

BIODIVERSITY OF THE REGIONS AND NORTH SEA

Biodiversity in the Brussels Capital Region

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1. INTRODUCTION: THE PARTICULAR STATUS OF THE REGION

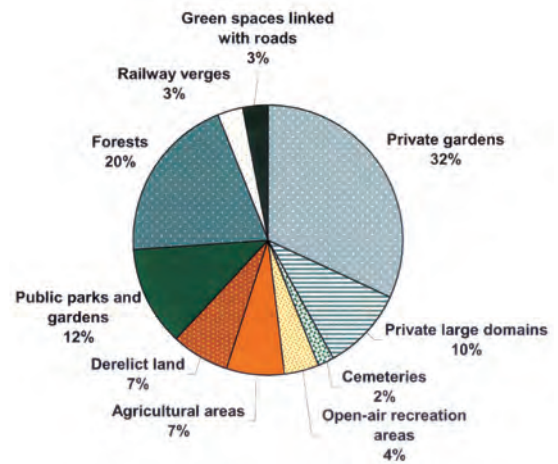
The Brussels Capital Region holds a distinctive position due to its limited area ($\pm 160 \text{ km}^2$) and its very high urbanisation level, high population density (almost 1 million inhabitants), tight infrastructure network and intense economic activity. It appears as a small, highly urbanised island embedded in the Flemish Region.

Available historical information on biological diversity within the Brussels Capital Region shows that it is among the richest areas in plant and animal species in northwestern Europe. This can be explained partly by a more important biological prospecting effort in urban areas in former times: many naturalists used to carry out their activities close to home, when transport was more difficult than nowadays. Nature is often better known in urban areas than anywhere else! It does not explain everything however. Cities did not develop at random locations but were generally situated near rivers (for water and transport), forests and rocky outcrops (for fuel and construction), arable land (for food production), etc. In this perspective, the case of Brussels is striking. The urban settlement started to take shape around 1,000 A.D. in an area with extremely varied physico-geographical characteristics: a high geomorphological diversity (asymmetric large plain valley with marshes, slopes and higher areas) and high geological diversity (clays, sands, calcareous sandstone, loamy deposits) combined with the presence of forests and arable land of good quality. Moreover, Brussels is situated in a biogeographical zone where Atlantic and medio-European biological elements meet (LEBRUN 1998). Thanks to this particular context, the flora and fauna developed a very high biological diversity, which, from the medieval period till the 20th century, was positively influenced by human activities.

During the 20th century, the rich biological heritage developed during centuries did not escape the general loss of biodiversity observed all over western Europe. Yet, contrary to popular belief, the present flora and fauna in the urban environment is anything but poor or trivial. The great variety of biotopes, both relict and newly developed (even typically urban ones), and the good contact and exchange possibilities have led to a typical urban biodiversity with its own ecosystems and its own species diversity.

An accurate perception of present biodiversity in an urban area requires a good understanding of the specific interrelation between the urban web and the remaining green open spaces. Although 1,000 years of civilisation and urbanisation have led to major changes, the region still offers a mosaic of urban landscapes. Four major zones can be identified. They are determined by the presence of water (web subregion), the city and its infrastructure

(densely urbanised subregion), forests (forest subregion) and rural relics of the periphery (rural subregion) (GRYSEELS 1998a, BRICHAU *et al.* 2000). Despite its high urbanisation degree, the Brussels Capital Region is still very green: green open areas (non built-up areas) cover 8,563 ha and account for 53% of the region's surface area. These green areas comprise the 'green spaces' and 'blue spaces', as detailed in figure 1 and below (GRYSEELS 1998a).



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Types of green spaces in % of total open and green surface area (8,563 ha) of the Brussels Capital Region (IBGE-BIM)

1.1. Green spaces

1.1.1. Private green spaces

Private greenery occupies a high proportion (42%) of the green open areas. It consists mostly of gardens and large domains not accessible to the public, and amounts to about 22% of the region's total surface area.

1.1.2. Public green spaces

Public green spaces include parks, forests and nature reserves. Public parks cover 1,044 ha and consist of classic urban parks, contemporary parks, scenic ('English landscape') parks and ecologically managed parks. Public forests amount to 1,735 ha. The main contributor is the section of the Sonian Forest located on Brussels' territory (1,642 ha)¹.

1.1.3. Green spaces linked to the railway infrastructure

These green spaces, generally inaccessible to the public, cover a surface area of 222 ha. They constitute ecological corridors as well as refuges for wild flora and fauna.

1.1.4. Derelict land

The presence of a significant amount of unmanaged land is typical of the urban environment of Brussels. Derelict areas correspond to spaces abandoned during or after industrial and urban activities, as well as relic and/or marginal farming land spontaneously colonised by vegetation. They are refuges for both relic and typically urban flora and fauna, with a mix of indigenous and exotic species. Derelict lands amount to about 613 ha and are subject to a very high urbanisation pressure.

¹ The entire Sonian Forest covers more than 4,000 ha distributed over the three Belgian regions (Brussels, Flanders and Wallonia). It is however almost completely embedded in the southern part of Brussels' agglomeration.

1.1.5. Agricultural areas

Agricultural areas under economic activity (agriculture, horticulture, poplar cultivation) cover 606 ha and are mostly situated on the periphery of the region, where they mark the region border. They often exist in combination with derelict land and are also subject to great urbanisation pressure.

1.1.6. Other green spaces

Other urban green spaces comprise graveyards, roadsides and open-air recreation areas. These typical urban areas often accommodate a surprising diversity (e.g. old graveyards).

1.2. *Blue spaces*

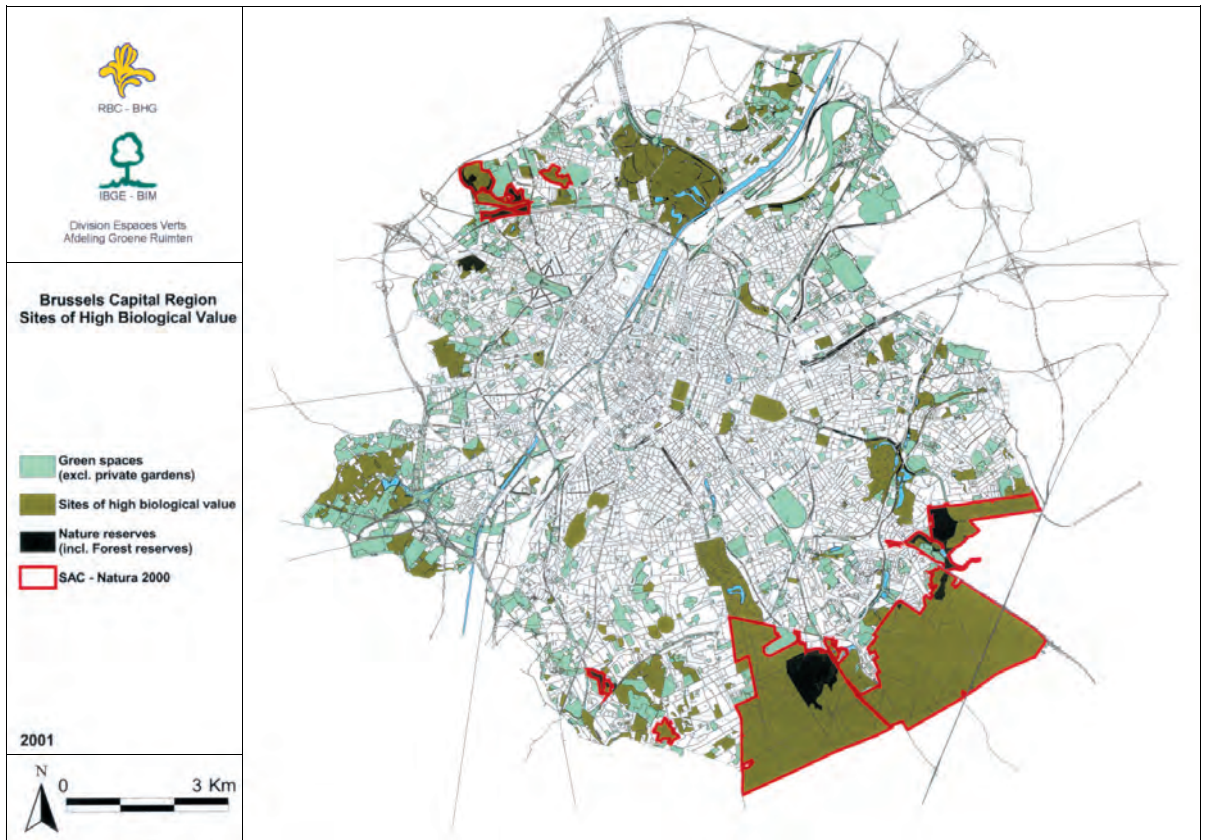
The presence of water is essential to preserve diversity. The only major open navigable waterway is the canal linking Brussels (Willebroek) to Charleroi. The most important natural waterway is the Senne, but the river and many of its tributaries have been vaulted over a large part of their course. Brussels also hosts a number of rivers, brook systems and ponds, which are often found in parks or forested areas. Ponds make up some 113 ha, and the total surface of open water reaches 172 ha.

