Chapter 7
Nature-Based Solutions as Tools for Monitoring the Abiotic and Biotic Factors in Urban Ecosystems

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Abstract Nature-based solutions (NBS) include a wide spectrum of situations: natural and seminatural green spaces, urban forests, designed gardens and parks, green road lines and roundabouts, bio-swales, productive gardens, green roofs and walls. In each site, the challenge is to provide the best solution according to the environmental and cultural context and the citizens' demand. The urban horticulture in synergy with NBS provides to design, realise and manage green solutions for specific problems in the urban context. NBS supplies actions able to improve urban resilience and many opportunities for improving urban quality, optimising the delivering of a mixed range of ecosystem services (ES). This chapter highlights that NBS can be used for monitoring, soil, air and water quality, water matrices and pollinator diversity. We therefore describe methods for monitoring the quality of soil, air, water matrices and pollinator diversity and abundance. In conclusion, we point out

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some key aspects, under an interdisciplinary perspective, in order to promote further and deeper knowledge in the application of NBS in the urban environments.

Keywords Air quality · Water quality · Soil fertility · Pollinators · Urban horticulture

7.1 Introduction

The International Union for the Conservation of Nature (IUCN 2020) considers nature-based solutions (NBS) as an umbrella concept for ecosystem-related approaches. NBS can be adopted especially in urban ecosystems that are altered and complex systems designed to mainly provide citizens with a range of economic and social services, rather than ecosystem services (Melles 2005). NBS address several societal challenges, contributing to green growth, improving human well-being and economic opportunities and creating ecologically, economically and socially resilient cities (van den Bosch and Sang 2017; Keesstra et al. 2018). Specifically, NBS can be a tool for combining biological information with planning methodologies (Pickett et al. 2004) in order to provide a pleasant environment for local residents and to protect the downstream environment.

With regard to the benefits for wildlife and living organisms, NBS can maintain or increase the level of genetic, biological, habitat and landscape diversity in cities, often higher than in several seminatural or rural areas out of the urban context (Savard et al. 2000; Niemelä 1999). This colonisation, which involves pollinators as well, is also related to the presence of different green areas with a rich variety of flowers and trees in the urbanised environment.

Regarding human well-being, NBS are strictly linked to the concept of ecosystem services (ES). ES have been framed into four different categories: provisioning (food, timber, fresh water), regulating (air quality regulation, pollination, pest control and climate control), cultural (psychological and cognitive benefits, sense of place, aesthetic value, tourism) and supporting (biogeochemistry, nutrient cycling) (MEA 2005; TEEB 2011). The ES concept, strongly anthropocentric (Hunter et al. 2014), was mainly based on economic and ecological disciplines (Chaudhary et al. 2015), but research in this area has considerably evolved. The supply/demand balance of ES was previously poorly considered (Baró et al. 2015). In addition, citizens do not always directly benefit from urban nature, but sometimes there is a disservice, considered as damages, costs and negative effects of nature on human well-being (e.g. allergies, human and plant pathogens, greenhouse gasses emission) derived from processes and functions of urban ecosystems (Shapiro and Báldi 2014; Shackleton et al. 2016). Specific applications of NBS could reduce such disservices supporting synergies among ES.

The extreme selective pressures exerted by human environmental changes suggest that the evolution of urban ecosystems is likely to be the evolution under unbalanced conditions in rapidly changing environments (Collins et al. 2000). The NBS concept supplies actions able to improve urban resilience, intended as the ability of a system to return to a previous or improved set of dynamics following a shock, strengthening the ability of a city to mitigate, adapt and recover from internal and external stresses (United Nations Conferences on Housing and Sustainable Urban Development 2017). The way in which an urban ecosystem recovers from a disturbing event can be drastically or positively influenced by human intervention. NBS have an integrative and systemic approach and include the experience of several stakeholders, so that positive actions contribute to achieving all dimensions of sustainability (Nesshöver et al. 2017). Urban greening represents a specific kind of NBS, facing the challenge of climate change adaptation and improving human well-being through the supply of ES (Panno et al. 2017).

