Introduction to the town of Ceske Budejovice

Ceske Budejovice was built as an important centre of royal power in the south of Bohemia. It lies at the confluence of Vltava and Malše rivers, near the former settlement Budiwojovice (Budowiz). It was founded as a royal town in the year 1265. The historical town plan with its regular central square and a rectangular network of wide streets reflects the architectural highlights of mediaeval urbanism at that time. The original street network has been used for modern road traffic until the present day. There are now approximately 100,000 inhabitants in an area of 55.5 km² (Jihocesky kraj, 2004) in the administrative district. Ceske Budejovice is at the centre of the South Bohemian Region where 624,778 inhabitants currently live (2001 data) in 623 municipalities in an area of 10056 km-² (JhK, 2004).

The Ceske Budejovice green areas represent nearly all the main categories found in Czech and European towns - parks, allées, playgrounds, gardens, important trees, wildlife and wetland areas along a well-developed environmental gradient between the built-up centre and semi-natural suburb. Useful information is summarised in basic documents of the town administration: the Master Plan (2000), Geographic Information System (GIS) of the Statutory Town of Ceske Budejovice (2002), Database of Vegetation (2), which are widely used institutional instruments of the evidence and management of the town’s green areas. Internet information and published research articles were researched and included in the analysis of the town’s green areas (Hanousková et al., 2002 and 2003). Results of the long and short-term monitoring of the area were made available during the development of the COST C11 project (Hanousková et al., in press); the multidisciplinary assessments based on the authors’ opinion and expert consultation were also used. The history of the town was taken from Podhorsky (2003) and Jirman (2001).

How have natural features influenced Ceske Budejovice's green structure?

Natural structures of the town from a landscape perspective

The town is situated in a landscape that is formed by the alluvial plain of the Rivers Vltava and Malše in a geomorphological area called the Ceskobudejovicka panev. In the Czech Republic, the term bioregion is widely applied for the administrative and scientific landscape classification at a regional scale at the date and is understood to be a biogeographical term classified on the basis of potential biota, identical vegetation stages and historical patterns of biota migration (Culek et al., 1996).
basin, near an important elevation, Lisovsky prah.

We use here the concept of bioregions, often applied in the Czech Republic, to interpret the town’s natural background. The natural climate, vegetation, biota and agriculture of the town’s cadastral area mostly represent the flat Ceske Budejovice bioregion (No.1.30). A small part of the area belongs to the Bechynsky bioregion (No. 1:21). The foothills along the Jihoceska pánev basin mark the boundaries between the bioregions and the border is indicated by a notable change in the angle of slope. The Ceske Budejovice bioregion was formed by the basin, which was filled by acid sediments and large areas of sub-irrigated terrain depressions. The freshwater basin was formed by wash out, mostly of incoherent sediments, such as clay, sand and gravel, compacted locally. The bioregion differs according to the surroundings, typically the occurrence of water surfaces, wetland biotopes and the presence and absence of beech forests. The oak-coniferous biota prevails, with isles of oak-beech stands. The potential vegetation was reconstructed as acidophilous oak forests with fir added, alluvial forests and meadows, willowed habitats and boggy alder carrs. The sub-irrigated forests are unique, where the oaks, fir and spruce are abundant. (Culek et al., 1996.)

The Bechynsky bioregion to the south east of the built-up area is characterised by rugged and habitats of the Rivers Vltava and Mase acted as important regulators and barriers to colonisation and urbanisation. This was evident as follows:

• the town was first built on well drained land and then subsequently on the wetlands, which had become unsuitable for historical forms of agriculture in the thirteenth century; this was in direct contrast with the building of most other towns in Europe, which avoided building on flooded land and swamps.

• this late construction date was to the comparative advantage of the mediaeval builders, who could adopt the latest concepts of city construction in their plans

• the subsequent urbanisation of the town followed the old town composition, which was defined by the surrounding nature

• the rectangular street network of the historic centre was accommodated to follow the curved lines of the Vltava and Malse. The natural patterns of these rivers, together with the builders’ experience, determined the town layout for more than seven centuries.