2. ECOSYSTEMS AND AREAS OF HIGH BIOLOGICAL VALUE

The majority of Brussels' green spaces with presumed biological importance have been studied to ascertain their biological value. The evaluation was carried out within the framework of an assessment at regional and national level. The biological value of an area was attributed on the basis of the diversity in vegetation structure, vegetation maturity, rarity of communities, fauna, (semi-)natural character, and to a lesser extent the importance for indigenous wild fauna (GRYSEELS 1998a). The study revealed that not only relics of semi-natural landscapes and nature areas (marshland, forests, meadows, etc.) but also artificially created urban open spaces (derelict land) with spontaneous nature development have a 'high biological value'. Typical urban green spaces (parks and squares) are also important. Although their ecological value has been recognised for a long time, their function for nature conservation and biodiversity is still too often considered of marginal importance.

Areas with a high to very high biological value cover about 2,540 ha (figure 2). They represent about 44% of the surface area of green spaces excluding private gardens or 15% of the region's total area. This estimation includes all forested areas (1,735 ha), considered to be very valuable from a biological viewpoint. When forests are excluded from the estimation, the proportion of areas with high biological value (805 ha) represents 19% of the total surface of green spaces.

Green spaces with a high biological value are essential for the conservation and development of biodiversity in the urban environment. They are often situated at the periphery of the region (figure 2): the Sonian Forest, the Woluwe river valley with its semi-natural parks, forest relics, agricultural derelict land and wetland areas in the south-west, forest and



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Map of the Sites of High Biological Value

marshes in the north-west and the large, inaccessible Royal Domain. These areas with high biological value concern the following ecosystems:

- broad-leaved forests with typical spring flora;
- forests on limestone;
- alluvial alder and ash forests;
- semi-natural grassland;
- dry grassland on acid (heathland relic) and limy soil;
- marsh vegetation (sedge and reed vegetation);
- eutrophic ponds with marsh vegetation;
- brushwood in various colonisation stages and various environments (industrial, urban, railways or agricultural environments).

A detailed description of the ecosystems can be found in the text accompanying the Biological Evaluation Map of the Brussels Capital Region (BRICHAU *et al.* 2000).

A large share of the natural green areas is made up of woodlands. The southeast of the region is particularly rich in forested areas but sizeable woodlands can also be found in the northwest. Two types of forests, with different origins, can be differentiated. In the southeast, a large area is occupied by the Sonian Forest and its remnants (e.g. the Verrewinkel). Before the Sonian Forest was given permanent protection in 1842, these remnant areas were part of private estates and often incorporated into wealthy neighbourhoods of villas, or into large wooded parks. They comprise mainly acidophilic beech or oak



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The Laarbeekbos / Bois du Laerbeek is situated in the northwestern part of Brussels and characterised among others by wild garlic carpets in springtime (photograph by M. GRYSEELS, BIM-IBGE).

forest, in addition to oak-hornbeam stands, with spring flora. The second type of forest corresponds to the wooded areas of the northwest -Laarbeekbos / Bois du Laerbeek, Poelbos / Bois du Poelbos and Dielegembos / Bois de Dieleghem- that developed during the afforestation of former calcareous sandstone quarries. They consist of beech and oak on calcareous soil, with abundant growth of wild garlic (*Allium ursinum*) in springtime. Ash-alder woods are also frequent and are generally found in large forested areas, such as the Sonian Forest and the Kinsendael. They correspond to alluvial ash forests with springtime flora, nitrophilous alder and typical vegetation of springs.

The numerous parks (public and private) are a unique characteristic of Brussels' urban area. Many have a great ecological value. Wooded parks and estates still containing original 'ancient woodland vegetation' with spring flora are very typical. This is also the case of large landscape parks featuring ponds, old high forests, grasslands and a varied contour in a 'natural' English landscape style. These parks are ideally suited for an ecologically-oriented site management, which is nowadays being applied expressly in some of them. For example, actions are taken to stimulate the development of natural and potential features in the Woluwe river valley, in particular in flower-rich humid meadows (e.g. Woluwe Park).

Many ponds are found in parks and estates. Although they are nearly all fitted out with artificial and/or reinforced banks and may be influenced by plantations, they occasionally feature natural aquatic plants and/or riparian vegetation. Most of the ponds serve as suitable habitat for fauna, among others birds and bats. This is particularly the case of some of the large ponds in the Woluwe river valley. In addition to open water spaces in parks, there are also remnants of natural marshy zones along the numerous small rivers and brooks. These remnants correspond mainly to reed marshes and consist of often ruderalised, small-surface sedge and tall herb vegetation.

Acidophilic vegetation of dry meadows and heathland used to be widespread on the Brusselian sands. It has now become very rare following its conversion into built-up areas. A few remnants are found mainly in Uccle, on dry meadows and on roadsides. Heather (*Calluna vulgaris*) can be encountered occasionally on these roadsides and in the Sonian Forest. Mesophilic ‘flower-rich’ meadows on sandy calcareous subsoil appear locally alongside railway embankments and highways.

A few farming zones with fields on loamy soil and meadows remain in Brussels, usually on valley fringes. They are often in the hands of declining farm holdings. One of the consequences is that they are generally managed rather extensively and are frequently rich in species. Embankments, hedges and trees form still part of the landscape.

The most typical urban vegetation type in Brussels is no doubt found on derelict lands. These derelict lands may be abandoned farmlands or vegetable gardens, wasteland or former landfills in abandoned quarries (often filled in with household and other waste and covered with a thin layer of soil) where vegetation develops spontaneously. Well-known examples include the sites of the Plateau van de Vorsterie / Plateau de la Foresterie, Gulledele, Scheutbos, Josaphat and Tour & Taxis. These intrinsically ‘common’ wastelands are rapidly gaining added value, as they are the only lands where nature can develop spontaneously in the urban environment. All stages of vegetation development are represented, from herbaceous to scrub species. The larger wastelands often host a variety of habitats. This is due to the fact that they have been neglected in different periods in time and their topography has been altered by the addition of various types of soil material as well as soil shifting. This ecological multiplicity, with accompanying side effects and structural complexity, is the main reason why these sites are so rich, both in local and exotic flora and



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An important biotope of the Kinsendael is the alluvial ash-alder forest, which has been designated as a priority habitat under the Habitats Directive (photograph by M. GRYSSELS, BIM-IBGE).

fauna. The vegetation of open wastelands usually benefits from sunny conditions that lead to the production of an abundance of flowers, in particular along railway lines. This environment proves to be an invaluable refuge for insects and other invertebrates.

Apart from these semi-natural ecosystems under varying levels of human influence, several typical urban man-made habitats are also suitable for biodiversity. For example old buildings, walls or roofs serve as habitat substitutes for some species: they replace holes in rocks for swifts (*Apus apus*) or stony habitats for succulent plant species (*Sedum* sp.), they serve as shelter for house-dwelling species like bats or simply become suitable habitats for plant species with great adaptation power such as *Buddleia davidii*.

3. ACTIVITIES AND THREATS TO BIODIVERSITY

The urban nature of the Brussels Capital Region and its social-economic context create severe threats for biodiversity. High population levels and urbanisation result in a concentration of threatening activities and a high recreation pressure. Cities are also important immigration areas for alien plants and animals introduced either with or without the help of man. This results in a high pressure from invasive alien species on the native fauna and flora.

Activities and threats listed below have been compiled using the following references: IBGE-BIM (1997), GRYSEELS & ONCLINCX (1994), GRYSEELS (1998b), ONCLINCX *et al.* (1998, 2000).

3.1. High population density

The Brussels Capital Region has currently about 950,000 inhabitants and an average regional population density of 59.2 inhabitants/ha (by comparison, the density for Belgium is 3.1 inhabitants/ha). This high population density is unevenly distributed and varies from 19 (Watermaal-Bosvoorde / Watermael-Boitsfort) to 180 inhabitants/ha (Sint-Joost / Saint-Josse). The majority of inhabitants -about 75% of the households- have no, or only very small, gardens. They have to resort to parks and semi-natural areas (especially forests) for their recreational activities. The main consequence is a very high recreation pressure on the green open spaces. In addition, there is also real pressure from the commuters, whose number is estimated at least at 300,000 a day.

3.2. Occupation of space

About half (47%) of the region's total surface area is built up. Traffic infrastructure occupies 2,485 ha (15% of the total area) of this urbanised area. This represents 2,000 km of canal, roads and railways. Car parks and infrastructure for public transport increase this proportion to 21%. Residential, industrial, commercial or public buildings take up the remainder (26%).

Open spaces are still being converted into built-up areas, however at a slower rate than in the 1980s. Data for 1990-95 indicate an increase of 2.7% for built-up land and 1.2% for the traffic infrastructure, as compared to a rise of 9% and 11.6% respectively in the 1980s.

