SUSTAINABILITY MANAGEMENT OF WIENER STADTWERKE

Promoting biodiversity at cemeteries

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Responsible: Dipl.-Ing. Isabella Kossina, MBA, Corporate Sustainability Officer and Head of Sustainability Management of Wiener Stadtwerke. Fon: +43 (1) 53 123 - 7 40 90 isabella.kossina@wienerstadtwerke.at

Authors: Rebecca Lahl, M. Sc., Dr. Barbara Zeschmar-Lahl (Dipl.-Biol.), BZL Kommunikation und Projektsteuerung GmbH, Oyten (D)

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1. Definition of biodiversity

According to the UN Convention on Biological Diversity (CBD), biodiversity is "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" [1].

The concept of biodiversity includes
- Diversity within species (**genetic diversity**),
- Genetic diversity between species (**species diversity**),
- Diversity of habitats (**ecosystem diversity**).

These three aspects are inseparable. All species require sufficient genetic diversity within their kind as well as ecosystems and suitable habitats in order to survive. Conversely, ecosystems will only be effective if they have a broad spectrum of species, where each species fulfils its function within the system. The stability and resilience of ecosystems (i.e. the tolerance to interference and the ability to regenerate itself) is highly dependent on the biodiversity present. The greater the diversity of genes and species is in an ecosystem, the more likely the whole system will adapt to environmental changes such as climate change. Therefore, protecting individual demarcated areas is not sufficient. Cross-linking different habitats is an important prerequisite for sustaining genetic diversity [2].

2. The worldwide threat to biodiversity

Protection of biodiversity and climate are internationally regarded as the main challenges for the future of humanity. As stated by the European Commission, biodiversity is at risk worldwide. Indeed, the loss of biodiversity in the tropical rainforests of the Amazon is taking place far away from us. But we can observe species extinction and destruction of ecosystems right on our doorstep. „Only 17% of habitats and species protected under EU legislation are in favourable conservation status. 65% of assessed habitats and 52% of assessed species are in unfavourable conservation status. ... Up to 25% of European animal species, including mammals, amphibians, reptiles, birds and butterflies face the risk of extinction. 22% of species indigenous to the EU are threatened by invasive alien species.. ... Most of the ecosystem services in Europe are judged to be ‘degraded' – no longer able to deliver the optimal quality and quantity of basic services such as crop pollination, clean air and water, and control of floods or erosion.“ [3]

According to the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW), the EU has now lost more than half of its wetlands. More than 40% of mammals, 25% of birds, 45% of butterflies, 30% of amphibians and more than half of the freshwater fish are threatened [4], despite the efforts made so far to protect biodiversity (see section 12)!

The threat to biodiversity does not stop at national borders. Trans-national or international agreements are required. Section 12 contains a brief overview of the most important rules for biodiversity conservation.

3. Threatened biodiversity in Austria?

According to BMLFUW, the European continent is home to an estimated total of approximately 200,000 animal and plant species. Austria is **among the most biologically diverse countries in Europe**. After all, there are about 67,000 species in Austria, which is around one third of all species in Europe! They include about 45,000 animal species, most of which (about 37,150) are insect species. Moreover, 3,000 ferns and flowering plants constitute a substantial part of the biological diversity in Austria [4].

In Austria (according to the BMLFUW), large parts of the flora and fauna are at risk according to Red Lists:
- 60% of reptiles and amphibians
- 33% (approximately) of ferns and flowering plants
- 27% of mammals
- 27% of birds

Based on the Red List of endangered biotopes (habitats) of Austria
- 57% of the total of 93 forest biotope types are at risk,
- 90% of the 61 types of grassland habitats occurring in Austria are assigned a risk category.

4. Why is biodiversity so important?

So far, we have taken it for granted that nature provides us with goods and services free of any visible charge. The advantages nature provides us are reflected in the concept of **ecosystem services**. These are the benefits that people obtain from ecosystems, e.g. examples food, freshwater, timber, climate regulation, protection from natural hazards, erosion control, pharmaceutical ingredients and recreation. The value of ecosystem services provided by nature is substantial. According to Balmfort et al. (2002) cited by TEEB[1] [5], an additional investment of $45 billion per year in an 'ideal' global protected area network – if expanded to cover 15% of land and 30% of marine areas – could secure nature-based services worth some $4.5 to $5.2 trillion a year [6].

Ecosystem services are thus an important factor when talking about biodiversity. If the wealth of genes, species, habitats or ecosystems decreases, natural systems become destabilized and the production of goods and services is considerably reduced. Among the services provided by ecosystems is the pollination of crops by insects. Such services are further likely to gain in importance in the wake of climate change. According to the EU Commission an estimated 80% of the plants in the EU are at least partly dependent on insect pollination. The insect pollination in the EU has an estimated economic value of 15 billion euros per year (Gallai et al. 2009 [7]).The continued loss in bees and other pollinators could therefore have serious consequences for Europe's farmers and the agricultural sector [8].

The protection of biodiversity is not based on a sentimental love of animals or a romantic idealization. We will only notice what ecosystem services are actually worth when they are no longer available. Or as described by the EU Commission: „Biodiversity loss also has impacts on jobs, since one in six jobs in Europe is directly or indirectly linked to the environment and biodiversity. It also limits the delivery of several ecosystem services essential to maintain a healthy population, from the provisioning of food and potable water to clean air and medicine. In addition, it has a strong bearing on the EU's territorial cohesion, since biodiversity and ecosystems cement the social fabric and identity of many European regions." [3].

5. Biodiversity conservation in Vienna

Vienna has designated a variety of areas to protect biodiversity: national parks, nature reserves/conservation areas, landscape protection areas, protected landscape elements, ecological development areas, protected habitats/biotopes, 'green belt' protected areas or park reserves. Also, the Danube-Auen National Park (Viennese part), the conservation area Lainzer Tiergarten, the protected landscape (reserve) Liesing (parts A, B and C) and the protected landscape areas of the Bisamberg were reported to the European Commission as implemented by both, the Birds Directive as well as the Fauna-Flora-Habitat Directive [9].

Parts of the 'Wiener Nationalpark' are designated NATURA 2000 or wetlands of international importance under the terms of the RAMSAR Convention. [For NATURA 2000 and RAMSAR Convention see section 12.]

Table 1: Comparison proportion of protected areas Austria - Vienna [10]

Conservation status	% of the total Austrian surface	% of the total surface of Vienna
Ramsar site	1.6	2.2
Biosphere park / reserve	1.8	23.4
National park	2.8	5.4
Nature reserve / conservation area	3.6	5.4
Natura 2000	13.8	13.2
Protected landscape area /Landscape reserve	15.1	14.8

Nearly 30% of Vienna City's area are protected, see Table 1, Table 2 [10] and Figure 1 [11]. Beyond this, parts of the western districts are part of the biosphere park (Vienna Woods, Wienerwald) [12].The protection status of the landscape area Vienna Woods is ensued since 1905. The protection of biodiversity was not the main purpose at that time. The respective resolution rather aimed for securing and promoting the city's supply of clean air and the possibility for recreation outdoors and an aesthetic stimulation for the inhabitants [13]. Today this area mainly includes parts of the Vienna Woods located in the west and north-west of Vienna, smaller green areas at

[1] The Economics of Ecosystems and Biodiversity. http://www.teeb.org

'Wiener and Laaer Berg' in the south, the northern and the southern sector of the Danube Island, the Lobau in the southeast, a green area in the northeast in the 21st district, and the Bisamberg in the north. It is further protected by the Nature Conservation Act [9] and by the protected area category given by the Building Code for Vienna (Wiener Bauordnung).

Table 2: Protected areas in Vienna – area statistics (data from 2012); ranked by size in hectare [10]

Name of the protected area in German (English)	Status/category of protection	Size (ha)	% of the respective district (district no. in brackets)	% of the total area of Vienna (41,489 ha)
Donau-Auen (Danube Floodplains)	National park	2258	22.1 (22)	5.4
Lainzer Tiergarten	Conservation area (NSG)	2259	59.9 (13)	5.4
Penzing	Protected landscape (area)	1977	58.6 (14)	4.7
Ex lege landscape protection areas	Protected landscape (area)	1279	–	3.1
Döbling	Protected landscape (area)	1209	48.6 (19)	2.9
Liesing	Protected landscape (area)	654	20.4 (23)	1.6
Hernals	Protected landscape (area)	593	52.4 (17)	1.5
Prater	Protected landscape (area)	513	26.7 (2)	1.2
Obere Lobau	Protected landscape (area)	461	4.5 (22)	1.1
Hietzing	Protected landscape (area)	365	9.7 (13)	0.9
Ottakring	Protected landscape (area)	230	26.6 (16)	0.6
Währing	Protected landscape (area)	154	24.4 (18)	0.4
Wienerberg	Protected landscape element	94	3.0 (10)	0.2
Blaues Wasser	Protected landscape element	57	2.5 (11)	0.14
Erdberger Stadtwildnis	Ecological development area	5.03	– (3)	–
Endlichergasse	Protected landscape element	1.5	– (10)	–
Stefan-Zweig-Platz/ Korngasse	Ecological development area	0.57	– (17)	–
Franz-Glaser-Höhe	Ecological development area	0.39	– (17)	–
Total				**about 28**

The Vienna Urban Development Plan STEP includes the crucial tasks of preserving and developing these landscapes, but also to encourage biodiversity conservation outside of these protected areas. The STEP 2005 and the STEP 2010 progress report [14] pursue the vision of "green spaces in the city region". In order to protect biodiversity, STEP proposes principles on activities and options for action in 'green and open spaces' in urban landscapes [9]:

Provide sufficient spaces for water bodies

- Increase biodiversity and groundwater allocation by breaking up hard river regulation (e.g. for/in Liesing, Petersbach), "excavation" of piped creeks.
- Preservation of floodplains (and their water bodies).
- Provide full public access to lakeshores of artificial lakes. Otherwise comply with the "rule of thirds", i.e. use one third of all lakeshores for public access, one third for natural succession and one third where building activity is permitted behind a riparian zone that is held free.
  Systematically clear the waters from polluting loads, renounce combination sewer systems.

