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Green infrastructure and urban biodiversity: overview and city level examples

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1 Introduction

The portion of Europe's population living in cities is projected to increase from 73% to 82% between 2015 - 2050, translating to an increase of more than 36 million new urban citizens (United Nations 2014). A range of challenges for city infrastructure, inhabitants and surrounding areas are projected to accompany this growth, such as finite resource availability, decreasing quality of urban environments, and mounting pressure on biodiversity. The aim of developing more sustainable urbanisation processes has thus moved to the forefront of European policy discussions, as illustrated by e.g. the current efforts toward an EU Urban Agenda (European Commission 2015). The potential to utilize urban green infrastructure (planning) has emerged as a promising multifunctional tool by which to support both biodiversity and provide citizens with healthy and liveable conditions (Naumann et al. 2011)

This report comes as a response to these discussions and compiles evidence from scientific and grey literature as well as experiences and impacts studied at city level to contribute to the advancement of debates. More specifically, this report aims to:

1. Provide an overview of urban biodiversity focusing on the understanding of urban biodiversity, associated trends and data limitations, and the main drivers of biodiversity loss
2. Provide relevant examples and practices regarding urban planning and urban management (green infrastructure development) at national and local levels to promote and conserve urban biodiversity
3. Outline current and future challenges to improving Green Infrastructure and urban planning with regards to biodiversity conservation in urban and peri-urban areas and new and novel approaches to overcome these challenges and maximize the efficiency of GI for conserving biodiversity in urban areas
4. Provide an overview of existing data sets on biodiversity that can be used for spatial analysis of urban and peri-urban areas.

Box 1: What is meant by 'urban' and 'urban biodiversity'?

In this report, we adopt the definition of **urban in the European and North American context** as presented in Elmqvist et al. (2013): "an area with human agglomerations and with >50 % of the surface built, surrounded by other areas with 30–50 % built, and overall a population density of more than ten individuals per hectare." (Elmqvist 2013, 3)

Urban biodiversity is defined by the Convention on Biological Diversity (CBD) as: "The variety and richness of living organisms (including genetic variation) and habitat diversity found in and on the edge of human settlements. This biodiversity ranges from the rural fringe to the urban core (CBD 2012).

The results of this study will feed into the development of the EEA report on Green Infrastructure, which will be published by the end of 2015 and will present a succession of maps and figures with a factsheet for different cities and synthesis for all the addressed issues (e.g. the difference between Nordic and Mediterranean cities). The outcomes of this work will be presented as a map book that will be linked to the EEA map book on urban vulnerability.¹

¹ <http://climate-adapt.eea.europa.eu/tools/urban-adaptation/introduction>

2 Urban biodiversity in the EU: an overview

European cities provide habitats for many common and protected species, 179 of which are targeted for conservation by the EC's Habitats Directive (BISE 2015b). Portions of Europe's urban areas are also protected under the Natura 2000 Network, which includes 5,000 km² of protected urban areas (EEA 2015b). Despite these and other legislative efforts taking place across the European Union and within the Member States, urban biodiversity remains relatively poorly integrated into wider biodiversity considerations (EEA 2010a) and faces a number of ongoing challenges which are expected to be further exacerbated if not adequately addressed. This chapter focuses on these considerations, presenting an overview of the traits common to urban biodiversity, challenges in determining their trends in Europe based on available data, and the underlying drivers of these figures.

2.1 Classifying urban biodiversity

Establishing a clear picture of biodiversity within an urban context is complex, as it requires the consideration of a range of attributes. These defining factors, as follows, are elucidated in this section: (1) the diversity of urban areas in terms of the quantity and quality of green spaces; (2) the types of diversity desired to be measured (i.e. the number of individuals of a single species, or the total number of species present); and (3) the variation between groups of species in their ability to adapt to urban environments (Faeth, Bang, and Saari 2011; Kowarik 2011; Concepción et al. 2015).

A comparison of bird and plant diversity in an urban context can be helpful to illustrate these considerations. Looking at birds, the number of individuals of a given species is often greater in cities than in rural or natural habitats; however, the degree of species richness (i.e. the number of different species represented in the environment) is lower in city centres than on the peripheries. Plants exhibit a different pattern, with species richness tending to increase in urban areas (particularly areas with high population density) as compared to rural areas (Kowarik 2011; Secretariat of the Convention on Biological Diversity 2012). Variation within and amongst groups of species is also notable. Certain subsets of birds (e.g. granivores) have been found to be more negatively affected by cities than others (e.g. insectivores); similar patterns can be seen in arthropods (Faeth, Bang, and Saari 2011, 70).

Characteristics of species such as their degree of mobility and ability to survive in a range of environmental conditions and utilize diverse resources also play a determining role in terms of their status within urban settings. Less mobile species, for example, are more impacted by habitat fragmentation, a phenomenon which becomes more common with increasing degrees of urbanisation (see 2.3.1); more mobile species face greater limitations from the presence or structure of specific habitat features than from connectivity considerations (Kowarik 2011; Aronson et al. 2014). Furthermore, many species that are common to and thrive in urban areas are classified as generalists, meaning that they have the ability to survive in a variety of environmental conditions and live off of a wide range of resources. Such species can be found in cities across Europe and the world, like the house sparrow *Passus domesticus* and annual meadow grass *Poa annua* (Aronson et al. 2014).

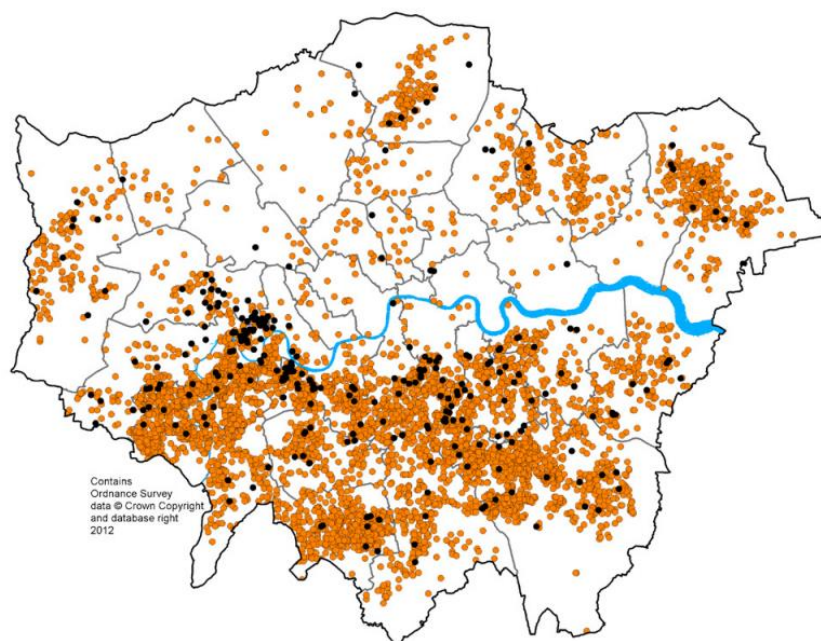
Box 2: A protected species found in European urban habitats: the Stag Beetle

The Stag Beetle *Lucanus Cervus* is a species of terrestrial insect protected under the Habitats Directive and which thrives in urban gardens, parks, and forests. The Stag Beetle's distinctive antler-shaped jaws and chestnut color, pictured below, make it easy to identify.



Male Stag Beetle (London Wildlife Trust 2015)

In 2011, a citizen science survey of Stag Beetle sightings in London was carried out by the London Wildlife Trust. A total of 307 sightings were recorded via the online platform (see map below), which is consistent with records from other surveys of the beetle in London.



Map of Stag Beetle sightings from 2011 Wildlife Trust survey (black) and from Greenspace Information for Greater London data (orange) (London Wildlife Trust 2012, 8)

Most sightings of this urban adapted species were recorded in suburban gardens. This is probably due to the fact that people are more likely to spend time in gardens rather than forests, parks, or other areas containing potential beetle habitats. Nevertheless, the number of sightings demonstrates the importance of urban and suburban private gardens for some species of biodiversity in urban areas.

Source: London Wildlife Trust 2012

2.2 Assessing urban biodiversity trends: data availability as a limiting factor

While it is undisputed that urbanization processes affect and change local biota, studies exploring the degree to which this occurs and the impact on biodiversity are lacking (Aronson et al. 2014). As such, limited cohesive data is available from which trends can be deduced.

Existing studies frequently examine the effect of degrees of urbanisation on biodiversity, comparing biodiversity along the urban-rural gradient instead of adopting a temporal approach (Faeth, Bang, and Saari 2011; Elmqvist 2013; Concepción et al. 2015). Put differently, most studies investigate differences in biodiversity *across land use types* at a given point in time, but do not investigate how the number of species or individuals in a given location changes *across time*. The latter approach is extremely rare and thus serves as a limiting factor for being able to determine trends. The case of Halle, Germany is a unique example that follows species turnover within the city over more than three centuries (see Box 3).

Furthermore, data on the status of urban biodiversity is largely incomplete and often sheds light on only part of the larger trends for specific species or geographic locations. Data generally takes the form of city-level monitoring reports (for single or multiple species and/or habitats), or site-specific findings in a very restricted urban area. Urban habitats are also sometimes challenging to capture as a result of their transient nature; short-term land uses such as the abandonment of buildings or land use changes in agricultural areas often only exist temporarily in a given state.

Examples of available data on urban biodiversity within a city level or more localized context exist for Brussels, Belgium and Bonn, Germany. In Brussels, for example, 248 plant and animal species were identified in the city (see Fig 2.1) (Bruxelles Environnement 2012: 7). A further study in Germany found that 40% of Germany's breeding bird species (108 species) were found to occur in the city of Bonn and nearly 1,000 species of beetle were identified in the city's botanical gardens alone (Hachtel et al. 2008: 7).

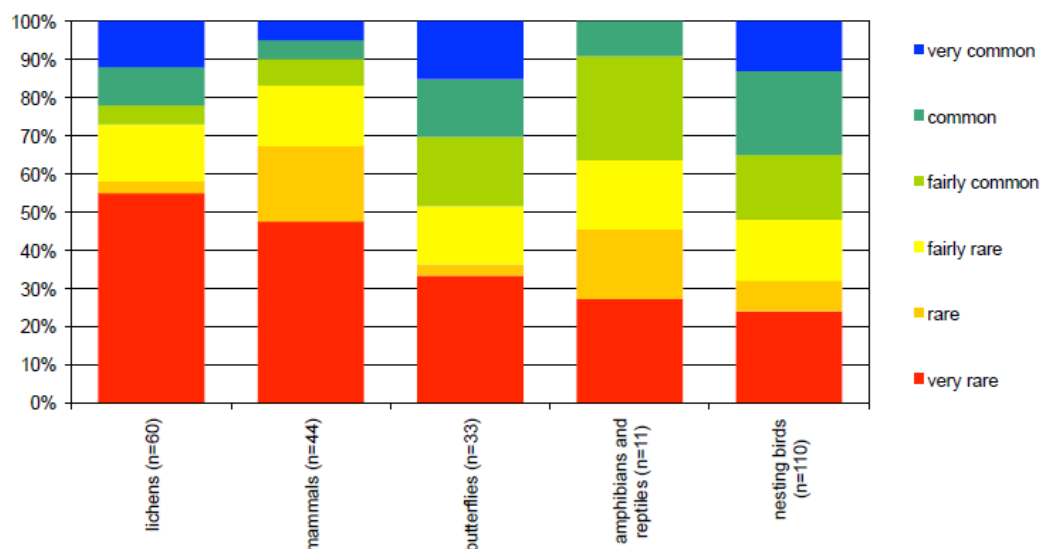
Box 3: Historical urban biodiversity trends in Halle, Germany



Halle, a city of about 230,000 inhabitants in the German state of Saxony Anhalt, has a uniquely long historical record of urban biodiversity. Data on plant biodiversity stretches back to the mid-17th century. Analysis of the data found a 22% species turnover as the city developed over more than three centuries. The drainage of bogs and expansion of built areas into agricultural land, along with climatic changes, contamination of habitats, and planting preferences of gardeners, could be seen to decrease the biodiversity of bog species and species that require nitrogen-poor soils, while species dependent on humans for dispersal and species that prefer warm climates and nitrogen rich soils increased. This data provides a rare view into the effects of humans and urbanisation on biodiversity in and around cities. (Knapp et al. 2010)

Image source:
[http://de.wikipedia.org/wiki/Halle_\(Saale\)#/media/File:HERTZBG\(1\)_p548_Marktplatz_zu_Halle_a.d_.Saale_\(anno_1500\).jpg](http://de.wikipedia.org/wiki/Halle_(Saale)#/media/File:HERTZBG(1)_p548_Marktplatz_zu_Halle_a.d_.Saale_(anno_1500).jpg)

Figure 2.1 Frequency of species in different specific groups in the Brussels-Capital Region



Source: Bruxelles Environnement 2012, 7

This type of monitoring delivers valuable insights into the state of biodiversity in individual cities and sites. However, because it is largely carried out on an irregular and uncoordinated basis, it is difficult to derive generalisations or generate a complete picture of urban biodiversity status and trends. To try and combat this challenge, the City Biodiversity Index (CBI)² has been developed to support cities in gathering more standardized and comparable data in order to be able to evaluate progress in reducing the rate of biodiversity loss in urban ecosystems. This approach has gained ground and been used in full or in part in 40 cities worldwide between 2009 and 2013, including several European cities. Among these are Brussels (Belgium), Edinburgh (UK); Frankfurt, Neubrandenburg, and Heidelberg (Germany); Tallinn (Estonia); and Edinburgh (UK). Further cities including Paris and London have expressed interest in carrying out the CBI (CBD 2012). Moreover, a selection of the CBI indicators was used for the European “Capital of Biodiversity” competition in 2010 with over 330 local authorities from Germany, Hungary, France, Slovakia and Spain participating, making it the first large-scale trial of the CBI.³ The table 2.1 portrays a selection of results from European cities which have implemented the CBI show some of the statistics that are gathered in assessments to determine Index scores

The results below represent the initial CBI evaluation in each city; follow-up evaluations are intended in order to monitor trends in urban biodiversity. Because these evaluations include only baseline data for certain indicators, e.g. number of species measures, for which the change over time is the basis for the score, it is not yet possible to give Index scores for all measures.