Nevertheless, vast open spaces are still converted into offices, dense housing areas and commercial estates. Land reserve areas (land without a defined planning destination), which often contain vast semi-natural areas of high biological value, are especially at stake.

The ecological consequences of this high level of urban development are the following:

- there is a continued decrease in semi-natural areas with spontaneous flora and fauna (particularly of derelict land). According to the current Regional Plan of Soil Affectation, few 'open' spaces with undetermined destination are left available;
- the relentless split-up of existing green spaces leads to a reduction of green areas, parcelling, habitat fragmentation and the destruction of linear connecting elements;
- soil is increasingly impenetrable to rainfall, with local drought or local flooding as a consequence;
- a general drying up is caused by groundwater pumping for soil stability (underground buildings and spaces, underground traffic infrastructure, etc.) and the drainage of wetlands for construction purposes.

3.3. Pollution

3.3.1. Atmospheric pollution

In all major agglomerations, traffic and domestic heating have replaced industry as the main source of atmospheric pollution. The Brussels Capital Region is no exception to this phenomenon. Even if the situation is not as dramatic as in other European metropolises, some trends remain alarming. Air pollution is intrinsically linked to energy consumption. Air pollutants concern in particular SO₂, NO_x, ozone, CO, heavy metals such as lead, volatile organic substances, dust, black smoke as a result of diesel use, etc. The most worrisome of these are ozone, nitrogen oxides and volatile compounds. Domestic heating is responsible for more than 70% of CO₂ and SO_x emissions and 45% of N₂O. Transport accounts for about 80% of CO, NH₃ and polycyclic aromatic hydrocarbons (PAH) emissions, 58% of NO_x and 69% of lead. Industrial processes are the main contributors to CH₄, dioxin, cadmium and mercury emissions.

Atmospheric pollution contributes to two major environmental problems, acidification and eutrophication. Acidifying emissions disrupt air, surface water and soil composition and can contribute to forest decline, even though their direct effects are difficult to apprehend. Eutrophication is caused by an excessive supply of nitrogen compounds. Its direct effect on biodiversity is noticed by a degradation of vegetation through the decline of vulnerable species and the dominance of competitive species, mostly tall herbs. Indirect effects are very complex and difficult to measure. There are indications that air pollution causes changes in insect composition, which could be responsible for the decline in forest bird diversity (see subchapter 4).

3.3.2. Water pollution

Water pollution constitutes a huge problem in Brussels. There is only one water treatment installation currently active in the region. Situated in the south of Brussels, it treats only part of the household water and industrial waste water of the region, reaching only 360,000

inhabitants-equivalents. However, a new and large water treatment installation is under construction in the north of the agglomeration. It should be able to treat 1,100,000 inhabitants-equivalents and would cover the northern and Woluwe hydrographic basins.

Most of the waterways are still used for the discharge of waste water and are therefore of very poor water quality. The Senne receives all rain water and all waste water. Consequences are: low concentrations in dissolved oxygen (less than 1 mg/l during a 1998 survey, indicating heavy pollution), high amounts of total nitrogen concentration and sludge pollution with heavy metals. The Belgian Biotic Index, used to characterise the biological quality of water, is also very low. Usually, it does not exceed two in a scale from zero (very low quality) to ten (very good quality). The Brussels-Charleroi canal theoretically does not receive any waste water, except in case of thunderstorms. Still, its water quality is rather poor. The 1998 survey has shown that water quality decreases between its regional entrance and exit points, with a change from six to five in the Belgian Biotic Index. Important deterioration in the water quality may also occur during accidental pollutant flows as well as during droughts, when water quality decreases through eutrophication, mineralisation and decomposition of accumulated sludge.

Luckily, the picture is not completely dark. A number of surface waters still show excellent water quality, as for example in the Woluwe river basin. The 1998 study indicated that nitrogen and phosphorus concentrations were low all year round and heavy metals were absent.

The region is currently developing a more ecological approach to water management and is setting up a project for integrated water management: the 'blue network'. This programme is designed to improve the region's water basins through the improvement of water quality and the re-establishment of the continuity of the water network. Diverting clean water from waste water collectors should re-establish river flows, feed the ponds and wetland areas and reduce the quantity of water to be processed in the treatment stations, as well as limit flooding problems. An improvement in the quality of surface waters and the restoration of river banks, ponds and wetlands should make it possible to improve the ecological, landscape and recreational values of the sites.

3.3.3. Soil pollution

Soil pollution has mainly an historic origin. It is found on old industrial sites and old waste dumps. Problems are mostly linked to soil and surface water. Its effects on biodiversity have not been investigated yet.

3.3.4. Noise pollution

Noise is the greatest environmental nuisance in Brussels, with transport (road, railway and air) considered as the main source of acoustic discomfort. It is followed by noise generated by industrial activities, construction sites, neighbourhood (e.g. schools) and public transport (e.g. tramways). Noise nuisance, especially from aircrafts, is often resulting in unacceptable noise levels for the population but negative effects on the fauna have also been noted (see subchapter 4).

3.4. *Exploitation of natural resources*

Historically, sand and sandy limestone used to be extracted within the territory of the region. Nowadays, the exploitation of natural resources is limited to the extraction of ground water (4% of needs) in Ter Kamerenbos / Bois de la Cambre and the nearby portion of the Sonian Forest. The effect of water catchment on the forest ecosystem is not apparent, but it has never really been examined.

3.5. *High recreation pressure*

Growing and changing recreation needs are typical urban threats to biodiversity. The population pressure on the remaining open spaces is high. Even though Brussels is considered a 'green city', nearly one million inhabitants basically rely on 8,500 ha of green spaces, of which half is public but not always within reach: only 2,860 ha are accessible to the inhabitants as public parks and forests. On average, an inhabitant in Brussels has access to about 30² m of public greenery. If the Sonian Forest is not taken into account this decreases to about 9 m². Moreover, this figure depends on the area of the city, as access to greenery ranges from less than 1 m² in the town centre to more than 20 m² per inhabitant in the peripheral neighbourhoods.

There is a big difference between urban parks and larger semi-natural areas. Degradation of neighbourhood greenery or public parks in densely urbanised areas has to be placed in a social context -the small offer of green spaces- and can only be solved from that perspective. The degradation of larger green areas in the periphery of the region (especially of forests) constitutes however a real threat to biodiversity. It has reached alarming levels. The following observations can be made:

- visitor pressure is too high, especially during week-ends (exact figures are not available). Related problems are traffic congestion and increased areas used as parking spaces;
- too many visitors do not respect elementary rules of conduct and have no respect for the green spaces. This is translated by walking outside paths and treading on vegetation, excessive picking of mushrooms and flowers, high noise levels (radios, shouting, etc.) with as a consequence the destruction of flora and the disturbance of fauna;
- a number of new recreation forms such as mountain biking cause important damage to the soil and vegetation;
- the increasing number of dogs is an ever growing problem. They disturb the fauna when allowed to run loose.

These problems lead to habitat fragmentation (creation of new paths), soil degradation (trampling, compaction), destruction of flora and fauna, etc. It is difficult to find solutions: stronger regulations and a more repressive attitude from authorities are difficult to conciliate with the social role of the green areas. More importance should therefore be given to education and public awareness.

3.6. *Human impacts on semi-natural areas*

The urban context can also induce unexpected threats to semi-natural areas. For example, the 'park transformation' of semi-natural areas -or the landscape design of wild areas in

order to meet recreation needs- can yield mixed results. Positive examples include the creation of footpaths to protect vulnerable zones. Negative impacts often result from the ordering and/or embellishment of nature, e.g. through so-called ecological plantations, the removal of 'potentially dangerous' dead trees or the creation of access to previously inaccessible areas. Another threat to spontaneous vegetation is the transformation of natural areas into vegetable and allotment gardens. This is certainly a commendable initiative from a social perspective, but, because of a lack of space, it often adversely affects relic semi-natural areas.

3.7. *Alien and invasive species*

The urban environment is a privileged immigration place for species: the concentration of transport facilities, the human influence, the presence of substitute biotopes, the contact and exchange possibilities all give rise to a typical urban biodiversity. However, in recent years, it has appeared that a number of these phenomena have had negative consequences. Many exotic species find optimum conditions in the disturbed, contact-rich urban environment, and seem to become, by their explosive development, a specific threat to indigenous species diversity. More insight into this matter will be given in the following subchapter.

4. SPECIES DIVERSITY IN RELATION TO URBAN THREATS AND ALIEN SPECIES

Reliable and recent overview data about species in the Brussels Capital Region are available for the following groups: mammals, birds, amphibians, reptiles, higher plants, mosses, macrofungi and lichens. Since 1992, data collection has been co-ordinated within the framework of the establishment of a bio-indicator information network (IBGE-BIM 1998). Only fragmentary recent information is available for invertebrate species.