• the hydrological conditions were favourable for setting up fish ponds, which contributed to the town’s prosperity from the sixteenth century. Some of the ponds have become bird habitats, which are of European importance today.

• the high water level enabled hydrological technologies to be used. In the landscape scale, historical attempts to increase water production through redistribution resulted in an important cultural feature, the system of ponds, drainage, wetlands and corridors along the ponds and ditches, with well developed and structured vegetation, its high semi-natural quality typical of the southern Bohemian cultural landscape and tourist areas at the time.

• wet meadows were converted to arable land after (sub)surface hydrotechnical amelioration

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• the town landscape was mostly deforested
• large areas were lost during the second phase of agricultural reforms, with self-maintaining vegetation cover stabilising the soil surface, genetic pool, species and habitat diversity.

**The role of vegetation in merging cultural features with nature**

In the green areas of the town conserving the recognised role of vegetation and/or changing it according to cultural demands was considered important (Figure 1); its role was promoted in practice by individuals, institutions and their instruments, through historical forms of environmental and resources management. The vegetation forms and their management are evident at various levels of the ecological hierarchies in the landscape and have resulted in functional types of green in town planning and engineering. The types were summarised by Srytr et al. (2001). The resulting green structures contribute individually to biodiversity by means of controlling forms of management and environmental services, species behaviour and species vectors, facilitating the penetration of organisms into new habitats and/or town areas (Figure 2). Many green space issues are considered trivial and are left out of the planning system as a result, or they are still too intricate to be introduced in practice, for example, the ecosystem/ecological behaviour of individual species and systems, their interaction, relationships and ecological services.

![Figure 2](image)
I. role of natural vegetation before the towns appeared
- protective: shelters
- source in food chain from wild herbivores to carnivores
- principal component of food chain for man
- source of health via food chain
- source of additional energy
- source for instruments
- managed object ‘when Nature agrees’
- spiritual: vegetation as object of spirituality and/or rituals
- barrier
- environment when travelling through the landscape
- environment for relaxation
- living conditions

II. role of vegetation in towns in rural society
- protective: shelters, fences
- source in food chain of domestic and wild herbivores
- principal component of food chain for man
- source of health via food chain
- source of additional energy
- source for constructing instruments, buildings, etc.
- spiritual: vegetation as object of spirituality and/or rituals
- aesthetic
- means of livelihood
- object managed in co-operation with nature
- barrier
- enemy that might be eradicated or controlled
- means of physical training
- environment for leisure time
- environment created for social contact
- living conditions

III. present role of vegetation in the town district
- protective: shelters, fences
- food source of domestic and wild herbivores
- principal component of food chain for man
- source of health through impact on psychological well-being and on distribution of biota
- source of additional energy
- source for constructing instruments, buildings, etc.
- spiritual: vegetation as object of spirituality and/or rituals
- aesthetic
- vegetation as means of livelihood
- vegetation as object managed in co-operation with nature
- vegetation as a barrier
- object that might be managed as self-maintaining
- enemy that might be controlled or even eradicated
- object that might be restructured
- object under protection
- environment during physical training
- environmental component for travel
- environmental component for leisure time
- environment for social contact
- recovery of habitats impacted during sources management
- living conditions

Figure 1. Changes in the role of vegetation for users of green space
Resulting structure of green space in Ceske Budejovice - Master Plan and expected benefits

In the Master Plan, the nature of green structures merges with the cultural role of the vegetation structures and might be found (in)directly under the category levels of the plan. Each category/area of nature contributes to biodiversity in an individual way (Figure 2). Nature conservation developed in the framework of physical planning and other forms of integrative planning in the Czech Republic (Sanderson and Harris, 2000). The various roles of green space are identified under individual topics in the Master Plan of Ceske Budejovice. They are:

• built areas. It is indicated, indirectly, that green space has neither an important nor a subsidiary role in forming the environment. The vegetation assemblages might change rapidly or might be stabilised in the long-term, or they may have limited importance in time. The built areas have a residential role for working activities, agriculture and forestry, traffic construction and services, sport and recreation, public facilities, technical facilities and water resources, residential housing with gardens and green structures of farmhouses.