² Also known as the Singapore City Biodiversity Index or Singapore Index; for more information, refer to Chan et al (2014), available online at: <https://www.nparks.gov.sg/~media/nparks-real-content/biodiversity/singapore-index/users-manual-on-the-singapore-index-on-cities-biodiversity.ashx?la=en>

³ For more information on the European Capitals of Biodiversity competition, please visit <http://www.capital-biodiversity.eu/54.html>

Table 2.1 Selected CBI results from European cities

		City							
		Brussels (BE)	Lisbon (PT)	Porto PT)	Talinn (EE)	Heidelberg (DE)	Neubrandenburg (DE)	Frankfurt (DE)	Vitoria-Gasteiz ES)
Indicators and Index Measure	1. Proportion of Natural Areas in the City	18.0 – 20.4%	22%	3.7%	25%	44%	53%	14-20%	38.17%
	2. Measure of connectivity	82.9%	3,616 ha of linked areas	0.2%	tbd	tbd	tbd	n/a	2,343.6 ha linked areas
	3. Number of native bird species found in built-up areas	31	76	61	40-50	68	79	n/a	47
	4. Baseline number of native vascular plant species	578	342	61	1,482	1,054	500-600	500-999	1,434
	5. Baseline number of native bird species	92 (breeding)	126	132	243 (144 breeding)	130	n/a	>151	221
	6. Baseline number of native butterfly species	28	33-45	67	73	98	n/a	>151	136
	7. Number of species (selected by city)	8 herpetofauna	19 mammals	7 amphibians	10 bats	15 bats	n/a	n/a	13 amphibians
	8. Number of species (selected by city)	39 mammals	12 amphibians	37 lichens	20 bumblebees	32 fish	23 fish	n/a	59 mammals
	9. Proportion of protected natural areas	14.4%	16%	3.76%	8.2%	54%	39.9%	>5%	37%
	10. Proportion of alien invasive species to native species	4.35% (birds)	9% (plants)	1.29%	< 20 invasive alien species	1.33 %	0.7% (plants)	1-10%	2.51%

Source: City Biodiversity Index Factsheets, Hansen and Richter (2013), city data and reports provided by city contacts (July 2015)

Currently cities are also allowed some freedom in choosing which indicators to apply and how. For example, Heidelberg and Porto compared the proportion of invasive alien species to native species across taxonomic groups, while Brussels compared only bird species and Lisbon compared only plant species. It is left up to the cities to choose taxonomic groups for indicators 7 and 8 which are relevant for their cities and for which data is available; these necessarily vary from city to city. This option gives cities the flexibility to implement the CBI according to their needs and capacities, but also means that results are not completely standardised, limiting comparability between cities.

Based on its current state of maturity, it is fair to say that a prolonged and more wide-scale application of the CBI in Europe, in whole or in part, could greatly improve the quantity and quality of data available on urban biodiversity. However, to date CBI data is not collected in a centralized form, and not all results are publicly available as they are owned by the authorities who conduct the analysis. If the results from cities were publicly available in a centralised and standardised database, the indicator set and base data could in the future provide a very useful source of monitoring data on urban biodiversity.

Existing large-scale monitoring initiatives also have limitations when it comes to understanding urban biodiversity. Many monitoring surveys have a spatial resolution that is too large to take into account the heterogeneous nature of city landscapes. For example, the European Breeding Bird Atlas⁴ and the EuroBirdPortal⁵ - two initiatives mapping the occurrence of European breeding birds - use a spatial resolution of 50x50 km and 30x30 km respectively. This scale cannot account for the small spatial scale variations within cities or the range in feature size that can play a role for biodiversity (e.g. a single tree, part of a building facade, or cracks in pavement).

While selected data sources can potentially address these limitations, additional restrictions often arise. Member State reporting on species and habitats protected by the EU Nature Legislation⁶, for example, can only deliver partial insight on trends in urban biodiversity. A list of the species and habitat types used in analysis can be seen in Table 2.2. Though rare and protected species do play an important role in urban biodiversity, a large portion of urban biodiversity consists of common species that are monitored less rigorously and thus not included for interpretation. Some general findings can be derived from these datasets, however. A study commissioned by the city of Brussels⁷, for example, addresses the issue of urban biodiversity using data under EU Nature Directive reporting and identifies statistics about habitats, non-bird species and bird species. For habitats, the study assesses such information as the number and area covered by the most frequent habitat categories, as well as the number of habitat types per Natura 2000 site. For species, the report assesses the number of species in Annex I (Birds Directive) and Annex II (Habitats Directive) found in urban N2K sites and finds that apart from birds, invertebrates and fish are well represented. Other useful datasets that deal with common species, on the other hand, do not adequately highlight urban species⁸ (for more details on available data sets see 6 Annex).

⁴ <http://www.ebba2.info/>

⁵ <http://eurobirdportal.org/ebp/en/>

⁶ The EU Nature Legislation is an umbrella term that refers to Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (commonly referred to as the Birds Directive) and Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (commonly referred to as the Habitats Directive).

⁷ Sundseth, Kerstin and Geert Raeymaekers, 2006, Biodiversity and Natura 2000 in urban areas: A review of issues and experiences of nature in cities across Europe for the Brussels Capital Region, Bruxelles Environnement-IBGE/Leefmilieu Brussels-BIM.

⁸ The Common Bird Index, for example, is considered the best available dataset for common bird species and indicative of general environmental status, it only distinguishes between common farmland species, common forest species and common bird species as a whole, which includes generalists.

Table 2.2 Species and habitat types linked to MAES ecosystem types for assessment

Habitat types	<ul style="list-style-type: none"> Habitat types covered by the Habitats Directive Annex I
Species	<ul style="list-style-type: none"> Amphibians, Reptiles, Mammals and Butterflies from published European Atlases Species covered by the Habitats Directive, Annexes II and IV Species covered by the Habitats Directive, Annex V except: genera <i>Lycopodium</i>, <i>Spagnum</i> and <i>Cladonia</i>
Bird species	<ul style="list-style-type: none"> Bird species covered by the Birds Directive

Furthermore, the methodology used for linking species and habitats with MAES ecosystem types provides an incomplete picture of protected species in urban areas as a selection of species is necessary. This allocation of species and habitat per ecosystem is done for each of the nine terrestrial biogeographic regions (according to the Habitats Directive) and each of the five marine regions (according to the Marine Strategic Framework Directive). While linking habitat types to broad ecosystems is rather straightforward, it is more complex for species, as some of them use different ecosystems during their life cycle. In addition, their ecological requirements may differ depending on the biogeographical context. Therefore, while habitat types can only be attributed to one ecosystem type, bird and non-bird species can be attributed to a number of different ecosystems within limits set for inter alia whether the ecosystem is preferred, suitable or occasional for non-bird species and whether bird species prefer the ecosystem for breeding or wintering.

The selection is performed by the European Topic Centre on Biodiversity (ETC/BD) and is based on the information extracted from the Natura 2000 database and from the Article 12 and 17 databases. For some species, the allocation to a given biogeographical or marine region was made by ETC/BD experts. Many protected species present in urban areas are also present in other ecosystems and may be categorized under these ecosystems, making their assignment particularly difficult. Therefore, the species categorised as “urban” in reporting may only represent a portion of protected species found in urban areas. Therefore, although data from reporting under the Habitats and Birds Directive can help illustrate trends in urban biodiversity, it should be handled with caution. This is one of the reasons why urban habitats and species were excluded from the “Results by ecosystem” chapter of the recent EEA report State of Nature in the EU: Results from reporting under the nature directives 2007-2012.

2.3 Key drivers of biodiversity loss

Urban areas can serve both as an opportunity for or a threat to biodiversity, depending on how and the degree to which it is taken into account and managed within urbanization processes. The following sections outline the predominant pressures facing urban biodiversity in Europe and highlight the drivers underlying urban biodiversity status.

2.3.1 Urban development and sprawl

Urbanisation in Europe is largely characterized by the expansion of urban land area (‘urban sprawl’) rather than increases in population density (EEA 2015a). Inadequate management of this expansion process can produce an array of negative effects on biodiversity, predominantly arising from land use and land cover changes. Known as ‘land take’, urbanization impacts biodiversity mainly via the conversion of agriculture, forest, and other semi-natural and natural land into urban and other artificial land development.⁹ This results in e.g. habitat fragmentation, soil sealing and changes in species composition and biotic homogenization¹⁰ (EEA 2015a).

⁹ <http://www.eea.europa.eu/data-and-maps/indicators/land-take>

¹⁰ Biotic homogenization refers to the process of native species being gradually replaced by non-indigenous and expanding non-native species (Olden and Poff 2004).

The level of impact of urban development and sprawl depends largely on individual species' ability to disperse, degree of habitat specialization or ability to use available resources (Concepción et al. 2015). However, some general trends can nevertheless be identified. European urbanisation, residential and commercial development are reported to currently threaten approximately 10% of protected habitats, 7% of protected species and 4% of protected birds across the continent (EEA 2015a). Agricultural land and the species dependent upon agricultural ecosystems are especially threatened (EEA 2013), as this type of land use is declining most rapidly in Europe and being replaced with artificial land uses (such as roads and railways) (EEA 2010b). Finally, urban-gradient studies indicate that for several taxonomic groups – such as plants, birds and butterflies – the amount of non-native and non-indigenous species is growing towards the centre of urbanized areas, while the richness of native species is decreasing (McKinney 2002).

2.3.2 Pollution

Urbanisation can exacerbate the impact of pollution on aquatic biodiversity as a consequence of physical and chemical changes in water bodies. Soil sealing increases with urban development, altering water and nutrient cycles. Paul and Meyer (2001) found that increases in discharges from municipal and industrial sources as well as runoff from sealed surfaces also increase nutrient, metal, pesticide, and other contaminant loads in water bodies such as streams. This was linked to decreased biodiversity in streams in and near urban areas (Paul and Meyer 2001). Emmanuel, Balthazard-Accou, and Joseph (2008) also found that urban effluents can contain substances toxic to marine life, and that these pollutants can negatively impact marine biodiversity in urban areas at the genetic, species, and ecosystem level. Pollutants can have short term toxic effects (e.g. mortality), long term toxic effects (e.g. reproductive disorders), and disturb ecosystem equilibrium (e.g. by contributing to algae blooms). Some of these pollutants are difficult to eliminate through sewage treatment (Emmanuel, Balthazard-Accou, and Joseph 2008).

Water pollution is not the only type of pollution in urban areas. Noise and light pollution can also affect species in urban areas. For birds, for example, there is evidence that the impact of noise pollution differs by bird species and by the frequency of the noise disturbance. Birds tend to avoid areas with noise pollution that has a frequency likely to mask their own calls (Francis, Ortega, and Cruz 2011). Since noise pollution in urban areas tends to have a low frequency, birds with lower frequency seem to be more affected by urban noise pollution than birds with high frequency calls; since larger birds tend to have lower frequency calls due to their size, larger birds therefore are more likely to avoid urban areas (Francis, Ortega, and Cruz 2011).

Though pollution negatively affects urban biodiversity, conversely urban biodiversity can also impact pollution. Phytoremediation, or the process of removing pollution using vegetation, is one example. Trees and other urban vegetation are effective in removing air pollution such as PM₁₀, ozone, carbon monoxide, nitrogen dioxide, and sulphur dioxide, thereby improving air quality in cities (Beckett, Freer-Smith, and Taylor 1998; Nowak, Crane, and Stevens 2006). Vegetation can also be used to remove urban soil pollution while largely preserving other soil properties, as certain plants take up and store pollutants, given that the waste from these plants is properly disposed of (see e.g. Jensen et al. 2009).

The above mentioned pollution threats to biodiversity refer to direct impact of urban areas. The demand for resources such as fossil fuels and food driven by high populations in urban areas also leads to significant indirect pollution impacts on aquatic and terrestrial biodiversity.

2.3.3 Climate change

Climate change poses a particular risk for urban species, largely due to the urban heat island effect. This phenomenon involves the absorption of sunlight by dark surfaces (e.g. buildings, roads and pavement) and its emission as heat, resulting in higher temperatures in cities than surrounding areas in which evaporation from plants and soil serve to cool the air temperatures (Georgescu et al. 2014). The

main effects on urban biodiversity of the resultant higher temperatures and climate change more generally will be more frequent flooding, drought, extreme rainfall and heat wave events, and water shortages (Bonn et al. 2014). These changes influence complex interactions and interdependencies among urban species and their habitats, leading to biological and ecological changes. Biological changes include, for example, changes in species' distribution, potential extinction, and changes in life cycle patterns. Ecological changes caused by climate change include a misalignment of species' life cycles and the availability of food sources, changes in predator-prey relationships, new invasive species, and changes in the spread of diseases and vectors (BISE 2015a).

2.3.4 Non-native and invasive species

While species richness is generally high within moderately developed urban environments, more advanced stages of urbanization tend to result in a loss of native specialist species and an increase in non-native species that are able to survive in the highly disturbed habitats (Concepción et al. 2015). The introduction of non-native species can be deliberate (e.g. in plant selection processes within landscape design, or the release of private pets by citizens into the urban environment) or accidental via e.g. the commodities arriving or passing through urban centres for trade and commercial activities. Furthermore, urban environments are particularly susceptible to biological invasions due to the high number of potential pathways found within, such as botanical gardens, zoos, nurseries and private gardens (IUCN 2013).

This high potential for frequent non-native species introductions in turn increases the risk of such species becoming invasive and a threat to native species (Secretariat of the Convention on Biological Diversity 2012). These species pose a risk to native biodiversity through competition, predation, disease and parasitism. In the UK, for example, the approximately 9 million invasive cats have been estimated to be responsible for the deaths of 52–63 million mammals, 25–29 million birds and 4–6 million reptiles and amphibians during a 5-month survey period, and in London specifically, the invasive 'floating pennywort' (*Hydrocotyle ranunculoides*) has been shown to deoxygenate rivers and thereby kill aquatic life (IUCN 2013). Invasive species also present direct challenges for infrastructure (e.g. Tree of Heaven), landscapes (e.g. Red Palm Weevil), and human health (e.g. Tiger Mosquito and Common Ragweed) (IUCN 2013).

2.3.5 Policy frameworks

The European Union has established a strong biodiversity policy framework based around the Birds and Habitats Directives and Natura 2000 Network, complemented by the Green Infrastructure Strategy and EU Biodiversity Strategy. However, most urban areas fall outside of designated protected areas, with only 3% of the Natura 2000 Network falling on urban land (EEA 2015a). The successful conservation of urban biodiversity is thus dependent on a far wider spectrum of policies¹¹ which often neglect its consideration in their design and decision making processes, but which have the power to prevent or cause harmful impacts (Medarova-Bergstrom et al. 2014). Some progress has been made in recent years, such as within European fisheries policy, but many areas remain (such as trade, finance, transport, and tourism) in which the mainstreaming of biodiversity concerns has yet to be adequately integrated (EEA 2010a).

Given the goal of transitioning to a Green Economy, an overarching challenge in Europe and beyond is to reconcile environmental - and specifically biodiversity - objectives with political pressure for growth and jobs (Gasparatos and Willis 2015). The Cohesion Policy, for example, has historically

¹¹ Relevant policies for biodiversity more generally were identified in IEEP, GHK, and TEPR (2012) as: the Common Agricultural Policy, Cohesion Policy, Connecting Europe Facility (CEF) – Energy, and the Trans European Energy Network, CEF – Transport, and the Trans European Transport Network, Common Fisheries Policy and the proposed Common Marine and Fisheries Policy and European Fisheries Fund, Research and Technical Development framework programmes and the LIFE+ programme.

been found to invest less frequently in environmental and biodiversity-related actions than in 'traditional' infrastructure, such as transport and energy; this can lead to direct habitat loss, habitat fragmentation, other disturbances during construction or from the infrastructure itself, or indirect habitat degradation which can all harm species and habitats (Kettunen et al. 2014). The policy's reform for the period 2014-2020 aims to address some of these concerns through investments in sustainability-oriented (urban) projects and therewith counteract previously imbalanced investments; conclusions on the effects are, however, not yet able to be determined. Spatial planning policies at the EU level – most importantly the Strategic Environment Assessment, Environmental Impact Assessment and Environmental Liability Directive – also have the potential to play a key positive or detrimental role as they set the framework for planning policies and decision making processes at the national and local levels. Other relevant policies and regulations in the areas of regional development, settlement, trade and transport often override or threaten environmental objectives in an urban/ peri-urban context and – given their frequent application of subsidiarity principles - highlight the need for strong multilevel governance.