As the Brussels Capital Region is embedded within the Flemish Region, data interpretation for Brussels may not be useful from a purely scientific perspective. The major green spaces run across region borders (e.g. Sonian Forest), while a number of taxonomic groups are dependent on ecosystems present in surrounding regions (e.g. birds). The interpretation of criteria such as rarity, vulnerability and threatened status is therefore a complex matter and must be adapted to the specific context of the urban environment (GRYSEELS 1998c). Current distribution data must also be evaluated in combination with threats and impacts generated by alien species.

Recent data are summarised in table 1 below. Red lists of threatened species and species of special European importance have not officially been designated yet. Research, data validation and discussions are currently being carried out for a number of taxonomic groups. It should be noted, as presented in table 1, that all vertebrate species except fish are legally protected in Brussels.

Table 1. Estimation of species numbers for major groups in the Brussels Capital Region. ⁽¹⁾The 'Regional Law pertaining to wild fauna and hunting' (29 August 1991) protects all vertebrates (except fish), and bans all hunting; ⁽²⁾Wild flora is only protected by the federal law 'Pertaining to measures aimed at protecting certain plant species growing in the wild' (16 February 1976), which is not adapted to the rare urban flora and its threats.]

Groups	Total	Indigenous	Exotic	Endangered	Vulnerable	Declining	Extinct (since ± 1950)	Legally protected	Remarks
Mammals (DEVILLERS <i>et al.</i> 2000)	42 (+ 6?)	39 (+ 6?)	3	7	11		2	All ⁽¹⁾	Status of at least 10 spp. unknown; at least 6 others are rare
Birds (WEISERBS & JACOB 2001)	99	90	9	8 + 6	18	12	± 15-20	All ⁽¹⁾	
Amphibians (WEISERBS & JACOB 2001)	7 (8?)	6 (7?)	1	1 (1)	5		3 (4?)	All ⁽¹⁾	
Reptiles (WEISERBS & JACOB 2001)	3 (1?)	3 (4?)	1	1 (1?)	1	2		All ⁽¹⁾	
Fish	No detailed data available								
Invertebrates	No detailed data available								
Higher plants (GRYSEELS 1998c)	± 730	± 580	± 150	± 65	± 62	?	187	14 ⁽²⁾	Rare + vulnerable + endangered spp. = ± 231
Mosses (VANDERPOORTEN 1996)	223	223		49	67	?	40	1 ⁽²⁾	
Macrofungi (VANHOLEN <i>et al.</i> 2000, 2001)	± 913		1						Total recorded spp. (20 th century) = ± 1,334
Lichens (VANHOLEN <i>et al.</i> 2000, 2001)	36								Total recorded spp. (20 th century) = ± 120

4.1. Mammals

Most of this subchapter has been compiled using the following information: DEVILLERS & DEVILLERS-TERSCHUREN (1997, 1998a, 1998b, 1999, 2000). Other sources are indicated in the text.

The mammalian fauna of Brussels includes at least 42 existing species and 9 extinct or probably extinct species. The beaver (*Castor fiber*), wolf (*Canis lupus*), brown bear (*Ursus arctos*) and dormouse (*Muscardinus avellanarius*), disappeared before the 20th century. Other extinctions occurred only recently: the otter (*Lutra lutra*) disappeared in 1990 and the badger (*Meles meles*) in 1993.

The presence of a further 6 species is probable or possible. These numbers reflect a rather high species richness for the small surface concerned (160 km²). It is close to, or slightly above, the richness expected on the basis of the continental species-area curve. The important forest cover in the region is no doubt one of the main reasons for this richness, combined with the total protection of mammals since 1991.

Bats represent a particularly significant part of the mammalian fauna, with 14 species known to occur and a further 3 whose presence is probable (out of a total of 19 species recorded in Belgium). The soprano pipistrelle (*Pipistrellus pygmaeus*) was discovered as recently as 2002. This chiropterological richness can be explained by the very high biological value of the Sonian Forest, coupled to favourable feeding grounds in its periphery, in particular above and around the ponds of the Woluwe river hydrographic network. The presence of many old trees with cavities, both in the Sonian Forest and in the nearby parks, is essential as most of the sensible species are tree- or forest-dwelling species (e.g. *Nyctalus noctula*, *Myotis daubentonii*). Nevertheless, city buildings also offer opportunities for house-dwelling species (e.g. *Pipistrellus pipistrellus*, *Eptesicus serotinus*). The common pipistrelle (*P. pipistrellus*) is certainly the most frequent species in the city.

The richness in bat species has justified the designation of Natura 2000 areas in the Brussels Capital Region (figure 2) (GRYSEELS 1996). The Sonian Forest hosts three species of Annex II of the Habitats Directive: the greater mouse-eared bat (*Myotis myotis*), notch-eared bat (*Myotis emarginatus*) and barbastelle bat (*Barbastella barbastellus*). Other populations of international importance found in Brussels include Natterer's bat (*Myotis nattereri*), Daubenton's bat (*Myotis daubentonii*) and the pond bat (*Myotis dasycneme*).

Although bats have few natural enemies, they are extremely vulnerable. Pesticides, noxious wood treatment products (e.g. in attics) and the disappearance of suitable habitats (e.g. removal of old, hollow dead trees) are the main causes of their vulnerability. An indirect threat for bat populations is the decrease in insect diversity and abundance due to habitat loss and pesticide use. House-dwelling species also suffer from the closure of openings in church and house roofs, carried out to prevent pigeon damage. Measures taken for the protection of bats in Brussels include total legal protection, better-adapted forest management, the installation of nest boxes, etc. Further action could include adaptation of historic ice houses to host bat populations, as it is already carried out in other regions of Belgium (IBGE-BIM 2001, 2002).

Urban populations of fox (*Vulpes vulpes*), hedgehog (*Erinaceus europaeus*), red squirrel (*Sciurus vulgaris*) and roe deer (*Capreolus capreolus*) are also very interesting when replaced in the European urban context. Foxes have been observed in the Sonian Forest for more than forty years. Since the protection of the species, foxes have been moving closer into the city, using railroad embankments and wooded parks as dwelling spaces and stepping-stones in their progression. It is a typical example of a species that has adapted well to the urban environment and which represents an improvement in urban biodiversity. The fox is present in forested areas in high densities, but is also spreading towards more urban as well as more rural areas. Population dynamics are currently investigated in order to better assess its presence (cohabitation with man) and possible epidemiological risks (KERVYN *et al.* 2001, DE BLANDER *et al.* 2002).

Hedgehogs are linked to the presence of scenic parks and the important surface of private gardens. Red squirrels are increasingly spreading into dense urban areas from their important source population in the Sonian Forest. This progression is carried out via wooded scenic landscape parks, private estates and private gardens (VERBEYLEN *et al.* 2001). Like for hedgehogs, their recent positive development is linked to their total legal protection since 1991, coupled with a better ecological understanding by green spaces managers and a greater public awareness concerning those 'nice animals'. The suburban population of roe deer is limited to the Sonian Forest, where it is under severe pressure. Population estimations suggest a presence of less than 100 individuals. Stress is linked to the disturbance caused by dogs and visitors, as well as to forest fragmentation due to road and railway infrastructures.

Several species have become very rare and are threatened. This includes most mammals linked to forest environments. Mustelids are a noteworthy example. Stoats (*Mustela erminea*) are nearly exclusively limited to the Sonian Forest, while weasels (*Mustela nivalis*) seem to be somewhat more frequent both in the Sonian forest and in other forested areas of the region. The western polecat (*Mustela putorius*), beech marten (*Martes foina*) and pine marten (*Martes martes*) are rather uncommon and difficult to observe.

Three exotic mammals are found in Brussels: the brown rat (*Rattus norvegicus*) (although generally not considered any more as an exotic species), muskrat (*Ondatra zibethicus*) and Siberian chipmunk (*Tamias sibiricus* = *Eutamias sibiricus*). The first two species have important effects on public health and riverbank stability, but they do not seem to cause any direct problems for indigenous species. The case of *T. sibiricus* is interesting (RIEGEL *et al.* 2001). The species established a stable population from the release of captive-bred animals in the 1970s. Until now, its presence has been recorded only in the Sonian Forest, where it has constituted substantial populations reaching up to 2,000 individuals. Its prevalence has been suggested as a possible cause for the severe regression of bird populations, particularly of insectivore passerines. However, until now, studies on this topic have not been able to detect a significant impact on bird populations. Within current knowledge, the presence of the Siberian chipmunk therefore does not appear to represent a serious management concern.

High pressure factors on the Brussels mammal fauna, such as the disappearance, fragmentation and degradation of habitats, have been more or less stabilised for wetlands and wooded

habitats thanks to site protection and ecologically-oriented site management. For open habitats however, shrinking areas and fragmentation remain important stress factors. Disturbance by dogs is also a highly significant threat.