• areas that cannot be built. This section identifies the long-term stable, natural and (assisted) semi-natural green areas. They are: town green vegetation, landscape green vegetation, water surfaces, agricultural land resources, areas of forestry services, and gardens.

• landscape and vegetation system. The section identifies the long-term stable, natural/semi-natural, potential and/or remnant green structures. The system is introduced in the Master Plan by applying an instrument developed for landscape planning in the 1980s, which was applied to the whole of the Czech Republic, the Territorial System of Landscape Ecological Stability, TSLES (USES), see origins in Michal et al. (1991) and its later development in Löw et al. (1995), Bucek et al. (1996), Ministry for Regional Development (1997) and comparison with the Netherlands practice (Boresova, 2001). The idea of the system was based on the experience of multidisciplinary teams of biologists, landscape ecologists and planners and is interpreted as a mutually integrated complex of natural and changed, nearly natural ecosystems, which maintain natural stability, and consist of what exists at present as well as what has been proposed for the future. The TSLES is distinguished as a local, regional and supra-regional system. It was applied to conserve and support the gene pool at landscape scale, to influence less ecologically stable patches of the landscape, to contribute to landscape multifunctionality and to preserve important landscape phenomena. The important idea was that remnants of natural or semi-natural communities, that are typical of a biogeographical region, are valuable for maintaining landscape ecological stability by preserving biodiversity. The structural categories of the TSLES, the corridors and biocentres of local, regional and supra-
regional importance, were incorporated in the town Master Plan as basic groupings of landscape and vegetation systems reflecting the nature of the Ceske Budejovice and Bechynsky bio-regions. The green areas of natural and semi-natural importance are included in the Master Plan in all the categories of landscape system under the TSLES: for instance, ponds and the cultural/natural heritage allow for the natural development of communities with a higher level of ecological stability.

- binding proposals for public constructions/utilities, such as establishing parks, developing bank vegetation, associated and recreational plant cover of the supra-regional biocorridor of the River Vltava and its permanent management and enlargement of the local biocentre.

**Action for the future**

In the Czech Republic, green space planning in urban areas is promoted institutionally by the state administration, within the framework of legal instruments and influenced by local environmental conditions. The latest instrument, developed with the support of the Ministry for the Environment, is a system for processing and registering data of recorded green (dendrological elements) to enable the more efficient maintenance of green by using the latest information technology and through the application of the Geographical Information System (GIS, Finstrle, 2003). The use of GIS, as has been shown from its application as a practical instrument in other branches of research and data management, will enhance the ecological practice in urban areas.

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1 Introduction

Helsinki is the capital and largest city in Finland. The urbanised area with around one million inhabitants extends far beyond the administrative borders of the municipality of Helsinki (some 560 000 inhabitants in 2003). Helsinki is a northern and maritime city located at the Gulf of Finland. Its municipal territory covers 185 km² of land area and 500 km² of sea area.

The population and housing production have grown very fast in Helsinki during the 1990s. Helsinki aims to have 620 000 inhabitants, which would mean, for example, 7 million m² of floor space for new housing and 9.2 million m² of floor space for business premises by the year 2025. This growth puts much pressure on green areas, both within the city structure as well as in the urban fringe areas.

Nature and culture shaping the green structure in Helsinki

The landscape of Helsinki is dominated by glaciofluvial landscapes, exposed bedrock and forested hills alternating with flat, clay areas which once constituted the seabed. The city centre is situated on a rocky peninsula near the open sea. The shoreline is long and there are hundreds of islands, most of which are small rocky outcrops from the sea. Inland the landscape scenery is dominated by granite hills (30-60 m. above sea level).