3 Utilising green infrastructure planning to safeguard urban biodiversity - Examples from EU cities

Green infrastructure is key for fostering biodiversity in urban areas as it encompasses “the network of natural and semi-natural areas, features and green spaces in rural and urban, and terrestrial, freshwater, coastal and marine areas, which together enhance ecosystem health and resilience, contribute to biodiversity conservation and benefit human populations through the maintenance and enhancement of ecosystem services” (Naumann et al. 2011: 1). The approach targets ecosystems holistically and aims to connect individual GI elements into a strategic network by using physically connected corridors and functionally connected habitat ‘stepping stones’ instead of focusing only on select features such as resource flows, species, or habitats. While many categorizations of GI elements exist, a comprehensive list has been compiled specifically for the urban context within the European Commission-funded project Green Surge¹² and is outlined in Table 3.1.

Table 3.1 Urban green infrastructure categories and elements

Category	Urban green infrastructure element
Building greens	Balcony green, ground based green wall, facade-bound green wall, extensive green roof, intensive green roof, atrium
Private, commercial, industrial, institutional urban green space (UGS) and UGS connected to grey infrastructure	Bioswale, tree alley and street tree/hedge, street green and green verge, house garden, railroad bank, green playground/school ground
Riverbank green	Riverbank green
Parks and recreation	Large urban park, historical park/garden, pocket park, botanical garden/arboreta, zoological garden, neighborhood green space, institutional green space, cemetery and churchyard, green sport facility, camping area
Allotments and community gardens	Allotment, community garden
Agricultural land	Arable land, grassland, tree meadow/orchard, biofuel production/ agroforestry, horticulture
Natural, semi-natural and feral areas	Forest, shrubland, abandoned and derelict area, rocks, sand dunes, sand pit/quarry/open cast, mine, wetland/bog/fen/marsh
Blue spaces	Lake/pond, river/stream, dry riverbed, canal, estuary, delta, sea coast

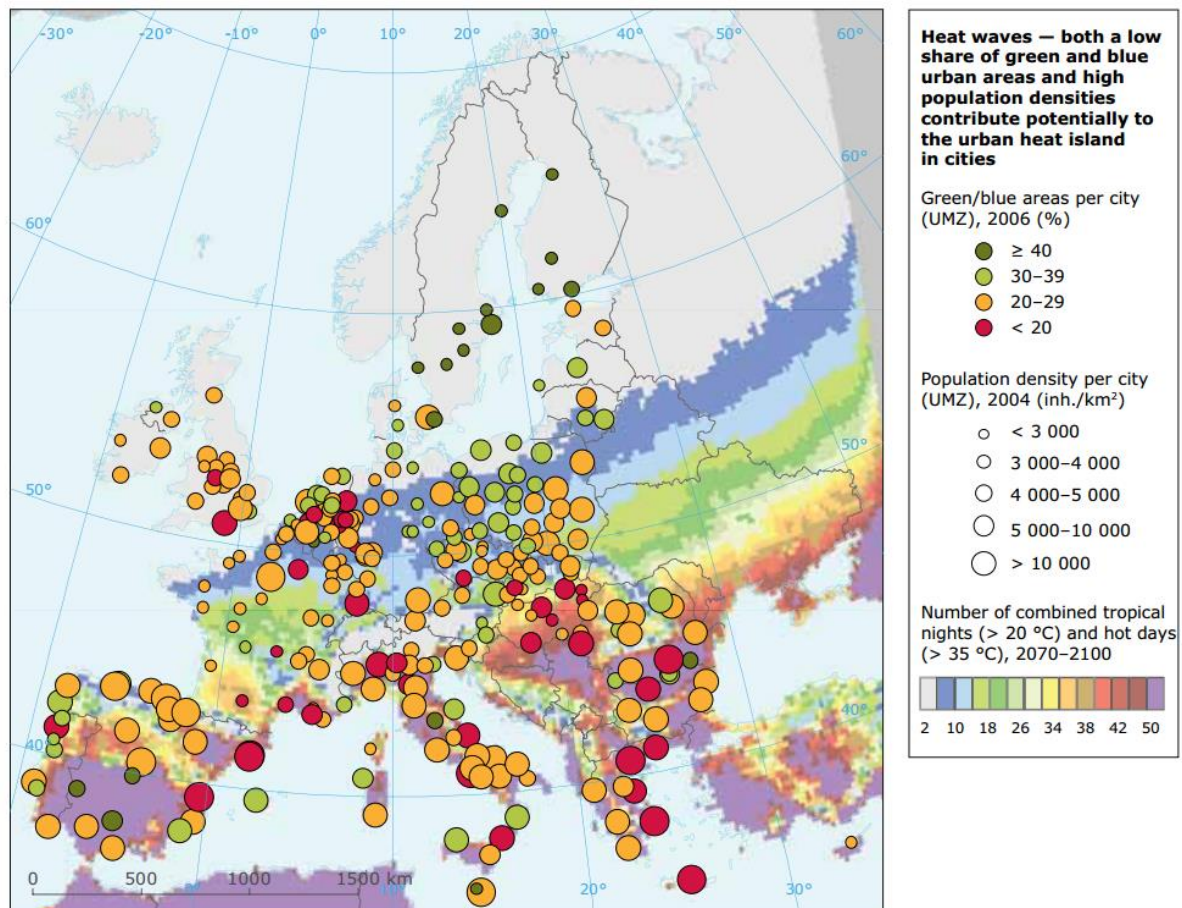
Source: Braquinho et al. (2015)

Strategically planned infrastructure development and the provisioning of habitats via urban green space creation or restoration have been highlighted in the literature as holding large potential to offer a range of environmental, economic and social benefits. Regarding biodiversity, high quality green spaces within a GI network can increase the density and diversity of urban bird and plant species (Aronson et al. 2014) and act as urban biodiversity hot-spots or provide ‘stepping stones’ for otherwise fragmented habitats. Building greens in particular, such as green facades and green roofs, provide habitats for a range of species, but particularly generalist insects (Williams, Lundholm, and MacIvor 2014). While providing high quality habitats and habitat networks for urban species, GI can also deliver a range of additional benefits, such as: local climate and air quality regulation, waste water treatment, recreational opportunities, mental and physical health benefits, carbon sequestration and storage, moderation of extreme events, enhanced socio-economic equality, and local economic stimulation via e.g. increased tourism and improved aesthetic appeal (Braquinho et al. 2015).

¹² <http://greensurge.eu/>

Green infrastructure has been implemented and utilized to varying degrees across European Member States. The map below shows the population density and the share of green infrastructure in European cities as a percentage of green and blue space in the total city area (in the map, projections of heat waves are shown as GI can help reduce urban heat island effects).

Map 3.1 Percentage of green/blue areas per city and population density



Source: EEA (2012)

This chapter will look more closely at several city level examples of GI planning efforts which have been implemented across Europe in an effort to safeguard urban biodiversity. The case studies were selected on the basis of several criteria, namely:

- Deliberate implementation of urban development strategies that incorporate a focus on urban biodiversity
- Representation of a variety of sizes of cities
- Good geographical coverage across the EU and different biogeographic regions
- Availability of reliable data

Ultimately, the selected case studies represent a variety of approaches utilized for urban biodiversity across Europe and serve to illustrate the multifaceted benefits which can potentially arise from such coordinated, city level planning efforts.

3.1 Case study 1: Ljubljana

3.1.1 Status of urban biodiversity and GI

Ljubljana is the capital and largest city of Slovenia. Slovenia is characterised by a relatively low level of urbanisation overall. Ljubljana has a relatively high level of urban green space per inhabitant compared to other European cities, and urban green spaces generally feature high levels of biodiversity (Száráz and Nastran 2015).

According to the city's reporting, about 80% of the city's green space is on the urban periphery, and about 20% is in the city core (City of Ljubljana 2015). Forest covers 46% of Ljubljana. The city is also home to several other types of ecosystems, including grasslands and wetlands. Most of the urbanisation in Ljubljana has taken place in the lowland areas, meaning that these ecosystems have been more affected than the mostly forest ecosystems of the hilly area around the city. The city has however taken efforts to preserve natural and semi-natural green space, the city authorities can take care of this kind of areas. The city itself manages 180 ha of green space, 40 ha of which were added or improved since 1998 (City of Ljubljana 2015). 16.5% of the city's area is designated as part of the Natura 2000 Network of protected areas, and including other types of nature protection designations over 20% of the city's land area is protected. The city financially supports the park administration for Natura 2000 areas and is involved in creating management plans and monitoring activities. Ljubljana's activities demonstrate that cities can be actively involved in implementing biodiversity policy, including European policy.

Box 4: Ljubljana basic statistics

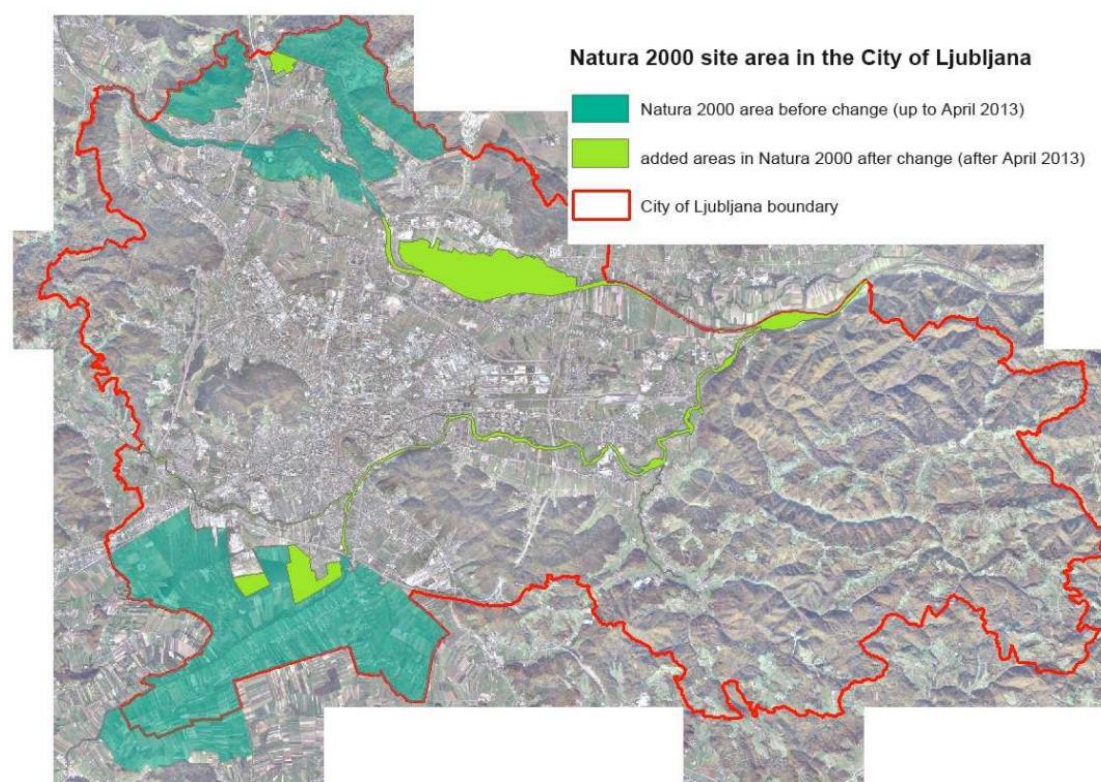
Location: Central Slovenia Ljubljana river basin, capital city of Slovenia

Population: ca. 280,000 (2012)

City area: 163.8 km²

Green space per inhabitant: 560 m² in the whole city region, 160 m² in the urban core

Map 3.2 Natura 2000 sites in Ljubljana



Source: City of Ljubljana 2015

Urban forests, farmland, and green corridors help network habitats throughout the city, leading to a high biodiversity especially of nesting birds and saproxylic beetles. 268 species of birds have been identified in Ljubljana (Tome et al. 2013). The city focuses on “green wedges”, wedge-shaped green areas that connect the city center with green areas at the urban periphery, for extending high quality green space into the city center and networking habitats (City of Ljubljana 2015).

Ljubljana’s efforts in GI focus not only on the quantity of green and blue infrastructure but also on the quality. Many projects have been undertaken or (co-)financed by the city to improve the quality of green and blue areas, such as ecoremediation of streams and removal of invasive species. For example, an ecoremediation project was implemented in a tributary of the Glinščica stream to reduce pollution, in which a new inflow water course was laid out to meander through revitalisation and water purification features (City of Ljubljana 2015). The city also puts in significant effort to involve the public to encourage stewardship and education, e.g. through activities together with local schools and NGOs.

3.1.2 GI and biodiversity policy in the city

The Urban Planning Department of the Ljubljana City Hall is the body primarily responsible for city planning. The city does not have an explicit GI policy, but GI is regulated through city planning policies.

The city’s Municipal Spatial Plan is Ljubljana’s central city planning policy and is a legally binding. In 2010, this policy was revised after two decades, following the long-term strategic urban development document Vision 2025 (Százaz and Nastran 2015). Alongside social goals such as cultural and economic development, Ljubljana’s city planning policy places emphasis on improving the urban environment for biodiversity and wellbeing with well-networked, accessible¹³ urban green space. Maintenance of the multi-functionality of urban GI is one of the Spatial Plan’s strategic goals. The Spatial Plan also focuses on preserving the city’s compactness (avoiding urban sprawl).

There are two principles applied in city planning in Ljubljana to ensure the maintenance of urban GI and reduce urban sprawl. 1) The Green Area Factor ensures that the ratio of green to built area cannot be reduced in redevelopment in the urban core for non-residential plots unless it is to construct a public square or multi-purpose area. 2) The Open Living Area Factor ensures that the ratio of built area to open area (referring to any type of non-built area) of a parcel of land cannot be reduced in development, and the area of green space must be at least 50% and the area of built space (excluding traffic features) cannot exceed 50%. Additionally, focus is put on redeveloping built areas and areas close to existing public transport rather than new development (City of Ljubljana 2015). The objective of these factors together is to reduce urban sprawl and preserve urban green features by ensuring compact development.

The Spatial Plan is supported by other municipal policies, such as the non-binding Environmental Protection Programme 2014-2020. The goal of the Programme is to prevent decline of biodiversity. It defines the measures to achieve its main objectives, indicators of the state of nature, and indicators of implemented measures. In 2014 under the Programme, €3,000,000 were planned for implementing green corridors to link the urban core to green areas on the city periphery (City of Ljubljana 2015). The city also has several bodies that support urban GI in policy. These include the Public Space Council, an advisory board, and the Deputy Mayor’s Collegium for Public Space and Traffic, an operative body of representatives from departments of municipal public authorities to encourage better coordination.