Consideration of the objectives of the nature network „Netzwerk Natur"

- Make it possible to experience differences in site-typical vegetation and topological formations (and conserve these differences), e.g. Austrian black pine (*Pinus nigra* subsp. *nigra)*, rugged rockfalls in the 'Kalk-Wienerwald' (limestone terrain in the Vienna Woods), oak and beech in the soft 'Flysch-Wienerwald'
- Conservation of native waterside vegetation and diverse forest edges
- Improvement of habitat structures for animals (amphibians, reptiles and fish)
- Create stepping stones and eco-corridors to develop a network of biotopes
- Minimize sealing and thereby prevent heat radiation

- Establish agricultural field margins in particular along footpaths and cycle tracks
- Preserve and enhance habitats of specific plant and animal species
- Facilitate crossings of roads for small animals and wildlife (green bridges, tunnels)
- Amplify self-cleaning capacities of standing and flowing waters by technical placement of plants (reedbeds, macrophytes)

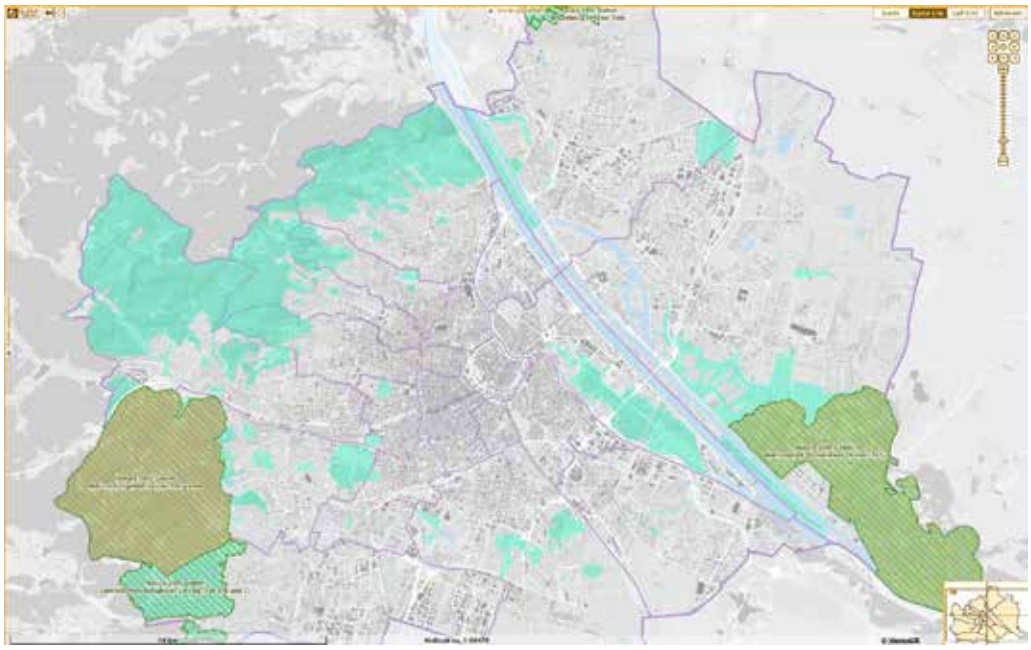

Figure 1: Map of protected areas in Vienna [11]

The future development objectives of the Urban Development Plan Vienna (STEP 2025) have been adopted by the municipal council in the end of June 2014. STEP 2025 includes a concept with technical specification on the management of green and open spaces: “More than 50 percent of the total surface of Vienna is taken up by green and leisure areas (see Green space monitoring), and this situation is to remain unchanged. To further evolve green and open spaces, the strategic framework of STEP 2025 will lead to the elaboration of a detailed green and open space concept that visualises and structures the existing green and open spaces and pinpoints further development options.” [15].

The quality of a city’s green and open spaces is determined by the size of contiguous areas and the identity and usability of landscapes. The goal is the preservation and development of the" Green Grid "(= green backbone) of the city in order to preserve and further develop the quantity that is required for a growing Vienna. “In the future, the function of open spaces for the urban climate will become more and more important alongside their recreational value. They must be designed in a manner that allows them to withstand the effects of climate change and to support the city in adapting to climate change as well. For the latter, the conservation of fresh air corridors and cold air source areas plays a central role. Small-scale measures, e. g. minimal soil sealing, planting of trees, shading, rainwater management, a high degree of urban greening, greened roofscapes and façades, are equally significant.” [15].

The flagship initiative “Vienna’s open space network” (Freiraumnetz Wien) represents the city’s will to offer all Viennese more open space qualities. “Targeted interventions (afforestation, planting of trees in streetscape and other greening measures, temporary and permanent (micro) gardens or small parks, possibilities to sit down or play, water elements, multiple use of municipal infrastructure facilities such as swimming pools and schools, etc.) not only create leisure options close to home, but also generate an attractive network of routes that links green and leisure spaces and provides access and the emotional experience of enjoying water bodies like Danube, Danube Canal, Wien River and Liesing Brook. In addition to greater recreational value, the open space network will also make an important contribution to greater environmental quality by improving the micro climate of neighbourhoods, by strengthening the fresh air corridors so important for urban air quality and by protecting the habitats of animals and plants” [15].

“The principles of the Mission Statement for Green Spaces of the Urban Development Plan of 2005 (STEP05) thus remain unchanged. The types of agricultural use so emblematic and characteristic of Vienna’s landscape will be preserved, in particular the identity-creating vineyards and meadows with scattered fruit trees. Moreover, the City of Vienna will continue to ensure the sustainable preservation of existing protection zones and superordinate green corridors” [15].

Figure 2: Vienna's mission statements of green spaces in the city. Source: STEP 2025 [15]

6. Why promote biodiversity in cemeteries?

Cemeteries are primarily places for rest and reflection. Friends and relatives are given an opportunity to visit the resting place of the deceased, to commemorate the lost and to process their grief. Cemeteries are also urban green areas that are central and close elements of an urban green space network (Figure 3) especially in densely populated urban areas. These areas are important for local recreation, as they are natural green space that offer visitors room for relaxation.

Figure 3: Map of municipal cemeteries in Vienna (see black shaded areas). Adapted from [16].

Currently, there are 46 municipal cemeteries in Vienna (Figure 3) and six other denominational cemeteries in use. The municipal cemeteries cover an area of nearly 5.2 square kilometres [17], representing around 1.2% of the total area of Vienna. With two exemptions, all municipal cemeteries are more than hundred, fourteen of them even more than two hundred years old (see Table 3).

Table 3: Municipal cemeteries in Vienna in use, ranked by age (according to data from July 2014) [17]

No.	Cemetery (German name)	District (German)	Size in m²	Operating since	Ranked by age
39	Simmering	11., Simmering	56,955	Medieval times	1
34	Ottakring	16., Ottakring	173,461	before 1230	2
27	Leopoldau	21., Floridsdorf	4,949	around 1489	3
24	Kaiserebersdorf	11., Simmering	12,060	before 1681	4
37	Siebenhirten	23., Liesing	8,511	around 1780	5
36	Rodaun	23., Liesing	12,029	1783	6

1	Altmannsdorf	12., Meidling	3,807	1784	7
28	Liesing	23., Liesing	47,272	1784	8
17	Hetzendorf	12., Meidling	7,583	1784	9
21	Inzersdorf	23., Liesing	95,056	around 1784	10
35	Pötzleinsdorf	18., Währing	5,544	1785	11
18	Hietzing	13., Hietzing	97,175	1787	12
9	Eßling	22., Donaustadt	22,649	after 1789	13
20	Hütteldorf	14., Penzing	49,510	1811	14
3	Atzgersdorf	23., Liesing	39,282	1825	15
12	Grinzing	19., Döbling	45,265	1830	16
33	Oberlaa	10., Favoriten	33,737	1833	17
41	Stammersdorf-Ort	21., Floridsdorf	8,217	1833	18
30	Meidling	12., Meidling	129,811	1862	19
29	Mauer	23., Liesing	49,378	1867	20
8	Erlaa	23., Liesing	4,651	1869	21
19	Hirschstetten	22., Donaustadt	5,959	1872	22
16	Hernals	17., Hernals	161,019	1872	23
15	Heiligenstadt	19., Döbling	20,315	1873	24
22	Jedlesee	21., Floridsdorf	55,994	1873	25
4	Baumgarten	14., Penzing	236,362	1874	26
46	Wiener Zentralfriedhof*	11., Simmering	2,500,000	1874	27
14	Hadersdorf-Weidlingau	14., Penzing	12,868	1875	28
40	Stadlau	22., Donaustadt	14,788	1875	29
26	Lainz	13., Hietzing	7,248	1876	30
32	Ober-St.-Veit	13., Hietzing	35,886	1876	31
43	Strebersdorf	21., Floridsdorf	31,722	1878	32
11	Gersthof	18., Währing	31,714	1880	33
31	Neustift	18., Währing	150,851	1880	34
7	Dornbach	17., Hernals	44,047	1883	35
6	Döbling	19., Döbling	49,981	1885	36
13	Groß-Jedlersdorf	21., Floridsdorf	58,138	1885	37
38	Sievering	19., Döbling	37,152	1885	38
23	Kagran	22., Donaustadt	55,781	1887	39
2	Aspern	22., Donaustadt	89,564	1892	40
25	Kalksburg	23., Liesing	7,658	1892	41
45	Süßenbrunn	22., Donaustadt	5,053	1893	42
42	Stammersdorfer Zentral	21., Floridsdorf	192,970	1903	43
5	Breitenlee	22., Donaustadt	11,987	1909	44
44	Südwest	12., Meidling	241,828	1921	45
10	Feuerhalle Simmering	11., Simmering	215,383	1922	46
	Total		**5,181,170**		

* Central Cemetery of Vienna

Cemeteries ensure the crucial function of balancing the city's climate and the microclimate ("green lung") and they also counteract regional air pollution. Moreover, they are important habitats for plants and animals. Cemeteries offer a variety of structures enabling a wide range of species the option for retreat. Hence, cemeteries are particularly valuable for urban biodiversity conservation.

All these aspects contribute to making urban cemeteries to special places for nature and species protection (so-called "islands") that require to be duly considered and promoted because of their value [18]. As a matter of fact, the conservation of cemeteries as ecological niche in our polluted environment is urgently needed [19].

Cemeteries are particularly worthy for biodiversity protection because they comprise the following features:

- a high **species diversity**[2], including a wide range of threatened and / or endemic species[3],
- a high **diversity in ecosystems, structures and habitats** and
- a variety of valuable **ecosystem services**.