4.2. Birds

Major references used in the following subchapter are IBGE-BIM (1992-1997), WEISERBS & JACOB (1996, 1998, 1999a, 2000, 2001a, 2001b), WEISERBS *et al.* (1997), DE SCHUTTER *et al.* (1998), VANGELUWE & ROGGEMAN (2000).

The avian fauna of the Brussels Capital Region comprises about 100 breeding species, which is quite typical for an urban area of this size. It is estimated that, in a medium-term perspective, the number of indigenous bird species will probably slowly decrease while the number of exotic species will increase. This phenomenon has been observed in several other countries, and is more marked in heavily urbanised regions (10% of Brussels bird species are exotic). Since 1961 (table 2), 14 indigenous species disappeared as breeding bird, although isolated cases of reproduction are still possible. During the same period, 8 new indigenous species have appeared, often as the result of an increase in their population levels and distribution area elsewhere in Belgium. In the waterfowl category, population levels of the most demanding species remain very low. Habitat changes have favoured more adaptable species such as Corvidae and Columbidae. Formerly persecuted species such as the grey heron (*Ardea cinerea*) have recovered thanks to protection measures. Birds of prey also benefit from such protection and have progressed significantly both in terms of species and abundance.

Table 2. Evolution of the avifauna composition since 1960 (after WEISERBS & JACOB 2001b).

	1961-1968	1973-1977	1989-1991	1997-2001
Source	LIPPENS & WILLE 1972	DEVILLERS <i>et al.</i> 1988	RABOSÉE <i>et al.</i> 1995	WEISERBS & JACOB, in prep.
Indigenous breeding species	97	95	93	90
Exotic breeding species	3	5	7	9
Total	100	100	100	99

Diversified habitats in cities produce heterogeneous communities. This is reflected both in terms of the number and the distribution of species. For the period 1989-1991, an average of 36 species per km² was observed, with a range of 12 to 71 species per km². Omnipresent species are heavily represented and are favoured by the fact that they are well tolerated and that all indigenous bird species are protected. Consequently, opportunistic Columbidae and passerines are widespread and abundant and can be observed at close range (e.g. *Columba palumbus*, *Turdus merula*, *Pica pica*). Two anthropophilous species linked to the urban environment, the black redstart (*Phoenicurus ochrurus*) and black swift (*Apus apus*), are abundant. Their evolution is now under study, as modern building methods do not seem to be beneficial to these two species.

Amongst those species that adapt to city life, the peregrine falcon (*Falco peregrinus*) reappeared recently after it stopped breeding in the city nearly 70 years ago. Observations of this general predator become more and more frequent and it is assumed that there has been one breeding couple in Brussels in 2001. This pattern is similar to those observed for other diurnal birds of prey (*Falco tinnunculus* and *Accipiter nisus*). It can be attributed to the falcon's ability to adapt, in particular regarding nesting sites and the predation of a small number of abundant species (feral pigeons!). The presence since 1966 of a colony of grey herons (*Ardea cinerea*) in the Royal Domain should also be noted (141 nests were recorded in 2001).

Several species in regression in Belgium have been declining more rapidly in Brussels than in the neighbouring regions. The numbers of house martins (*Delichon urbica*) have decreased dramatically. This could be due to problems linked to wintering, such as migration hazards in their route towards Africa or expanding desert areas in the Sahel. But other hypotheses, directly related to the urban environment, have also been put forward: the lack of mud -a necessary material for nest-building- in urban areas, the deliberate destruction of nests by uninformed people or changes in availability of flying insects. The disappearance of the barn swallow (*Hirundo rustica*) is undoubtedly related to agriculture intensification and, in the Brussels region, to the gradual disappearance of farms and agricultural areas. The dramatic decline of the house sparrow (*Passer domesticus*), formerly one of the most common birds in Brussels and the symbol of anthropophilous species, has been observed for several years. A number of causes have been put forward to account for the observed changes, but no convincing explanation has been found until now. Several factors may act in combination: changes in nest sites availability (less adapted houses and roofs), changes in food supply (disappearance of arable fields and wastelands as main food source, reduction in insect populations) or predation (e.g. by the numerous domestic cats!).

Spectacular decline or disappearance have also been observed for several species that were widespread in wooded areas in the past. The cuckoo (*Cuculus canorus*) and golden oriole (*Oriolus oriolus*) have disappeared. The tree pipit (*Anthus trivialis*), redstart (*Phoenicurus phoenicurus*) and wood warbler (*Phylloscopus sibilatrix*) are scarcely found. This is partly due to the high recreation pressure on suburban forest areas, but it cannot explain everything. There are serious indications that the decline in forest bird diversity is linked to changes in insect composition, the main food source for the birds. These changes may be due to increased air pollution from roads or motorways crossing the Sonian Forest. However, the constant noise from road and air traffic seems to be the main cause of the catastrophic decline: a linear negative relationship between forest breeding birds and traffic noise from motorways has been observed (WEISERBS & JACOB 1996).

Outside the nesting season, the arrival of migratory and wintering birds in forested areas is sometimes spectacular. This depends among others on the extent of beechnut production in the Sonian Forest. Elsewhere, migratory and wintering birds are less numerous or are difficult to observe.

For the past 30 years, there has been a major increase in the exotic bird fauna in Brussels, both in terms of numbers and species. Part of the exotic 'population' is made up of solitary birds and/or species not habituated to our climate and whose presence is anecdotal. The

occurrence of these birds is sometimes due to caretakers of public parks, as for example the peacock (*Pavo cristatus*) or the black swan (*Cygnus atratus*) that are the subject of attempts of reproduction in semi-captivity. In addition, birds escape from captivity or are sometimes released intentionally. They contribute to the variety of avian fauna, such as parrots (Psittacidae family) and waterfowl (e.g. the wood duck, *Aix sponsa*).

In general, isolated individuals are considered to have little or no impact on the indigenous fauna. However, some species may acclimatise and start reproducing. The resulting habitat colonisation may lead to growing competition between exotic and indigenous species. Only breeding species that are a potential threat for native birds are described below. It should be noted that exotic passerines have not acclimatised, as opposed to what has been observed in southern Europe.

Three species of parrots are breeding in Brussels, two of them having done so for over 20 years. The ring-necked parakeet (*Psittacula krameri*) can be declared as the symbol of exotic species present in the Brussels Capital Region. The origin of the Brussels population is related to the release in 1974 of some forty birds following the closure of a wildlife park. The first nesting observations were made the same year. Since then, the rate of expansion of this parakeet has been particularly high. Population counts at the only roost in Evere show an exponential population increase resulting in a total of nearly 4,500 birds in 2001 and 5,300 in 2002! This population increase has been accompanied by an expansion of the breeding area in the city.

The parakeet can now also be found outside the region. Bird monitoring activities in Brussels so far have not indicated any direct negative impact of this species on indigenous breeding birds. The availability of nesting cavities and food sources are possible points of contention. It has often been suggested that indigenous tree- or cavity-dwelling species would be naturally susceptible to this type of competition. However recent studies have not shown any signs of regression in their populations yet, even in areas where the parakeet is very abundant. As far as food is concerned, feeding by citizens does make a sizeable contribution to the parakeet's diet.

The monk parakeet (*Myiopsitta monachus*) is the second parakeet present in Brussels since the end of the seventies. Current populations amount to 50-60 individuals. This species most interestingly is the only parakeet to build big collective nests made of branches and twigs. Monk parakeet colonies are located in heavily urbanised areas. Their impact on the local fauna is low as there is only a small number of species with which they co-exist. In addition, it is likely that artificial feeding is a determining factor for the survival of the species.

The Alexandrine parakeet (*Psittacula eupatria*) first appeared in the region in 1998, as the result of individual birds that escaped from captivity. The current population is estimated at 20-30 birds. As soon as it appeared in Brussels, the Alexandrine parakeet associated with *P. krameri* in terms of nesting, feeding and gathering at the dormitory. The exponential development of *P. krameri* has raised concern about the potential increase in this new species. In 1999, as the numbers of *P. eupatria* were still relatively low, a capture campaign was planned by the Brussels Institute for Management of the Environment (BIME) in order to prevent its implantation. This delicate action was finally not carried out. Like for

P. krameri, the issue of the impact of *P. eupatria* on the indigenous fauna has been raised. It essentially concerns the competition with indigenous cave-dwelling species. *P. eupatria* being more robust, the interaction with indigenous species could be different from *P. krameri*. However, the actual population is currently too small to have any considerable impact.