The geographical location of Helsinki on a narrow peninsula has had a significant influence on its urban and green structure. Because of the topography of the region and the historical possibilities of the city to expand, there are long stretches of green from the north that penetrate deep into the centre of the city (Figure 1, Map A, next page). Most of these main continuous radial green areas, the so-called green fingers of Helsinki, are a mixture of former agricultural river valleys, rocky forested ridges with spruce swamps and other wetlands, that were difficult geo-technically difficult for construction. As the City of Helsinki owns 69% and the state some 7% of the land inside the municipal borders, the City is also the largest owner of the green areas.

About one third of Helsinki was designated ‘green space’ in 1998, which amounts approximately to 100 m² per inhabitant (Table 1, next page). The (mainly) locally planned public green areas comprised about 4.2 hectares/1000 inhabitants (42 m²/inhabitant) in 2002, totalling 5 654 ha. Public urban forests cover 63% of this green space. Otherwise it consists of built parks (17%), manor estates (1%) and meadows.

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and ‘landscaped’ fields (11%). Mostly accessible nature conservation areas cover 4.2 km² (of which 2.8 km² is land), comprising 0.6 % of the total area of Helsinki.

The sea, shoreline and archipelago are also of great importance when discussing the green areas in Helsinki. There are almost 100 kilometres of shoreline and over 300 islands in the Helsinki archipelago. More precisely, complete data on the present land use or land cover types (regardless of land use planning categories) does not yet exist. Helsinki has only data on planned land use categories (zoning). For habitat distribution in 2001, see Table 2.

Table 1. Land use in Helsinki in 2001 and in land use plans 2002.

<table>
<thead>
<tr>
<th>Land use</th>
<th>2001 Km²</th>
<th>%</th>
<th>Helsinki Master plan 2002 Km²</th>
<th>%</th>
<th>Uusimaa regional plan 2002 Km²</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built-up areas</td>
<td>98</td>
<td>52</td>
<td>112</td>
<td>60</td>
<td>150</td>
<td>80</td>
</tr>
<tr>
<td>Green areas</td>
<td>85</td>
<td>45</td>
<td>70</td>
<td>38</td>
<td>33</td>
<td>18</td>
</tr>
<tr>
<td>Nature protection areas</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>187</td>
<td>100</td>
<td>186</td>
<td>100</td>
<td>187</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: Green areas and nature protection strongly exaggerated.
Sources: Land use in 2001 according to basic database of Helsinki metropolitan region.
Uusimaa regional plan: http://www.uudenmaanliitto.fi/mkaava/map.html
The biodiversity in Helsinki is unusually well known. A nature database for the City, with map applications in different scales, was created in 2001. It includes at the moment nature conservation area boundaries, protection data on sites and species, criteria and valuations of observed taxa, lists of sources, observations and sampling methods, and GIS-based presence/absence atlases on e.g. breeding birds and vascular plants. To serve the various needs of different branches of administration, still more development work is needed on, for example, thematic maps, and ‘warning and guiding’ environmental applications.

There is an unusually high biodiversity within hemiboreal Helsinki, compared to rural neighbouring municipalities, or other European temperate cities and towns. This has been measured by several taxa (vascular plants, breeding birds, polyporous fungi, butterflies and bumblebees), their species number, ecological and historical groups and threatened species (Figure 2). Green areas are the most important areas for vascular plant flora (they host most of maximal species-rich sites, endangered, rare and native species) (Tables 2 and 3). Present nature protection areas host only some 4%-15% of endangered vascular species habitats. Many species also live within the built-up urban fabric, such as threatened semicultural species (Vähä-Piikkiö et al., 2004).

### Table 2: Habitat distribution on present land use and loss on planned land use in Helsinki

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Present occurrence on:</th>
<th>Planned loss on green areas, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Built-up areas</td>
<td>By Helsinki</td>
</tr>
<tr>
<td></td>
<td>Green areas</td>
<td>Master Plan 2002</td>
</tr>
<tr>
<td>Shores and aquatics</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Swamps</td>
<td>27</td>
<td>73</td>
</tr>
<tr>
<td>Mires</td>
<td>29</td>
<td>72</td>
</tr>
<tr>
<td>Herb rich forests</td>
<td>38</td>
<td>62</td>
</tr>
<tr>
<td>Heath forests</td>
<td>46</td>
<td>54</td>
</tr>
<tr>
<td>Dry natural and semi natural meadows</td>
<td>38</td>
<td>62</td>
</tr>
<tr>
<td>Manor and villa environment.</td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>National and regional threatened species</td>
<td>49</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>73</td>
</tr>
</tbody>
</table>

Note 1. Seminatural, agricultural and artificial habitats are also called cultural habitats (IUCN 2001, CORINE 2001).