NGOs and public-private partnerships play an important role in planning and implementing urban GI in the city. In the process of post-socialist transition in the 1990s, the city lacked proper investments.

¹³ i.e. geographic proximity of residents to green space

Especially after private financing for urban development slowed down with the financial crisis in 2008, the city began to take a larger role in planning, implementing, and maintaining urban development projects and GI (Száráz and Nastran 2015). From the 2000s, the city has made efforts to maintain existing green space, develop new green areas and rehabilitate degraded brownfield areas. The later, while not present in all cities, offers potential to support urban flora particularly in Ljubljana as the young pioneer and tall herb phases can flourish on the nutrient poor substrate typical of such sites and later develop into more established grassland or scrub ecosystems via natural succession (UCD Urban Institute Ireland 2008). Cooperation with NGOs encourages public participation in urban GI planning and maintenance. Public-private partnerships help the city engage private stakeholders such as land owners in GI implementation (Száráz and Nastran 2015).

3.1.3 Observed policy impacts

Impacts on biodiversity

Ljubljana's GI consists mostly of small green and blue areas and features, meaning urban habitats are fragmented. The focus of urban planning policy on maintaining and networking urban green spaces helps prevent further fragmentation and degradation. Efforts at habitat preservation, such as designation and effective management of the Landscape Parks, have been able to preserve protected and endemic species within the city (City of Ljubljana 2015).

One major project initiated by the city is the restoration of the banks of the River Ljubljana. The restoration combined improved green space and infrastructure such as walking paths, benches, and bridges to increase the usability of the riverbank space. The project won the city the 2012 European Prize for Urban Public Space. It utilizes many green elements, which simultaneously provide important urban habitats as well as multifunctional recreational urban space. Efforts at public education and involvement, e.g. through partnerships with NGOs, have been key for increasing public awareness and appreciation for urban biodiversity and GI (City of Ljubljana 2015). Awareness and acceptance facilitates the city's ability to address both the needs of the human population and biodiversity conservation.

Figure 3.1 Two areas of the renovated Ljubljana river bank: the Špica city park green riverbank in the city center (left), and a new pavilion using vines to provide shade on the Petkovškovo embankment (right)



Source: publicspace.org 2012

Other benefits of urban GI

The role of urban GI for water management is well recognized in Ljubljana. Ljubljana is located in a flood prone region, and coping with flooding is one of the major challenges of planning in the city. GI has also been recognised for its value for providing drinking water to the city's inhabitants. The city

has prioritised preserving grasslands in the region for water quality regulation, and because of this has not had to invest in grey infrastructure to treat drinking water.

Sustainable food production is another benefit of Ljubljana's urban GI efforts. Allotment gardens and gardening projects in former brownfield areas help convert formerly unsustainable land uses to sustainable and productive areas, providing residents with healthy food and sustainable recreation activities.

Other recognized benefits of urban GI in Ljubljana include air circulation social and cultural services such as recreation and education, and sustainable economic development.

3.2 Case study 2: Bristol

3.2.1 Status of urban biodiversity and GI

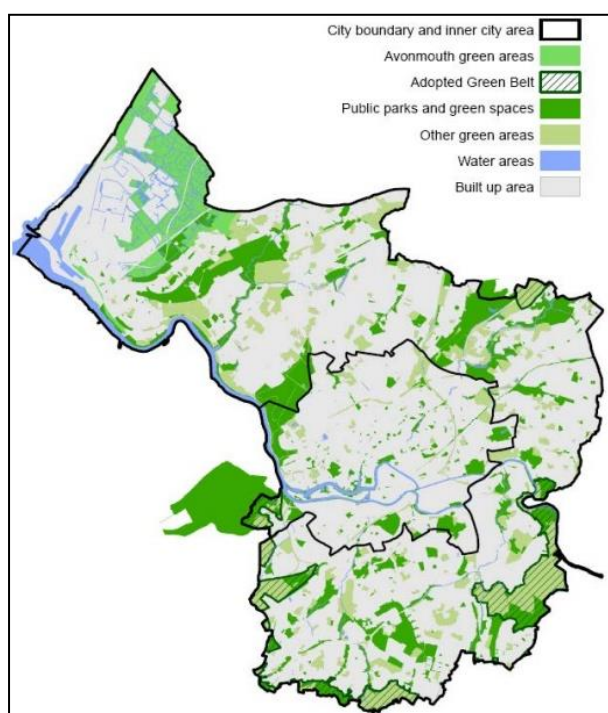
Bristol is the 7th largest city in England and the economic capital of the country's South West region. In addition to being an efficient city with a growing green economy, Bristol is the UK's greenest and most energy and carbon efficient city, with high air quality and an extensive green and blue infrastructure network which supports a wealth of biodiversity. This status and the city's recent designation as a European Green Capital 2015 can be largely attributed to long-sighted municipal planning support from national legislation and the high involvement of local citizens in participatory decision-making processes (Bristol City Council 2015b).

Box 5: Bristol basic statistics

Location: England, UK (7th largest city)
Population: ca. 430,000 (2012)
City area: 1150 ha (city region); 7350 ha (built up areas)
Area of green and blue infrastructure: 34% of city area
Green space per inhabitant: 41 m²
Proximity of citizens to green space: 88% of residents are within 300m of a green space, including 87% of the inner-city population

Land use within the city can be categorized as having a concentric form, with commercial areas and high-density housing being found in the inner city (with limited green and blue areas), large-scale industry on the city border close to the international trading port, small-scale commerce spread across the urban area and suburban areas being mainly residential with substantial green spaces (Bristol City Council 2015b) (see Map 3.3). With 34% of the city made up of green and blue open spaces, approximately 75% of the population lives within 300m of public green urban areas larger than 5,000m² and 88% lives within the same distance of public green urban areas of any size (Bristol City Council 2015b). Examples include urban farms, nature reserves, more than 400 parks, children's play and active sport areas, as well as the River Avon.

Map 3.3 Bristol Green/Blue Distribution Map



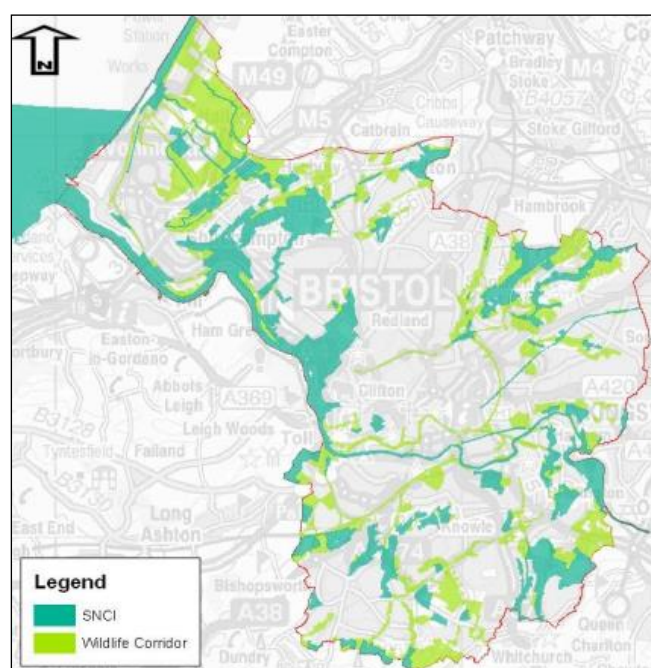
Source: Bristol City Council 2012 © Crown copyright and database rights 2012

Biodiversity in Bristol is rich and varied, encompassing 21 of the UK's 45 identified priority habitats. As outlined in the city's Biodiversity Action Plan¹⁴, Bristol boasts extensive species rich grassland, woodland, pond and open water, reedbeds and sedgebeds, estuarine habitats, scrub and rivers and rhines. The more built-up areas of the city support biodiversity as well, particularly the few remaining open mosaic habitats on previously developed lands. Priority species for which Action Plans have been developed include the water vole, otter, house sparrow and hedgehog.

Targeting biodiversity specifically, approximately 27% of the city (over 3000 ha of land) is designated as a 'Wildlife Network' and strives to protect wildlife while also ensuring benefits for inhabitants as well (Bristol City Council 2015a) (see Map 3.4). This network is a major component of the city's GI network and generates a variety of ecosystem services, including reducing the urban heat island effect and increasing flood storage and carbon absorption (Bristol City Council 2015a).

¹⁴ See <http://www.bristol.gov.uk/sites/default/files/assets/documents/BBAP.pdf>

Map 3.4 Bristol Wildlife Network Map



Source: Bristol City Council 2011 © Crown Copyright and database rights 2011

3.2.2 GI and biodiversity policy in the city

Bristol's population grew by 10% between 2001 and 2011, exceeding the national average of 7% and resulting in significant pressure on the city's green areas to address demands for residential and business development (Bristol City Council 2015b). However, on account of the city's efforts to defend and expand these spaces, protected wildlife space has actually grown by 12 ha in the same period and currently covers 27% of the city (comprising a significant portion of the existing GI network) (Bristol City Council 2015b).

The city's aggressive approach to protecting wildlife and green urban areas has been a process driven by citizen action and statutory duties stemming from the central government's planning system, as outlined below. Overall, the central objectives regarding green space planning in Bristol is – by means of an inclusive, participative process – to provide a multitude of types of accessible, equitably distributed green space to all city inhabitants and to maximize the multi-functionality of these areas in providing social, economic and environmental benefits. The two main documents driving the GI agenda and decision-making processes in the city are the *Parks and Green Space Strategy* and the *Local Plan*, outlined below.

In 2008, the non-binding *Bristol Parks and Green Space Strategy*¹⁵ was published by the Environment and Leisure Department after a two-year public engagement process between citizens and BCC. The consultation was focused on how to improve the attractiveness, perceived sense of security and quality of urban green spaces and revealed a clear public preference to have wildlife spaces as the main type of accessible green space. Thus, the Strategy was adopted to improve the quality of wildlife spaces from a citizen perspective, work with and support disadvantaged groups, and focus community outreach programmes in a network of 16 equally accessible Local Nature Reserves spread across the city. In the same year, the *Bristol Biodiversity Action Plan*¹⁶ was also adopted as a framework for

¹⁵ <http://www.bristol.gov.uk/doc/bristols-parks-and-green-space-strategy>

¹⁶ <http://www.bristol.gov.uk/sites/default/files/assets/documents/BBAP.pdf>

species and habitat conservation in the city, emphasizing the value of biodiversity for the enjoyment and benefit of citizens.

Following the national mandate, Bristol developed its *Local Plan* (2011-2026), outlining the city's development strategy and establishing strong policies to enhance and protect green areas. A crucial aspect of this plan was defining and outlining how to protect Bristol's Wildlife Network, which links and buffers individually protected sites on the basis of an 'Urban Wildlife Corridor Assessment Methodology' (Bristol City Council 2015a). One key document within this is the non-binding *Core Strategy on Green Infrastructure*, which sets out the strategic goals, direction and commitment of the BCC for maintaining, protecting and enhancing the city's GI network (van der Jagt et al. 2015). The Strategy highlights the potential of green spaces for promoting healthy lifestyles and social inclusion as well as in adapting to climate change adaptation and mitigation and protecting wildlife. A map of open spaces, waterways and other green spaces across the city is also included within the Strategy. A second main component of the Local Plan is the *Site Allocations and Development Policies Documents* (DPD) and *Area Green Space Plans* (focusing on the neighbourhood level), which consist of criteria and guidance for provisioning various forms of green space in new developments and site-specific proposals (van der Jagt et al. 2015). Criteria include standards regarding: quality, distance (travel distance required to access the green space), and quantity (how much green space of different types should exist). This progressive policy mix requires new developments to enhance the city's GI, based on a multifunctional approach using an ecosystem services model (e.g. trees can be required where they would assist in forming wildlife corridors, mitigating air pollution, assisting in flood risk reduction or contribute towards urban cooling) and replace any valuable trees which are lost or damaged due to development with up to eight new trees (Bristol City Council 2015b)..

Further initiatives also contribute to the development of GI in Bristol, such as the 'Urban Green' program. This national initiative was launched by Velopost (a bicycle postal delivery service in Bristol and Bath) to increase the number of urban indigenous trees across the UK. Over the course of 2014-2015, the program aims to plant 500 trees in Bristol.¹⁷

3.2.3 Observed policy impacts

Impacts on biodiversity

Several monitoring programs have been introduced in Bristol to monitor and respond appropriately to changes in biodiversity status at both a city and site-specific scale. Citywide monitoring efforts include Bristol Bird Watch, The Breeding Birds of Bristol, Sites of Nature Conservation Interest (SNCIs), Water Quality, and site-specific efforts include, for example, Fixed Point Photography Troopers Hill; several trends can be identified, such as (Bristol City Council 2015a):

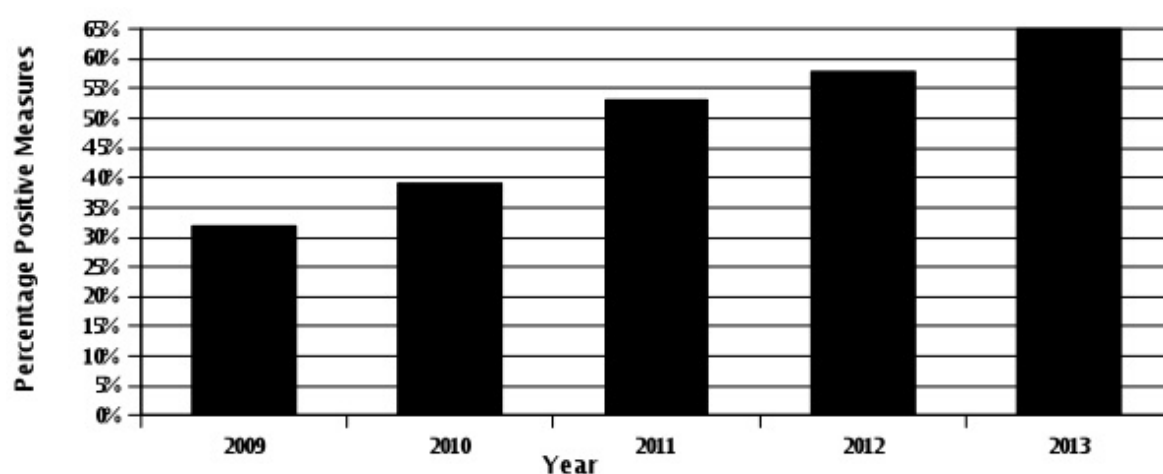
- The Bristol Bird Watch ran from 2001 - 2011. Annually 1,000 residents logged bird species visiting their garden. By adding Niger seed (*Guizotia abyssinica*) to bird food mixes, there were significant increases in recorded goldfinches.
- Since 2008, the condition of all SNCI's has been monitored by the Bristol City Council to determine whether habitats are in positive conservation measures. Increases in the overall percentages have been recorded, as illustrated in Figure 3.2 below.
- Tree planting by BCC has increased from 74 trees in 2005 to 1200 in 2012. Ongoing support is provided by local initiatives such as the Tree Pips project¹⁸, which has planted 10,000 trees in Bristol since March 2014 and aims to plant a total of 36,000 by March 2016.
- Since 2010, the area of protected sites has increased by 6.5 ha.