In the next paragraphs, some specific characteristics of NBS in urban areas are analysed. In particular, the topics of environmental and ecological monitoring are investigated.

7.1.1 Urban Horticulture

The cultivation of vegetables and ornamental plants in cities is called urban horticulture (UH). Commonly, it is easy to identify UH practice in urban gardens and parks, thus influencing and modifying their structure and use. Therefore, like the UH concept, the concept of urban gardens and urban parks has evolved over time, conceiving the new green areas as spaces that must provide ES, thus focusing on ecological aspects and ensuring human well-being. As stated in the introduction section, currently there seems to be a tendency to conceive the green areas as spaces that must provide ES, focused to ecological aspects and to guarantee human well-being. The tendency to construct new buildings is decreasing in favour of re-using the existing ones; similarly, many industrial areas around the world are being transformed into urban parks (e.g. Dora Park in Turin, Landschaftspark Duisburg in northwestern Germany or Freshkills Park in New York).

Therefore, in order to achieve these objectives, NBS is necessary and a new and attentive UH is the key for proper management. In Turin (Italy), a good example is the birth in 2019 of a new public-private area of community gardens called *Orti generali*, located in the neighbourhood of Mirafiori, the former headquarters of the ex-FIAT car company (now STELLANTIS Group) (Fig. 7.1), managed with an innovative economic, ecological and social approach (www.ortigenerali.it).

In such contexts, UH plays an important role in providing or maintaining multiple ES. In the last years, therefore, UH is applied to design, realise and manage green solutions for specific problems in the urban context (NBS) so authors introduced the concept of environmental horticulture as the application of environmentally sustainable practices in urban greening (Cameron and Hitchmough 2016). In this context, many opportunities to promote NBS as tools for improving urban quality – optimising the delivering of a mixed range of ES – can be developed.

Fig. 7.1 Example of NBS Community gardens *Orti generali* at Mirafiori neighbourhood in Turin

Box 1: NBS for the urban environment

Since 2016, the European Union, with the Horizon Research and Innovation Programme, funded several large-scale demonstrative projects in cities as living labs for NBS for driving urban sustainable development. As preliminary results issuing from some of these projects, catalogues and applied examples of NBS have been proposed (URBANGREENUP, URBiNAT, CLEVER, ThinkNature, proGIreg, EdiCitNET). Some important and common solutions aim at supporting biodiversity in cities and enhancing the quality of the urban environment. In this chapter, we outline some aspects describing NBS as tools for monitoring, in particular, soil, air, water matrices and pollinator diversity.

The NBS realisation starts with a particular attention to preserve the soil capital and improve soil ES (Morel et al. 2015). Experimental research with new regenerated soils are going to be performed in Turin (Italy), while some interesting examples in France are already available as 'Le Jardin des Joyeux est' in Aubervilliers, by the Wagon landscaping studio (www.wagon-landscaping.fr).

Moreover, the issue of air quality in urban areas is more and more perceived by citizens. As the effectiveness of air purification service mostly depends on the complexity of the structure of the vegetation found in green areas, wooded areas play a major role. Otherwise managed and other vegetation types, like lawns and single trees, appear to be less effective in mitigating climate changes and improving air purification (Vieira et al. 2018).

(continued)

Another important component of urban spaces is water: its quality and availability and its regulation are the main issues. Ponds and other small water bodies frequently occur in parks and gardens, and they turn out to be important ecological features. Furthermore, water bodies are useful for water purification, temperature regulation, flood control, biodiversity and aesthetic enjoyment (Blicharska et al. 2016). These ecological characteristics must be considered by the various forms of urban horticulture practised in urban green areas, so as to preserve high biodiversity levels.