Note 2. Indicators: The 40 threatened vascular plants in Helsinki, including occurrences of 27 nationally in Finland and 13 regionally threatened species. The 100 rarest native vascular plant species present in the least number of squares in Helsinki.

2 Green structure benefits for biodiversity and the environmental services in Helsinki

**Biodiversity**

The biodiversity in Helsinki is unusually well known. A nature database for the City, with map applications in different scales, was created in 2001. It includes at the moment nature conservation area boundaries, protection data on sites and species, criteria and valuations of observed taxa, lists of sources, observations and sampling methods, and GIS-based presence/absence atlases on e.g. breeding birds and vascular plants. To serve the various needs of different branches of administration, still more development work is needed on, for example, thematic maps, and ‘warning and guiding’ environmental applications.

There is an unusually high biodiversity within hemiboreal Helsinki, compared to rural neighbouring municipalities, or other European temperate cities and towns. This has been measured by several taxa (vascular plants, breeding birds, polyporous fungi, butterflies and bumblebees), their species number, ecological and historical groups and threatened species (Figure 2). Green areas are the most important areas for vascular plant flora (they host most of maximal species-rich sites, endangered, rare and native species) (Tables 2 and 3). Present nature protection areas host only some 4%-15% of endangered vascular species habitats. Many species also live within the built-up urban fabric, such as threatened semicultural species (Vähä-Piikkiö et al., 2004).
For migratory and breeding birds the archipelago and three large protection areas are the most important. The ‘green fingers’ make continuums of diminishing communities of shore breeders and forest indicator species, and host several endangered species. Supporting non-fragmented and continuous regional green structure is important. Existing green connections are crucial to support resident populations, also in surrounding municipalities. Establishing new east-west connections between the green fingers would be profitable for flora and fauna, including threatened species.

Environmental services

In Helsinki, the potential for green areas to improve the climate, reduce air pollution and manage water flows is not considered the most important issue in planning. The local environment — the sea and a cool climate — mean that cooling and ventilation are not issues in green planning. The tools to protect against air pollution are mainly emission control, efficient energy production and traffic policy (Helsinki Metropolitan Area Council, 2000). For politicians, water issues and the state of the Baltic Sea are the most important. These are success stories in local environmental politics, but remain an unsolved regional and global problem. The status of the coast, archipelago and rivers has been politicised, whereas streams have only recently gained fresh attention as something more than parts of the drainage system. The management of

Table 3. Prioritised habitats of threatened vascular plant species in Finland and in Helsinki in 2001.

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Finland</th>
<th>Helsinki</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No of species</td>
<td>%</td>
</tr>
<tr>
<td>Forests</td>
<td>35</td>
<td>19</td>
</tr>
<tr>
<td>Mires</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Aquatic habitats</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Shore habitats</td>
<td>37</td>
<td>21</td>
</tr>
<tr>
<td>Rock, bolder field and cliff habitats</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>Alpine habitats</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Seminatural, agricultural and artificial habitats</td>
<td>50</td>
<td>28</td>
</tr>
<tr>
<td>Altogether</td>
<td>180</td>
<td>100</td>
</tr>
</tbody>
</table>

Note 1. Seminatural, agricultural and artificial habitats are also called cultural habitats (IUCN 2001, CORINE 2001). Uusimaa regional plan: http://www.uudenmaanliitto.fi/mkaava/map.html

Note 2. Indicators: The 40 threatened vascular plants in Helsinki, including occurrences of 27 nationally in Finland and 13 regionally threatened species. The 100 rarest native vascular plant species present in the least number of squares in Helsinki.
flows in Helsinki is mainly dealt with by means of other environmental management systems. The potential of green areas for waste management in Helsinki is small.

