

Urban Biodiversity and the Case for Implementing the Convention on Biological Diversity in Towns and Cities

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Summary

Climate change, loss of biodiversity and the growth of an increasingly urban world population are main challenges of this century. With two-thirds of a considerably larger world population predicted to be living in urban areas by 2050, we argue that urban biodiversity, that means the biodiversity within towns and cities, will play an important role by holding the global loss of biodiversity. As a consequence, the Convention on Biological Diversity (CBD) must promote the engagement of cities and local authorities in future.

In the first part of this chapter, the efforts of the CBD towards urban biodiversity are analysed from their foundation in 1992 until now.

In the second part, the current knowledge of urban ecosystems and their biodiversity is summed up and the importance of urban biodiversity for global biodiversity is highlighted.

In the third part, challenges for the future of urban biodiversity are presented. These challenges were addressed to the partners of the CBD during the International Conference 'Urban biodiversity and design – implementing the Convention on Biological Diversity in towns and cities' held in Erfurt in May 2008.

Keywords

biodiversity, cities, convention on biological diversity, design, urban ecosystems

Background – the world goes urban

The year 2007 was a historical turning point in the development of the world population, for it was at that time that more than half of the world's human population had come to live in urban settlements. The prediction is that by 2050, more than two-thirds of a considerably larger world population will be living in urban areas; see Figure 1.1.

Land-use changes represent the main factor in the loss of biodiversity on the local, regional and global scales. Both agriculture and urbanization are quoted as the primary driving forces that result in changes to the vegetation (and therefore of plant and animal species). Some scientists consider urbanization to be the sole cause of the threat to global biodiversity (Czech *et al.*, 2000). That is especially true if agriculture is not considered to be an independent sector but as a supplier of food for the predominantly urban population. This is linked to the question of whether, from a global viewpoint, cities should be described and evaluated primarily in terms of the 2% of the world's surface that they cover or of the 75% of resources that they consume and the 80% of greenhouse gases that they produce (CBD, 2007). These are relevant issues when considering the ecological footprint of cities, which is likely to expand rapidly as the result of the increasing number and income of the world's human population.

In recent years, several scientists have discovered that increasing urbanization results in a large proportion of existing plant species in urban areas being replaced by a small number of widespread and aggressive species. This process of a few winners and many losers is termed *biotic homogenization* (McKinney, 2006; Olden *et al.*, 2006). In some regions of the world, most of the invasive species are non-native, which were first introduced into cities where they got established and naturalized, and spread. Thus, cities were the principal starting points from where many of these aggressive species spread.

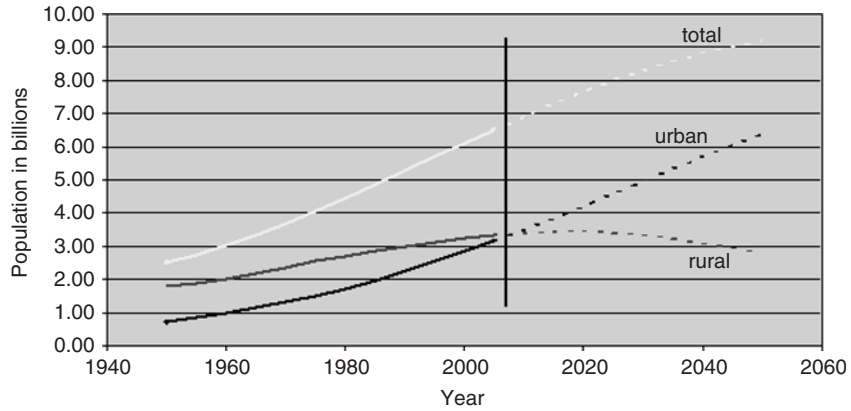


Figure 1.1 Development of world population (based on data of UN; <http://esa.un.org/unup>; last accessed 18 February 2008).

Another important issue that must be considered is that in the future, most of the urban population growth will mainly occur in the fast-developing countries in South America, Africa and Asia that have a very high biodiversity (= global biodiversity ‘hot spots’; see Figure 1.2).

Consideration of these main challenges for life on earth indicates that changes in the climate and biodiversity will drive the planning, design and

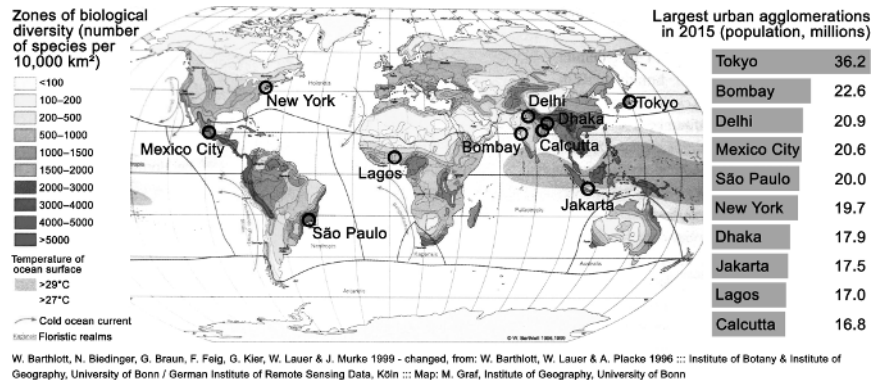


Figure 1.2 Hot spots of global biodiversity and the 10 largest urban agglomerations in 2015 (map amended from Barthlott *et al.*, 1999).

management of existing and future urban development, or to sum up in the words of the Executive Secretary of the Convention on Biological Diversity (CBD) in Curitiba 2007 'The battle for life on earth will be won or lost in urban areas' (CBD, 2007). To include sustainability by the design of cities, urban agglomerations and mega cities will be therefore a major task to solve global environmental, economic and social problems (e.g. Töpfer, 2007).

Whilst cities pose major challenges for the protection of biodiversity, the opportunities they offer have received little consideration in the global debate about biodiversity, at least so far. In principle, there are two complementary ways for cities to play their part in meeting the CBD target of stopping biodiversity loss, namely

- the sustainable use of ecosystem goods and services for and within cities;
- the conservation of biodiversity within towns and cities and the sustainable design of all urban areas to maximize their ability to support biodiversity.

This chapter will give an introduction to the second target which was also the focus of the International Conference 'Urban Biodiversity and Design – Implementing the Convention on Biological Diversity in towns and cities' held from 21 to 24 May 2008 in Erfurt, Germany.