Moving to the plant species selection, it is possible to plan, design and manage green spaces aimed at increasing the environmental quality and biodiversity. The realisation of areas with meadow-like vegetation contributes to increase plant and animal diversity and aesthetic, with low cost involved in maintenance (Bretzel et al. 2016). In this way, the presence of pollinators due to a high level of biodiversity is beneficial to the community gardens, both to ensure the production of vegetables and to strengthen the food web. These aspects are explained more in detail in the following paragraphs.

7.2 NBS as Environmental Monitoring Tools

The evaluation of the benefits related to the NBS implementation in urban areas is a crucial aspect for assessing their efficiency, for increasing the measurability of their effects and the comparability between different nature-based approaches (Sparks et al. 2011). However, the assessment of these benefits still represents a challenge, since existing systems are rarely able to address the cross-sectoral benefits provided simultaneously by NBS (Ordóñez et al. 2019). To this aim, several key indicators, monitoring parameters and recommended methods have been developed and applied. Furthermore, the definition of standardised protocols for the monitoring of NBS environmental benefits would also bring, and in few cases have already brought, to the use of NBS themselves as suitably designed monitoring stations in urban context.

7.2.1 Monitoring and Indicators of Local Climate and Air Quality Regulation Provided by NBS

Climate change is expected to worsen climate conditions of cities, due to the so-called urban heat islands effect (UHI) (IPCC 2014). NBS can ameliorate urban microclimatic conditions, mainly by shading and/or regulating evapotranspiration (Vieira et al. 2018).), thus reducing air temperature, mitigating extreme heat-wave events and, as a consequence, reducing urban energy use (McDonald et al. 2016). The cooling effect of several NBS can be evaluated through direct measurements, meteorological modelling of air temperature or key indicators, such as mean and maximum daily temperatures (NCAR & UCAR n.d.). Cameron et al. (2014) investigated the performances of different green wall types for air temperature reduction, proving the efficiency of green walls by measuring ambient air temperature, irradiance and humidity through weather stations and temperature sensors. Largest temperature differentials were recorded at mid-late afternoon, when air close to green walls was 3 °C cooler than the one near to non-vegetated walls. Interestingly, the relevance of the species selection for increasing the cooling efficiency of NBS was also reported.

Green infrastructure also plays an important role in urban air pollution abatement (Abhijith et al. 2017). The interaction between vegetation and air pollutants is mainly driven by the leaf stomata uptake of gaseous pollutants and by the leaf deposition of particulate matter (PM) (Tong et al. 2015; Jayasooriya et al. 2017). The NBS impact on air quality can be evaluated by monitoring the concentrations of atmospheric pollutants such as PM_{10}, $PM_{2.5}$, O_3, NO_2, CO and SO_2 and toxic metals (As, Cd, Ni, Pb and Hg), as retrieved from monitoring stations or during experimental campaigns (ISO 2018). Net fluxes of air pollutants can be either measured by eddy covariance (Guidolotti et al. 2017) or estimated through the application of air quality models (such as the i-Tree Eco model, USDA Forest Service, 2019). However, these approaches have been proven to be effective more at the city scale, rather than at the NBS scale (Selmi et al. 2016). Air quality mitigation at the NBS level should be assessed through experimental techniques able to determine the pollutant uptake at the single tree scale (or lower). To this aim, several approaches have been already proposed to assess PM removal at the single leaf scale and applied to green roofs, green walls and urban parks. The vacuum filtration procedure, described in Dzierżanowski et al. (2011), is a widely used gravimetric technique able to assess leaf-deposited PM amount, into different size fractions (e.g. PM_{10}, $PM_{2.5}$). Saturation isothermal remanent magnetisation (SIRM) signals allow to assess the amount of magnetic PM on leaves (Power et al. 2009), and SIRM has been successfully used to evaluate the removal of traffic-related PM from a street tree canyon in Gent (Belgium) (Kardel et al. 2012). Finally, the analysis of leaf surfaces by scanning electron microscopy combined with energy dispersed X-ray (SEM/EDX) can provide a detailed characterisation of leaf-deposited PM in terms of particle size distribution and elemental composition (Baldacchini et al. 2017) and also a reliable quantification of leaf-deposited PM (Baldacchini et al. 2019). Weerakkody et al. (2018) analysed by SEM/EDX microanalysis the leaves of a green wall situated in a busy road of Stoke-on-Trent, UK, thus estimating an average number of $122.08 \pm 6.9 \times 10^7$ PM_1, $8.24 \pm 0.72 \times 10^7$ $PM_{2.5}$ and $4.45 \pm 0.33 \times 10^7$ PM_{10} captured on 100 cm^2 of the living wall. The use of SEM allowed also to highlight differences between the PM capturing efficiencies of the living wall species, likely due to specific leaf surface characteristics, as further confirmed also on tree species (Sgrigna et al. 2020).