**Ecological goals and tools in the planning, design and management processes in Helsinki**

There are no policy goals regarding biodiversity in Helsinki, except for those already laid down in legislation (such as species and nature types to be protected nationally). According to an ongoing study it also seems that biodiversity, especially the so-called ‘ordinary urban nature’ (with no clear, detailed, or explicit protection in law) is a secondary interest in land use planning (Maijala, 2004). However, last year the City Council approved a very general statement that the biodiversity in Helsinki “will not be reduced”. But this statement has not led to any further elaboration of what it will actually mean in practice.

Landscape planning in Finland does not appear in separate, formal plans but approaches are integrated in the land use planning instruments. Land use planning is carried out according to formal and legally binding instruments, using various informal tools that have been developed in order to complement the formal tools, as well
as to compensate for their shortcomings.
The main formal legislative instrument to govern both the green structure and urban
growth in Helsinki - as well as in every municipality in Finland - is the General
Master Plan, which is approved by the municipal council. The overall green planning
is tightly integrated within the General Master Plan. The General Master Plan inte-
grates green with other issues at an early professional planning stage: no separate sec-
toral green plan is considered or approved by any political decision-making agency.
In the new General Master Plan 2002 the strong emphasis on growth and densifica-
tion along with a lack of clear goals on urban green and especially biodiversity may
lead to conflicts and a severe reduction in the total amount of green areas available,
as the proposals retain only two thirds of the present green (Table 1, and Figure 1,
Map B).

The phrase ‘green fingers’ is an informal, basic concept used to define the main
structure of green in Helsinki. It is a substantial tool, too, but it does not contain any
specific supporting instruments in itself to strengthen the status of this basic struc-
ture. The support in practice is threefold: firstly, the concept of ‘green fingers’ has a
long established status as the representation of green structure in Helsinki (but quite
how secure that status is has not been ascertained, either in discussion or in prac-
tice). Secondly, the ‘green fingers’ will receive a legal status when integrated in the
General Master Plan. The status of individual ‘fingers’ can also be strengthened by
other specific policy tools: as an example, the most well-known of the ‘green fingers’,
the Central Park of Helsinki, was protected from development by a Local Master Plan
drawn specifically for this sub-area in 1977. However, this policy has not been contin-
ued in relation to other “green fingers”. Another new tool, which has been included in
the new legislation, is the possibility of creating a National Urban Park. Helsinki has
used its own version of this concept in one of the ‘green fingers’, the Vantaa River
Valley, and named it ‘Helsinki Park’. So far this is only a kind of ‘status tool’ that
increases the ethical commitment to the area nominated as a National Urban Park.
The Regional Land Use Plan used to have a clear regional green goal in its focus
during the 1970s-1980s. However, the first Regional Land Use Plan for the Helsinki
region during the new Land Use and Building Act of Finland (brought in from
1.1.2000) includes only one third of the present green areas (Figure 1, map C),
and does not offer any biodiversity policy or aims besides legislative requirements.
Although the areas for the development of urbanisation can be said to contain smaller
local green areas, the plan basically allows two thirds of the present green to be lost.
This would result in considerable changes in biodiversity, environmental qualities and
green structure services (Vähä-Piikkio et al., 2003). The previous structural emphasis
would also be lost.
Nationally, the Environment Departments at the municipal and regional level (state)
are often in the limited position of giving an expert opinion or formal statement in the
land use planning processes, even though they are responsible for the nature policy
information for the whole of the municipal administration. The environmental admin-
istration has so far been mainly successful in taking care of national programmes on nature protection, but less so with regard to local biodiversity policies, or in enhancing green area policies. This is also the case in Helsinki (Vähä-Piikkiö et al., 2004). In green management, however, the administrative division in charge (Public Works Department) has strived, on its own initiative and with success, for multi-goaled and participatory practices.