¹⁷ See <https://velopostuk.wordpress.com/2014/03/25/urban-green-bringing-free-trees-to-bristol/>

¹⁸ See <http://www.bristol.gov.uk/page/environment/one-tree-child>

- Since 2005, Local Nature Reserves have increased from four to nine and four more sites are being considered; the target is to reach 16 reserves by 2016.
- BCC manages 178 ha of summer-flowering meadow. In 2006, specifications and contractual arrangements were improved for a total cost of £76,361 per year; all are now in positive conservation measures.
- BCC manages over 400 ha woodland and 400 veteran trees. Since 2001, 3 ha community woodland has been planted and 160 ha of woodland restored. Consequently, 30 of 51 woodland sites are now in positive measures.
- In 2010, floating reedbeds (small, buoyant rafts made of vegetation) were installed in the former industrial dock in the heart of the city; this has increased biodiversity and otters have now returned to this area.

Figure 3.1 Percentage of SNCI's in positive conservation measures (2013 projection)



Source: Bristol City Council (2015)

Other benefits of urban GI

Over the last decade as a consequence of Bristol planning policy (including green infrastructure legislation), 98% of business developments and 94% of new homes were constructed on brownfield sites out of recognition for the necessity to leave green areas for wildlife and flood risk protection. The city's *Core Strategy* requires the layout and design of development to promote urban cooling, integrate green infrastructure, encourage walking and cycling and require high standards of energy efficiency and reduce emissions; this contributes to climate change adaptation and mitigation, particularly regarding the reduction of water run-off, provision of flood storage capacity, and reducing in impermeable surfaces leading to soil sealing (van der Jagt et al. 2015). Other benefits include increased access to recreational opportunities (e.g. walking paths, cycle routes, accessible river corridors) and therewith increased levels of physical activity by city residents.

3.3 Case study 3: Ghent, Belgium

3.3.1 Status of urban biodiversity and GI

Ghent is the capital city of the province of East Flanders and is the second largest city in the region of Flanders in Belgium. Flanders is the most fragmented landscape in Europe and is very densely populated (Demolder and Peymen 2011). Nearly one third of Flanders' area is characterized as urban (Stevens et al. 2014), making urban areas extremely important for Flemish and Belgian biodiversity. About half of the land in Flemish urban areas, including the area of Ghent, consists of buildings or paved areas; the rest of the area is urban green or blue space. These spaces range from the small scale, such as private gardens, tree rows, and green surfaces in industrial areas, to larger scale parks, urban forest, and water bodies (Demolder et al. 2014).

Box 6: Gent basic statistics

Location: East Flanders province (provincial capital city), Flanders, Belgium

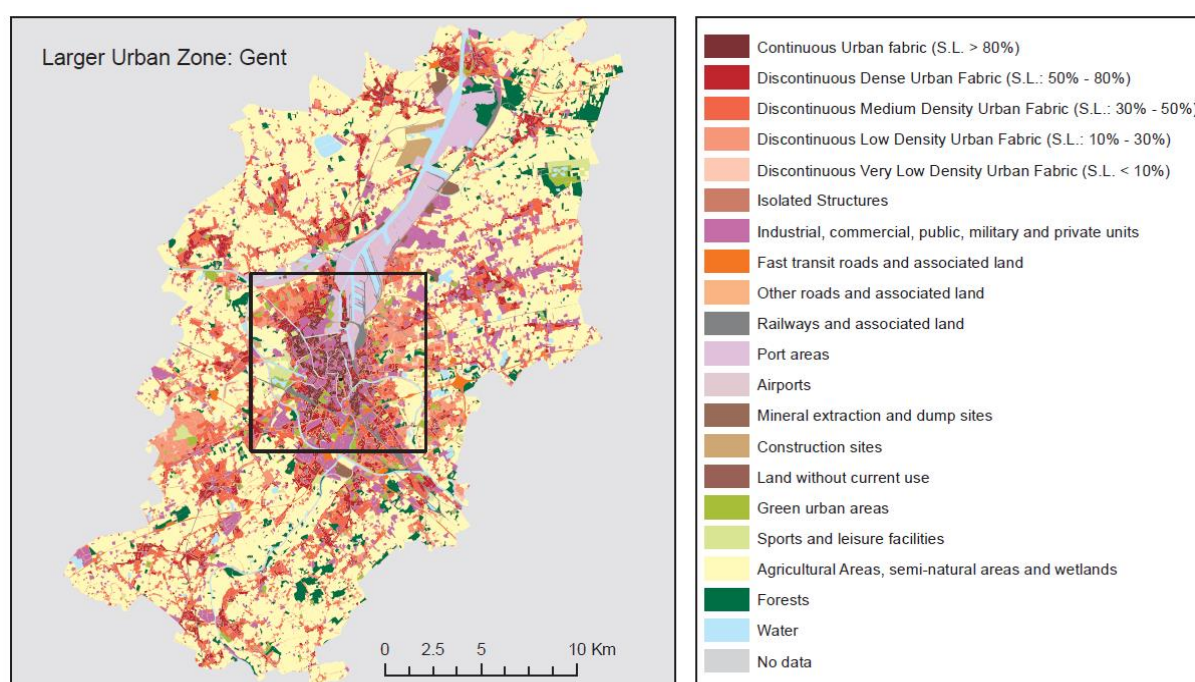
Population: ca. 250,000 (2011)

City area: 156.2 km²

Percentage of inhabitants with close access to green space: ca. 65% live within 800m to green space with a minimum surface area of 5 ha (Van Herzele and Wiedemann 2003)

The urban GI in Ghent's city core consists mostly of small-scale green space and green features. Towards the city periphery, agricultural, wetland, and semi-natural areas dominate the landscape, interspersed with forests.

Map 3.5 Urban Atlas map of land uses in Ghent



Source: Urban Atlas (2010)

Modelling of potential habitats of Red List species shows that the area in which Ghent is located contains a high species diversity potential, meaning that according to the model, species biodiversity in the area should be high (Demolder et al. 2014). In Flanders, about 10% of urban areas enjoy some sort of protected status (Demolder et al. 2014).

The Ghent harbor is a key feature of Ghent's physical and economic infrastructure. A long-term monitoring study of aquatic invertebrate species in the Ghent harbor (Boets, Lock, and Goethals 2010) identified 11 crustacean species and 14 mollusc species. Due to improved laws regulating water pollution, the water quality in the Ghent harbor increased over the past 20 years, and this correlated

with an increase in biodiversity. However, many of the species found in monitoring samples were alien species, and it was primarily alien species that increased over time. The Ghent harbor receives a high volume of international shipping traffic, which increases the risk for alien species introductions, especially of aquatic species.

Land take remains a challenge in Flanders and in Ghent. Existing GI policy has been unable to halt the expansion of urban areas in Flanders, including in the region around Ghent. Over 10,000 ha of agricultural land and between 5,000 and 10,000 ha each of forest and grassland are expected to be lost to urban expansion in Flanders in the near future (Demolder et al. 2014), which is expected to negatively affect species dependent on these habitats. Though forest land is also expected to expand, this will likely come at the cost of agricultural land. Special attention is required from Ghent, Flemish, and Belgian policy to ensure that valuable expansion of one type of green space does not occur at the expense of another valuable type of green space.

3.3.2 GI and biodiversity policy in the city

In December of 2009, the city of Ghent signed a Biodiversity Charter with the Belgian nature protection NGO Natuurpunt. In the charter, the city committed itself to action in policy and practice to improve biodiversity conservation in the city. The biodiversity charter is built around four pillars:

- Knowledge: improved data integration
- Communication: improved communication between stakeholders and to the public
- Community involvement: engaging with target groups and civil society
- Concrete action: applied habitat and species conservation in practice

The Biodiversity Charter lead to policy changes at the city level, detailed below, and to action to improve biodiversity conservation practice. This includes the expansion of the city's nature reserves; application of improved management practices in existing parks and green spaces, for example applying the Flemish Government's principles for holistic park and green space management; and improvement or addition of green space features to support biodiversity (Balthazar 2009).

Following the signature of the Biodiversity Charter, the city passed a revised Structure Plan in 2010 which includes a Green Structure Plan ("groenstructuurplan") (City of Ghent 2010). This structure plan applies principles of the Flanders regional structure plan at the municipal level. The plan builds on initiatives in the past. For example, in 2000, the creation of four "green poles" ("groenpolen") was anchored in the municipal coalition government agreement. These green poles remain key elements of Ghent's urban green space.

The plan includes improving the connection and quality of a ring of a "green ring" along the ring road around the city center, protecting the river valley areas at the "green poles" on the city's periphery, expanding green axes throughout the city, strengthening the quality of sandy forest areas in the north of the city, and improving the size and quality of parks in the city center. Special emphasis is placed on networking green space elements to support high-value ecological spaces. The green structure plan recognizes the importance of single and small green landscape features for ecological networking due to the dense structure of Ghent's core. The use of green spaces not just for biodiversity, but also for recreation and other ecosystem services, receives a great deal of attention in the green structure plan.

Municipal, regional, and national policies for green infrastructure for biodiversity are applied synergistically in Ghent. On a regional and city level, special emphasis has been placed on the creation and maintenance of urban forests. Unlike in some other European regions, Flanders does not have a cultural history of maintaining urban forests (Van Herzele 2006). This situation is reflected in Ghent as well and is acknowledged in the Green Structure Plan. In recent decades, proponents for urban forests have gained ground in political and planning discourses, and urban forest has become a more widely used green space feature in urban planning. Urban forests are seen as a useful way to

provide accessible green space for recreation, provide multiple ecosystem services, and create planned barriers to urban sprawl. Since the early 2000s, increasing the area of urban forest has been a priority in urban planning in Ghent yet has met barriers to do conflicts of interests between different stakeholders (Van Herzele 2006). The city has leveraged national, regional and municipal strategies and regulations as well as public and private funding sources to support efforts to create more urban forests (Van Herzele 2006).

3.3.3 Observed policy impacts

Impacts on Biodiversity

One example of progress made in urban GI in Ghent is the Gentbrugse Meersen, a multifunctional green space which serves as one of the city's green poles. The Gentbrugse Meersen comprises an area of 204 ha and includes forest, wetlands, and grasslands. Forest areas have been planted and are being allowed to develop naturally. Plans to expand water features in the area intend to create more suitable habitats for waterfowl.

The development of the Gentbrugse Meersen area is constrained by limited finances. In order to cope with this situation and progress with plans, development is therefore being undertaken in stages, focussing on the development of parts of the space rather than the whole space.

Map 3.6 Map of Gentbrugse Meersen green pole area



Source: Balthazar (2015)

The Gentbrugse Meersen is now home to a wide variety of species including rare birds, butterflies, and mammals. The Working Group Gentbrugse Meersen collects records of species in the area and conducts citizen science events such as species censuses. In 2015, for example, the return of the Savi's Warbler *Locustella luscinioides*, a Red List bird species rare in Belgium, to the area was recorded (Working Group Gentbrugse Meersen 2015a).

Figure 3.2 Sample of fauna recorded in Gentbrugse Meersen in Spring 2015



Source: Working Group Gentbrugse Meersen (2015b)

Other benefits of urban GI

The GI in Ghent is valued in policy documents for its multi-functionality. For example, plans for the green ring emphasize the value of the green space surrounding the ring road for safe transport areas for pedestrians and cyclists as well as for recreation space for health and wellbeing and to create a physical barrier between residential areas and the ring road. A study comparing the health benefits of urban green space in Ghent found that urban green space was the most important determinant for happiness in a neighborhood (Van Herzele and de Vries 2011). Emphasizing the multiple benefits in communication and planning processes helps ensure that the needs of both residents and nature are taken into account.

3.4 Case study 4: Gallecs, Spain

3.4.1 Status of urban biodiversity and GI

Gallecs is a rural municipality located 15 km north of Barcelona in the Catalonia region of Spain. Gallecs is surrounded by a rapidly urbanising area on the periphery of the city of Barcelona. However, due to historical factors explored in further depth in the following subsection, the area was spared from development as the areas around it continue to urbanise and suburbanise. Now Gallecs features a unique rural landscape on the peri-urban fringe of Barcelona and serves as a buffer zone between the coastal and mountainous regions (Timeus and Anzaldúa 2011).

Box 7: Gallecs basic statistics

Location: Barcelona province, Spain

Population: Gallecs is a low-density peri-urban area over which jurisdiction is split by several municipalities with populations ranging from 6,354 (in Llíser de Vall) to 51,719 inhabitants (in Mollet del Vallès); because of the shared jurisdiction, specific populations statistics for Gallecs are not available

Municipal area: 737 ha

Gallecs is characterised by agricultural and semi-natural ecosystems with some built areas. This includes oak and pine forests, streams and wetlands, agroforestry areas, and dry and irrigated agriculture. As a transitional zone between mountainous and forest areas as well as between rural and urban zones, it is an important habitat for both common and threatened birds. Gallecs is one of only four places in the region where the Greater Short-Toed Lark *Calandrella brachydactyla*, a Red List bird species in decline in Catalonia, is known to breed (Generalitat de Catalunya 2014).

3.4.2 GI policy in the city

In the 1970s, about 1500 ha of land in Gallecs and the surrounding areas was expropriated from the original owners by the Franco regime. This land was planned to be developed into a city of 130,000 inhabitants as part of the expanding city region of Barcelona. Yet an economic downturn slowed Barcelona's expansion and prevented the plan from being carried out. Following this, the area was subject to incoherent spatial planning policy and inefficient land use (Timeus and Anzaldúa 2011).

In 2001, the Gallecs Rural Space Consortium, comprising two neighbouring municipalities, received EU funding to develop the area as a reserve for nature, tourism, organic agriculture, and forestry. The goal of the project was to protect the region from urbanisation and environmental degradation and strengthen the area's ecological function. In 2005, a Master Plan was created for Gallecs, designating it as a non-urbanising space of natural interest and developing an integrated approach to land management, planning, and conservation. The ecological improvements in the Master Plan are intended not just to support biodiversity but also to improve wellbeing of residents of the surrounding suburban areas.

3.4.3 Observed policy impacts

Impacts on Biodiversity

The Master Plan explicitly included the creation of GI elements, including forest restoration, wetland restoration, and organic agriculture. Protected areas were also established.

The agrobiodiversity of the area has been increased through organic farming and crop rotation practices. The increase in agricultural variety and change of agricultural practice has also been associated with an increase in biodiversity of wild fauna. Studies also found an increase in plant biodiversity (Timeus and Anzaldúa 2011).

Other benefits of urban GI

Education and communication measures have increased knowledge of the ecology of the area. They have increased tourism by drawing attention to the recreation opportunities and ecological value of the area. Farmers in Gallecs have also enjoyed higher profit margins on organic produce than on the conventional produce grown previously in the area (Timeus and Anzaldúa 2011).

Sustainable water resource management is being undertaken as part of a plan to improve the region's drinking and irrigation water supply. Water management in Gallecs has had other benefits too, such as reducing torrent flows and erosion in the streams and reducing the amount of water used for irrigation (Timeus and Anzaldúa 2011).