7.2.2 Indicators of the NBS Impact on Soil Fertility and Stability

Soil sealing, connected to the urbanisation process, can increase the risk of floods following intense rain events, which are becoming increasingly frequent in the climate change scenario (Marafuz et al. 2015). This process is also responsible for a significant reduction of soil-atmosphere gas exchanges (Weltecke and Gaertig 2012), soil organic carbon, basal respiration and microbial activity, thus limiting soil fertility and the overall provision of ecosystem services (Fini et al. 2017). NBS can counteract these negative effects, providing several benefits on soil stability, fertility and resilience towards the impacts of climate change.

Carbon storage can be used as an indicator of the increased resilience and mitigation potential against climate change impacts provided by specific NBS such as green roofs (Getter et al. 2009). Whittinghill et al. (2014) evaluated the differences in carbon storage and sequestration potential of various in-ground or green roof systems. Green areas composed by woody plants (shrubs), or herbaceous perennials and grasses, resulted to have higher content of carbon stored (up to 78.75 kg m^{-2}), while green roof systems were less efficient in this sense.

The NBS-induced soil physical resilience can be evaluated by measuring its organic matter content, texture, structure and permeability. Oldfield et al. (2014) investigated the potential of afforestation procedures in increasing soil quality in an urban park in Queens, NYC. Data analysis underlined positive effects on soil quality provided by trees in combination with specific procedure of soil preparation (weeding, rototilling and the use of compost). These practices determined significant changes on soil properties and resulted effective in improving soil traits that are critical for ecosystem services such as water infiltration and nutrient retention.

7.2.3 Monitoring and Indicators of the Impact of NBS on Water Quality and Management

Urbanisation leads to changes of surface cover that are able to affect negatively also the hydrological cycle, reducing the interception, storage and infiltration of rainwater and increasing the volume of storm water runoff and the risks of local flooding (Zölch et al. 2017). Runoff waters are often characterised by the presence of several pollutants (US EPA 2009) that are able to cause the degradation of downstream ecosystems (Pennino et al. 2016). In this context, NBS represent an efficient alternative to grey infrastructures for the mitigation of runoff water and for the improvement of water quality, being also able to control the circulation of pollutants (Tiwary and Kumar 2014). As a result, specific NBS defined also as storm water control measures (SCMs), such as rain gardens, detention ponds and green roofs, have been implemented in order to help mitigate flooding and water quality problems in urban areas (Jayasooriya and Ng 2014).

Zölch et al. (2017) reported quantitative evidences of NBS efficiency, using an integrated hydrological simulation tool (MIKE SHE) for the modelling of future scenarios based on different variations of green cover in a high-density population area of Munich (Germany). Results obtained revealed the high efficiency of NBS (trees and green roofs) for the regulation and the management of storm waters.