Firstly, we will give a short summary in the so far unsuccessful efforts to add the item 'biodiversity and cities' on the agenda of the Convention on Biological Diversity.

Secondly, we will present an overview of the scientific view of urban ecosystems and will highlight the importance of urban biodiversity for global biodiversity.

Finally, the challenges and opportunities for the future of urban biodiversity are summarized, as a recommendation of the above-mentioned conference.

History of urban biodiversity within the Convention on Biological Diversity

The Conventions on Biological Diversity and Climate Change were concluded in Rio de Janeiro on 5 June 1992 and has been ratified by 191 nations. They are the most important international environmental conventions of the late 20th and early 21st centuries.

The aims of the CBD are as follows (UN, 1992):

- The conservation of biological diversity; maintaining the earth's life support systems and future options for human development
- The sustainable use of its components, that means providing livelihoods to people, without jeopardizing future options
- The fair and equitable sharing of the benefits arising from the use of genetic resources

The impact of urbanization on biodiversity and other natural resources was considered by the CBD in 1992 and has been discussed at the subsequent nine 'Conferences of the Parties'. Whilst cities pose major challenges to the protection of biodiversity, the opportunities they offer have received little consideration, at least until now. An exception was the sixth Conference of the Parties (COP 6) in The Hague in 2002, when it was recommended that part of the COP 9 should focus on the issue 'Biodiversity of urban & suburban areas'. However, during the seventh COP in Kuala Lumpur in 2004, the topic was postponed indefinitely.

Cities are centres of economic, financial, social and political power, as well as of culture and innovation. They are also the places where most people have the most contact with nature. In this sense, cities are not only the problem but also the solution to the global challenges such as the CBD target of stopping biodiversity loss by 2010. A major step towards recognizing the potential of cities for increasing biodiversity was made in Curitiba in March 2007, when 34 mayors and many of their senior officials from cities across four continents initiated a global partnership to promote 'cities and biodiversity' with the objective of encouraging local authorities to implement the CBD. The 'Curitiba Declaration', adopted at the meeting reaffirmed the urgency that is needed to achieve the CBD objectives in urban areas and to engage local authorities for the 'Battle of life on Earth.' Particular emphasis was placed on raising public awareness and educating future generations, as well as on disseminating best practices and lessons learned through cooperation between cities. In order to provide a forum for the exchange of knowledge and experiences, the Declaration also recommended the establishment of a 'clearing house' mechanism within the Secretariat of the CBD. The participants mandated a steering committee, comprising mayors from each of the four continents to take the lead in engaging local authorities in the implementation

of the CBD and to participate in the municipal pre-conference of the ninth meeting of the COP that was held in May 2008 in Bonn (SCBD, 2007).

At the COP 9 in Bonn, Germany in May 2008, the parties discussed the role of local authorities in the implementation of the CBD and for the first time, adopted a decision on cities and biodiversity (Decision IX/28). This decision encourages the 191 parties to the Convention to recognize the role of cities in national strategies and plans, and invites the Parties to support and assist cities in implementing the Convention at the local level. Indeed, one of the greatest achievements of the ninth meeting of the COP is the recognition that the implementation of the three objectives of the CBD requires the full engagement of cities and local authorities. A plan of action on cities and biodiversity will be submitted at the 10th meeting of the COP, to be held in Japan, in October 2010, the International Year of Biodiversity. A Nagoya summit on 'Cities and Biodiversity' will be convened during the meeting. This important decision was based on two events that occurred during the ninth COP meeting in 2008, namely

- the International Conference on 'Urban Biodiversity & Design' in Erfurt, uniquely brought together almost 400 scientists and practitioners from 40 countries. Ecologists, planners, designers and managers discussed how to implement the CBD in towns in cities. At the end of the conference, they united in issuing the 'Erfurt Declaration' and promised to support the CBD initiative through their network 'URBIO' and further meetings on the subject (for example Urbio 2010, which will be held in Japan in 2010);
- the 'Mayor's Conference on Local Action for Biodiversity' was held on 26–27 May 2008 in Bonn, where over 50 mayors and other senior local government officials discussed strategies, activities and experiences relating to 'Biodiversity and the Urban Space' and adopted the 'Bonn Call for Action'.

Characteristics of urban ecosystems

Alterations to local climate, soil, water and biodiversity

An urban area can be defined by applying the following criteria (Sukopp & Wittig, 1998; Pickett *et al.*, 2001).

1. Human population larger than 20,000 and with a population density (in the central area) greater than 500 persons/km²

2. Configuration of buildings, technical infrastructure and open spaces, whereby the extent of hard surface (including buildings, paving and other structures) covers an average of approximately 40–50% of the land surface and well in excess of 60% in the core areas
3. In temperate and boreal zones, formation of an urban heat island with longer periods of plant growth, warmer summers and milder winters than the surrounding countryside
4. Modification of the water soil-moisture regimes, tending to become drier in temperate zones, but with opposite effects in desert areas due to irrigation
5. High levels of nutrient input – point source and broad-scale
6. High productivity, especially in areas such as parks, gardens, allotments and similar intensively cultivated or managed areas, together with intentionally and unintentionally elevated food availability for animals – wild and domesticated
7. Soil contamination, air and water pollution, particularly in relation to soil organisms, lichens and aquatic species
8. Disturbance such as trampling, mowing, radical soil change, noise and litter or fly-tipping
9. Fragmentation of open spaces, especially green spaces, including semi-natural areas
10. High proportion of introduced species
11. Large number of euryoecious and common species

The variations of the criteria can be used as measures of the degree of urbanization. In Figure 1.3, the effects of urbanization on local climate, soils, water and biodiversity are summarized and visualized with respect to the urbanization gradient.