4 Challenges and new concepts for urban GI

Given the diversity of approaches to designing and implementing green infrastructure, it follows that an equally varied set of challenges accompanies such efforts. Increasing the awareness of these inhibiting factors, adapting frameworks and developing new concepts to try and minimize their negative potential is key to ensuring effective GI and addressing biodiversity conservation objectives. This chapter highlights key potential challenges on the basis of the explored case studies and additional desk. New approaches and successful concepts for addressing some of these difficulties within an urban context have also been identified and are outlined in this chapter.

4.1 Potential challenges and barriers

Green infrastructure projects that aim to support biodiversity are often privy to a range of challenges. Naumann et al. (2011) developed a typology of these barriers, including: structural, regulatory, cultural/behavioural, contextual, capacity and technical barriers. These are described below on the basis of urban specific examples; unless otherwise specified, these stem from Kronenberg (2015) and Naumann et al. (2011).

- *Structural barriers* refer to obstacles posed by the structures and procedures of institutions and organizations, which can be a significant problem particularly in urban areas. This refers to changes in management mid-project or power imbalances and a lack of effective public participation in urban planning processes, i.e. priority given to certain (development) interests. Alternatively, a challenge is that most local authorities are limited to reacting to existing problems (such as grey infrastructure damage by tree growth) instead of being able to prevent similar future damages.
- *Regulatory barriers* are hurdles set up by the means an organization or government has to regulate and control their members' interactions and the procedures they follow. Dominant challenges were posed by difficulties in addressing heavy administrative procedures and burdens, for example in funding applications and the accompanying paperwork required. The lack of legal protections for urban green space and fragmented ownership structures also fall under this category, as well as confusion or unclarity regarding responsibility for urban green infrastructure, such as street trees.
- *Cultural/behavioural barriers* denote the influence generated by customs, values, beliefs, interests and individual personalities, and predominantly refer in the case of urban GI to a low level of public acceptance due to dissimilar priorities or points of view. Costs associated with GI, for example, remain seen through the lens of grey infrastructure costs, as few local authorities have effectively taken up the valuation of ecosystem services in decision-making processes due to an aversion to change their established perspectives. Competing interests and personal agendas also come into play.
- *Contextual barriers* are hindrances and thematic priorities created by external forces to which a government or organization is subject to and must respond. For example, limited windows of opportunity are a challenge, referring to the limited chances available to influence spatial plans and other long-term funding schemes, as well as lacking synergies and integration between different relevant sectors. Insufficient knowledge about GI and its impacts is another major barrier, including e.g. the effects of green infrastructure on urban biodiversity and detailed data on (cost) effectiveness as compared to alternative grey infrastructure solutions.
- *Capacity barriers* signify a lack of resources, including technical, human, financial, etc. Regarding management considerations, local and regional authorities are primarily responsible for making and implementing spatial planning decisions in most European countries (European Commission 2013). However, urban authorities responsible for planning and implementing green infrastructure often have limited capacities to take ecosystems

services and biodiversity in their complexity into account. Furthermore, where the capacity of urban actors for planning, regulation, and implementation is limited, there is a higher risk of informal and illegal development, which can occur in areas of ecological significance for cities, such as natural and semi-natural areas (Santos, Reis, and Branquinho 2015). Finally, a dominant barrier is the unsatisfactory implementation of existing legislation or political will to inspire GI action.

- *Technical barriers* are physical or functional impediments in constructing or implementing green infrastructure, which can delay or necessitate a revision of project plans. This can include, for example, difficulties in harmonizing the GI activities (such as the restoration of a canal) and public use of the area. Delays in implementation also occur as a result of weather conditions, complicated installations or other unavoidable environmental factors.

Several of these categories may be present at a given time, or may be specific to a certain project phase or set of conditions. Potential approaches to overcoming some of these inhibiting factors are presented in the subsequent section.

4.2 New approaches and concepts

In order to address the challenges outlined above and maximize the efficiency of GI for conserving biodiversity in urban areas, a number of new approaches and concepts have been identified as being particularly relevant. These are outlined below, including linkages with the specific types of challenges or barriers they could potentially address.

4.2.1 Urban gardening and urban agriculture

Many cities have a long history of urban and peri-urban agriculture, but the trend has seen a boom across Europe in recent years. Urban agriculture can take many forms and can be commercial or non-commercial, private or public, large-scale or small-scale, industrial or traditional). Different types of urban agriculture provide different benefits for biodiversity.

Allotment gardens are one type of urban agriculture with a high value for urban biodiversity. Allotment gardens are a common feature of many European cities and for decades have assisted urban residents in producing some of their own food. These gardens often provide important habitat area for natural urban biodiversity (Elmqvist 2013), and can conserve agricultural biodiversity in the form of traditional crop varieties eschewed in commercial production but cultivated by hobby gardeners. The impact of allotment gardens on biodiversity depends on management of individual plots by gardeners, such as choices about crop selection, watering, fertilization, and use of plant protection.

As urban areas expand and populations become increasingly urbanised, urban agriculture will become more important for urban food security. As traditional agricultural land is lost to development, food production in cities can be one way to provide urban populations with fresh and healthy food (URBES Project 2014). Using urban space for agriculture and gardening is both a way of creating and managing urban green spaces beyond classic measures like parks, as well as a way to engage urban populations in stewardship of green space. Encouraging urban gardening and agriculture can therefore be a way to increase the amount and quality of GI in a city when municipal budgets and capacities are constrained.

4.2.2 Re-connecting people with nature: fostering community stewardship and citizen observatories

Involving the general public in decision-making processes surrounding GI measures as well as their implementation, maintenance and monitoring is often key to obtaining high levels of acceptance as well as addressing capacity deficiencies. Effective and early public outreach and communication in the process of planning GI projects or initiatives can help avoid conflicts with stakeholders, increase support and instil a sense of ownership in the community for the planned measures (Naumann et al.

2015). Involvement in subsequent project stages, such as monitoring and maintenance, can also contribute to improved data collection and increase the ability to identify biodiversity trends resulting from the GI measures.

Community stewardship and citizen observatories are two approaches to accomplish these aims and increase public involvement in the processes surrounding green infrastructure. Community stewardship involves local stakeholders in the active maintenance of green spaces. Some examples include involving residents in planting and maintaining street, park vegetation or forests (see Box 8), in removing litter from parks or water bodies, or in running community gardens. This can help surmount cultural and behavioural barriers by increasing the understanding and therewith acceptance of GI measures, particularly regarding the public perception of the value of GI, and by fostering a sense of responsibility amongst stakeholders. Citizen observatories, alternatively, is a concept that evolved in EU policy circles to foster participatory community monitoring and support data collection and the tracking of selected environmental issues. The approach is based on citizens' own devices (e.g. smart phones, tablets, etc) and combined with innovative technologies that can strengthen monitoring capacities; the idea is to facilitate increased data collection, reduce investments and running costs and cultivate increased partnerships between the private sector, public bodies, NGOs and citizens¹⁹. These approaches are also a way to reduce capacity barriers by distributing the responsibility of maintaining and monitoring GI and biodiversity between additional individuals or groups outside of the standard responsible actor structures.

Box 8: Forest of Young Viennese

The Wald der jungen WienerInnen („Forest of Young Viennese“) in Vienna is a successful example of actively involving the public in GI measures. Since the launch of the project in 1985, residents in Vienna have been encouraged to participate in planting actions to create urban forests in former industrial or agricultural areas. Each year, approximately 10,000 native trees and plants are planted through the programme. Initially, the programme was targeted at children and youth and had difficulties finding participants and gaining public support. The communication strategy was then adjusted to target families and companies and the media strategy was strengthened; these actions and cooperation with NGOs has increased participation and ensured the sustainability of the project in the long-term (Naumann et al. 2015). The high public participation and project visibility has also helped overcome contextual barriers, particularly the lack of political will.

4.2.3 Planning regulations

Planning regulations can be a powerful tool to overcome some of the challenges associated with GI. The following present some examples of how planning regulations can be used to overcome barriers in different contexts.

Green roof legislation in Basel, Switzerland

In 2002, the city of Basel on the Swiss-German border revised its Building and Construction law mandating that all new and renovated buildings with flat roofs receive green roofs. The city has also sponsored financial incentive programmes as well as awareness raising campaigns such as a green roof contest. The measures have been accompanied by a research partnership with the University of Applied Sciences in Wädenswil. Thanks to the city's proactive approach, Basel is now the city with the highest share of green roofs in the world (Kazmierczak and Carter 2010). Research has shown that the green roofs measurably benefit urban biodiversity by increasing the amount of suitable habitat for flora and fauna, including for locally endangered species (Brenneisen 2006) and by functioning as habitat stepping stones for select species. The combination of measures and scientific monitoring have helped address a variety of challenges in a holistic way.

¹⁹ See <http://www.2020-horizon.com/Demonstrating-the-concept-of-Citizen-Observatories-i2106.html>

Biotope area factor in Berlin, Germany

The German capital city enacted a measure in 2000 as part of its suite of urban planning regulations mandating that new construction and certain renovations on land parcels in the city centre set aside a certain percent of space as green space.²⁰ The measure is flexible and leaves it up to the discretion of the planner what type of green space to include and where on the land parcel. Different types of features are given different weights based on their ecological value. Creation and improvement of the quality of habitat for urban flora and fauna is one of the explicit goals of the regulation (Berlin Senate, n.d.). The city's budget is constrained, making financial incentives for creating urban GI an unattractive option. Instead, the use of regulations with flexibility mechanisms has shown success in this context.

National law mandating green or solar roofs on new buildings in France

In 2015, France became the first European country to pass a nationwide law mandating that new buildings feature either green or solar roofs. Activists who pushed for the law originally called for the law to apply to all new construction and require roofs to be completely covered (Agence France-Presse 2015). The government was able to pass a compromise which applies to commercial area construction and incorporates more flexibility for planners, including the option to choose either greening or solar panels, and the requirement for the chosen measure to cover part of the roof. Compromises like this represent productive steps in the correct direction and avoid the alienation of important stakeholders. The nationwide coverage ensures that individual cities or regions are not unequally burdened by regulation, capacity, contextual or structural barriers. Nation-wide results regarding impacts are not yet available given the recent nature of this law.

4.2.4 Ecosystem disservices: a tool to increase transparency and GI support

As cultural/behavioural barriers and specifically a lack of acceptance often arise in urban contexts when discussing green infrastructure, transparency in terms of the lines of argumentation used in support of GI and their underlying data basis is needed to increase public and political support. One approach for accomplishing this is to introduce 'ecosystem disservices' alongside the standing practice of focusing on ecosystem services, or the potential benefits generated by a proposed project or initiative. Ecosystem disservices are a relatively young concept referring to the negative impacts of ecosystems and biodiversity to humans (von Döhren and Haase 2015) that, in this case, could potentially arise from the implementation of green infrastructure.

In urban areas, ecosystem disservices produced by green infrastructure could include the increased generation of organic waste by trees and urban fauna, obstruction to traffic infrastructure, damage to property by plant root systems, maintenance costs associated with urban vegetation, human health problems (e.g. allergies caused by street trees, vector-spread diseases from urban wetlands or air pollution) (Lyytimäki and Sipilä 2009; von Döhren and Haase 2015). Impacts may vary between individuals and groups in a city, and in different locations. In Finland, for example, urban forests have been found to provide different ecosystem services and disservices amongst demographic groups. For native Finns and certain immigrant groups, e.g. Russians, forests were perceived as relaxing places that provide recreational and cultural ecosystem services in addition to biodiversity protection and other services. For other immigrant groups such as Africans, however, forests were perceived as places of fear (Lyytimäki and Sipilä 2009), highlighting the importance of education and communication about such topics.

In presenting ecosystem services (benefits) alongside disservices (negative impacts), more informed decision-making processes can take place by policy makers and other stakeholders. Increased transparency is accomplished by presenting trade-offs and acknowledging potential unwanted effects that could arise out of planned GI developments.

²⁰ http://www.stadtentwicklung.berlin.de/umwelt/landschaftsplanung/bff/index_en.shtml

5 Conclusions

Urban areas are home to a significant amount of biodiversity in Europe and can serve to support or negatively affect individual species and species groups. For example, the number of individuals of a given bird species is often greater in cities than in rural or natural habitats, while the degree of species richness (i.e. the number of different species represented in the environment) is lower in city centres than on the peripheries.

Many species that are common to and thrive in urban areas are classified as generalists, meaning that they have the ability to survive in a variety of environmental conditions and live off of a wide range of resources, such as the house sparrow, rock dove and annual meadow grass. While cities harbour important habitats for native common and rare species as well as many non-native species, they also pose a number of threats to biodiversity. Characteristics such as a species' degree of mobility and ability to survive in a range of environmental conditions and utilize diverse resources play a determining role in terms of their status within urban settings and largely dictate how capable they are of surviving urbanisation pressures. The most prevalent pressures facing urban biodiversity within Europe include urban development and sprawl, various forms of pollution, climate change and its associated impacts, a high prevalence of non-native and invasive species, and a poor integration of biodiversity concerns within existing policy frameworks.

As urban populations continue to expand, both the ecological as well as the educational and socio-cultural importance of urban areas for biodiversity will also grow as these areas serve as the primary contact with nature for an increasing share of the population. Green infrastructure has been shown to be an efficient way to protect urban biodiversity and achieve multiple benefits for city populations, as illustrated in the case studies profiled in this study. Successful conservation and utilization of GI is, however, not without its challenges and comes with a range of human and system-induced barriers. The explored case studies offer a range of lessons and approaches which can potentially be applied to overcome these challenges in urban contexts across Europe, such as urban gardening and community stewardship as well as selecting and combining appropriate planning policy instruments at the local or national level. More generally, it is also necessary to 'mainstream' biodiversity and conservation priorities across policy sectors in order to reduce the implementation gap in biodiversity policy targets and reduce potential damages arising from policy silos or fragmented interventions.

Biodiversity monitoring and data availability on urban biodiversity at the European level has considerably improved over the last two decades, among other things due to Member State reporting requirements and European scientific cooperation. Notably, the recently published State of Nature in the EU report based on Member State reporting under the EU Nature Directives represents the most comprehensive assessment of biodiversity ever conducted in the EU. Moreover, attention to the issue of urban biodiversity, as well as the importance of biodiversity monitoring at the local level has increased, at least in part driven by efforts in the run up to COP 10 of the Convention Biological Diversity (CBD) in Nagoya.

Nonetheless, data monitoring of biodiversity specifically focused on the urban environment remains inadequate to the challenges ahead. The study clearly reveals that there is a need for more targeted and systematic data gathering and monitoring both at a European and a project level. While some cities already perform considerable monitoring of biodiversity in the urban context, little of this data is comparable or harmonized. In particular, data is limited that is specifically focused on urban biodiversity trends over time.

The existence of adequate indicators and clear frameworks for data collection and reporting which can be implemented harmoniously across Europe and the globe are central to filling these gaps. Existing research and policy initiatives (e.g. the City Biodiversity Index and the European Capital of Biodiversity Award, which used an adapted version of the CBI) are still far from delivering wide-scale data that can be used in an EU policy or planning context. It is thus necessary to make better use

of existing data, including employing previously tested methodologies, such as the use of Natura 2000, Urban Atlas and UMZ data (see Annex), as well as apply the data more widely. Both, Natura 2000 data as well as Article 12 and 17 reporting data, could, for example, be used to better analyze pressures and threats reported by Member States in urban environments.