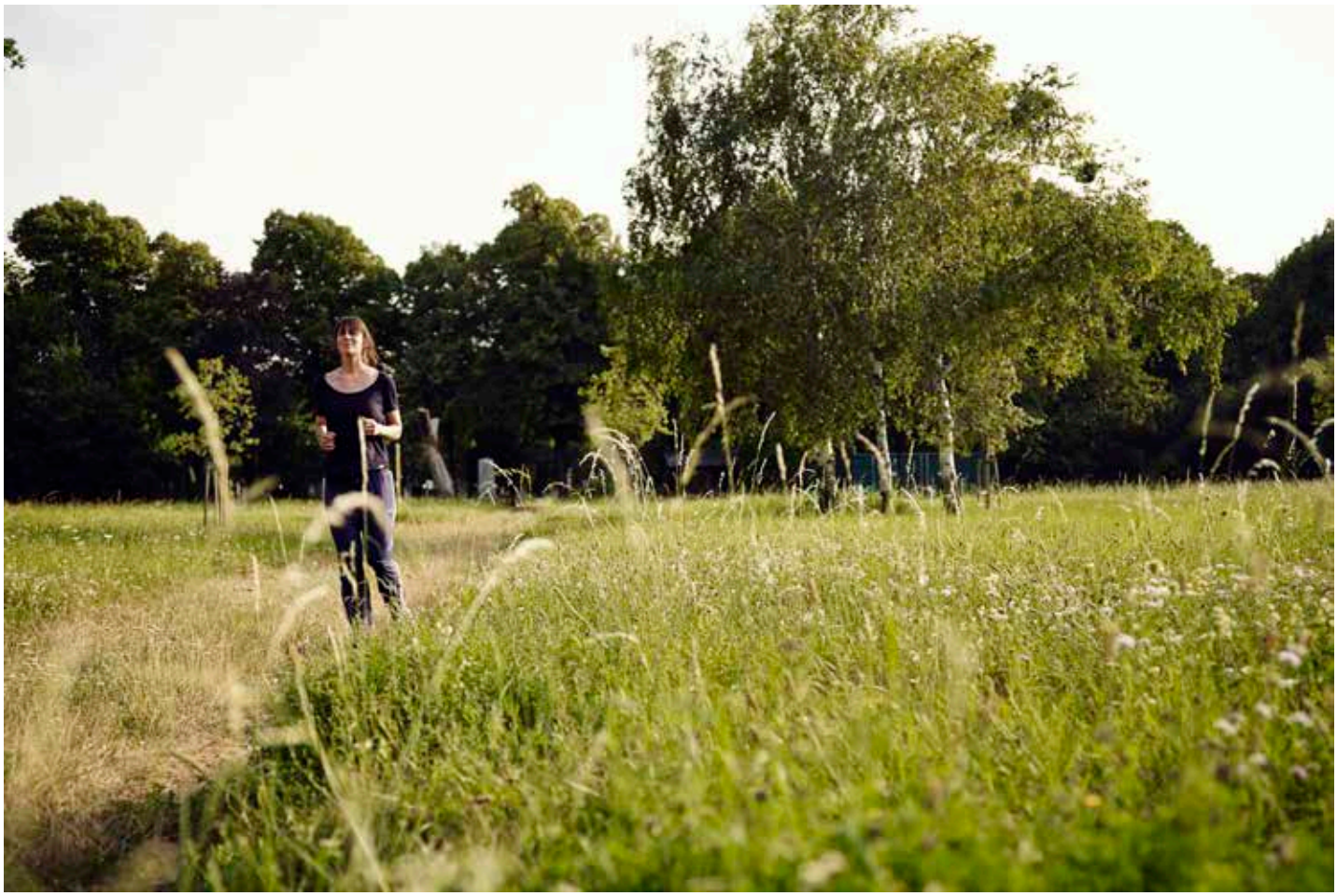

Figure 4: (Pristine) grassland on the Central Cemetery of Vienna (Zentralfriedhof Wien) (© Wiener Stadtwerke)

[2] A species can be defined as a natural group of organisms capable of reproduction; the individuals of a species show consistency in all essential traits among themselves and compared to their descendants.

[3] Endemic species are indigenous species that are unique to geographically defined regions. Familiar examples are the Darwin's finches and the giant tortoises endemic to the Galapagos Islands or lemurs that can only be found on Madagascar. With 581 animal and 167 plant species, Austria has the most endemic species compared to other countries of Central Europe. Cf. http://www.biologischevielfalt.at

6.1. High species diversity in cemeteries

6.1.1. Characteristic features of cemeteries

Cemeteries take over various functions in urban areas like providing important habitats for a variety of species. Which species benefit from these habitats? This varies and unfortunately there are only few studies with complete coverage of the spectrum of species that can be found at cemeteries. This is mainly due to the fact that studies are mostly focused on the occurrence of a certain type or family. This is not surprising since most researchers have mostly dealt intensively with only a certain type, family or species in their academic careers. So far, only lichens and mosses (Salzburg [20]), microfungi (Bratislava [21]), microbial communities (Moscow and St. Petersburg [22]) or snails (Istanbul [23]) have been recorded on (single) cemeteries. Also, in most of these studies there is a clear reference made to the importance of monuments. More precisely, it is referred to the tombs stones and cemetery walls, which represent a unique niche for the examined species.

Following studies from German-speaking countries, the urban building types that are the richest in species are rail track areas [24, 25, 26, 27], old industrial areas, and old cemeteries [28]. Also the German Federal Agency for Nature Conservation suggests that structurally rich green areas – like old parks, old cemeteries and old domestic gardens – often have a higher than average biodiversity [29]. Parks and cemeteries both belong to the sites that combine the particularities of urban ecosystems with special proximity to nature. Hence, they are important habitats for e.g. wild plants [30]. Rare and endangered species can find new habitats in urban cemeteries [31, 32, 33]. Cemeteries and parks hence function as refuges for endangered plant species. A number of endangered plant species find cemeteries to be attractive sites that are crucial for reproduction. This is due to characteristic features of cemeteries such as under others

- Multi-layered, semi-open habitats
- Old age of soils and locations
- High level of habitat diversity
- Many pristine biotopes, partly cultivated areas and unique features [30].

Protective measures are therefore of particular importance.

6.1.2. Diversity in lichens and plants

The richness of plants in cemeteries is documented in numerous literature sources. It is known, that cemeteries on both sides of the Danube are refuges for many sensitive and demanding lichens[4] [34, cited in 35]. In Germany, for example, the number of species in cemeteries was determined for the cities of Essen (about 570,000 inhabitants) and Cologne (around 1 million inhabitants). Here, more than 450 wild plant species, lichens and mosses, including many endangered species, have been identified [36].

Old cemeteries are also areas that are rich in **geophytes** – these are higher plants, such as tulips, daffodils, crocuses and ‘lilies of the valley’, which outlast the bad seasons in the soil [28]. There are, for example, reports from a variety of geophytes in old cemeteries located in the Berlin districts of Neukölln and Kreuzberg [37].

6.1.3. Diversity in animals

The fauna diversity in cemeteries is high and particularly worth protecting. Cemeteries with a high structural diversity are an important habitat especially for **insects** [38, 39, 40]. E.g. a great variety of heteroptera (also known as ‘true bugs’) was found on the Central Cemetery of Vienna. The occurrence of species from this suborder is considered to indicate high biodiversity. Hence, these species are seen as biodiversity indicators [41] (see also info box on the next page).

In cemeteries **birds** can find a higher than average number of singing vantage points and nesting opportunities. Both the absolute number of breeding pairs and the number of species of breeding birds is surprisingly high. For example, about 40 species of breeding birds were registered in a cemetery in the City of Kiel and even 80 species in a cemetery in West Berlin [19]. Also in other German cities such as Essen and Bielefeld about 40 breeding bird species were observed in the urban cemeteries [36]. However, due to the degradation of surrounding landscapes a decline in species numbers is recorded in many ecosystems including cemeteries [19].

Cemeteries do not only fulfil the function of a [diverse] breeding space, but provide a resting and wintering place for migratory birds. Although old cemeteries are often rich in species, the age is not the primary factor determining the diversity. The diversity of animal species is closely linked to the structural diversity [19], which can often be found on old cemeteries (see also below).

[4] Lichens are a symbiotic biocenosis between a fungus and one or more photosynthetic partner(s). The latter can be green algae, cyanobacteria or even sometimes both.

Species diversity at the Central Cemetery of Vienna (Zentralfriedhof Wien)
Opened in 1874, the Vienna Central Cemetery covering approximately 240 hectares and around 330,000 grave sites is the second largest cemetery in Europe (behind the cemetery Ohlsdorf in Hamburg).

Rabitsch (2009) investigated the occurrence of heteroptera at the central cemetery and suggested that the community is rich in species with 192 identified heteroptera species [41]. In comparison, Rabitsch (2004) only found 171 species at the Botanical Garden of the University of Vienna [42]. This difference can be explained by the fact that the cemetery has a larger area though offering less diversity in food plants. According to the author, heteroptera are an excellent indicator group for the overall system diversity (e.g. Duelli & Obrist 1998 [43]). He also assumes that investigating the diversity of other groups of organisms (especially insects) at the Central Cemetery of Vienna would be rewarding.

Many other species find refuge at the Central Cemetery of Vienna. Here, the most extensive and most numerous population of European hamsters of Austria has been recorded. Up to 1,035 individuals can be found on 238 ha, which corresponds to about four individuals per hectare [14].

In Germany, more than half of the bee species is either threatened to be extincted or has already disappeared from the ecosystem. The Red List of invertebrates from 2012 published by the German Federal Agency for Nature Conservation (BfN) [5] includes 52% of all German bee species. For Austria however, there is no data available[6], but a high degree of risk can be assumed. The Wiener Stadtwerke located ten colonies of bees in the summer of 2013 in the garden (“Naturgarten”) of the Central Cemetery of Vienna to contribute to the protection and preservation of bees.

The Central Cemetery of Vienna is also considered a natural monument (no. 272) of great age. Fifty English oaks, which are more than 350 years old, form an oak grove that is located just around the corner of the ballot close to the crematorium. This oak grove was first described in Zeiler's “Topographia Austriae” (published in 1649) [44]. Old trees particularly contribute to structural diversity and thus the promotion of biodiversity (see next page).

6.2. High diversity in ecosystems, structures and habitats in cemeteries

A high structural diversity allows a large number of species to settle and thus promotes biodiversity. A complex and highly structured ecosystem is generated by various habitats. In a cemetery potential habitats are formed by paths, waysides, graves and tombstones, lawn and meadow areas, natural and planted trees, shrubs, hedges, bushes, groups of trees, flower beds and ornamental plants as well as piles of leaves or compost.

Structural diversity is also generated by interaction with neighbouring systems. The degree of interaction is dependent on the location of the cemetery within the urban structure, the population density of the surrounding urban area, the number of visitors and the frequency of human interference, the permeability to other ecosystems, and the cultural and cost-related practices in the management/ maintenance of a cemetery. The relevant factors for the structural diversity and hence the species richness of a cemetery are the occupation density of the graves as well as the size and age of the cemetery.

The importance of a cemetery’s age for its ecological value has been described by Richter (2003) for the City of Stuttgart [28]. He suggests that age is an important criterion for the differentiation of cemeteries due to the partially forest-like structures, the often extensive care and the preferred ornamental plant species of old cemeteries. Many older cemeteries are characterized by a share of big-crowned deciduous and coniferous trees.

A homogeneous appearance often indicates that the space is poor in different structures and biodiversity. Too often cemeteries are cultivated intensively and uniformly planted with species of short stature andalso exotic conifers (e.g. cedar, arborvitae, or false cypress). But especially valuable are rather (domestic) deciduous trees, because they increase the capacity of the soil to retain water, thus reducing the need for irrigation while effectively providing shade. Native deciduous trees are especially adapted to native soils, the nutrients present and the existing climate. Also the (endemic) fauna is adapted to native trees and the wealth of potential food and shelter that they provide. Domestic deciduous trees in Vienna include under others birch, sycamore, beech, oak, linden, willow and ash trees [45].