Alterations to biodiversity within the rural-to-urban gradient

It is well known that there is a gradient of increasing human impact from the rural fringe of a city to its centre, and hence an increasing intensity of the attributes mentioned above (Figure 1.3). In general, there is a reduction in species-richness from the urban fringe to the centre, with the species-richness of some groups (e.g. angiosperms and birds) peaking at the urban fringe (McKinney, 2008 and Figure 1.4). The species-richness of the urban

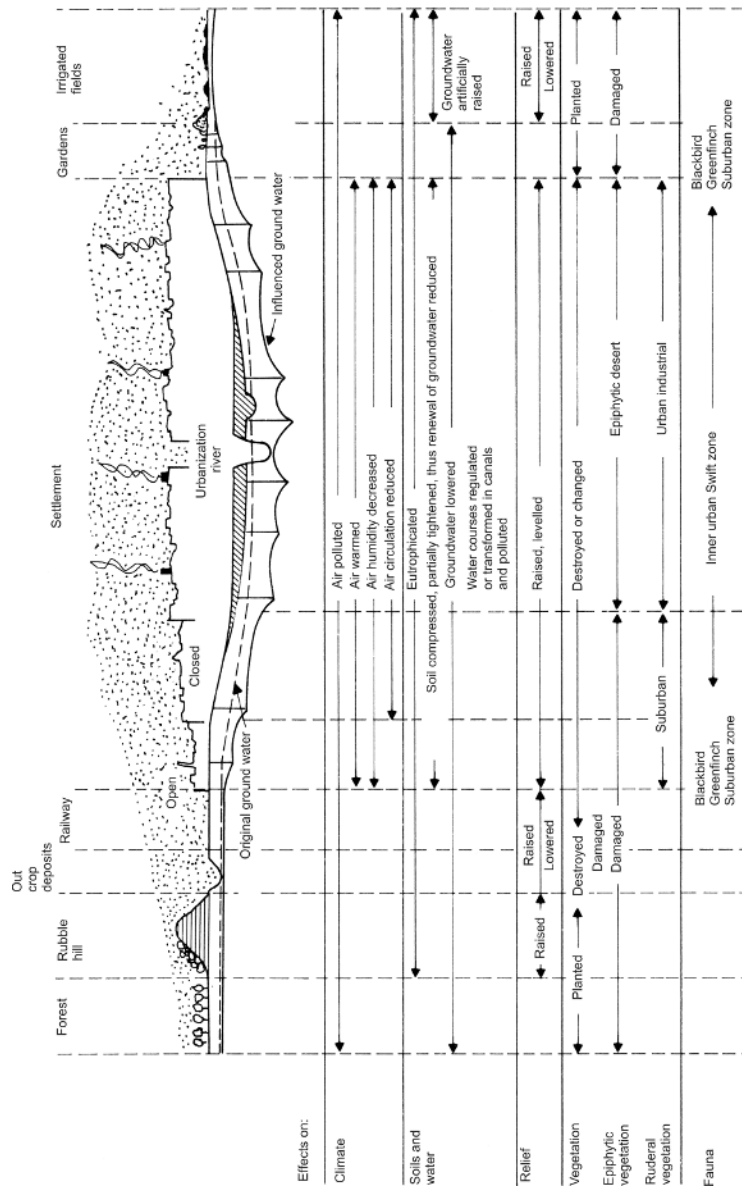


Figure 1.3 Variations in the biosphere of urban areas (from Sukopp, 1973, last updated 1982).

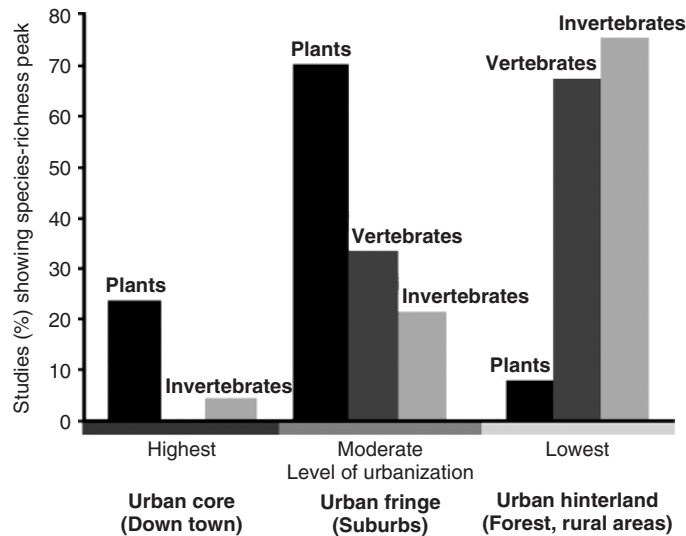


Figure 1.4 Studies showing species richness along the urban–rural gradient with peak in the urban fringe (from McKinney, 2008, modified).

fringe results from the area being particularly heterogeneous and subject to intermediate levels of human disturbance (Zerbe *et al.*, 2003). It is clear that there is a strong correlation between the greatest human impact in the central core and the reduction of species-richness.

In Central European cities, the number of vascular plant species decreases from more than 400 species per km² at the urban fringe to less than 50 species per km² in the city centre (Landolt, 2000; Godefroid, 2001). Worldwide, the increasing presence and frequency of few generalist birds are reported, for example in temperate and Mediterranean regions, most of the species are granivores or omnivores as well as cavity-nesting species that breed in buildings (Adams, 2005) whilst in tropical zones there can be a shift to the benefit of seed-eating (granivores) and fruit-eating (frugivores) species (Lim & Sodhi, 2004). The proportion of native to non-native plant species also changes along the gradient, with the number of non-native species increasing towards the centre (Zerbe *et al.*, 2003; Hahs & McDonnell, 2007). This is different to bird species; in inner urban areas of European and American cities, the majority of species are native however, non-natives have much higher population densities (Marzluff *et al.*, 2001; Kelcey & Rheinwald, 2005).

Centres of immigration and adaptation

There are many examples describing how animals and plants (especially birds and angiosperms) have migrated from their natural habitats to newly created urban habitats (e.g. Gliwicz *et al.*, 1994).

High food supply (including feeding by people), a large variety of new ecological niches and the lack of predators may be some of the main reasons why animals migrate from natural or rural areas to cities. Many species have migrated from their original natural habitats (especially rocks and cliffs) to urban centres. For example, in European cities the dominant breeding species include Rock Dove (*Columba livia domestica*), Collared Dove (*Streptopelia decaocto*), House Sparrow (*Passer domesticus*), Blackbird (*Turdus merula*), Starling (*Sturnus vulgaris*) and Black Redstart (*Phoenicurus ochruros*). Other species also breed in urban areas but feed (at least partially) outside it, for example Common Swift (*Apus apus*), Kestrel (*Falco tinnunculus*) and Eurasian Jackdaw (*Corvus monedula*) (Kelcey & Rheinwald, 2005).