Ordinary citizens have indicated in numerous surveys that they value green areas highly, both in their own vicinity and outside urban areas. However, a conscious green policy does not exist in Helsinki, nor is it apparent in discussions connected with planning. This clash of values may cause trouble in what is considered to be a worsening of environmental qualities, in the future planning participation processes and in green management. It almost seems as if it is left to the citizens to show an interest in green and biodiversity, instead of planners and politicians.

3 Conclusions

Helsinki is unusually rich in biodiversity and has a high percentage of green within its land area. It also has quite a good database of nature information. However, despite the strong growth and pressure on existing green, no overt policy or goals for biodiversity have been established and the position of the green structure overall (including the backbone, the ‘green fingers’), is vulnerable. Helsinki, with its densification policy, is reaching the point where the urban green is not any more a matter-of-course option, not to mention its structural continuity and regard for biodiversity. An explicit policy, clear goal-setting, monitoring and new types of tools and co-operation are urgently needed. Some weak ‘shoots’ of this may already be seen.

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10 - Herning

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1. Introduction

Green structure as the subject of planning goes back in Denmark to the middle of the twentieth century, when the famous ‘Fingerplan’ was created for the Greater Copenhagen Region. This first green structure plan was adopted by a few regional planning authorities and local municipalities in the 1970s. However, in the 1980s interest in overall planning issues was low and was not resumed until ecological issues were brought into focus by the United Nations in the reports ‘Our common future’ in 1987 and the Agenda 21 document from the Rio conference in 1992. This officially recognised commitment to sustainable development was a great challenge to the local authorities with responsibility for translating that commitment into everyday planning and management practices. With this in mind, an interactive research study involving the Municipality of Herning and researchers at the Danish Forest and Landscape Research Institute was set up. In order to analyse the unique local conditions, system analyses were developed using flowcharts and a GIS-based mapping tool to bridge the gap between different disciplines. This paper relates to the interdisciplinary research study in Herning.

Herning is a medium sized Danish municipality, with the town of Herning as the urban centre. The landscape around the urban development is an extensive landscape of natural resources, forests and mainly agriculture. The Municipality covers a total area of 542 km² and has 59,000 inhabitants. With a population density of 108 per ha., Herning is sparsely populated in comparison with many other European towns and cities. However, Herning is the twelfth largest among Danish towns and cities, according to the number of inhabitants. Furthermore, at present Herning is expanding as a modern commercial centre and plays an important role in promoting new ideas in town planning and environmental management.

How have the natural and cultural features influenced the development of green structure in the urban environment?

From its original formation, the landscape was dominated by small hills and plains of heath, subdivided by streams and valleys. This landscape was formed in the most recent and second most recent glacial period of Denmark. The living conditions in the region were poor and the population was very sparse until the railway was established in the late nineteenth century.

Over the following years the changing economic conditions have influenced land use. Heathland, streams and meadows were cultivated effectively during the first part of the twentieth century and drained to provide sufficient agricultural land. Due to
a decline in agricultural interest nowadays, streams and meadows are again being restored as wetlands and grassland.

The landscape of wetlands today forms an almost complete green/blue ring around the town and the former agricultural land around the urban development is today an attractive area for wildlife and recreation, managed as a nature reserve or as grassland. These landscapes define and structure the urban development.

Most new housing and business developments are located outside the blue ring as attachments to the former agricultural villages in the area. These developments are also separated from one another by green belts of agricultural land. The small hills to the north and south are nowadays plantations of pine and fir. In these areas landscape elements such as urban forests and wetlands have been integrated within new housing developments.

South of the centre are 276 ha. of bog called Knudmosen. This wetland has limited the urban development and resulted in a rather extensive recreational area close to the urban centre. Knudmosen includes the oldest landscape park in Herning, but today most of the bog is managed by grazing cattle and offers indigenous flora and fauna as an attraction to visitors.

Besides providing habitats for flora and fauna, the urban green structure traditionally provides amenities such as playgrounds, lawns and greens, picnic sites, trails and greenways, etc., the construction and maintenance of which limit biodiversity to varying degrees.
What does the green structure mean for biodiversity, environmental services and management of flows?