[5] http://www.rundschau-online.de/magazin/schlimme-folgen-bienen-sind-vom-aussterben-bedroht,15184902,16898224.html

[6] No current data for Hymenoptera available on http://www.umweltbundesamt.at/umweltsituation/naturschutz/artenschutz/oasis/

This is also confirmed inter alia by Landmann (2006) for the city of Innsbruck. Here, it is anticipated that a generally higher diversity of woodland in a varying but balanced mixture of different tree species, tree growth habits and stature heights is not only an important contribution to the recreational value of green areas, but also provides functions such as the interception of emissions and climate regulation. Diversity is significant from a functional ecological perspective. Offering a variety of structures increases the diversity of small (regulating) key species and the variety of higher life forms. According to the author, such positive linkages between tree species and animal species are also found in urban areas (e.g. Landmann 1993, 1998 for birds in green areas of Innsbruck, and Helden & Leather 2004 for insects). The author concludes that a great variety of more mature and above all native tree species is valuable and should be aspired [46].

Despite old (domestic) trees, even deadwood contributes to the diversity in structures and habitats. With its crevices and caves deadwood provides habitat and food source for insects, including beetles such as the great capricorn beetle and the stag beetle, but also for small mammals and cave-dwelling birds such as the black woodpecker and the nuthatch. Despite its ecologically valuable function deadwood is still often removed [19].

Cemetery walls are of great importance with respect to the structural diversity in cemeteries. Walls can (often only) get over a hundred years old and are also likely to be excluded from intensive care. This makes them a special habitat for well adapted vegetation (see Figure 5). In the literature results can be found on the composition of species and the protection value of the vegetation of wall joints [47, 48]. Walls of natural stone (limestone, sandstone) or joints made of weathered lime mortar have proven to be sites of high biodiversity [19]. (Old) walls are often unplastered and rich in joints offering retreats for spiders and insects such as bees, wasps and ants.

Figure 5: Cemetery wall in Heiligenstadt near Bamberg [7]

Also reptiles and amphibians can find niches in cemetery walls. Toad species like the natterjack toad (Bufo calamita) have been discovered in cemeteries at wall bases or at the foot of a chapel. According to Fauna Flora Habitat Directive (FFH Directive) Annex IV it is a "strictly protected species". Within the Red List of Austria it is classified 'Critically Endangered'. The common toad, blindworm and grass snakes (all classified 'Near Threatened' according to the Red List of Austria) have also been found here [19].

It can be concluded that particularly greater native tree stocks and extensively cultivated areas promote biodiversity. In contrary, intensification, insensitive restoration of the masonry and structural simplifications reduce species richness.

6.3. Valuable ecosystem services provided by cemeteries

The ecosystem services provided by cemeteries are not to be underestimated. Like other unsealed urban green areas, they form an important function in water management since rain water can seep away and contribute to groundwater recharge. If the surrounding walls are not too high and hermetically seal the cemetery, cemeteries affect the urban climate positively. Temperature is lowered, air humidity increases, dust is bound and oxygen is released. Therefore cemeteries in many cities have been designated as “climate regulation areas” and partly as “cold air producing areas” [19].

Especially in big cities cemeteries are green oases of calm, because they offer rarely found places of recreation that are far away from the hectic pace, the stress and noises of the urban machinery. They are also meeting places while simultaneously preserving cultural heritage. Due to the high value as public green and recreational areas ("green political value"), the cost of care and maintenance of cemetery areas is often financed by public budgets, because these costs should not be passed on to the fee payer (customers).

[7] Foto: Immanuel Giel, 12. June 2006 http://commons.wikimedia.org/wiki/File:Friedhofsmauer_in_Herzogenreuth.jpg

7. Biodiversity survey at Southwest Cemetery Stahnsdorf (Berlin)

A full inventory of diversity found in one place is often not possible. At the Southwest Cemetery (Südwestkirchhof) in Stahnsdorf (Berlin/Germany) the rare opportunity to conduct extensive studies on flora and fauna in a single location was possible due to the financing from the German Federal Environmental Foundation (DBU). For that purpose, a large scale **biotope mapping** with special attention to rare and endangered species was performed (Red List species, protected species under federal protection regulation) in spring 2002. {Note: There are extensive instructions to biotope mapping such as [49, 50, 51].} Bentele et al. (2002) describe in almost 300 pages the species richness of the Stahnsdorf cemetery [52].

According to Bastian & Schreiber (1994 cited by Bertele et al. 2002 [52]), it is important to use a scientifically sound evaluation process to draw conclusions concerning the ecological value of a location. One option is the ecological value analysis, which evaluates the factors variety, closeness to nature, completeness, integrity and functioning of ecosystems and landscapes. Yet the applicability of this method to cemeteries is limited, because cemeteries form only a comparably small part of an ecosystem or a landscape. Therefore characteristic and value-determining biotopes including their typically featured plant and animal species are used for evaluation and assessment. Bertele et al. compiled an area-wide biotope mapping based on botanical and phytosociological characteristics. Here, the identification and assessment of the flora and fauna was performed based on selected groups of species (indicators) and their habitat structures with particular regard to rare and endangered species (EU Species Protection Regulation, Red List etc.). The ecological value results from the overall species and biotope diversity and the occurrence of rare / endangered species[8]. The authors initially created species lists including information on the protection status, also habitat and small structures are evaluated that are particularly valuable for the respective indicator organisms.

The observation was initiated to serve as a model project for showing solutions for comparable locations. Biotypes, flora, and fauna relevant for cemeteries were recorded and evaluated. The results were compared to studies conducted in other cemeteries to describe exemplary measures that can be taken at other major sites.

Table 4: Stahnsdorf cemetery (Berlin/Germany): Examined groups of organisms with their respective total numbers of species and the number of endangered species after Red List and/or Federal Species Protection Regulations (BArtSchV = Bundesartenschutzverordnung) [following 52, modified]

Examined groups of organisms*	Recorded species (total)	Share of endangered or protected species
Wild and escaped ferns and flowering plants (vascular plants)	**503**	66 species (about 13%) according to the Red Lists Berlin, Brandenburg or Germany are at risk; including 5 species specifically protected under BArtSchV. In comparison: 1986 A.GRAF examined a total of 42 cemeteries in Berlin with a total surface area of about 297 ha and identified 690 wild and escaped plant species. **With about 500 species the cemetery is very rich in species.**
Wood-dwelling insects	**310**	47 species (15%) are at risk according to the Red List of Germany.
Fungi	**273**	11 species (4%) are at risk according to the Red List of Brandenburg.
Butterflies	**211**	20 species (about 10%) are at risk according to the Red List of Berlin-Brandenburg and the Red List of Germany.
Mosses	**119**	38 species (32%) are at risk according to the Red List of Brandenburg; 27 rare species. Comparable cemeteries in Berlin: 20-60 species.
Lichens	**72 groups (= species and subspecies)**	19 species (26%) are at risk according to the Red List of Brandenburg or Germany, 8 species are specially protected by BArtSchV, populations development of 4 of them has to be monitored according to FFH-Directive Annex V.
Avifauna (birds)	**53**	37 breeding birds (BB) and 16 other species of birds (migratory birds, food and winter visiting birds), including 8 potential BB species of which the sparrowhawk is at risk according to the Red List of Brandenburg. Cemeteries in Berlin: 10-39 BB species; Ø 22 BB species; Stahnsdorf cemetery: 37 Ø BB species.
Vertebrates	**20**	10 species (50%) are at risk according to the Red List of Brandenburg or of Germany. The 20 vertebrates include 15 mammals (including 4 species of bats), 3 species of reptiles and 2 species of amphibians.
Grasshoppers and crickets	**16**	4 species (25%) according to the Red Lists Berlin, Brandenburg or Germany are at risk, including 1 species protected after BArtSchV.

* Not included in the study are ground beetles, hymenoptera, snails and spiders.

[8] Note: The study of Bertele et al. does not include FFH species.

The study about the Stahnsdorf cemetery has revealed that the area assessed is very diverse in species, mainly due to extensive use and care. A high proportion of rare and protected species is linked to the occurrence of specific habitats. Bertele et al. consider the cemetery as the most species richest in comparison to the cemeteries of Berlin but also nationwide. The proportion of rare and endangered species per group of organisms is significant when looking at the total number of identified species in the area. The high number of species results, inter alia, from the size of the cemetery of approx. 170 ha. Moreover the area is fenced which warrants effective dispersal and retreat. The presence of structurally rich habitats, the extensive use and care and undisturbed spaces are also reason for the high number of species [52].

The study about the Stahnsdorf cemetery shows that the factors location, size, age, type of cemetery and the intensity of use and care have great influence on the environmental and historic preservation value. According to the authors, the study confirms the findings of other studies showing that higher than average numbers of species can be found in forest cemeteries, especially when these areas belong to church institutions. If forest remnants are extensively utilized, grave departments are allowed to become overgrown with ivy and the number of burials is kept low, the number of species is generally higher [52].