Wild Rock Doves started to be domesticated at least 3000–4000 years ago. During that time, selective breeding was undertaken to improve the birds for different purposes, for example meat, sending messages, performance, decoration or orientation. This resulted in the species undergoing changes in phenotype and behaviour (Kelcey & Rheinwald, 2005). Domesticated Rock Doves (*C. livia domestica*) were released or escaped from captivity and have become naturalized in cities all over the world. In city centres, the biomass of feral pigeons (*C. livia domestica*) is higher than in natural habitats (Nuorteva, 1971).

Plants that have changed from their natural habitats to urban habitats are called ‘apophytes’. A recent overview of the origin of the urban flora of Central Europe (Wittig, 2004) described the natural habitats from which some urban species originated. (nomenclature of plants according GCW, 2007) Examples are as given below.

- River banks, floodplains, woodlands and swamps: *Aegopodium podagraria*, *Calystegia sepium*, *Galium aparine*
- Periodically flooded, nutrient-enriched mud, sand and gravel surfaces of inland waters: *Bidens tripartita*, *Plantago major*, *Potentilla reptans*
- Strand lines, dunes and coastal rocks: *Elymus repens*, *Sonchus arvensis*
- Areas of wind throw, clearings: *Cirsium arvense*, *Cirsium vulgare*

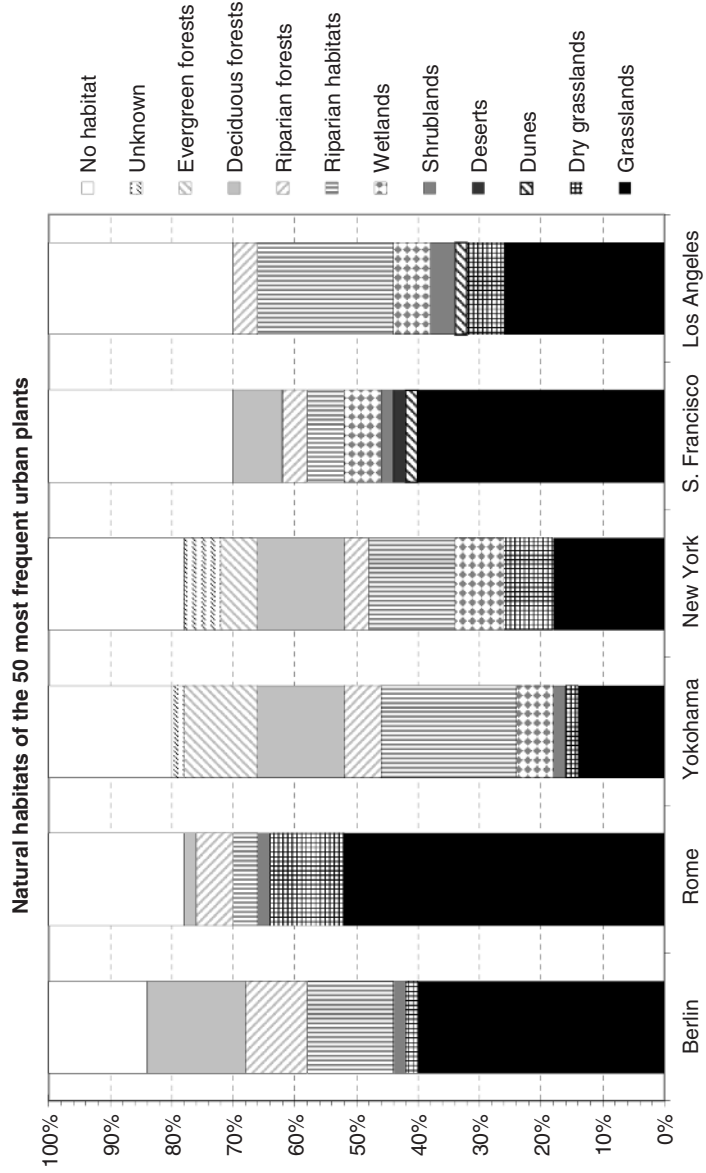


Figure 1.5 Natural habitats of the 50 most frequent plants in six large cities of the Northern Hemisphere (from Müller, 2005a, slightly altered).

- Scree and rubble: *Chaenorinum minus*, *Sedum acre*, *Tussilago farfara*
- Rocks: *Asplenium ruta-muraria*, *Asplenium trichomanes*, *Sedum album*

A recent study of the most common plants in six large cities of the northern hemisphere (Müller, 2005a) has shown that many of the most frequently occurring species in cities are species of natural grasslands and riparian habitats; see Figure 1.5. Some species (called anecophytes) probably even evolved in urban areas under the influence of humans and, therefore, have no natural habitat (see section *Urban areas as centres of evolution* in this chapter).

Biological characteristics of the plant species that are restricted to urban conditions include annual or biennial life form, large seed production, high genetic variability and phenotypic plasticity. Animals adapted to urban areas are mobile, generalists, often omnivores and have a smaller body size (especially invertebrates). Plants and animals that are restricted to urban areas have been named urbanophile (Wittig *et al.*, 1985). Species that are well adapted to, thrive, occupy a wide range of conditions and are common in urban areas have been also named *urban exploiters* (Blair, 2001).

Centres of importation, naturalization and exportation of non-native species

Cities are important centres for the importation and naturalization of non-native species (e.g. Gilbert, 1989; Klausnitzer, 1993). Regarding plants, deliberate introductions for horticulture, forestry and landscaping purposes play the major role while unintended introductions in goods are of less importance (e.g. Mack & Erneberg, 2002; Martin & Stabler, 2004; Wittig, 2004; Krausch, 2005; Dehnen-Schmutz *et al.*, 2007).

