of a meadow during the Mediterranean summer dry season will be considered aesthetically acceptable or that the delicate blooms of native species will be preferred to the gaudy ones of many exotic plants.

The success of the revolutions must be sought much more in the psychological and cultural conditions of the rulers than in those of the ruled. Colonialism stopped when the public opinion in colonialist countries understood the absurdity of the colonial system in a modern world. By this, we do not mean that humanity did not have to fight to achieve this goal. In our case, we attribute great importance to every single individual choice in the design and construction of green spaces. At the same time, an improved green literacy should align educational institutions with lifelong ecological stewardship, in order to avoid mistaking reforestation with *Eucalyptus* spp. as a natural forest or *Opuntia* spp. as a typical and essential element of the Mediterranean landscape, as it still frequently happens.

This book opens new perspectives for urban sustainability practices where UGI should be seen as a place to reconciliate people with nature. The design and maintenance of urban ecosystems should therefore foresee and encourage spontaneous

colonisation, the dynamics of plant and animal communities and natural cycles, so as to make our cities and landscape better integrated.

UGI designers and planners have to be able to recognise the natural identity of places and to move from the usual anthropocentric design aimed at satisfying human needs towards a systemic and *ecocentric* design (Austin 2014). In other words, professionals involved in the implementation of UGI should be *able to combine the ways of nature to the ways of mankind*, taking into account climate and soil conditions, potential vegetation and interactions within the surrounding ecosystems.

One of the aspects which the authors tried to emphasise is that correct and updated scientific information about the natural wealth (plants, animals, ecosystems, etc.) surrounding cities should represent the key for a more functional, effective and sustainable reshaping of urban spaces and, hopefully, encourage a deep revision of local strategies and policies.

In our opinion, another main issue raised by this book is the need to abandon the old-fashioned distinction between *cultural* and *natural* landscapes, which in many cases, especially in urban and suburban areas that have been prone to human activities since millennia, appears completely meaningless.

As for the *functioning* and the *services* provided by GI, all the professionals involved in the planning, the making and the implementation of GI should not neglect the historical perspective, remembering that until a few decades ago large portions of present-day cities and megacities were still natural and hosted plant communities, as well as wild animals. In many cases, worldwide urban sprawl developed dramatically fast and chaotic: this is true not only for developing countries but also for many Old World and North American cities. In all these contexts, special attention should be paid to the possibility of restoring and connecting the remnant patches of seminatural ecosystems and the populations of living beings within the extant cities. Many of these patches still testify the past texture and identity of the landscape (watersheds, stony ridges, woodlands, pastures, orchards, etc.) and may still be used as stepping stones for nature and life.

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