In order to quantify the effects of NBS implementation on water quality, the concentrations of nutrients and metal pollutants are monitored (Reedyk and Forsyth 2006). To this aim, test kits or ion selective electrodes (ISEs) can be used, thus providing rapid but usually less accurate results. Other known chemical pollution indicators are the biogeochemical oxygen demand (BOD) and the chemical oxygen demand (COD). Total suspended solids (TSS) or turbidity (% or total) measurements can be used to assess the reduction of sediment runoff, before and after the NBS implementation. TSS is typically calculated through a gravimetric approach based on the filtration of water samples and subsequent drying and weighting of the sediments removed. Leroy et al. (2016) reported the evaluation of the efficiency of vegetated swales for the improvement of water quality, taking into account 12 different storm events and carrying out measurements of parameters such as TSS, COD, BOD, total phosphorus (TP), trace elements and polycyclic aromatic hydrocarbons (PAHs). Results underlined the efficiency of swales planted with macrophytes in reducing trace metals and PAH concentrations from 17% up to 45%.

7.2.4 NBS as Living Monitoring Stations for Environmental Quality Parameters

The efficiency and the high spatial resolution of some of the techniques developed to monitor and assess the NBS benefits have suggested that NBS could be used as monitoring stations within the urban context (Baldacchini et al. 2019; Cherqui et al. 2019). This results in the potential of having high-spatial resolution networks useful for environmental monitoring and in the decreasing need of on-site stations. To date, very few research studies have focused on this aspect. In Baldacchini et al. (2019), leaves are proposed as passive samplers, proving their efficiency for low-cost and in situ urban PM biomonitoring. The chemical and physical characterisation obtained through SEM/EDX microanalysis of leaf surfaces allowed to obtain information useful to identify the impact of PM emission sources. As shown in Fig. 7.2, the proposed approach efficiently discriminated the different impacts of sources on leaves of seven different *Quercus ilex* L. trees located within an urban park of Naples (about 6 ha): PM collected on the trees close to the street was characterised by high levels of traffic pollutants (such as Fe, site 2 and 4); PM deposited on leaves from trees exposed to the marine breeze (sites 1, 5 and 7), with high levels of ions linked to salt-spray exposure (Na and Cl), was observed; elements from the crustal component (namely, Si and Al) were mostly abundant in the leaf-deposited PM recorded in the remaining sites.

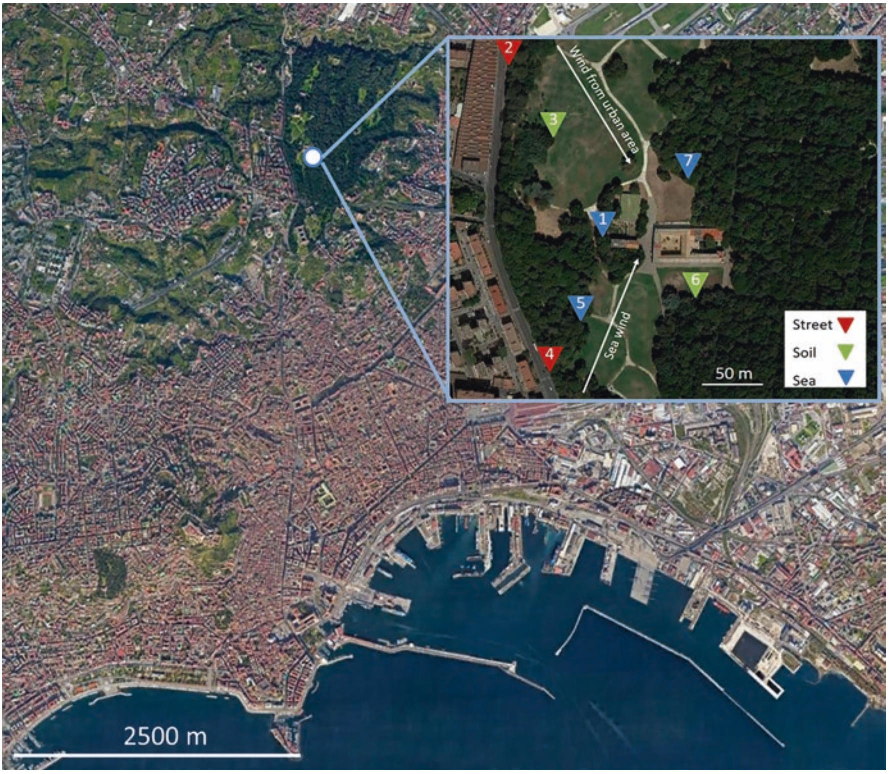

Fig. 7.2 Air pollution source apportionment issued from the SEM/EDX analysis of the PM deposited on the leaves of *Quercus ilex* L. trees in an urban park in Naples, southern Italy. (Adapted from Baldacchini et al. 2019)