According to the 'Catalogue Hortus Belvedereanus 1820', even in the 17th century, Goethe had established 7900 native and non-native plant species in his Botanical Garden in Weimar, Germany. It is estimated that since the Neolithic period, 12,000 species have been introduced into Central Europe for ornamental and cultural purposes, and approximately 2–3% of those plants have become naturalized (Lohmeyer & Sukopp, 1992 and 2002). There is a very strong correlation between the expansion of an urban area and the number of naturalized, non-native plant species it contains. In Berlin, it was shown (Figure 1.6) that due to the rapid population growth between the

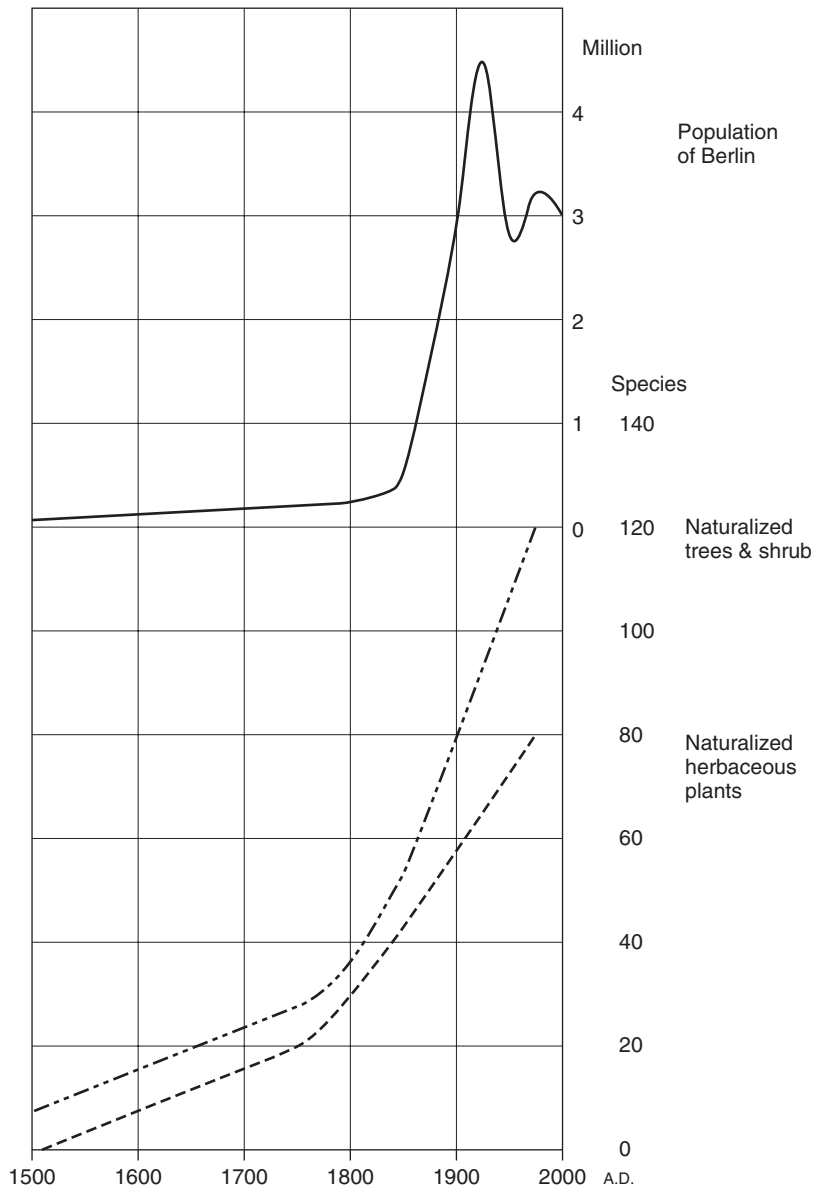


Figure 1.6 Correlation between human population growth and naturalized plants in Berlin (from Sukopp & Wurzel, 2003).

19th and 20th centuries, the number of naturalized species (trees, shrubs and herbaceous plants) increased significantly (Sukopp & Wurzel, 2003).

Urbanization is regarded as the main cause of ‘biotic homogenization’ (McKinney, 2006); it results from the deliberate planting of a relatively small number of non-native species and cultivars in gardens and landscape schemes associated with development (Reichard & White, 2001; Sullivan *et al.*, 2005) that spreads as invasive species into the surroundings. There are many examples of species that were imported for horticultural or landscape purposes and which have become naturalized in other areas; they include Tree of Heaven (*Ailanthus altissima*) from China, Black Locust (*Robinia pseudoacacia*) from North America and Waterhyacinth (*Eichhornia crassipes*) from South America. Recently, Lippe and Kowarik (2007) demonstrated that traffic is an important factor for the dispersal of non-native plant species to the surrounding landscape.

Accidentally or deliberately introduced animal species may also become naturalized in cities. In the early 1850s, House Sparrows (*P. domesticus*) from England were imported to the major cities of the eastern United States to control the infestation of trees by drop worms (*Geometridae*) (Garber, 1987). The birds adapted successfully and by the mid-1870s, they had become a serious problem in that part of the United States. As a consequence, a vigorous debate began as to their value or harm – a debate that often exceeded the bounds of scientific discourse. This debate became famous as ‘The English Sparrow War’ (Fine & Christoforides, 1991).

In relation to the introduction of the North American Raccoon (*Procyon lotor*) into Germany in 1934, Hohmann *et al.* (2002) state:

The North American Raccoon (*P. lotor*) had been introduced into Germany in 1934 and in forested areas of some German Federal States racoons became an established species reaching densities of more than 1 individual per 100 ha. However, much higher densities are recorded for urban areas. According to investigations in parts of the city Bad Karlshafen (in Northern Hesse) densities of approx. 100 individuals per 100 ha are estimated, a number which can be considered as normal for urban habitats in America. Racoons have become numerous in other German cities, too, and the common features of all these cities are that they are located in valleys and are surrounded by forests. Racoons can transfer diseases to humans (e.g. roundworms) and can cause damage in houses.

The distribution of pavement ants (*Tetramorium caespitum* L.) in North America, is another example of an animal species that has naturalized

successfully. About 200 years ago, the pavement ant was introduced to the United States and is now among the most abundant ant species in urban and highly developed suburban areas along the Atlantic Coast, occurring from Canada to Florida. It is believed that *T. caespitum* was brought from Europe to North America in colonial times in the soil that was used as ballast in merchant vessels. When the ships arrived at the ports in North America, they would empty the soil and replace it with raw and manufactured goods to take back to Europe (King & Green, 1995).

Parrots such as the Ring-Necked Parakeet (*Psittacula krameri*) – a secondary cavity nester and a native species of Africa and Asia – were introduced into Europe and United States as pets. Many escaped and, during the last few decades, they have established successful breeding colonies in several cities throughout Europe and the United States. In the decades before the end of the 19th century, when the first parakeets were introduced to Britain, until the middle of the 20th century, the populations always disappeared after a short time in European cities due to frost damage. Parakeets have now started to spread in the rural areas where farmers consider them to be a serious local pest because of the damage they cause to crops and stored grain. Feral species of parrots also adversely affect native cavity nesting of species such as Mynas, Hoopoes, Rollers and Owlets (Butler, 2005; Strubbe & Matthysen, 2007).