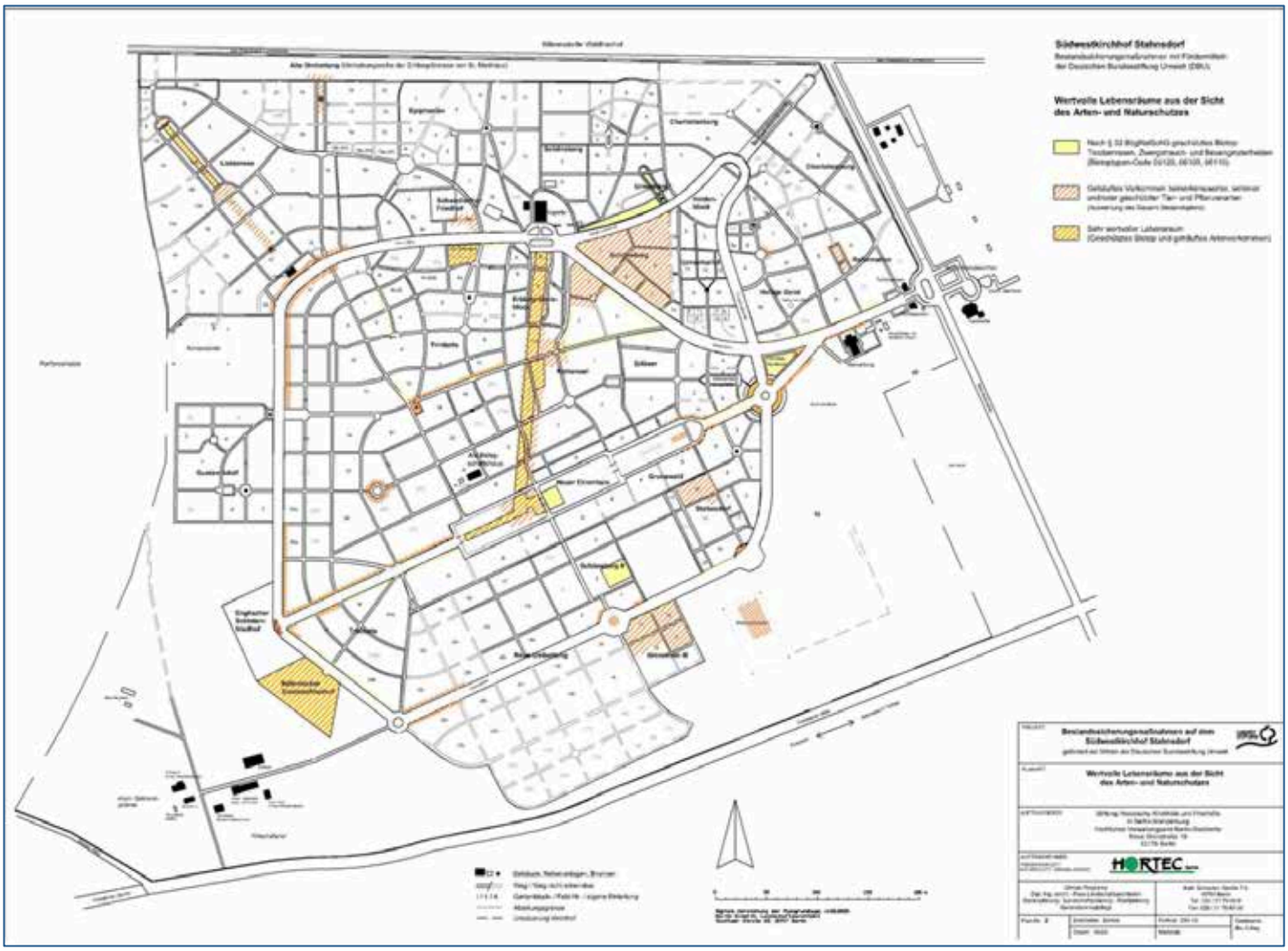

Figure 6: Valuable habitats in the Stahnsdorf cemetery [52]. Yellow shaded areas indicate protected biotopes (by Nature Conservation Act of Brandenburg, BbgNatSchG), hatched red areas indicate a high degree of rare or endangered species.

8. Best practice biodiversity measures in cemeteries

8.1. Neustift cemetery: A best practice model for environmental management

Regarding the needs of biodiversity protection, the Neustift cemetery in Vienna represents a good example of the deliberate adaption of cemetery management. According to the nature conservation report of 2010 for Vienna [53] a comprehensive concept was created at the initiative of the director of the Neustift cemetery. Various groups of species and biotopes were considered including bats, semi-hole nesters, meadows, and others. Following substantive preparatory work, butterfly meadows were set up, habitats for reptiles and amphibians were constructed or improved and bat and semi-hole nester boxes installed. Also various measures were taken to improve conditions for songbirds, butterflies and the giant peacock moth [54].

Moreover, according to the nature conservation report of 2010, the activities to promote biodiversity are explained in detail on notice boards or in the context of guided tours. The promotion of biodiversity includes the creation of structures and habitats that are specifically tailored to the needs of different species, as described in a document about the Neustift cemetery published by Friedhöfe Wien, a company of the Wiener Stadtwerke Group [55]. It also states, that the Neustift cemetery is a cemetery very close to nature. Because it is situated close to the Vienna Woods the cemetery has the potential to attract animals from this area. For a long time the cemetery offers areas that support biodiversity in particular [55].

Figure 7: Site map of the Neustift cemetery. Adapted from [55].

Based on local conditions there are seven areas at the cemetery (as illustrated in Figure 7) where habitats for certain species – bats, reptiles, songbirds, butterflies and the giant peacock moth – and biodiversity are given particular support. There is also a small wetland and a flower meadow, where biodiversity is particularly encouraged.

Bats

The quiet attic of the administration building has roughly sawn beams and boards so the bats can find a great day shelter. The bars were removed from the windows of the bell tower and replaced with wooden slats. The slats have a spacing of about 5 to 8 cm, making them passable for bats but not for pigeons [55].

Bat boxes for tree bats were installed in addition in the oak forest – with success: by now the noctule bat (*Nyctalus noctula*), which is the largest bat species in Europe, and the greater mouse-eared bat (*Myotis myotis*), which is the largest bat species in Austria and Germany, were sighted at the Neustift cemetery.

Butterflies

Vienna's parks and green spaces provide valuable habitats for many butterflies. To support the Hungarian glider (Red List of Lower Austria considers species "at risk", Red List of Austria classifies it "vulnerable") it is already a great help to plant ornamental spiraea preferably on sunny places. As butterflies lay down their eggs only on young shoots, it must be ensured that pruning of shrubs – if necessary – is completed ahead of the moths' flight time (i.e. in May) in order to avoid the destruction of eggs or young larvae. Basically, the shrubs should never be pruned all at once. Thus, at least a portion of the offspring remains even in case pruning has taken place on an unfavourable date [55].

The following measures have been taken to improve the habitat for butterflies at the Neustift cemetery [55]:

- Raising of the original terraced part of the cemetery,
- Application of humus, seeding or planting of fodder plants for the larvae,
- Provision of nectar sources by planting suitable shrubs (such as native wild plants and ornamental plants with single blossoms),
- Development of special sites (e.g. cairns and ponds), which increase structural diversity and create additional ecological niches for butterflies.

In order to improve the habitat of moths including the giant peacock moth (*Saturnia pyri*) – the largest butterfly in Europe (up to 15 cm wingspan) – the following measures have been implemented [55]:

- Planting of fruit trees at sunny spots. An unmown margin was left around the trunk base of potential foraging trees, as the eye-catching caterpillars otherwise could be easily captured by tomtits. The unmown area increases visual protection to the caterpillars.
- Waiving of artificial light sources as far as possible and in particular of light sources that emit blue or white light. Yellowish or orange light is far less problematic for the fauna.
- Preservation and promotion of structures close to nature (especially species-rich meadows).

Figure 8: Display board about the ecology of moths in the Neustift cemetery [56]

Reptiles

Among the reptiles are turtles, scaled reptiles ("squamata", including snakes and anguidae), crocodilians (crocodiles, only tropical and subtropical areas) and tuatara (only in New Zealand). Among the domestic reptiles in Austria are turtles, snakes and lizards. Blindworms (a lizard within the family of anguidae) and other lizards are relatively common. Snakes and turtles are however rather scarce in Austria. In order to improve the habitat for reptiles, the following measures have been taken [55]:

- Maintenance and creation of undisturbed sunny places close to forests for reptiles to sunbath,
- Creating piles of leaves or stones as hiding places, winter quarters and places to sunbath,
- Creating sand piles on sunny locations as nesting sites,
- Educational work on the harmlessness of domestic reptiles. The only snake that can be found in Vienna is the non-poisonous aesculapian snake.

Amphibians

Amphibians are terrestrial vertebrates that need fish-free ponds or other small bodies of water for spawning. Many amphibian species spend their entire larval stage (e.g. tadpoles) in the water. After a metamorphosis they proceed to life on land. The vast majority of amphibian species are still at least temporarily dependent on the presence of fresh water. Therefore, a specially designed waterbody for spawning was created at the Neustift cemetery. The adjacent meadow is rarely mowed in order to provide cover and food more effectively.

In 2013 Friedhöfe Wien sold the former gardening plot (7,000 m^2) to "Wohnfonds Wien", a non-profit organisation that coordinates property developers, house owners, municipal departments and service centres of the municipality of Vienna (http://www.wohnfonds.wien.at/website/article/nav/103). The sold land also included the amphibian pond, which was an essential part of the project for the environmental best practice model cemetery. Subsequently, the building contractor has filled this pond. Unfortunately, this has a negative impact on the entire environmental management of the cemetery.

8.2. EMAS certified cemeteries at Friedhofswesen Tübingen (D)

Friedhofswesen Tübingen (The cemeteries of Tübingen) have been managed by the municipal parks and gardens department ('Grünflächenamt') for several years. In 1996, the owner-operated municipal enterprise was founded and since then the cemetery management represents an independent operating department. The department had the cemeteries in the city area certified under EMAS (Eco-Management and Audit Scheme, http://www.emas.de) in 2002, 2006 and 2009 [57].

The 13 cemeteries in Tübingen that are the subject of the EMAS certification cover an area of 27 hectares (as part of 250 hectares of urban green space). As part of this concept (and as required by EMAS) the citizens are informed about the objectives by an environmental statement covering all thirteen cemeteries. These statements, which are published and are available for the press and all citizens via internet, describe corporate environmental impacts and possible measures that could reduce the use of resources.

Table 5: Extract from the new environmental program 2012 – 2016. Review of the objectives and measures as described in the environmental statement to the municipal cemetery management of Tübingen. Adapted from [57].

Environmental objectives	Measures	Organizational sector	Amendments	Status	Date
Reduction of soil contamination	Amendments to the cemetery statutes – use of fast-degradable ash capsules and waiving of not degradable urns	Administration		Implemented – preparation for ban of products from child labour	2011, 2013
Reduction of (drinking) water consumption by 10%	Technical measures to aggravate water withdrawal with hoses. Possibly reducing number of taps	Planning and construction, administration		Not yet implemented	Feb 14
	Partial renewal of the water network	Planning and construction		Not yet implemented	Middle of 2015
Align waste management with the German Waste Management and Product Recycling Act. Reducing residual waste by 6% and bio-waste by 15% (with respect to 2011)	Establish 'waste-free' cemeteries. Reviewing and minimizing existing waste sites in all cemeteries	Planning and construction	Politically difficult to implement, emotional matter	Gradual implementation by 2016 as part of the cemetery development concepts - direct dialogue with the municipalities	2016
	Informing visitors, gardeners and others	Planning and construction	Increasing information by a brochure	Template for brochure has been elaborated	Sep 13
Improve economic and environmental prospects	Opening of the cemeteries for burial for people coming from outside of Tübingen	Administration		Already practiced	End of 2016

The successful implementation of measures to reach objectives is examined and confirmed by an external expert. According to the environmental statement by the municipal cemetery management of Tübingen, the adaption of to the EMAS has been achieved cost-neutral and was financed from the current budget available [58].

According to the environmental statement, management includes the consideration of necessary aspects such as soil protection, water and climate protection, but also nature conservation and species protection. Therefore, it is useful to first analyse all activities in the cemetery management in terms of their impact on the environment. This includes the force of impacts and how the impacts are interrelated. In a second step, environment-friendly alternatives are considered and a catalogue can be created that offers specific measures to counteract adverse environmental effects. This also includes that employees consider potential environmental degradation caused by their activities in the processes of planning and construction, maintenance, grave care, burial operations and the management of buildings and machinery in the cemetery [57].

In the environmental statement the various activities are also assessed in terms of their environmental relevance (see Table 6). For example, the environmental relevance of the planning and construction is rated highly relevant, because it is an activity that could potentially lead to a sustainable landscape development. It can thus significantly lead to species conservation and biodiversity promotion. The burial operation on the other hand is considered to have low environmental impacts, though it is based on the use of various resources and possible emissions. These processes are dependent on administrative activities, the general energy consumption as well as waste generation and disposal. Yet the environmental relevance is comparably low.