A similar approach has been proposed by Cherqui et al. (2019) for water management: the use of a micro-controller (e.g. based on easy-to-use hardware and software) applied to specific SCMs, in combination with open-access monitoring data, with the purpose of designing a monitoring system. This innovative approach results to be useful for the achievement of information with high spatial resolution that can be used for the management of storms and flood events in urban areas**.**

7.3 NBS as Arthropod Diversity Monitoring Tool

A wide range of insect taxa can potentially play a crucial role as pollinators in ecosystem services, even if the most effective ones are bees (Hymenoptera: Apoidea) (Potts et al. 2016). Among non-bee flower-visitor insects, hoverflies (Diptera: Syrphidae), tachinids (Diptera: Tachinidae), butterflies (Lepidoptera), beetles (Coleoptera), sphecids (Hymenoptera: Ampulicidae, Sphecidae and Crabronidae) and wasps (Hymenoptera: Chalcidoidea) may provide key ecosystem services, such as pollination and biological control (Ferracini and Alma 2007; Corcos et al. 2019). Pollination is an important ecosystem service, providing food production and enabling plants to reproduce. Over 80% of wild and cultivated plants grown in Europe strictly depend on insect pollinators, mainly bees. In 2005, this pollination service represented over 153 billion € throughout the world and over 14.2 billion euros in Europe, with about 84% of all crops that have been studied depending on, or benefiting from, insect pollination (Gallai et al. 2009; Ferrazzi et al. 2017). Moreover, other beneficial arthropods (e.g. predators and parasitoids) may sustain easily their populations when they have access to non-prey foods as pollen and nectar (Picciau et al. 2019).

In urban green areas, pollination and biological control represent very impressive examples for NBS supported by and using nature to provide environmental benefits. Unfortunately, the impact of urbanisation on pollinators is poorly studied. Although landscape changes, due to increasing urbanisation, have been identified as drivers of pollinator decline, there is evidence of the biological value and ecological importance of cities providing nutritional resources and suitable habitats for pollinators, thus helping in conserving biodiversity (Hicks et al. 2016; Hall et al. 2017).

Bees, and in particular honey bees, are good indicators of biodiversity in cities, and any type of biomonitoring aiming to census and quantify them is an effective method to evaluate the ecosystem supply of urban environments.

Urban green spaces include a range of habitat types. Habitats with greater vegetation complexity often benefit natural enemies by providing resources, such as alternative preys and hosts, nectar and pollen for omnivores, suitable microclimates and habitat for multiple life stages (Parsons and Frank 2019). A positive correlation between flower numbers and pollinator abundance has been demonstrated (Pardee et al. 2014). Awareness of the role of wild pollinators has significantly grown in recent years. According to Underwood et al. (2017), training initiatives for local authorities and procurement policies for green space management to adopt pollinator-friendly management strategies are needed.

Besides floral abundance and richness, beneficial arthropods are positively affected by increased mulch and leaf litter cover, larger garden size, perennials and increased structural diversity (Arnold et al. 2019). Several research comparing pollinator communities in urban and non-urban landscapes demonstrated that cities can support higher bee species richness compared to agricultural and natural ecosystems (Matteson et al. 2008; Kennedy et al. 2013; Goulson et al. 2015; Baldock et al. 2019; Wenzel et al. 2020). Bees include both solitary and eusocial species, especially cavity nesters and pollen generalist species (Hernandez et al. 2009; Cariveau and Winfree 2015), and specialised species indicative of high-quality habitats, even though specialist bees are rare in cities (Tonietto et al. 2011). In particular, urban areas can host greater species richness of bumblebees than rural or natural landscapes, and green roofs can be also used by pollinators as foraging and nesting habitat (Ksiazek et al. 2012; MacIvor et al. 2015).