Urban areas as centres of evolution

It is assumed that during the several thousand years since the first permanent human settlements, many plant species have evolved as the result of human influence and natural processes including isolation, hybridization and introgression (Wittig, 2004). These species have no natural habitat and are, in general, strongly restricted to anthropogenic habitats. Plants falling into this category are called anecophytes or obligatory weeds (Scholz, 1991; Sukopp & Scholz, 1997). Weeds which mainly evolved in European cities and have a worldwide distribution today in cities (Müller, 2005a) include: Shepherd's Purse (*Capsella bursa-pastoris*), Lambsquarters (*Chenopodium album*), Bermudagrass (*Cynodon dactylon*), Mouse Barley (*Hordeum murinum*), Common Plantain (*P. major*), Annual Bluegrass (*Poa annua*), Prostrate Knotweed (*Polygonum aviculare* agg.), Common Groundsel (*Senecio vulgaris*), Common Chickweed (*Stellaria media*), Common Dandelion (*Taraxacum officinale* agg.).

The evolutionary processes have been observed in cities with increasing frequency during recent times, mainly as the consequence of the introduction of non-native species. Sukopp *et al.* (1979) have given as an example, the Evening Primrose (*Oenothera* agg.) in Europe. In the 1980s, more than 15 species had been identified in Europe; with two exceptions, they were not identical with the North American plants from which they are descended. These new European taxa have evolved since their American parent species were introduced into Europe about 350 years ago. Their main occurrence in cities is on artificial soils, for example, along railway land and urban waste grounds (Tokhtari & Wittig, 2001). In a similar way, the Michaelmas Daisies (*Aster novi-angliae*, *Aster novi-belgii*, *Aster lanceolatus*, *Aster laevis* and hybrids), introduced from North America, in British cities appear to be becoming increasingly variable, both morphologically and in their ecological amplitude, which suggests that new taxa may be evolving (Gilbert, 1989). In the former mining area in Ruhr in Germany, numerous new *Populus* taxa were recognized as the result of hybridization between native and non-native taxa (Keil & Loos, 2005).

Several new taxa originate from plant breeding and selection in the horticultural, agricultural and forestry industries, for example the development of numerous grass cultivars, such as Perennial Ryegrass (*Lolium perenne*), Red Fescue (*Festuca rubra*) and Kentucky Bluegrass (*Poa pratensis*) for lawns, sports turf and cattle pasture. It is the modern extension of similar plant selection that has existed for millennia in relation to the improvement of plants for food, fibre (for clothing), animal fodder and other purposes.

Zoologists are increasingly discovering the importance of urban areas as evolutionary laboratories. For example, Johnston and Selander (1964) found that the House Sparrows (*P. domesticus*) introduced into the United States in 1879, evolved into new races within 50 years.

In general, the evolution of new taxa in cities can result from

- domestication and cultivation of useful animals or plants in former times and their later escape and establishment in the wild (e.g. Doves, Parsnip (*Pastinaca sativa*));
- unintentional selection resulting from the special conditions or treatments that occur in urban areas (e.g. impact of herbicides, air pollution);
- hybridization between native and non-native species from the same genus (e.g. *Populus* spp.) respectively, providing opportunities for hybridization that would not otherwise occur;

- accelerated speciation as a result of the dispersal of a number of individuals to a new location, the 'founder effect' (e.g. genus *Oenothera*).

Complex hot spots and melting pots for regional biodiversity

There is general agreement that cities are characterized by high species richness in terms of vascular plants and most animal groups. This is the result of the high beta-diversity (Niemelä, 1999) that means the large variety of habitats present and the variation in vertical and habitat structure, the considerable variation in the types and intensities of land use, the range of materials used and the huge array of micro-habitats, and the most varied habitat mosaic configurations (Crooks *et al.*, 2004; McKinney, 2006; Sukopp, 2006; Reichholf, 2007). The large number of vascular plants results from summing the number of native and non-native species. In many cases, the decline in the number of native species caused by development is compensated for by the introduction of non-native species. Nevertheless, it is remarkable that despite these declines, the number of native species in cities, especially in cities of the northern hemisphere, is relatively high. Studies across many taxonomic groups have shown that 50% and more of the regional or even national species assemblage are to be found in cities. For instance, more than 50% of the flora of Belgium can be found in Brussels (Godefroid, 2001), in Rome, about half of the bird species occurring in the surrounding landscape are also found in the city itself (Cignini & Zapparoli, 2005), and 50% of vertebrates and 65% of birds of Poland occur in Warsaw (Luniak, 2008). However, in some regions of the world like New Zealand, the non-native species are dominant in urban areas. For example, from the total of 317 vascular plant species found in Christchurch biotopes, only 48 are native (Ignatieva *et al.*, 2000).

Ricketts and Imhoff (2003) found a strong positive correlation at the regional level between species richness and the degree of urbanization. The early settlements from which European cities have evolved, tend to have been established in regions that are naturally highly heterogeneous in terms of landscape, so that they have, from the outset, a relatively high level of species richness (Kühn *et al.*, 2004). This does not necessarily apply to all cities and to all parts of the world, but it is likely to hold true in principle. The correlation between landscape heterogeneity and settlement development can be explained by the fact that the locations of human settlement have the following ecological characteristics: favourable climate,

productivity, location at junctions of habitat types, relatively constant natural development (catastrophic events are not unduly frequent).

The location of existing or proposed urban developments in regional 'hot spots' of biodiversity gives rise to a special responsibility for the conservation of biological diversity. In these 'hot spots', rare species are particularly threatened by urbanization (Kühn *et al.*, 2004). In the case of plants, species numbers are high in cities, but the number of threatened and rare species is also high.

An analysis of large-scale floristic mapping exercises and the relationship between cities and species richness shows an interesting 'phenomenon', namely, that cities with academic institutions appear to be particularly species-rich. In simple terms, this is because they have been better studied (Moraczewski & Sudnik-Wójcikowska, 2007). The same 'phenomenon' has been referred to by Barthlott *et al.* (1999) in their description of the development of global biodiversity.

In addition, most cities contain sites of special importance for nature conservation with respect to protection of threatened species and habitats. Many are 'pristine' remnants of native vegetation that often survived because topography, soil and other characteristics are unsuitable for housing, commercial or infrastructure development. Other sites are retained and protected because of ownership or their use and management has remained unchanged for decades (sometimes centuries) or they are important sites of cultural heritage or have remained unused for a long time. Many of these sites contain rare species (both spontaneous and cultivated) or contain species-rich habitats.