Biodiversity data must also be more effectively integrated with other efforts at environmental monitoring in cities. For example, the European Topic Centre on Urban, Land and Soil systems (ETC-ULS; formerly ETC/Spatial Information and Analysis)²¹ has been working on a new city typology that is based on an integrated analysis of around 60 indicators and parameters, attempting to take into account the huge diversity of cities in order to support the assessment of urban sustainability. However, as of now the typology does not directly include biodiversity data as such data does not exist in a harmonized way on a European scale for almost 400 cities. Therefore, proxies have been used that are on the one hand more directed towards urban green infrastructure, and on the other hand often derived from land use/cover data (such as CORINE Land Cover or Urban Atlas). This leads to an over-representation of such land use/cover and also socio-economic data, while direct biodiversity data are lacking. By consequence, integrating urban biodiversity data into these and other efforts (such as the dedicated ETC-ULS-led task on the development of an urban GI related typology) will be essential to ensuring that biodiversity concerns are reflected in future assessments of urban sustainability.

Green infrastructure planning processes can contribute to addressing the aforementioned gaps by utilizing developed sets of standardized indicators to obtain baseline data in a scoping study or in the early stages of implementation. Projects should also planning for regular data collection processes throughout subsequent project stages to enable the tracking of trends in a given location over time and help to more directly correlate specific GI measures or actions with changes in biodiversity and other ecological aspects. Several approaches have been highlighted which can improve monitoring capacities and complement existing data collection processes and data sets, such as citizen observatories. The existence of robust, reliable data combined with public participation in GI management and common guidance in data collection has the potential to increase both public acceptance and political support for GI and therewith contribute to more effective biodiversity conservation within urban areas.

²¹ See ETC SIA (2014), Draft Final Report I1.0, Task 183_3 City typology

6 Annex: Data sets on urban biodiversity

The following section provides a brief overview of some of the efforts to improve data collection and assessment of urban biodiversity, as well as some of the existing data sources (other than Article 12 and 17 reporting data) that could be relevant for future urban biodiversity assessment.

6.1 City Biodiversity Index

The City Biodiversity Index (CBI) (aka. Singapore City Biodiversity Index or Singapore Index) is “a self-assessment tool for cities to monitor and evaluate their biodiversity conservation efforts in an urban context²²,” and the most ambitious attempt to develop a common framework for urban biodiversity monitoring. The CBI was proposed on the initiative of Minister Mah Bow Tan of Singapore in the context of the World Cities Summit in June 2008 and subsequently developed by expert workshops in 2009 and 2010, before featuring prominently in the Plan of Action of Subnational Governments, Cities and Other Local Authorities for Biodiversity adopted at COP 10 of the Convention on Biological Diversity in Nagoya²³ as a potential tool for monitoring urban biodiversity.

The first expert workshop defined the objective of developing the CBI as to²⁴:

1. Serve as a self-assessment tool;
2. Assist national governments and local authorities in benchmarking biodiversity conservation efforts in the urban context at the city level;
3. Help evaluate progress in reducing the rate of biodiversity loss in urban ecosystems;
4. Help measure the ecological footprint of cities,
5. Serve as material for the development of guidelines for the preparation of a cities and biodiversity plan of action,
6. Make cities aware of important gaps in information about their biodiversity.

The CBI comprises two main parts²⁵:

- (i) A profile of the city
- (ii) Indicators to be evaluated by the city and the calculation of the index

In the **profile of the city**, the city lists background information relevant to biodiversity conservation as supplementary information to the data captured in the indicators, including: location and size, climate, rainfall/precipitation, physical features of the city, demographics, economic parameters, biodiversity features, administration of biodiversity, and links to relevant websites. Subsequently, a

²² “Singapore Index on Cities’ Biodiversity”, presentation by Dr. Lena Chan at the World Cities Summit 2012, available at http://www.worldcitysummit.com.sg/sites/sites2.globalsignin.com.2.wcs-2014/files/Dr_Lena_Chan.pdf, accessed on 15. July 2015.

Or <https://www.nparks.gov.sg/biodiversity/the-singapore-index-on-cities-biodiversity>

²³ COP 10 Decision X/22. Plan of Action on Subnational Governments, Cities and Other Local Authorities for Biodiversity, available at <https://www.cbd.int/decision/cop/?id=12288#cop-10-dec-22-fn58>.

²⁴ Convention on Biological Diversity 2009, ‘Report on the First Expert Workshop on the Development of the City Biodiversity Index’ in the First Expert Workshop on the Development of the City Biodiversity Index, Singapore City, February 10-12, viewed 22 September 2010, < <http://www.cbd.int/doc/meetings/city/ewdcbi-01/official/ewdcbi-01-03-en.pdf>>

²⁵ CBD 2012, USER’S MANUAL FOR THE CITY BIODIVERSITY INDEX, <https://www.cbd.int/authorities/doc/User's%20Manual-for-the-City-Biodiversity-Index18April2012.pdf>

total of **23 indicators** across three component areas (Native Biodiversity, Ecosystem Services, and Governance and Management) are evaluated covering a range of physical, biological, and policy-related information. Each of these indicators is given a score, which are subsequently aggregated for the **calculation of the index** out of a maximum of 92 points. The framework of the indicator section of the CBI can be seen below.

Table 6.1 Framework of the Singapore Index on Cities' Biodiversity²⁶

	Core components	Indicators	Maximum score
PART II - Indicators	Native Biodiversity in the City	1. Proportion of Natural Areas in the City	4 points
		2. Connectivity Measures	4 points
		3. Native Biodiversity in Built Up Areas (Bird Species)	4 points
		4. Change in Number of Vascular Plant Species	4 points
		5. Change in Number of Bird Species	4 points
		6. Change in Number of Butterfly Species	4 points
		7. Change in Number of Species (any other taxonomic group selected by the city)	4 points
		8. Change in Number of Species (any other taxonomic group selected by the city)	4 points
		9. Proportion of Protected Natural Areas	4 points
		10. Proportion of Invasive Alien Species	4 points
	Ecosystem Services provided by Biodiversity	11. Regulation of Quantity of Water	4 points
		12. Climate Regulation: Carbon Storage and Cooling Effect of Vegetation	4 points
		13. Recreation and Education: Area of Parks with Natural Areas	4 points
		14. Recreation and Education: Number of Formal Education Visits per Child Below 16 Years to Parks with Natural Areas per Year	4 points
	Governance and Management of Biodiversity	15. Budget Allocated to Biodiversity	4 points
		16. Number of Biodiversity Projects Implemented by the City Annually	4 points
		17. Existence of Local Biodiversity Strategy and Action Plan	4 points
		18. Institutional Capacity: Number of Biodiversity Related Functions	4 points
		19. Institutional Capacity: Number of City or Local Government Agencies Involved in Inter-agency Cooperation Pertaining to Biodiversity Matters	4 points
		20. Participation and Partnership: Existence of Formal or Informal Public Consultation Process 4	4 points
		21. Participation and Partnership: Number of Agencies/Private Companies/NGOs/Academic Institutions/International Organisations with which the City is Partnering in Biodiversity Activities, Projects and Programmes	4 points
		22. Education and Awareness: Is Biodiversity or Nature Awareness Included in the School Curriculum	4 points
		23. Education and Awareness: Number of Outreach or Public Awareness Events Held in the City per Year	4 points
	Native Biodiversity in the City (Sub-total for indicators 1-10)		40 points
	Ecosystem Services provided by Biodiversity (Sub-total for indicators 11-14)		16 points
	Governance and Management of Biodiversity (Sub-total for indicators 15-23)		36 points
	Maximum Total:		92 points

²⁶ CBD 2014, Users manual on the Singapore Index on Cities' Biodiversity, <https://www.cbd.int/doc/meetings/city/subws-2014-01/other/subws-2014-01-singapore-index-manual-en.pdf>

In evaluating the usefulness of using the index, the user's manual highlights three main benefits that have proven themselves in practice²⁷:

- As a tool to create baseline measurements of current biodiversity and monitor its development over time
- As a public platform to launch public awareness measures
- As a portal among relevant policy-makers and stakeholders to achieve better policy outcomes

Currently space4environment in cooperation with Concordia University conduct a project commissioned by the European Space Agency (ESA) to create data sets for specific CBI indicators based on satellite imaging. These indicators include: Proportion of natural areas in city (indicator 1), Connectivity measures or ecological networks to counter fragmentation (indicator 2), Regulation of quantity of water (indicator 11) and Climate regulation: carbon storage and cooling effect of water (indicator 12). Once completed, the data provided by this project will facilitate the Europe-wide implementation of these four CBI-indicators.²⁸

6.2 Natura 2000 Data

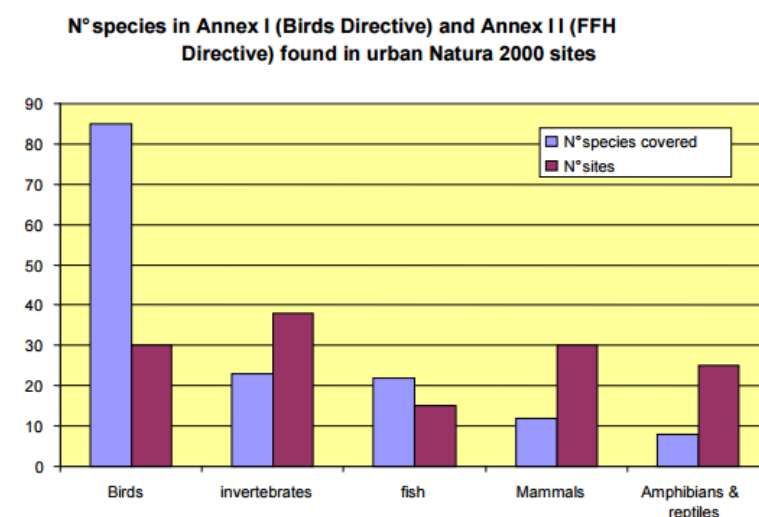
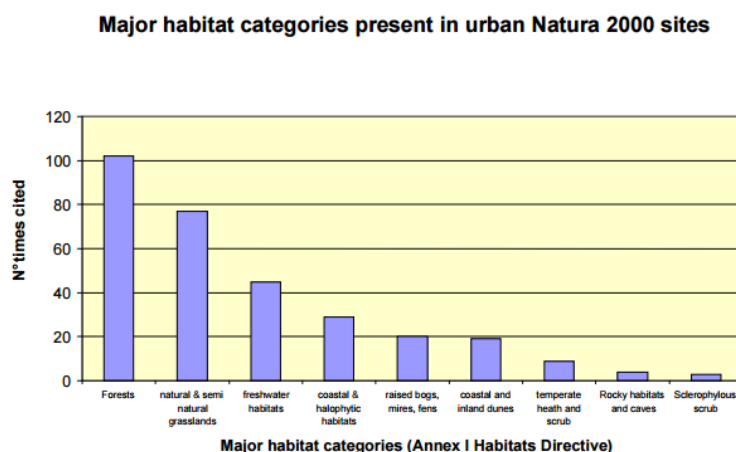
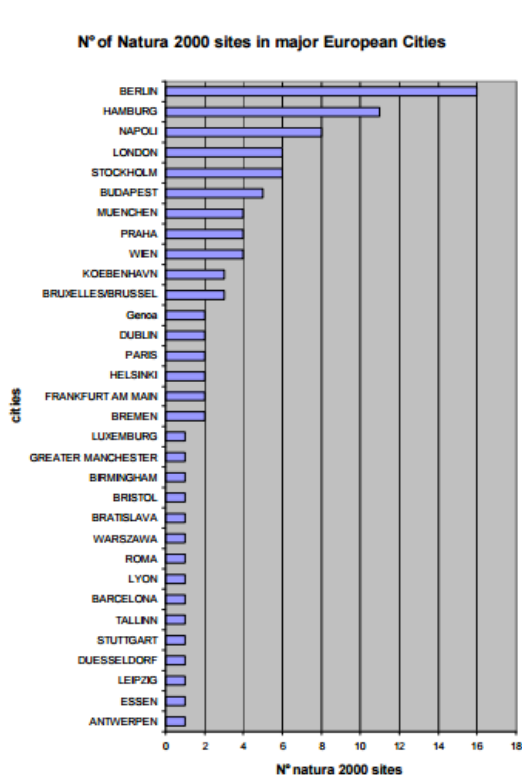
In 2006, a study commissioned by the city of Brussels - Biodiversity and Natura 2000 in urban areas: A review of issues and experiences of nature in cities across Europe for the Brussels Capital Region²⁹ – was published, which addressed the issue of urban biodiversity using data under EU Nature Directive reporting. To assess the status of the urban Natura 2000 network (N2K) the study looked at all N2K sites found in cities having 500,000 or more inhabitants, as well as all (then EU-25) capital cities. This threshold was chosen to make the data set manageable, as well as relevant and comparable to the Brussels region. Only N2K sites where the estimated urban area overlapped with that of the N2K sites were assessed. However, some discretion was required to assess whether the N2K areas were correctly placed in the urban area or were simply close by. Therefore, the authors recommend a certain level of caution in interpreting the data.

The assessment found that 97 N2K sites existed in 32 major cities in Europe, including 16 capital cities. The largest number of N2K sites in any individual city were found in Berlin (15), whereas the largest N2K area in an urban area was found in Copenhagen. Moreover, the study found that while some cities had N2K site with large areas, most were 150 ha or less. Further statistics about habitats, non-bird species and bird species are also included (see figures below).

²⁷ CBD 2014, Users manual on the Singapore Index on Cities' Biodiversity, <https://www.cbd.int/doc/meetings/city/subws-2014-01/other/subws-2014-01-singapore-index-manual-en.pdf>

²⁸ See http://space4environment.com/fileadmin/user_upload/files/pdf/EO4CBI_brochure.pdf for more detail on the project

²⁹ Sundseth, Kerstin and Geert Raeymaekers, 2006, Biodiversity and Natura 2000 in urban areas: A review of issues and experiences of nature in cities across Europe for the Brussels Capital Region, Bruxelles Environnement-IBGE/Leefmilieu Brussel-BIM.



The use of this methodology to assess urban habitats and species on the basis of N2K data is similar to that of linking Article 12 and 17 reporting data with the MAES typology in the sense that it uses EU Nature Directives data. An important distinction, however, is that the study uses N2K data and the focus of the assessment is on N2K sites instead of individual species and habitat assessments. Moreover, the assessment only takes into account N2K sites which are geographically situated at least partially within cities above a certain population level. However, this assessment could be relatively easily repeated and expanded to include a relatively robust assessment of other data included in the N2K database, such as management status and impact, or expand the analysis through a lower population threshold.