Alien waterfowl species are the other major category of exotic bird species found in Brussels. The mute swan (*Cygnus olor*) has been domesticated and commonly found as early as the 19th century. The urban population is stable. Interaction with indigenous birds (e.g. *Podiceps cristatus*, *Fulica atra*) and the destruction of nests have been reported but the small population has very little impact on the indigenous fauna. The Egyptian goose (*Alopochen aegyptiacus*) is breeding since 1984. Twenty-seven nesting couples were recorded in 1990-1991, whereas 234 individual birds were counted in 1999. During the moulting season, population concentrations are observed in some parks. The impact of the species on indigenous populations was studied between 1992 and 2000. The Egyptian goose is a rather aggressive animal and its influence on the breeding success of indigenous waterfowl seems probable. However, WEISERBS & JACOB (2001) could not so far detect any direct negative impact. There seems to be no signs of indigenous waterfowl population reductions at regional level. This provisional conclusion could be explained by the fact that densities of *A. aegyptiacus* per site remain small and that resources are sufficient to avoid or to contain competition. However, discussions between scientists and managers goes on (see e.g. VANGELUWE & ROGGEMAN 2000) and the study continues.

The mandarin duck (*Aix galericulata*), introduced for ornamental purposes, has been reproducing freely in Brussels since 1989. It most often stays in damp forested areas but can also be found in city parks. It is a discreet cave-dwelling species and is not a potential threat to indigenous birds. The wood duck, *Aix sponsa*, has been observed regularly in the past several years but no attempts to nest were reported in Brussels.

The Magellan goose (*Chloephaga picta*) comes from the Royal Domain and has formed a small urban population of less than 5 nesting couples. Its threat potential will depend on its reproduction rate in future years. Initial observations indicate that it is currently not very aggressive and not very prolific. A likely important breeding species is the Canadian goose, *Branta canadensis*, as it has been increasing significantly in other regions of the country. Several hundred individuals have been recorded in Wallonia and up to several thousands in Flanders. The large increase of observations for the Brussels region suggests that it might soon start reproducing. It is most likely that this will cause interaction problems with indigenous species. Another probable breeding species is the barnacle goose (*Branta leucopsis*), with several individuals observed breeding in a park close to the Brussels region. Other man-attributed species are mingling with the Brussels bird fauna, such as hybrids between wild and domesticated ducks or various forms of domesticated geese and ducks. Their presence in high numbers points to the extremely artificial nature of some ponds and could give problems on these sites.

Two other exotic species breeding in Brussels are worth mentioning. The pheasant (*Phasianus colchicus*) is still found in small numbers in the countryside in the periphery of the city. Until the 1960s, this species was very common due to artificial releases for hunting

purposes. The ban on hunting in the Brussels region has led to a halt in the replenishing and artificial feeding of the species. As a result, its numbers gradually fell. The other species, *Columba livia* (rock dove or feral pigeon), settled in the first half of the 20th century. It is now one of the most common species in heavily urbanised areas. However, its ecological niche is very different from that of other urban birds and no negative influence has been observed. However, their droppings are a scourge for buildings.

4.3. *Amphibians and reptiles*

General information can be found in PERCSY (1998) and WEISERBS & JACOB (2001).

The herpetofauna of Brussels is currently composed of 10 indigenous species: three reptiles and seven amphibians. The natural occurrence of some of these species can be debated, particularly of the grass snake (*Natrix natrix*) and the common midwife toad (*Alytes obstetricans*). The grass snake reproduces in the marshy areas of Jette-Ganshoren, whereas two populations of unknown origin of *A. obstetricans* are maintained on private and isolated sites. The last known natural populations of the toad have been extinct since the 1980s.



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The marshy area of Jette-Ganshoren is one of the most important of the region (photograph by M. GRYSEELS, BIM-IBGE).

Amphibians and reptiles constitute a very vulnerable species group in urban areas. Not only do they depend on various ecological conditions (water and land), but they are also very sensitive to fragmentation (roads as barriers for migration) and to the degradation of their habitats (water pollution, drainage or drying up of ponds). The distribution of indigenous species at the periphery of the region relies therefore on the occurrence of wetlands of sufficient quality, which are essentially protected areas. Species diversity has been reduced both by direct and indirect human action. The indigenous herpetofauna suffers from the release of animals sold on the pet market, such as turtles and snakes, as well as from the introduction of exotic or other species in private artificial ponds and wetlands.

Two exotic species are present in natural areas in Brussels. The first one is the red-eared terrapin -also called the 'Florida turtle' (*Trachemys scripta elegans*)- which is present in many ponds in parks and in the Sonian Forest. The presence of this species is the result of releases by individuals: when turtles are too big to be kept in aquaria, they are dumped in neighbouring ponds. The species has not acclimatised, and no reproduction has been observed yet. However, it seems to be insensible to hard winters and grows very large and old. The red-eared terrapin is a threat to invertebrates, which are eaten by the young turtles (i.e. individuals less than five years old). Vegetation is a major source of food for adults. In the Brussels region, threats from this species are not too severe as most of the occupied sites are heavily urbanised. However, the species has also appeared in the richest semi-natural sites, such as in the Sonian Forest, where its presence seems to become a nuisance. Public infatuation for these reptiles is not fading and it is unlikely that releases will decrease in the short term. Although importation of this species is now banned, importation of similar species is still allowed. In the medium-term, a fall in releases of Florida turtles will probably be counterbalanced by the appearance of new species, in particular those of the genus *Chrysemys*, whose feeding habits are similar to *T. scripta elegans*.

The second exotic 'species' actually corresponds to a group of closely related green frog species: the exotic green frogs *Rana ridibunda* and *R. perezi* have been observed in and around a dozen sites. Populations are often small and their connection is uncertain. These frogs are a threat to the indigenous green frogs (i.e. the pool frog, *R. lessonae*), with which they produce hybrids (*Rana esculenta* synklepton). However, as the latter has probably disappeared from the Brussels region, these exotic green frogs are no longer considered a serious threat in the urban region of Brussels. *Rana catesbeiana* however, already present in the other regions, could constitute a future problem.

4.4. Invertebrates

Synoptic data on invertebrates are not yet available. Several studies have been carried out, providing information on a few taxonomic groups. Some of the available information is presented below.

Studies on insect and spider populations in the Sonian Forest have indicated the faunistic importance of this 'ancient' forest. As far as insects are concerned, the only systematic study has been carried out for carabid beetles and identified 38 different species (DESENDER *et al.* 1987). The presence of the endemic coloured form of the beetle *Carabus auronitens* var. *putzeysi* is well documented. Another interesting characteristic concerns the presence of

viable populations of the stag beetle (*Lucanus cervus*), not only in the Sonian Forest but also in adjacent forest parks and forest relics with old oaks. *L. cervus* is a species of European importance, listed in Annex II of the EU Habitats Directive.

As for spiders, a total of 137 species have been recorded, including a species unique in Belgium (*Philodromus praedatus*) and several rare species (e.g. *Achaearanea simulans* and *Walckenaeria corniculans*). A population of about 100 individuals of the rare spider *Atypus affinus* was recently discovered. It should be noted that this spider is the only mygalomorph species present in Belgium. Causes of vulnerability are on the one hand the disappearance and degradation of its preferred habitats (heathlands and sandy open spaces), and on the other hand the compaction and erosion of soils following timber skidding and public recreation.

Although no general investigations have been carried out in wastelands, on the vegetation of open sunny derelict lands, those sites appear to be indispensable and valuable refuges for insects and other invertebrates. For example, the blue-winged grasshopper (*Oedipoda caerulea*) has been discovered in derelict railway areas (Josaphat, Tour & Taxis).

As far as Hymenoptera are concerned, preliminary sampling of the ant fauna carried out in 2000-2001 in city parks resulted in the observation of 16 species. *Myrmeca rubra* and *Lasius niger* were the most abundant species. The exotic ant *Hypoponera punctatissima* has been recorded in one site, suggesting that this species might be able to adapt to local climatic conditions (DELTENRE & DE BISEAU 2002).

Currently, a research project investigates the effect of the ecological management of grasslands in urban parks in relation to bat diversity. It addresses, among others, foraging opportunities (i.e. insects) for bats species.

The Brussels Capital Region is also concerned with potential threats from invasive alien insect species. A few examples are detailed hereafter.

For the past two years, urban trees have suffered from defoliation by an exotic moth, the horse chestnut leafminer (*Cameraria obridella*). This moth species has been spreading throughout central, southern and western Europe over the last 15 years, causing severe damage to *Aesculus* species and in particular to the horse chestnut, *Aesculus hippocastanum*. The horse chestnut is one of Brussels most common and typical trees along streets and is frequent in urban parks. A small research project is currently going on to develop an optimal control strategy for *C. obridella*.

Special attention has also been given to the arrival and behaviour of beech bark beetles (Coleoptera, Scolytidae) in the Sonian Forest, following the severe economic damage they caused to the Wallonian beech forests during the past few years. Three of these beech bark beetles (*Trypodendron domesticum*, *T. signatum* and *Anisandrus dispar*) are indigenous to the Belgian fauna and cannot be considered as exotic invasive species, but a fourth species, *Xylosandrus germanus*, is an alien introduced from East Asia (Japan, China). Interestingly, this species is more specifically found in the Sonian Forest and not in Wallonia. The moment of its arrival is unknown, but is probably relatively recent. Investigation cam-



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The multicoloured Asian ladybird *Harmonia axyridis* (Coleoptera, Coccinellidae) is sold by private companies as biological control agent of aphid populations. Reproductive populations have now been found in the wild at several Belgian locations (photo by S. BAUER, courtesy of ARS, USDA).

paigns in 2001 and 2002 seem to indicate that the beech bark beetles do not cause major threats to the Sonian Forest. Research is continued on a small scale (GRÉGOIRE 2002).