Table 6: Activities and their environmental impact on the protected goods in accordance with the environmental statement to the cemetery management in Tübingen. Adapted from [57].

	Environmental aspects and impacts	Environmental relevance	Measures / impacts
Planning and construction	Landscape and nature conservation, species protection, climate and soil protection*	High	Examination of the tree stock, creation of woodland development concepts, the creation of planting concepts with native trees, the designation of tree protection areas and of areas that are designed “close to nature”, extensive lawn and garden maintenance
Funeral operation	Energy consumption, waste generation	Low	Administrative activities, burials (digging and filling of graves, the exhumation and reburial of bodies and clearance of grave goods and grave plantings), energy use and emissions of buildings and used machinery
Cemetery and grave maintenance	Transport (fuel consumption and CO_2 emissions) Noise emissions by machines and equipment	High Low	Monitoring of the state of the cemetery and graves, mowing of lawns, trimming hedges and trees, care of the wooded areas, mechanical weeding on paths and squares, and waste management
Operations of buildings and machinery	Resource conservation, material use	Medium to high	Monitoring of the state of buildings and their repair, cleaning and maintenance of buildings, cleaning and winter maintenance of roads, inspection and maintenance of the extensive water supply network and sewerage
* Soil protection is significantly influenced by the share of sealed areas.			

Measures already implemented in the 13 municipal cemeteries of the city of Tübingen include [59]:

- Settlement of a jackdaw colony in the city cemetery
- Installation of jackdaw boxes in plane trees
- Allow for hollow willows for screech owls, dead wood trunks for woodpeckers
- Boxes for tomtits and bats
- Planting of hazelnut trees for domestic squirrels
- Botanical urn burial places instead of (artificial) urn walls
- Designation of tree protection areas
- Replacing alternating plants by permanent ones
- Advising users (fact sheet)
- Allowance for infiltration of surface water into the grave sites
- Reduction of grave sealing (increase to a minimum of 1/3 plant cover)
- Terraces for birds in the water well
- Unsealing of ways
- Prohibiting the use of herbicides and fungicides
- Mechanical weeding
- Extensive maintenance of green areas.

Additional measures include:
- Introduction of the “waste-free graveyard”
- Substitution of the use of drinking/tab water by well water (where possible)
- Use of solar technology (where possible)
- Amendment of cemetery statutes: waiving of imperishable urns; use of quickly perishable ash capsules (e.g. from cellulose)
- Reduction of grave coverings to 50% (50% plants, thus less sealing),
- Construction of community graves (also for burials) with areas near to nature.

Moreover, the cemetery management started cooperation with the university on the topic of biodiversity (e.g. the ‘initiative green meadow’ working group of ‘Greening the University’) [57]. In addition, the project is successfully acknowledged from several sides (several awards, including the *project of the month* by the German DUH [60]). Species conservation through certification has shown first positive effects: A jackdaw colony has settled at the city cemetery. Also woodpeckers and owls have found nesting spots. In his welcoming address, Boris Palmer, mayor of Tübingen, has emphasized that only by means of careful planning cemeteries can act as refuge for endangered animal and plant species [57].

Forest cemetery Lauheide in Münster (D)
The forest cemetery Lauheide in Münster has also been certified based on EMAS. Due to the certification many successes have been achieved, including the colonization of rare bat species, strictly protected amphibians and 40 different species of breeding birds in the cemetery (Bruns, 2009) [61]. Resource consumption has been reduced deliberately. Power consumption in the administration building has been reduced by five percent thanks to the establishment of a wood chip heating system.

9. Recommendations on design and maintenance of cemeteries

9.1. Fields of action

The experts of the study about the Stahnsdorf cemetery (Bertele et al. 2002) have suggested a number of possible measures for habitat and species protection (see annex 1/ section 11).

To promote biodiversity in cemeteries the following areas for action are recommended:
- Increasing the structural diversity, for example by allowing dead wood to remain and unsealing of surfaces,
- Extensive management of meadows/lawn
- Preservation and appropriate restoration of masonry and monuments
- Use of environmentally sound materials, to relinquish the use of pesticides, fertilizers and road salt
- Waste prevention and recycling
- Investment in public relations and increasing acceptance

Increasing the structural diversity
The trees and the variety of different structures directly affect the number of habitats that can be found at cemeteries. To increase the structural diversity, it is important to leave sufficient space for planting near to nature. Accordingly, a high density of graves should be avoided (about 40% of the area) [36]. Large shrub zones consisting of native species can be established with little effort and are highly valuable from an environmental perspective. In such zones the undergrowth, leaves and dead wood are left while an adjacent margin area is left unmown. Creating and maintaining broad hedges and bushes increases the interconnectedness and provides shelter and food source. Leaving open special areas to permit succession can be appropriate in special cases. However, in this case it may be useful to seek expert advice because certain habitats can lose ecological value because of succession [52]. Old trees (and dead wood) should be maintained if possible, because they offer a variety of excellent retreat options. For reasons of traffic safety, cemetery management is obligated to check regularly for potential dangers by fragile trees. The operation of a cemetery requires paved paths. However, sealed surfaces should be reduced as far as possible. A graded system of pathways with adjusted path widths and adequate water-permeable coverings, such as gravel or mown grass, can limit the adverse effects on soils.

Management of meadows/lawn
Meadows that are mown less frequently (about twice a year) allow a variety of herbs and grasses to settle. This increases the food sources for insects and birds. Less frequently mowed meadows thus have a higher ecological value and biodiversity. In case the fast growing plant coverage is perceived disturbing, it can be removed (if necessary). But if so, it should be removed mechanically without using herbicides. Note that extensive care actually means a reduced workload and simultaneously brings many advantages. Weed vegetation does not interfere with everyday’s business on unused land as well as in marginal areas or under trees. Weeds offer a wonderful habitat for many insects. Also autumn leaves need not necessarily be removed in these places, because they can serve as natural soil protection and also promote the development of early bloomers like snowdrops and primroses. Only grass paths should be

excluded from extensive care due to 'traffic safety' reasons. In shaded places such as under trees, ivy or periwinkle could be planted, if existing moss layers are not accepted. On the other hand, mosses, ferns and lichens are to be regarded as ecologically valuable and should therefore be tolerated [36].

Preservation of masonry and monuments
Old cemetery walls of natural stone look attractive and are an excellent habitat for many species. Therefore, old walls should be maintained or newly built walls should use natural stone [36].

Use of environmentally sound materials
The use of chemicals such as herbicides, insecticides and other pesticides, fertilizers or road salt should be avoided. Pesticides do not affect only the respective "pest" but (directly and indirectly) all other organisms and therefore the entire ecosystem. The use of mineral fertilizers should also be avoided as it alters the natural – rather (nutrient) poor – soil conditions of cemeteries. Moreover, mineral fertilizers and road salt endanger the groundwater quality.

Waste prevention and recycling
Both in wreaths and flower arrangements the plastic content is usually high. This is problematic for cemeteries because plastic does not rot. In consequence, many operators have already prohibited the use of plastics, for example in grave flower arrangements, e.g. in the cemetery statutes. Generally, materials used should be compostable or recyclable. For separate collection of green waste, packaging and residual waste containers have to be placed at appropriate places. The organic material can be composted directly on the cemetery grounds. However, experts advise against incorporating nutrient-rich materials, compost and similar stuff to nutrient-poor soils. In contrast, it is recommend to introduce sandy soil substrates and to remove nutrient-loving grasses and herbs for leaning soils [52].

Investment in public relations and increasing acceptance
It is important to communicate to visitors that "untidy" areas of the cemetery are not running wild, but are kept like this for reasons of promoting biodiversity and conservation. These areas are designed "close to nature" and managed in order to conserve resources. To obtain or increase the acceptance and to encourage observers to comply with the regulation (statutes) in order to protect biodiversity, various measures can be taken, including:

- Information for cemetery users using information boards, leaflets with instructions for grave and cemetery design,
- Zoological and botanical excursions with local conservationists,
- Installing bird nesting and bat boxes, nesting options for insects such as wild bees, hornets, wasps, bumblebees, and earwigs (so-called 'insect hotels') [36].

Recommendations on the design and maintenance may be stipulated in the cemetery statutes or in a cemetery development plan.

9.2. Examples of success

Today there are numerous cemeteries with concepts for extensive care. At the Görlitz cemetery (Germany), for example, some lawns are mowed less frequently. Some no longer occupied grave fields are no longer maintained and herbicides are not used anymore. As a result, the biodiversity in the flower meadows has increased in recent years. Here, native orchids (*Epipactis helleborine*), wild primroses and autumn crocuses can be encountered again today – all three are under threat in Germany and are legally protected [62].

The protestant cemetery in Duisburg-Marxloh is managed according to ecological principles since 1995. The very simple cemetery has become a friendly "green oasis" in the industrial city within a few years. Here, ways were unsealed, old trees preserved and new trees planted. On-site waste separation and composting were introduced, a deadwood hedge was established, and a drywall was built. There are bird nesting boxes and watering places and the use of herbicides is prohibited to support and increase the existing avifauna. For stimulation, model graves have been designed including a permanent planting of predominantly native plants [36].

10. Conclusion: Biodiversity conservation in cemeteries

Biodiversity conservation does not solely imply the act of species conservation. As mentioned earlier, functioning ecosystems that provide a broad spectrum of species are as important as the cross-linking of different habitats. Cemeteries perform various tasks as part of a **green infrastructure**. Preservation of intact ecosystems or providing habitat areas that have been rehabilitated in respect of certain species, including landscape elements like small streams, woods or hedges. The latter can serve as corridor/wildlife passage or as stepping stone for wildlife species.

Potential components of a green infrastructure [63]:

- "Protected areas, such as Natura 2000 sites;
- Healthy ecosystems and area of high nature value outside protected areas such as floodplain areas, wetlands, coastal areas, natural forests etc.;
- Natural landscape features such small water courses, forest patches, hedgerows which can act as eco-corridors or stepping stones for wildlife;
- Restored habitat patches that have been created with specific species in mind e.g. to help expand the size of a protected area, increase foraging areas, breeding or resting for these species and assist in their migration/dispersal;
- Artificial features such as eco-ducts or eco-bridges, that are designed to assist species movement across insurmountable landscape barriers;
- Multifunctional zones where land uses that help maintain or restore healthy biodiverse ecosystems are favoured over other incompatible activities;
- Areas where measures are implemented to improve the general ecological quality and permeability of the landscape;
- Urban elements such as green parks, green walls and green roofs, hosting biodiversity and allowing for ecosystems to function and deliver their services by connecting urban, peri-urban and rural areas;
- Features for climate change adaptation and mitigation, such as marshes, floodplain forestsand bogs – for flood prevention, water storage and CO_2 intake, giving space to species to react to changed climate conditions ... "

It is important to inform the visitors about the functions of the cemetery to ensure acceptance and willingness to cooperate.