Diverse urban bee communities also may provide a benefit by pollinating urban crops and garden plants (Larcher et al. 2017). Numerous lists of ‘pollinator-friendly’ plants are available, even if most of them are not well grounded in empirical data, nor they do specify the taxonomic composition of pollinator assemblages attracted by particular plant species (Mach and Potter 2018). Studies on floral resources and pollinators have traditionally focused on flower strips, urban gardens, parks and allotments (Somme et al. 2016). Besides, the urban foraging sources provided by urban areas may be consistent as investigated in the city of Turin (NW Italy) (Vercelli and Ferrazzi 2014). Several broadleaved trees, shrubs and herbs give an opportunity to urban beekeeping, also allowing to produce local monofloral and multifloral honey (Fig. 7.3) (MV, personal investigations). Regarding the pollination process, the correlation between high visitation rates and increased fruit and seed set in urban areas was demonstrated by several authors (Lowenstein et al. 2015). Concern for bees' survival among the general public has led to an increase in the numbers of beekeepers and pollinator-friendly gardens in cities. The introduction of bee-friendly gardening (artificial nests and bee flora) to enhance and support wild pollinators is quite a widespread practice in conservation programmes (MacIvor and Packer 2015; Bortolotti et al. 2016). Bee hotels are specialised nesting devices that can be installed in urban areas (Fig. 7.4). Using a variety of untreated materials and varying tunnel diameters will bring a diversity of bee species, even if mason bees (*Osmia* spp.) and leafcutter bees (*Megachile* spp.) are considered the most common ones.

Regarding urban beekeeping, it has recently become almost a fashion, with hives on the roofs of historic or prestigious buildings, as in Paris, London, Turin and many other European cities (Moore and Kosut 2013; Vercelli and Ferrazzi 2014) (Fig. 7.5). The blooming scalarity allows to maintain a high number of hives in the cities. This environment proves to be favourable for bees together with the heat islands effect, which ensures survival and reproduction during winter. Furthermore, a feasible management without chemical treatments may positively affect pollinators' life.

A growing body of research, national and international initiatives and citizen science activities have been carried out to monitor the support provided by cities to conserve and restore biodiversity (Quaranta et al. 2004, 2018; Van Swaay et al.

Fig. 7.3 Typical pollinator-friendly species of the urban environment

Fig. 7.4 An urban nesting device, also called “bee hotel”

Fig. 7.5 Urban beekeeping in Turin

2010; Nieto et al. 2014; Potts et al. 2016; Roy et al. 2016; Underwood et al. 2017; Bonelli et al. 2018; Maes et al. 2019).

A variety of sampling methods is available for arthropod census, even if some methods can be biased, and their performance varies widely (Rega et al. 2018). Direct counts of individuals, sweep-netting and trapping methods (pan traps, malaise traps and sticky traps) are commonly used (McCravy 2018).

Bee presence is measured in terms of diversity and abundance in several habitats using the estimate methods proposed by several authors (Westphal et al. 2008; O'Connor et al. 2019; Bartholomée and Lavorel 2019). The most common sampling methods for bees and beneficial insects are resumed in Table 7.1. To assess the total bee species richness and abundance, a combination of transect walks conducted by trained bee collectors and pan trap sampling is suggested.