Remarkable examples of pristine remnants include in Rio de Janeiro (Brazil), the remnant forests of the Mata Atlantica; in Singapore, the evergreen forests of the Botanical Garden; in Caracas (Venezuela), the National Park El Avila with its rock faces; in Perth metropolitan area, Sydney and Brisbane (all in Australia), various remnants of bushland; remnants of natural forests in York (Canada) or Portland (United States); the Ridge Forest in New Delhi (India); rock faces and outcrops in Edinburgh (Scotland) (Heywood, 1996; City of Edinburgh, 2000; Miller & Hobbs, 2002). Examples of cultural sites with a long use and management and with special nature conservation interest are: the archaeological sites in Rome (Italy); the Royal Parks in London (England); semi-natural forests in the precincts of temples or shrines in various Japanese cities; the 90-year-old Meiji Jingu artificial forest in the heart of Tokyo (Japan); and in Berlin (Germany), the

urban wastelands with Black Locust forests (Japan News, 2005; Royal Parks Foundation, 2008).

The importance of urban biodiversity

Is distinctive

The unique physical and ecological conditions, the mixed and small-scale habitat mosaic, the mixing of native plant and animal species with a large number of non-native species, and the various influences of people results in habitat types and plant and animal associations or communities in urban areas that are significantly different from other landscapes and land uses (e.g. Pysek, 1998; Sukopp & Wittig, 1998; Kelcey & Rheinwald, 2005). There are habitats and biocoenoses existing only in urban areas like the ruderal flora and fauna of urban wastelands and land awaiting redevelopment, which some scientists consider to be the 'real urban flora and fauna' (Wittig, 2002). In addition, some plant and animal species only occur in urban areas, for example the Black Redstart (*P. ochruros*) in Britain, where it only breeds on buildings. Finally, it is remarkable that the populations of some bird species increase in urban areas while the populations are decreasing outside the cities. Bird censuses in Germany in recent years have shown that the urban populations of the Magpie (*Pica pica*) and other common species are increasing (Schwarz & Flade, 2000). This demonstrates that the numbers of some species, particularly the so-called generalists, are expanding in urban areas and therefore the process of synurbanization is increasing (Luniak, 2004). In contrast, the numbers of some urban specialists (mainly species nesting on buildings) are decreasing in many Central European cities, for example House Sparrow (*P. domesticus*) and House Martin (*Delichon urbica*).

According to studies on beetles (Niemelä *et al.*, 2002), there are three distinct characteristics of urban animal communities along urbanization gradients: (i) species richness decreases from rural areas towards urban centres; (ii) generalist species become dominant and one or a few species dominate in cities and (iii) specialist species of the rural habitats (e.g. forests) decrease in cities.

All these aspects and examples are a clear indication that the biological diversity in urban areas is a special case within the CBD, which requires additional consideration and attention.

Reflecting human culture

In Europe, human beings have had a long and continuing influence on biodiversity. An important benchmark was the Neolithic period (often referred to as the *Agricultural Revolution*), when humans began to create permanent settlements and started to cultivate plants and domesticate animals (Millard, 2010). With the introduction of crops from Asia, many weeds were transported unintentionally and got naturalized (archaeophytes) in the new man-made habitats such as meadows, pastures and arable land. These activities resulted in the evolution of new taxa as the result of plant selection, new biological processes and hybridization (anecophytes). In addition, several taxa exchanged their original natural habitat and immigrated into rural and urban habitats (apophytes). This human influence resulted in a continuously increasing biodiversity in Europe. By discovering the New World in the 15th century, some of the biogeographical barriers were broken; the introduction of neophytes continued from that time until today.

Regarding the different eras of park and garden design each mirrors the perception and valuation of nature or the lifestyle and vogues of an era and of their people. In Europe for example the parks of the English landscape garden style can be habitats for very specific ensembles of native, cultivated and naturalized species and can sometimes harbour really rare and unusual species. In some cases urban parks can be even refuges for endangered semi-natural habitats and species (e.g. Kümmerling & Müller, 2008).

Contributing to the quality of life in an increasing global society

Green spaces are an important part of quality of life in a city. They offer valuable and much appreciated opportunities for exercise, social interaction, relaxation and peace (Tzoulas *et al.*, 2007). A better greening of urban areas does not only bring about better quality of life for the residents, it also promotes species richness. The proportion of native and rare species is positively correlated with the degree of greening (Kinzig *et al.*, 2005). The role of biodiversity is, however, less well known and is often overlooked by the residents of cities, even though the value of biodiversity in cities extends well beyond its influence on the quality of life (Sundseth & Raeymaekers, 2006). Ecological services like climate improvement and carbon fixing, absorption of pollutants, groundwater enrichment, soil quality, and nitrogen household

improvement does not only depend on the quantum and proportion of green space but also on the composition of the biocoenoses.

Many people in cities enjoy song birds and colourful butterflies. For example, they erect nest boxes to attract birds to breed and feed; in inner urban areas, the density of boxes is higher than in the suburbs (Kinzig *et al.*, 2005). People spend a lot of money on bird food, especially during the winter. This indicates that a growing number of the urban population wish to experience nature around them. It is for this reason that in Britain, intensity of bird feeding was selected as an indicator for biodiversity (Fuller *et al.*, 2008) because it combines ecological, social and economical dimensions.

In residential areas, both lower income levels and lower real estate prices are significantly negatively correlated with the area and quality of public and private green space (Hope *et al.*, 2003; McConnachie *et al.*, 2008). This leads to the situation that in lower income areas, only half the number of species can be found than in the areas of higher income; this has been clearly demonstrated by studies of the public green spaces of Santiago de Chile and Rio de Janeiro in relation to trees, and in Phoenix (Arizona) in relation to birds (De la Maza *et al.*, 2002; Kinzig *et al.*, 2005; McConnachie *et al.*, 2008). It has been noted that the number of native species is reduced in the areas of lower income.

The only biodiversity that many people experience

People's awareness of environmental issues is influenced crucially by their experiences of nature in their everyday surroundings (Savard *et al.*, 2000). For these reasons, it is essential that efforts to conserve biological diversity devote greater attention to urban areas (Miller & Hobbs, 2002).