The employees have to be involved in the conservation of biodiversity on cemeteries, too. Therefore we conclude that biodiversity conservation should become part of the training content for cemetery gardeners. The curricula for gardeners could be amended accordingly. As apprenticing company, cemeteries can effectively influence the superordinate institutions. Actually, future gardeners come into contact with nature protection and biodiversity solely when dealing with the issue of plant protection, as anticipated in the curriculum for cemetery and ornamental gardener in Austria [64]!

11. Annex 1: Stahnsdorf cemetery: List of measures for habitat and species conservation

Conservation / development goals	Measures, implementation
Coniferous, mixed and deciduous forest areas **Promotion of locally adapted native trees of pine-/sessile oak forest (tpnV = today's natural potential vegetation) and open forest areas with a dense shrub and bush cover**	Repression of non-native trees and shrubs through regular clearings, especially of fast-growing and shadow causing tree and shrub species like bird/black cherry (*Prunus serotina*), norway and great/sycamore maple (*Acer platanoides* and *A. psedoplatanus*), robinia/locust tree (*Robinia pseudacacia*). Strong thinning of all dense coniferous and (red) oak tree stocks in winter. New planting and replanting measures by means of native tree and shrub species of typical pine-oak forests. For such measures also use existing vegetation (-> high growth guarantee, low expenses).
Preservation of tree stumps and decaying branches as habitat for specialized species such as wood beetles and as habitat for mosses	No clearing directly above/on the ground. Decaying branches are not directly removed from the trunk but at about 1 m length (leave the rest for colonization of animals, e.g. for building cavities).
Maintaining dense ivy and bush covers as (breeding) habitat, i.a. for dunnocks, robins and wrens	No maintenance measures.
Development of areas that are rich in species and structures by means of layered/alternating elements (forest edges and wood-free open spaces like meadows and transition areas)	Mitigation of abrupt transitions between forest edges and open spaces by removing a portion of young to middle-aged trees, if necessary (trans)planting of individual native shrubs.
Preserving semi-open, park-like forests with typical cemetery trees as important habitats for lichens, fungi, butterflies etc.	Cautious thinning of woody regrowth, approx. once annually.
Improvement of the breeding and living conditions of bat and bird species	Preserving hollow trees (wherever possible) and installation of nesting boxes (incl. regular care / maintenance) under the guidance of professionals.
Reduction of forest monocultures in the peripheral areas of the churchyard: (pine, spruce, Douglas fir)	Medium-term conversion of plain forest areas in accordance with the national forest management objectives. Introduction of locally appropriate pine-oak forests by the addition of durmast / sessile oak, English oak and silver birch. An increase in rotation periods, the construction of layered stocks and balanced ages is also beneficial.
No use of heavy forestry machinery (wheeled and tracked equipment, harvester and the like) to prevent damage to trees and soil where possible	Introduction of timber harvesting methods (even after storm events) that are soil conserving (e.g. employing horses for transport).
Solitary trees, avenues and rows of trees	
Preservation of standing or lying deadwood and trees until natural death Especially: • Large trees with climbing plants (ivy, pipewine) • Solitary and dead trees, especially oaks with low horizontal branches (for lichens) • Trees with cavities, standing deadwood as living and nesting habitat for insects, birds, etc.	No or only demand-based maintenance (for traffic safety). Felling of hollow trees is limited to justified exceptional cases (traffic safety). In case of a required felling it has to be assessed whether high stubs of 3 to 10 meters can be preserved as valuable habitat.

Conservation / development goals	Measures, implementation
Development of trees in avenues / tree lines in order to become part of a permanent old tree population of native species, development of denser stocks Especially in dry and sunny waysides to allow for the development of ground covering vegetation -> Dry grassland waysides	No or only demand-based maintenance (for traffic safety). Targeted thinning by removing foreign coniferous species, such as spruce and Douglas fir. Preferentially planting of birch trees as new or supplementary trees along pathways (-> less shade pressure, optimal development of herbaceous layer).
Hedges **Maintaining of old hedges that are of importance in terms of environmental aspects and for monument preservation** like e.g. the hedges found around the English and Italian soldier cemetery	Careful trimming of hedges – if there is substantiated need to it. No trimming in the breeding season of typical bush-breeders; hence, only from October to February. Allow for herb-rich areas next to hedges (extensive mowing, every 2 to 3 years) and for autumn leaves under hedges as wintering quarters for insects. In case of replacement or new plantings, use of domestic, site-specific species, preferably fruit and floriferous species, such as hazelnut, yew, hawthorn, spindle tree, dog rose.
Dry grassland and heath areas **Permanent preservation and protection of habitats and their typical plant communities to secure open land habitats and sunlit lean soils and to promote animal species that favour open, cleared habitats (according to § 32 Nature Conservation Act of Brandenburg, BbgNatSchG).** Primarily occurring on the cemetery at the following locations: • Visual axis („Kapelle-/Erbbegräbnisblock, Ehrenhain-West, Lietzensee, Feld VI-IX“) • Italian military cemetery • Block Trinitatis, field 3a with the grave ‘von Siemens’ • lawn around the roundabout south of the Christ memorial • waysides characterised by dry grasslands conditions	In general: Regularly remove any woody regrowth in winter, especially of alien species. Periodic review of adjacent wooded areas on shade intensity. If required: clearance / pruning of interfering trees. Exclusion of pesticides and fertilizers, no introduction of nutrient-rich soil and composts etc. Areas with composted earth are to be ‘impoverished’ (by introducing sandy soil substrates, removing nutrient-loving grasses and herbs).
Sectional and temporally alternating mowing operations to maintain different flowering sections	Regular mowing of areas (approx. once a year between end of August and early September) depending on weather conditions using a string trimmer/brush cutter, thereby also removing woody regrowth; maintaining stocks of calluna and common broom: pruning of calluna only when overaged.
Protection and development of invertebrate populations (protect deposited eggs on plant stems)	**Mowing the lawns in the visual axes** Grazing by sheep if possible. Larger lawn areas are to be mown in sections and at different times, in the beginning of July at the earliest, no more than half of each lawn is mown in one operation, the other half is mown about 2 to 3 weeks later. Grass cuttings are to be left a few days and then removed to allow a migration of invertebrates to the uncut patches. **Mowing of waysides and small clearings** once or twice a year; individual sections are left as a winter quarters for invertebrate species throughout the year. No mowing on smaller, sunlit areas in the transition areas adjacent to trees and shrubs.

Conservation / development goals	Measures, implementation
Conservation of poor site conditions and improvement of supply by flowers for pollinators	**Mowing of lawn areas, Italian military cemetery** Mowing once a year: front area between the stone crosses and the large memorial are mown in the beginning of July at the earliest. The back area is mown in September, thereby the calluna stocks is spared. Remove grass cuttings only after several days of interim storage. Leave areas of 2 to 3 m width along the sides of the hedge unmown (yearly alternating areas) due to the aforementioned reasons. **Mowing of the lawns at the entrance of the churchyard and beside the chapel** Here, repeated mowing of lawns is acceptable, as these areas are important for representation and welcoming visitors. Twice a year mowing is in line with ecological and aesthetic aspects.
Keeping clearings and sun-exposed transition areas open or enlargement of the same. This objective can be met within the next 2 to 3 years to increase sun-exposure of the areas	Removing spontaneously emerging or planted trees during the winter months, especially of the atypical species of Brandenburg such as spruce, Douglas fir, larch and various ornamental shrubs.
Maintaining newly formed clearings as for example by the storm event in July 2002. This extends the habitat for specialized animal and plant species (open land species).	No reforestation of clearings. Leaving lying and standing deadwood, broken tree crowns and uprooted trees (if traffic safety is assured). Use local or nutrient-poor soil substrate to fill holes caused by uprooted trees; under no circumstances use nutritious compost earth or wood chaffs!
Ruderal sites and stocks dominated by shrubs and mosses	Irregular extensive mowing every 2 to 3 years. In mossy lawns: support development through targeted thinning of wood stocks.
Seeded grass areas **Transformation into species-rich, extensively cultivated grasslands,** i.a. to improve biotope quality and to increase the habitat of heat-loving plant and animal species	Reduce the mowing frequency, no fertilization. When seeding or reseeding areas, favour site-specific, species-rich grass seed mixtures.
Paths and path sides that are rich in vegetation **Conservation and development of dry grasslands, moss cover and the soft transitions between paths and embankments** by extensive maintenance of paths, roadsides, and embankments	If possible, no parting of path edges and no removing of sods from paths. Loose mosses can be removed by raking the paths (promoting resettlement of less competitive species). Extensive maintenance of embankments adjacent to paths to protect valuable moss species by light raking. Do not deposit piles of leaves, building materials, etc. and do not plant trees in areas and embankments adjacent to paths (not even on an interim basis).
Care and development of areas adjacent to paths as valuable locations for fresh and dry grassland species and for light- and heat-loving species	Regularly remove any newly emerging woody regrowth by mowing once to twice a year. Thinning of dense spruce and Douglas fir stocks, especially at sun-exposed path sides within the next 5 years, if possible. If necessary, replace conifers by oak or birch (low pressure shadow -> optimal development of growing conditions for herbaceous layer). Regular mowing in sections of larger transition areas and smaller clearings once to twice a year.

Conservation / development goals	Measures, implementation
Maintain water and air permeable soil conditions when repairing or restoring paths	Use locally available materials such as clay, sand and slag when restoring paths, driveways and squares, no use of asphalt or interlocking concrete paving. If feasible, you can use rare and/or protected plant and moss species in path restoration.
Gravesites, fountains, boulders, walls **Conservation/development as a habitat of mosses, lichens and herbaceous vascular plants, especially ferns**	Consult botanists, moss and lichen experts before restoration and repair work in order to keep site impairments as small as possible. In case of the occurrence of vulnerable species consider relocation to another place; preserve at least partial cover. Avoid aesthetically motivated cleaning operations. Inform visitors about grave care practices. Thick moss cover on (constructions made of) stones can be removed occasionally.
Preservation and support of (limepoor) boulder blocks as creative elements of the cemetery and as important habitats for rare and endangered moss and lichen species	Patch dry masonry and natural stones fixed with lime mortar are to be restored faithfully in rehabilitation work. Favour rough natural stones as grave stones. No use of fungicides, herbicides and other chemicals in restoration and renovation work. Favour mechanical cleaning and maintenance techniques.
Cemetery biotopes (grave sites dominating) **Development of structure- and species-rich biotopes** even for grave design; aspire lowest possible sealing of the soil also directly on the grave area	For conditioning of new and the maintenance of old graves increased use of blossoms rich perennials, possibly involving the spontaneous vegetation. No use of pesticides, and preferably no use of fertilizers to maintain typical lean ground locations in the cemetery. No use of large, ground-sealing memorial plates or the like; keep access routes open (dirt roads).
Buildings with entrances and undisturbed areas (chapels, mausoleums, crypts, etc.) **Preservation and (re)design of the cemetery buildings as a habitat for specialized species** Winter / summer quarters for bats and owls, nesting sites for birds, including kestrels, black redstart and spotted flycatcher	Preserve extensively used undisturbed areas, e.g. attics, towers, crypts with entrance holes and other access possibilities. Maintain access to attics, no closing of skylights and other entrance options. Attachment of resettlement assistance (incubators, bat boards, etc. by experts). Creating access to cellars and cellar-like crypts as bat quarters. In case of renovation or demolition of buildings prior consult specialists about necessary measures for conservation. Restoration measures are to be implemented section by section.