The indirect indicators of biodiversity, represented by food source availability in urban environments and the consequent bee foraging activity, can be measured through field surveys and melissopalynological analyses of the bee products. Nectar

Table 7.1 Typology and description of the most common estimated methods to monitoring bees and beneficial insect diversity and abundance [methods proposed by Westphal et al. (2008) and subsequently modified in terms of length, width and time of transect walk, and placing time of pan traps (Dennis et al. 2012; O'Connor et al. 2019)]

Typology	Description
Observation plots	Ten equally sized rectangular (1m long × 2 m wide) plots were located according to a random design. During a 6-min observational period, every bee visiting a flower is recorded and then identified checking wings or collected for further identification. The observations are conducted throughout the main flowering period
Standardised transect walk	Permanently marked (250 m long × 4 m wide) corridor divided into ten 25-m-long subunits is used for the standardised transect walks. Each subunit is surveyed for 5 min during which all bees visiting flowers are registered or collected (i.e. 50-min recording time for the whole standardised transect)
Variable transect walk	1-ha plot adjacent to the area where the other sampling methods are undertaken is identified. In the variable transect plot surveyors are allowed to search actively for bees throughout the plot by slowly walking around for 30 minutes
Pan traps	15 pan traps set up in five clusters separated by 15 m are established in the study area. Each cluster contains three UV-bright pan traps, coloured in white, yellow and blue taking account for different colour preferences of bee species. The pan traps are mounted on a wooden pole at vegetation height, filled with 400 mL of water and a drop of liquid dishwashing detergent and left active for 48 hours
Trap nests	Ten poles are mounted in the study area containing five trap nests each. Two types of trap nests are used: (1) traps made of ca. 150 stems of common reed *Phragmites australis* internodes each, with 2–10 mm in diameter and 15–20 cm in length, and (2) trap nests filled with paper tubes of distinct diameters, 6.5, 8 and 10 mm, respectively. Each pole carries two trap nests with common reed internodes and three paper tube nests

and pollen forage activity may be defined in relation to flower visitation rate, pollen loads and honeys. Furthermore, pollen transfer, pollination success and harvest for human consumption are used to measure the pollination capacity (Bartholomée and Lavorel 2019).

The abundance and diversity of native bee species in urban landscapes underline the biological value and ecological importance of cities. In this context, conserving pollinator assemblages may be essential for ecosystem restoration, and the urban environment with its variety of forage and nesting sites can act as a refuge for insect pollinators. In the last decades, research on bees and beneficial arthropods in cities showed that diverse populations live in urban landscapes (Somme et al. 2016; Wenzel et al. 2020). Bees, and in particular honey bees, are good indicators of biodiversity in cities, and any type of biomonitoring to census and quantify them is an effective method to evaluate the ecosystem supply of urban environments. Further evidence comes from the analysis of honey bees and wild bees and related products. Specific ecological green space management plans are needed, encouraging the use of native flowering plants and the combination of annuals and perennials, in field margins and flowerbeds. Weed species provide many important resources for beneficial insects such as pollen or nectar as well as microhabitats. The possibility to combine beekeeping and the use of flowers highlights the importance of adopting melliferous plants when designing urban areas, and also properly managing the practices for the urban green spaces (e.g. reduced lawn mowing practices) can significantly affect insect biodiversity.

7.4 Concluding Remarks

In conclusion, we point out some key aspects, under an interdisciplinary perspective, in order to promote further and deeper knowledge in the application of NBS in the urban environments.

NBS can be used as low-cost tools for the environmental monitoring in urban areas. New strategies are needed in order to upscale the information achieved through the measurements of parameters and key indicators described in the previous paragraphs.

In order to enhance the functioning and health of urban ecosystems, a larger engagement and a stronger connection of citizens and stakeholders to nature are desirable, for example, regarding the raising awareness on the decline of pollinators and biodiversity.

The more citizens comprehend the value of nature and participate reasonably in the codesign and co-management processes, the more NBS will achieve self-standing and long-term results. In this contest, the various forms of collective use of green spaces are essential for creating a nature-based educated population, promoting a more ecologically responsible behaviour (Colding and Barthel 2013; Battisti et al. 2017; Larcher et al. 2017).

Finally, since decisions concerning management can affect conservation of threatened and endangered species, we argue that a multifunctional approach to conserve and restore cities using NBS should be adopted.

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