For the residents of cities (especially the lower income), the countryside and wildlife can seem far off, remote and rather alienated from their daily lives. Their first encounters (especially of children) with nature tend to be in an urban environment. Here, nature is 'up close and personal' rather than distant or remote. This, in turn, creates many opportunities for people to learn about, and appreciate, wildlife (Sundseth & Raeymaekers, 2006). An adult's attitude to the environment and time spent in a green space is strongly influenced by his or her experience as a child. Children who spend time in woodland without parental supervision are the most likely to visit and enjoy woodland as an adult. The critical age of influence appears to be before 12 years. Before this age, contact with nature in all its forms but in particular 'wild' nature,

appears to strongly influence a positive behaviour towards the environment (Bird, 2007).

The objective is to obtain a positive attitude towards nature conservation via the direct experience of the natural world. The interaction with urban nature, especially in densely built-up areas, is mainly an interaction with dominant or non-native species. The feeding of feral pigeons or mallards is an important interaction of children and adults with urban nature that consolidates emotional relations with nature, but these are species which are also viewed as pests. That means we need the pigeons and we fight against the pigeon at the same time (Dunn *et al.*, 2006).

Because more than half of the world population lives in cities, their support for the objectives of nature conservation is essential to save and maintain global biodiversity.

Challenges for the future of urban biodiversity – the Erfurt Declaration Urbio 2008

Several recent scientific papers have highlighted the importance of urban biodiversity for global biodiversity and how important it will be to implement the CBD in towns, cities and urban agglomerations (e.g. Müller, 2005b). In this context, the main challenges and opportunities for the future are as follows:

- Raising greater public awareness of the importance of urban biodiversity, (e.g. Dunn *et al.*, 2006)
- Integration of biodiversity into existing and proposed urban development, (e.g. Savard *et al.*, 2000)
- Incorporating urban ecology with urban planning and design, (e.g. Niemelä, 1999; Ahern *et al.*, 2006; Ignatieva *et al.*, 2008; Pickett & Cadenasso, 2008)
- Fostering research and education into urban biodiversity and design (e.g. Dettmar & Werner, 2007)

Regarding the working program of the CBD the establishing of a new cross cutting issue will be necessary to support the above mentioned challenges.

Therefore, the participants of the International Conference 'Urban Biodiversity & Design – Implementing the CBD in urban areas' addressed the

‘Erfurt Declaration’ in May 2008 to the participants of the ninth COP (COP 9) in Bonn as follows:

- A. *Preamble:* The increasing urban population, climate change and loss of biodiversity are all strongly connected. With two-thirds of a considerably larger world population predicted to be living in urban areas by 2050, the ‘Battle for life on Earth’ will be lost or won in urban regions.

The role of urbanization in the loss and degradation of global biodiversity was acknowledged in the local Agenda 21 processes and in the CBD in 1992, and has been discussed in the subsequent eight Conferences of the Parties. Whilst cities pose major challenges for protecting biodiversity, the opportunities they offer have, so far, been understated.

A major step towards recognizing the potential of cities for biodiversity was made in Curitiba (Brazil) in March 2007, when a global partnership in ‘Cities and Biodiversity’ was initiated by 34 mayors and numerous high-level officials from cities across all continents in order to engage local authorities to protect and sustain their unique contribution to global biodiversity.

From the 21st to 24th May 2008 in Erfurt (Germany), 400 scientists, planners and other practitioners from around 50 countries summarized for the first time in a global context the current scientific and practical approaches of implementing the CBD in urban areas. This declaration reflects the views of the participants at the ‘Urbio 2008’ conference that urban biodiversity is a vital part of achieving the aims of the CBD.

- B. *The importance of urban biodiversity:* Urban biodiversity is the variety and richness of life, including genetic, species and habitat diversity found in and around towns and cities.

The ‘Urbio 2008’ conference discussed the current state of knowledge and practice in ‘urban biodiversity’. The contributions at the conference demonstrated clearly the range of different approaches necessary to understand the importance and function of urban biodiversity and to bring these into local practice. The approaches are as follows:

- Investigation and evaluation of biodiversity in urban areas
- Cultural aspects of urban biodiversity

- Social aspects of urban biodiversity
- Urban biodiversity and climate change
- Design, planning and future of urban biodiversity

Towns and cities are both important experimental areas and fields of experience in the interrelationship between humans and nature.

The case for urban biodiversity in relation to the aims of the CBD is compelling:

- Urban ecosystems have their own distinctive characteristics.
- Urban areas are centres of evolution and adaptation.
- Urban areas are complex hot spots and melting pots for regional biodiversity.
- Urban biodiversity can contribute significantly to the quality of life in an increasingly urban global society.
- Urban biodiversity is the only biodiversity that many people directly experience.

Experiencing urban biodiversity will be the key to halt the loss of global biodiversity, because people are more likely to take action for biodiversity if they have direct contact with nature. The task of considering urban biodiversity is urgent as it is facing serious threat due to increasing human population in cities which results in higher user pressure on existing green areas and the expansion of residential areas and infrastructure.

C. *Challenges for the future:* Halting the global loss of biodiversity and ensuring all our cities are green, pleasant and prosperous places requires

- raising greater public awareness of biodiversity in urban areas;
- fostering interdisciplinary long-term research into urban biodiversity for a better understanding of the interactions between humans, urban biodiversity and global biodiversity;
- linking research on climate change and urban biodiversity;
- intensifying dialogues and establishing a bridging mechanism between researchers, planners, policymakers and citizens to improve the integration of research findings into urban design;
- fostering education in urban biodiversity and design.

Initiating new programmes of activities concerning 'Cities and Biodiversity' within the CBD would provide the mechanism needed to tackle these challenges.

To address these issues, the following tasks and responsibilities are required:

- Scientific associations, networks and working groups should support international research networks on the importance of biodiversity in the urban context and its influence at regional and global scales.
- National and international institutions should support research and its translation into best practice for urban biodiversity and design.
- National governments and agencies for nature conservation should establish coordinating mechanisms. These should obtain, coordinate and monitor local and regional information concerning biodiversity and urbanization.
- Local authorities should link urban biodiversity with sustainable urban design.

As a community of urban biodiversity professionals, we will especially support further CBD initiatives on ‘Cities and Biodiversity’ through

- sharing our knowledge and commitment through this conference and in the future;
- establishing a global ‘URBIO’ network for education and research into urban biodiversity;
- promoting urban biodiversity through continuing dialogue with the CBD especially, linking future urban biodiversity network – ‘Urbio’ – meetings with future COP meetings.

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