Conservation / development goals	Measures, implementation
Other recommendation	
Protection and preservation of all rare and endangered or for other reasons remarkable plant species	Identification of locations of rare and endangered species to protect valuable plant species, coordination of specific protection measures for individual plant species occurring; e.g. implementation or installation of a conservation culture before starting construction. Here, the entrance of the churchyard is recommended as conservation culture. This would also serve as information on floristic diversity of the churchyard for visitors. Implementation with the help of professionals when elaborating the general cemetery maintenance.
Development of the former gardening areas to dry grassland, fresh meadows and tall herb/shrub surfaces while preserving all domestic (old) trees and individual shrubs to improve the biotope and recreational quality. (Abandoned land is transformed to coniferous and pioneer forests).	Remove atypical shrubs; thinning of conifer plantations (sale as Christmas trees) over the next 2 to 3 years. Subsequently, regularly mow meadows and tall herb/shrub surfaces twice a year. If necessary, seeding with sheep's fescue (*Festuca ovina agg.*) (after removal of the conifer plantations) without using nutrient-rich soils.
Setting up timber and brushwood piles as winter quarters for hedgehogs, as a nesting site for ground-nesting birds and as a habitat for invertebrate species	Implementation through maintenance work, e.g. use of accumulating timber from pruning and cutting.
Installation of winter feeding places e.g. close by the administrative and staff buildings and near the chapel	Implementation for example during the spring or autumn through the Südwestkirchhof e.V foundation resp. with volunteers.
Attaching nesting boxes on trees for supplementing natural caves (trees)	In cooperation with experts. Annual cleaning of the boxes in autumn.
Protection of heat-loving species (e.g. reptiles) on paths, squares, driveways and open, sunlit green areas	Areas of vegetation, especially dry grasslands and heaths, may not be frequented by heavy machinery. Briefing of employees and implementation of controls during construction and maintenance measures by cemetery operators and the respective construction authority. Management / reduction by the cemetery operator of "car traffic" (visitors, firms) in the churchyard, e.g. by billboards and information signs at the entrance, driving permits only for certain roads, speed limits. If necessary, set up barriers or blockage of certain routes.
Elimination / reduction of the wild boar population to protect graves and lawns as well as sites with rare and endangered animal and plant species	The current hunting methods are insufficient; restrictions arise from the hunting law itself (no hunting in the undergrowth and of sows with piglets). Consistent hunting by frequent battue (hunt), immediate repair of open fence sections, regular inspection / repair of fences, reinforcing existing fence sections, particularly in areas of frequent wild animal crossing.
Informing the public about the species richness, about rare and endangered species and the importance of the cemetery as biotope / habitat	Issue a **brochure / flyer** for the flora and fauna of the churchyard including descriptions and suggest possible walking tours. Develop signs explaining selected species. Implementation in cooperation with experts on grants from foundations as well as through cooperation and donations from members of the Südwestkirchhof e.V. foundation. Establish regular guided tours about **nature conservation** with varying themes. The Südwestkirchhof e.V foundation could advertise and recruit professionals who volunteer for guided tours, and could include these offers in its annual program.

12. Annex 2: Regulations protecting and promoting biodiversity

12.1. Convention on Biological Diversity (CBD) (1992)

The United Nations Conference on the Human Environment was held in Stockholm in 1972 (Stockholm Declaration). 20 years later in June 1992, the second global conference on the environment – the so-called "Earth Summit" – was held in Rio de Janeiro. At this conference, among others two international conventions on climate protection (Climate Change Convention – United Nations Framework Convention on Climate Change / UNFCCC) and to conserve biodiversity were decided. The latter – the Convention on Biological Diversity (CBD, also known as Biodiversity Convention) – had been signed by 167 States by the end of 1993. Following its ratification by 30 States, the CBD entered into force on December 29, 1993. Meanwhile, 196 signatories – including the European Union – have obligated themselves to protect biodiversity and to use biodiversity sustainably. The treaty has yet not been signed by Andorra and Vatican. The US has signed the CBD in June 1993 but has not yet ratified it [65]. The signatories to the CBD have committed to the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.

An important milestone in the implementation of the Convention was achieved in 2010 during the COP 10 in Nagoya, Japan. At this conference, a strategic plan with 20 concrete targets for the year 2020 has been agreed upon (see box).

The 20 Biodiversity Targets of the CBD until 2020 (Aichi-Targets) [66]

1. By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.
2. By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.
3. By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.
4. By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.
5. By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.
6. By 2020, all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.
7. By 2020, areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.
8. By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.
9. By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.
10. By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.
11. By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.
12. By 2020, the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.
13. By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.
14. By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.
15. By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.

The 20 Biodiversity Targets of the CBD until 2020 (Aichi-Targets) [66]
16. By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.
17. By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.
18. By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.
19. By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.
20. By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.

In Nagoya also an internationally binding protocol on access and benefit sharing (Access and Benefits Sharing Agreement, ABSA) was adopted. This concerns in particular the equitable sharing of economic gains from biological (genetic) resources between origin countries and industries, especially when indigenous knowledge is utilized commercially (bioprospecting).

12.2. Habitats Directive (1992)

The Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) is an EU directive adopted in 1992 aiming for wildlife and nature conservation. The Habitats Directive is a means to implement the commitments made by the EU and the EU Member States at the World Summit in Rio in 1992 for the protection of biodiversity (CBD).

The Habitats Directive stipulates the protection of wild animal and plant species of European importance, including their natural and semi-natural habitats and the cross-linking of these habitats. To this end, a representative system of protected areas (Special Area of Conservation = SAC) is to be set up. Along with the bird-protecting areas[9] and the Ramsar wetlands[10], they form the European system of protected areas "Natura 2000".

The directive established a comprehensive legal instrument for the protection of all plant and animal species of European importance and also for valuable habitats. The instruments include the Special Area of Conservation (SAC), the introduction of an “Environmental Impact Assessment” (EIA) for protected areas (= compliance check), and strict regulations to protect certain species from fishing, killing or disturbance, use regulations, and monitoring mechanisms and compensatory measures. More information: http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

12.3. EU Biodiversity Strategy to 2020 (2011)

The EU Biodiversity Strategy to 2020 from 2011 aims to accelerate the EU's transition to a resource-efficient and green economy (“Our life insurance, our natural capital: an EU biodiversity strategy to 2020“ [67]). The strategy seeks to halt the loss of biodiversity and ecosystem services by 2020 explicitly for economic reasons, because the loss of biodiversity hurts mainly actors from sectors that depend directly on ecosystem services. With its biodiversity strategy the EU wants to achieve the following targets [68]:

1 Fully implement the Birds and Habitats Directives
2 Maintain and restore ecosystems and their services
3 Increase the contribution of agriculture and forestry to biodiversity
4 Ensure the sustainable use of fisheries resources
5 Combat Invasive Alien Species
6 Step-up action to tackle the global biodiversity crisis

On 6 May 2013, the European Commission has adopted a new strategy that encourages the use of green infrastructures and is “ensuring that the enhancement of natural processes becomes a systematic part of spatial planning”. It includes the following priorities:

- “Promoting green infrastructure in the main policy areas such as agriculture, forestry, nature, water, marine and fisheries, regional and cohesion policy, climate change mitigation and adaptation, transport, energy, disaster prevention and land use

[9] Richtlinie über die Erhaltung der wildlebenden Vogelarten, EG-Vogelschutzrichtlinie, 1979

[10] Übereinkommen über Feuchtgebiete, insbesondere als Lebensraum für Wat- und Wasservögel, von internationaler Bedeutung, Ramsar Konvention, 1971

policies. By the end of 2013, the Commission will develop guidance to show how green infrastructure can be integrated into the implementation of these policies from 2014 to 2020.
- Improving research and data, strengthening the knowledge base and promoting innovative technologies that support green infrastructure.
- Improving access to finance for green infrastructure projects – the Commission will set up an EU financing facility by 2014 together with the European Investment Bank to support green infrastructure projects
- Supporting EU-level GI projects – by the end of 2015, the Commission will carry out a study to assess the opportunities for developing an EU-wide network of green infrastructure. […]

By the end of 2017, the Commission will review progress on developing Green Infrastructure and publish a report on the lessons learnt together with recommendations for future action“ [69].

12.4. Austria

Austria has ratified the United Nations Convention on Biological Diversity from 1992 (CBD) as the 77th state on August 18th, 1994 and thus committed to implementing the CBD. Species protection in Austria is governed by the nature conservation laws and regulations of the nine federal states.

12.5. The City of Vienna

Vienna has fully implemented the regulations defined at state level. This includes the provisions given by the EU NATURA 2000 program as well as the requirements of the Birds Directive and the Habitats-Directive. Vienna has implemented these regulations by means of the Vienna Nature Conservation Act (LBGl. No. 45/1998) and the Vienna Law on the National Park Donau-Auen (“Vienna National Park Act”) from 1996.

13. List of reference

Remarks on the sources considered for this study
Most of the evaluated publications are case studies from various (large) cities in Europe that describe the characteristics and importance of cemeteries as habitat in urban areas. Focus has been placed on the results from Germany and Austria. Due to different biogeographical properties and culturally determined management practices, it is difficult to compare cemeteries/studies with respect to the occurrence of certain species. Nevertheless, the value of cemeteries as important areas of nature and diversity of species are distinctly reflected in many publications. Overall however, one cannot speak of a high number of publications on this topic.

Note, that the considered sources are taken from different disciplines. Hence, academic publications, policy documents and publications from the business sector must be considered respectively. Studies from the fields of botany, mycology, and zoology are usually limited to a particular species and use entirely different survey methods as for example studies by planning offices. Scientific papers often do not focus on cemeteries as research subject. Here, the cemetery is usually investigated because it is (coincidentally) the habitat of the species under examination.

This is the main reason that the majority of sources considered have been published by conservationists or correlated institutions (such as the NABU – Naturschutzbund Germany). Great amount of the sources are information brochures of operators and planning offices. To a large extent they are based on available documents from the Internet. These documents consider a broad spectrum of species and the entire habitat with all its processes and functions.

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3 European Commission: Q&A on the Communication on EU biodiversity strategy to 2020. http://europa.eu/rapid/press-release_MEMO-11-268_en.htm

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