An emerging problem concerns the arrival of the multicoloured Asian ladybird, *Harmonia axyridis* (Coleoptera, Coccinellidae) in urban parks in Brussels (figure 6). Because of its facility to be mass-produced, this Asian species has been used for some years as a biological control agent to reduce aphid densities in greenhouses. Until recently, no wild observations of *H. axyridis* were reported in Belgium. However, data collected in Flanders and in Brussels during the summer of 2002 showed that the ladybird was able to reproduce in the wild. The extension of *H. axyridis* is followed with great attention, as it has shown competitive abilities towards native species during its introduction in North America.

4.5. Higher plants

This subchapter has been compiled using IBGE-BIM (1999), GRYSEELS (1998c), SAINTE-NOY-SIMON (1995, 1996, 1998, 2001) and GODEFROID (1996a, 1996b, 2001).

An exhaustive inventory of higher plants was carried out in 1991-94. The total number of spontaneously present plants was found to be about 730 species, which represents half of the Belgian flora. This high species number can largely be explained by the landscape diversity of the Brussels Capital Region and human activities such as agriculture, as well as by the fact that cities are important immigration areas for alien plants introduced either with or without the help of man.

Atlantic and sub-Atlantic influences on the vegetation are very pronounced. Species encountered include the bluebell (*Hyacinthoides non-scripta*) and narcissus (*Narcissus pseudonarcissus*), as well as species like *Gagea spathacea*, *Carex strigosa* and *Tamus communis*. The medio-European and sub-medio-European elements are represented by species such as *Oreopteris limbosperma* and *Phyteuma spicatum*. Even the sub-Mediterranean element is present, with species like *Ceterach officinalis* and *Opbrys apifera*.

Out of the 730 species, at least 231 indigenous species are considered to be rare, vulnerable and even threatened. Interesting and very rare species include *Aristolochia clematitis*, *Lycopodium clavatum* and *Neottia nidus-avis*.

The flora of Brussels is made up of the following eco-sociological groups:

- pioneer species of artificial habitats in anthropised and perturbed biotopes such as wastelands, roads and railway embankments, arable lands: 25% of the urban flora (e.g. *Berteroa incana*, *Bromus tectorum*);

- species of forests and woodlands: 20% of the urban flora. This can be explained by the importance of the Sonian Forest in Brussels territory (e.g. *Hyacinthoides non-scripta*, *Anemone nemorosa*);
- species of wood fringes: 14% of the urban flora (e.g. *Aegopodium podagraria*, *Silene dioica*);
- species of dry grasslands: 10%. This group includes species of typical dry urban habitats like rocks and walls. They are rare due to the restoration of ancient buildings (e.g. *Asplenium ruta-muraria*, *Cymbalaria muralis*);
- species of humid grasslands: 10% (e.g. *Carex disticha*, *Lycbms flos-cuculi*);
- species of water and wetlands: 10% (e.g. *Caltha palustris*, *Phragmites australis*);
- pioneer species of semi-natural habitats: 8% (e.g. *Centaurium pulchellum*, *Scirpus setaceus*);
- heath species of dry and poor soils: 3%. They are found as relics in the Sonian Forest and surroundings (e.g. *Calluna vulgaris*, *Molinia caerulea*).

The specific floristic richness varies greatly and depends on the localisation in the region. The densely urbanised centre hosts only about 50 species per km². Species richness at the periphery can reach 200-250 species per km² in forested areas (e.g. Sonian Forest) to 300 species per km² in semi-natural relic areas (e.g. wetlands and marshes)



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The Kawberg is one of the rare semi-natural sites embedded in the urban matrix (photograph by M. GRYSEELS, BIM-IBGE).

adjacent to derelict land in direct contact to railway areas. The species richness in derelict lands bordering transport infrastructure illustrates the importance of human influence in species composition. Transportation is responsible for the movement of seeds over long distances and thus for the dispersal of local species or the arrival of new, exotic species. It shows that the railway network can act as 'green corridors' and support significant areas of biodiversity importance.

Vegetation composition in Brussels is characterised by the presence of many exotic species, as approximately 20% of the 730 species are considered non-indigenous. The largest part of these exotic species (about 60%) results from voluntary introductions for ornamental purposes in gardens and parks or for cultivation, followed by the escape and naturalisation of the species. The remaining 40% is the result of accidental introductions, mostly by road, railway or boat transport.

GODEFROID (1996a) and SAINTENOY-SIMON (2001) provide an interesting survey of the origin of the naturalised plants: 16% have an American origin, with about 30 naturalised species; 16% African, with only one naturalised species; 34% Asian, with 12 naturalised species and 34% European, with about 10 naturalised species. The presence of introduced (and naturalised) exotic species in the urban area is mostly interpreted as 'being part of urban biodiversity' and as one of the reasons for the relatively high biodiversity of urban areas. Alien species tend to occur preferentially in well-lit, dry, nitrogen rich, alkaline and warm places: common habitats in urban areas, often resulting from human impacts through eutrophication, drainage, deforestation, soil enrichment with construction rubble and climate warming.

It is generally accepted that the flora of Brussels has become impoverished due to urbanisation impacts such as the loss and fragmentation of habitats as well as intensive recreation pressure. From 1943 to 1990, at least 187 species have disappeared, of which 140 indigenous ones. At the same time, the total number of plant species has remained more or less stable for the past fifty years, ranging from 789 to 730 species. There may therefore not be a significant quantitative reduction in species, but the qualitative impoverishment is obvious: native species of semi-natural areas (especially humid and forest ecosystems) and agricultural areas are regressing. Their regression is compensated by the arrival of non-indigenous species.

The introduction of alien species on derelict lands and in relics of natural ecosystems is worrying. Due to their invasive character, some naturalised species have become a serious threat to indigenous vegetation: once installed, their explosive development (often due to rhizomatic extension) mostly leads to monospecific patches and to the replacement of the native flora.

In this regard, threats from some Asian species are well known. *Impatiens parviflora* is spreading in the herbaceous layer of forested areas. Dense and monospecific populations of *Fallopia japonica* and *F. sachalinensis* dominate in many railway verges, derelict lands, woodlands and forest fringes and suppress every other species. The giant hogweed (*Heracleum mantegazzianum*), a dangerous plant whose phototoxic substances can cause injuries to the human skin, has been locally present for more than 50 years. During the

past 15 years, it has been showing rapid progression along roadsides and railways and now forms tall monospecific vegetation patches. American species seem to be less invasive, except for the Canada and late goldenrods (*Solidago canadensis*, *S. gigantea*). Their appearance is followed quickly by a spectacular extension of the population leading to large monospecific stands. More recently, Brussels has experienced the remarkable extension of *Senecio inaequidens*, a plant native to South Africa that is invading and quickly dominating dry open, and often derelict, lands.

Many exotic species, sometimes even locally invasive, are not always considered a direct threat but are also seen as an enrichment of the urban flora if they do not seem to be in competition with indigenous species. A well-known example is the butterfly bush (or summer lilac), *Buddleia davidii*. This exotic shrub of Chinese origin now feels quite at home in Europe, where it was introduced as an ornamental during the 19th century. It rapidly escaped from its cultivated state, colonising typical man-made stony habitats like walls, old houses or derelict buildings. It is well appreciated because of its attractiveness for butterflies. However, the question whether such exotic species really lead to the enrichment of the urban flora remains a point of discussion.

4.6. Mosses

An inventory between 1993 and 1996 recorded 223 species, of which 49 are threatened and 67 vulnerable. The number of deteriorating species is not known. At least 40 species have disappeared since 1980 (VANDERPOORTEN 1997).

The richest area in mosses of the Brussels region is the Sonian Forest, where for example *Sphagnum flexuosum* and a few very rare species such as *Ephemerum stellatum* are found. Recent research by SOTIAUX *et al.* (1999) points out that the number of bryophytes has not decreased from previous inventories. However, although some forest species of great phytogeographic interest were newly found, moss diversity is now largely due to the spread of non-forest species from their natural habitats into ruderal and man-made habitats. Genuine and rare forest species have disappeared, or are becoming increasingly rare: currently, about 30% of the species occur in only one or a few localities.

4.7. Macrofungi

The information below was compiled using the following sources: DE KESEL (1996, 1998a, 1998b), SCHREURS (1996), VANHOLEN & DE KESEL (1999, 2000), VANHOLEN *et al.* (2001).