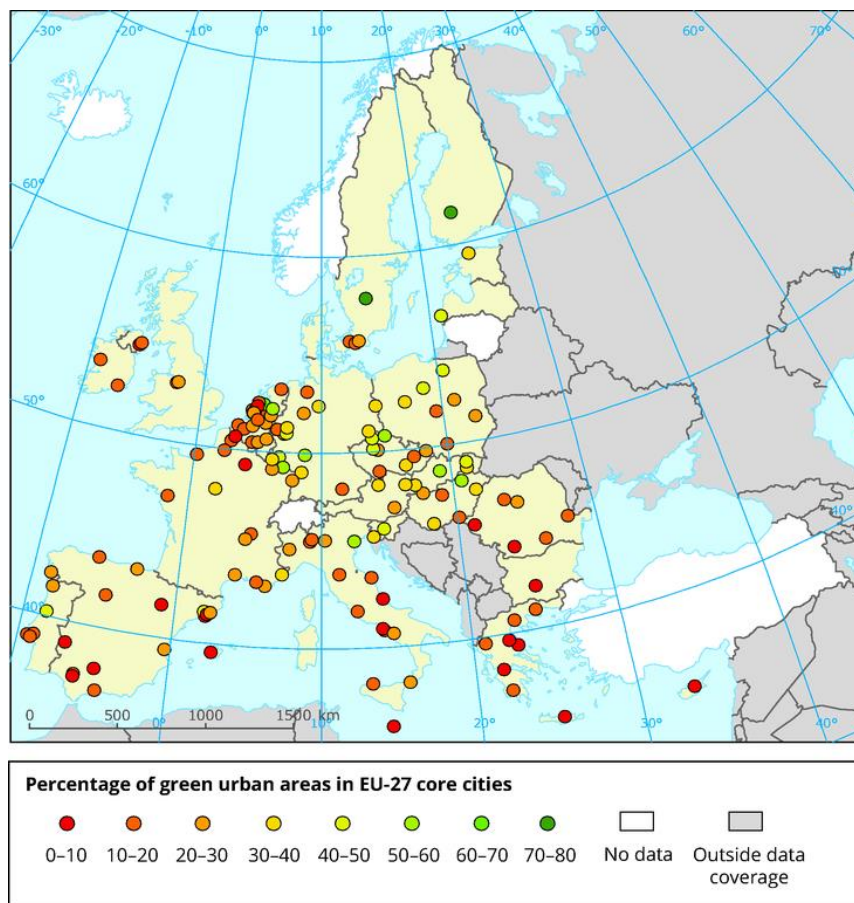
6.3 EEA and Eurostat Data

While neither the EEA nor Eurostat offer datasets or indicators specifically focussed on urban biodiversity, a number of indicators and maps are available that do provide relevant data for the urban context, in particular related to land-use.

6.3.1 The European Urban Atlas

The map below provides information on the percentage of urban areas in select core cities are classified as “green”. The map is based on data from the European Urban Atlas ³⁰, which provides land use maps for 305 Large Urban Zones (defined as more than 100,000 inhabitants) and their surroundings for the reference year 2006. The classes 141 (Green Urban Areas), 142 (Sports and Leisure Facilities), 300 (Forest) and 500 (Water) were extracted for core cities and summed up to a new class named Green Urban area. Next the percentage of Urban Green area compared to the total area was calculated of each core city yet available within the Urban Atlas database. This map provides important information on urban land use and greenery.

Map 6.1 Percentage of green urban areas in EU-27 core cities



Source: <http://www.eea.europa.eu/data-and-maps/figures/percentage-of-green-urban-areas-1>

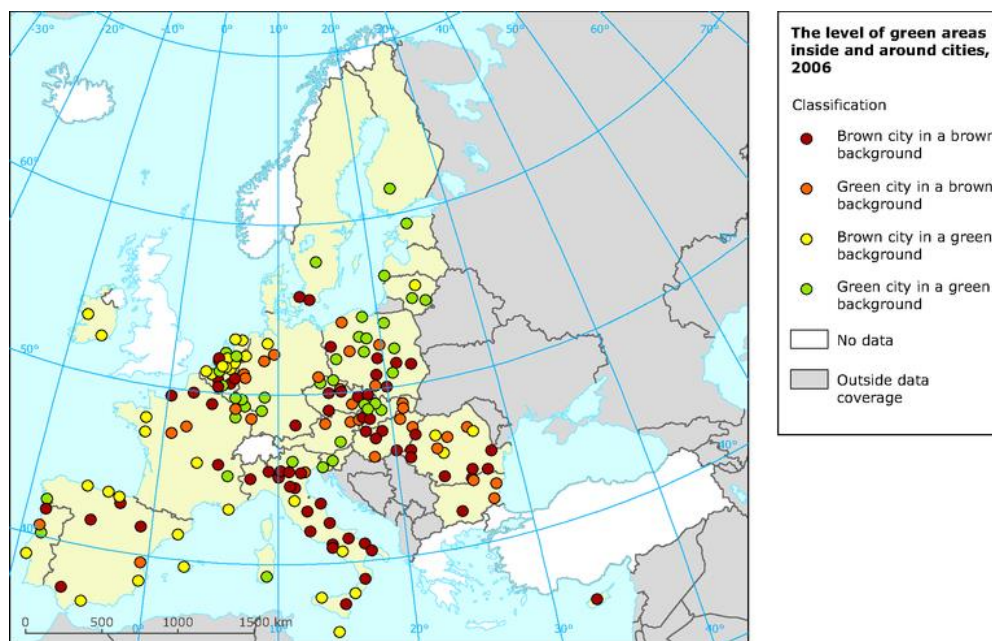
6.3.2 CORINE Land Cover and Urban Morphological Zones

This map has a similar focus to the previous one before, but is based on data on Urban Morphological Zones (UMZ) from 2006³¹ instead of the European Urban Atlas. The UMZ is a reclassification of the CORINE Land Cover 2006 data and includes ports, airports, sport facilities, roads, railways, rivers and forest and scrub classes fully within an urban area. The map shows the relation of green urban areas to its background. More specifically, it compares the mean value of green background of the city surroundings with the mean values of green urban areas of the core cities.

³⁰ <http://www.eea.europa.eu/data-and-maps/data/urban-atlas>

³¹ <http://www.eea.europa.eu/data-and-maps/data/urban-morphological-zones-2006#tab-metadata>

Map 6.2 The level of green areas inside and around cities, 2006



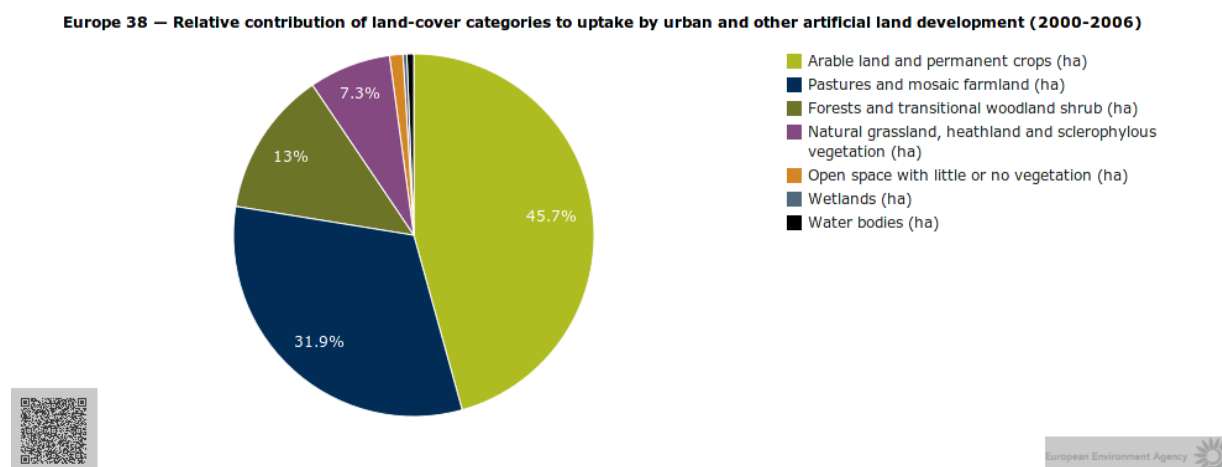
Source: <http://www.eea.europa.eu/data-and-maps/figures/the-level-of-green-areas>

The CORINE Land Cover inventory which was initiated in 1985 and has been updated in 2000, 2006 and 2012 (in production) is more generally a useful source of land use data. The inventory consists of data on land cover in 44 classes, including a change layer between inventory periods with a Minimum Mapping Unit (MMU) of 5 ha³². This data has been very effectively used to map land use change at the EU level, for example:

- Relative contribution of land-cover categories to uptake by urban and other artificial land development
- Annual land take by types of human activity (2000-2006)

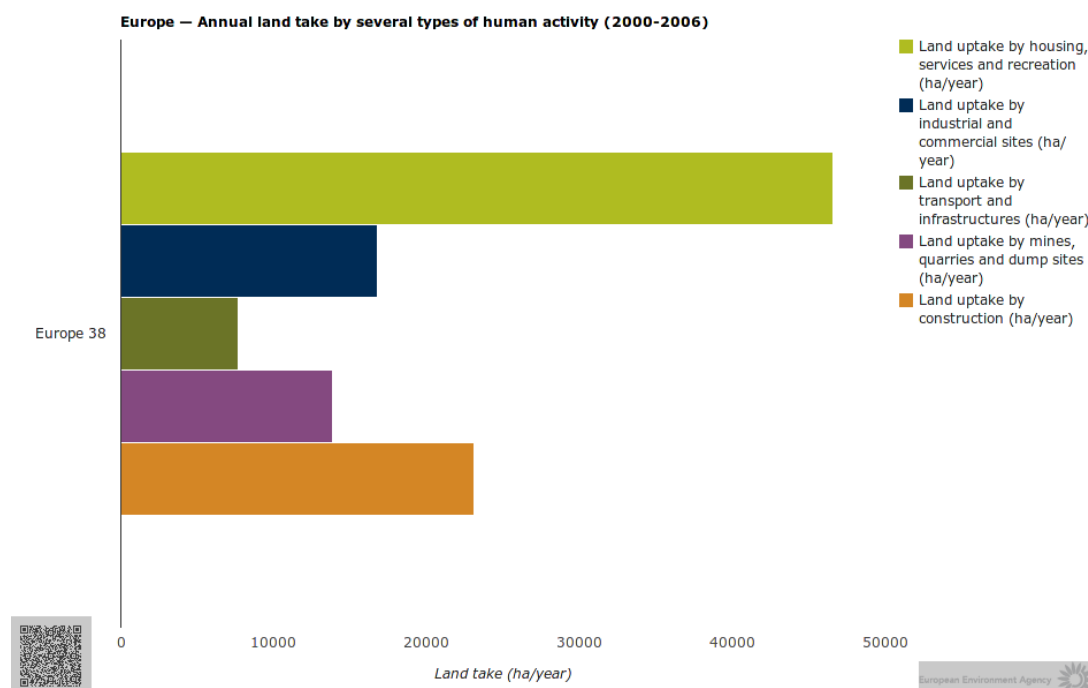
³² <http://land.copernicus.eu/pan-european/corine-land-cover/view>

Figure 6.1 Relative contribution of land-cover categories to uptake by urban and other artificial land development



Source: http://www.eea.europa.eu/data-and-maps/daviz/relative-contribution-of-land-cover#tab-chart_1

Figure 6.2 Annual land take by several types of human activity (2000-2006)



Source: http://www.eea.europa.eu/data-and-maps/daviz/annual-land-take-by-several#tab-chart_1

6.3.3 LUCAS – Land use and land cover survey

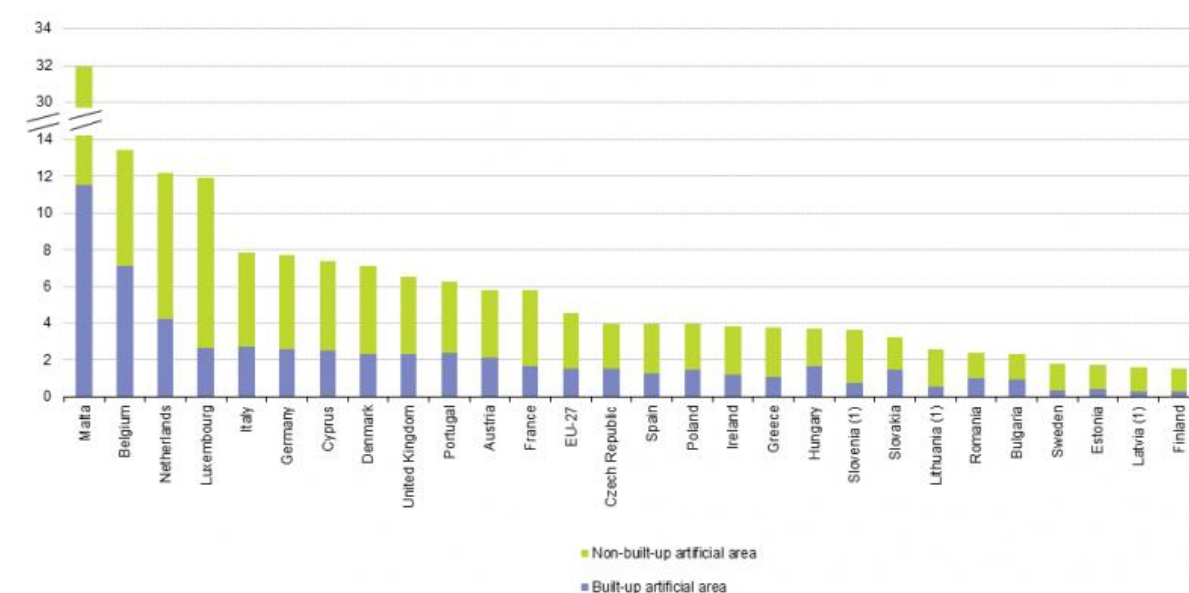
LUCAS³³ is a survey that provides harmonised and comparable statistics on land use and land cover across the whole of the EU's territory. The first survey was held in 2001, while updates were conducted in 2006, 2009 and 2012. The survey is based on interpretation of photos as well as field

³³ http://ec.europa.eu/eurostat/statistics-explained/index.php/LUCAS_-_Land_use_and_land_cover_survey

samples. Due to the continual updating the survey, LUCAS results can also be used to assess land-use changes between the surveys. One of the land cover classes included in the LUCAS survey is that of Artificial Land, which includes the sub-categories *built-up areas* and *artificial non built-up areas*. Built-up areas are areas covered with buildings and greenhouses whereas non built-up areas include streets and sealed surfaces³⁴. This class does not distinguish between urban and non-urban environments.

The LUCAS survey has been used in a variety of different contexts and policy areas ranging from agriculture & rural development, climate change to resource efficiency. For example, data on built-up areas has been chosen as a Sustainable Development Indicator (SDI) as it provides insights into resource efficiency related to land-use. However, it has not been extensively used to reflect land-use change in the urban environment.

Figure 6.3 Artificial land cover, 2012 (% share of total area)



(†) Built-up area: unreliable; Croatia: not available.
Source: Eurostat (online data code: lan_lcv_art)

Source:

[http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Artificial land cover, 2012 \(%25 share of total area\) LUCAS2012.png](http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Artificial_land_cover,_2012_(%25_share_of_total_area)_LUCAS2012.png)

³⁴ <http://ec.europa.eu/eurostat/en/web/products-datasets/-/TSDNR510>

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