Macrofungi are excellent bio-indicators as well as good biodiversity indicators: they are vitally significant in forests, breaking down dead organic material, acting as mycorrhizae or forming an important part of the diet of many animals. In this context, an inventory was carried out in 1996-2000 in the most important green spaces for macrofungi, the Sonian Forest and the adjacent Ter Kamerenbos / Bois de la Cambre. Due to the presence of very old historical forests dominated by beech and oak on loamy (locally calcareous) soils, macrofungi biodiversity is very high in the Brussels region. This is especially due to the exceptional species richness of the Sonian forest for macrofungi. About 1,334 species have been recorded when using information from historical data and literature sources. Myco-

logists estimate that the total number of macrofungi in the Brussels Capital Region could reach 3,000 species. Indeed, due to the intermittent presence of mushrooms, long investigation periods are needed to obtain an approximate number. About 913 species are currently present, of which some 748 species are rather rare to very rare. Nearly half (394) of the species have to be considered as very rare.

Air pollution -in particular nitrogen fallout- is a general threat. However, its direct effects on macrofungi are rarely evocated. Intensive forest management practices and exploitation often lead to severe consequences with an alarming effect on mycorrhizae fungi, important for tree health. Until now, the attention given to fungal diversity in forest management has been rather low. Results of the inventory have however influenced forest managers to adapt their management practices to take biodiversity into account.

Major threats arise from the social function of the forest. For the past few years, there has been a significant increase in mushroom picking, both for commercial purposes as well as for family use. Mushroom picking has become a very popular and fashionable occupation. On the one hand, this may be regarded as a rather positive fact as it shows that there is a growing number of city inhabitants interested in nature. On the other hand, the over-exploitation of wild mushrooms is becoming a real concern. It is worth mentioning that formerly common species of high culinary importance, like *Boletus edulis*, are becoming increasingly rare just because of this reason. In order to be able to allow future sustainable mushroom picking, regulations are urgently needed today. Whether mushroom picking could be tolerated in a controlled way or whether it should be forbidden to preserve biodiversity in our overstressed urban forests is still much debated. However, as control measures seem very difficult to establish and implement, total prohibition of picking may be the only effective manner to preserve fungal biodiversity.

Until now, only one alien macrofungus has been recorded in the Sonian Forest. *Anrburus archeri* was first discovered in the seventies, and was probably introduced with tropical hardwood. So far, the species is only very locally present and does not seem to pose any threat to indigenous species.

4.8. Lichens

Research on the presence of epiphytic macrolichens in Brussels combining herbarium material, historical and literature sources and field inventories (1998-2000) produced a list of about 120 different species. Only 36 species have actually been found between 1998 and 2000. Many lichen species must therefore be considered as having been extinct for a more or less long period of time. As lichens are excellent indicators for good air quality, this large number of extinct species is not surprising for an area that underwent major urbanisation changes since 1850. However, more frequent observations of lichens on trees are made nowadays and the recent rediscovery of *Usnea* cf. *U. subfloridana*, last observed in 1916, may be indicating an increase in lichen diversity following the improvement of air quality (mainly due to the reduction in sulphur emissions). So far, no exotic lichens have been recorded (VANHOLEN & DE KESEL 2000, VANHOLEN *et al.* 2001).

4.9. Conclusions

Contrary to popular belief, the recent data and studies *in-situ* presented above seem to indicate that alien species may not -so far!- always pose alarming direct threats to the indigenous fauna of the Brussels Capital Region. However, the competition between exotic and indigenous waterfowl species remains a serious point of discussion. There are certainly nuisances linked to the presence of invasive species, such as noise caused by the concentration of parakeets in big roosts. The high number of exotic geese in urban parks causes management problems for the grasslands, due to excessive amounts of droppings, trampling effects and excessive grazing.

The situation is quite different for plants. Some exotic species may have a true negative influence on the indigenous vegetation composition. In Brussels' urban area however, this often concerns typically man-made habitats or perturbed sites (like derelict areas) and it cannot be concluded that rare indigenous species or biotopes are threatened by the arrival of alien species. In order to avoid the arrival and/or explosive development of those species in areas with rare and vulnerable species (where threats to indigenous diversity are real), careful monitoring must be carried out constantly.

Scientists, environmental managers and the general public may one day have to accept the presence of alien species as part of the very diversified urban habitat. The main decline in biodiversity has occurred in the last decades, through the loss and fragmentation of habitats and through widespread pollution. Although the situation has improved nowadays thanks to a better ecological consciousness, it is still continuing in a less conspicuous way and on a



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The Woluwe Park, one of Brussels' public parks benefiting from ecologically-oriented site management, forms an essential link in the green and blue network (photograph by M. GRYSSELS, BIM-IBGE).

smaller scale. This subtle degradation should really be the first cause of worry. But at the same time, continued attention should be paid to the presence and threats of alien species. As eradication seems illusory in most cases, preventive measures and control are necessary.

In the Brussels Capital Region, the discussion on the development of action plans towards the control or eradication of alien species has been going on for some time. Experimental action plans and information campaigns regarding parrots (Psittacidae) and plants such as *Fallopia* sp. (e.g. Japanese knotweed) were not very successful as they arrived well after the explosive development of these exotic populations.

Recent investigations have shown that the success of exotic bird species is linked among others to bird feeding by the population. Information campaigns to limit or prohibit this activity are very difficult and not very successful, due to the high social impact of this popular, enjoyable and inexpensive hobby in the urban environment (parks), especially among children and lonely elderly people.

As far as exotic waterfowl is concerned, local control measures are now experimented in order to prevent nuisances caused by high densities of already present exotic goose species (e.g. *Alopochen aegyptiacus*), while precaution measures are prepared in order to tackle species that have just arrived (e.g. *Branta canadensis*). Are preventive action plans realistic? It is indeed difficult to predict the arrival or the behaviour of new species. For example, the weed *Senecio inaequidens* has been present in Brussels since 1981, but has only shown explosive development recently. The direct negative impact of the Egyptian goose (*A. aegyptiacus*) may not be entirely clear for the moment, but what will happen if the species continues its extension? What if the only roost of *Psittacula krameri* splits up? What if the 'Florida turtle' *Trachemys scripta elegans* starts reproducing? It seems impossible to predict whether or when an alien species will become invasive, and how dangerous it can become for the local flora and fauna. Management on local scale is not very effective. The presence of exotic species therefore needs constant monitoring and information networks and action plans with other regions (and similar urban areas) should be developed.

5. SOME REMARKS ON THE STRATEGIES AND ACTIONS TO DEVELOP BIODIVERSITY

From what has been presented above, it is clear that the Brussels Capital Region hosts a wide diversity of ecosystems and an often unexpectedly rich flora and fauna. It also demonstrates that the urban environment is compatible with wildlife. It therefore makes sense to take biodiversity into consideration when developing plans and strategies for the general management of the urban environment.

Any discussion concerning nature conservation in an urban environment, particularly at the small scale of the Brussels Capital Region, could seem trivial. It is clear that few animal or plant species depend on the preservation of their urban populations for their survival. On the other hand, at times where almost half of the world's population lives in urban areas, a debate on nature conservation in urban areas -however complicated- has become inevitable. The aim goes far beyond the preservation of species or the protection of nature relics by tight regulations. More than elsewhere, policy requires a sustainable dimension. The main issue is not nature in itself, but rather the development of a pleasant living environment, of

which biodiversity is a fundamental part. The social dimension of nature conservation in cities should not be underestimated. Little or no contacts with nature are known to lead to the increased occurrence of stress, depression and violence.

In this regard, it is essential to make city inhabitants aware of the wealth of biodiversity that surrounds them. While forming the majority of the population, they often have the least access to biodiversity or nature. Moreover, cities are major development poles where strategic decisions are made. If nature and biodiversity cannot be endorsed and developed in cities, it is unlikely that they will be taken into consideration as an essential part of development by the population and decision-makers. Biodiversity must thus be rendered accessible to a maximum of citizens, of course in a sustainable manner (DE SCHUTTER *et al.* 2000).

In this context, the Brussels Institute for Management of the Environment has laid down its major orientation lines for the development of the biological heritage in the Brussels Capital Region. The various plans are part of a strategy that takes into account the specific problems and characteristics of the city, including its complicated social aspects (DE SCHUTTER *et al.* 1999, GRYSEELS 2000, KEMPENEERS 2001).

The concept of the green and the blue network is presented below as an example (IBGE-BIM 2000). The green network emphasizes the cohesion and continuity of green spaces and semi-natural areas in the urban environment. The intention is to integrate the scenic, esthetical, social, recreational and ecological functions of the green spaces and to develop their inter-connectivity by greenways and new green areas. Simultaneously, work is being done to implement the blue network. Its purpose is to have an integrated, durable and ecologically-justified management of the open waterways in the region. This requires active co-operation between the various sectors, in particular between the green spaces managers and the infrastructure department. Much attention is devoted to the increase of natural values and biodiversity in such a way that the public still has access to the areas concerned. In this context, a project oriented towards the enhancement of bat populations is currently under way. (IBGE-BIM 1998b, 1999, 2001, 2002, VAN DER WIJDEN *et al.* 2001).

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