**Biodiversity**

An overview of the situation regarding biological diversity, surface water and organic waste management is presented below, with reference to the Herning research study. Thematic subjects such as air and climate are also mentioned briefly.

In Herning, as in most Danish municipalities, there is no systematic registration of fauna and flora and only sparse information on biotopes and natural vegetated areas. The local authority uses selected species as environmental indicators and maintains an overview in co-operation with privately organised societies on different biodiversity themes - birds, fungi and botany, for instance. Indicators are a well-known methodology used to assess environmental status and monitor changes. In Herning, for instance, certain bird species are used as indicators for water quality in streams.

With the purpose of analysing the possibilities for improving biodiversity in the urban green structures, existing information supported by field studies was presented on thematic GIS-based maps as part of the research study. In addition, historical maps indicating changes illustrated the natural potential of the landscape. Data on natural or urban vegetation types provided further information on the natural potential of the landscape. The actual vegetation types registered in the landscape are: creek, windbreak, moor, meadow, common, pond, bog, forest and agriculture. In urbanized areas dense urban character, open urban character, garden character, park character and grassland were defined.

The local authority has established a website - www.herning.biobank.dk.

**Surface runoff and urban green structures**

Surface runoff water constitutes a freshwater resource and can support ecosystems and be of value as an amenity to human beings. In the old (central) urban areas, surface runoff is handled in combined sewer systems, while in the more recent (peripheral) urban areas separate sewers are used.

The potential for using the urban green structure for surface runoff treatment is of considerable interest. The physical conditions for local infiltration have to be evaluated, since local infiltration is regarded as a sustainable management method. Necessary information on impervious cover, soil contamination sites and soil type has been gathered. The degree of impervious cover was grouped into three categories (residential areas with 40%; industrial areas with 60%; and central urban areas with 85% impervious cover). The original 13 soil types present in the area were grouped into the following soil types: ‘clay’, ‘sand’ and ‘peat’ - indicating different suitability for local infiltration or construction of reservoirs. These data not only support the overview, but also support the dialogue with other professionals within the local authority.

In Herning the conclusions relating to storm water management were that urban green structures have great potential for contributing to the handling of sustainable surface
runoff, since conditions for introducing a sewer-free system are generally favourable and sufficient green areas are available. As the operating sewer system functions quite well, it was suggested that a sewer-free system be introduced, as appropriate, in already urbanised areas and in new urban development. The use of vegetated systems has been recommended rather than subsurface infiltration tanks in order to support biological and recreational use of the area and to provide purification of the runoff.

Organic waste and urban green structures
Organic waste represents not just a problem to society, but it also provides a resource in terms of nutrients, energy and organic material. There is a demand for soil amelioration products in the management of the urban green structure. In many cases, organic waste products (for example, compost) can fulfil these demands and in this way reduce the mining of scarce resources such as phosphorus, lime and sphagnum, as well as the energy-expensive fixation of nitrogen from the atmosphere.

Following analysis, sustainable nutrient application criteria were agreed upon. These criteria range from the application of nutrients corresponding to that part of the nutrient demand of vegetation, which exceeds that provided by the soil itself (minimum amount), to the amount that can be justified from a soil and water pollution point of view (maximum amount). Due to the limited budget of the local authority, it was anticipated that their consumption of manufactured fertiliser and sphagnum was approximately equal to the minimum amounts of nutrients and organic matter that could be replaced with organic waste products. Annually, approximately 4 tonnes of nitrogen (N), 0.8 tonnes of phosphorus (P) and 20 tonnes of sphagnum are purchased and used by the Parks Department.

Information on the use of fertiliser on private lots in the urban green structures was
not directly available, but this was assumed to be not less than the amount used in public areas. Thus, the minimum quantity of nutrients and organic matter from organic waste products that can be applied in the urban green structure amount to 8 tonnes of N, 1.6 tonnes of P and 40 tonnes of sphagnum. In order to estimate the maximum amount of organic waste products that can be applied within the urban green structure having regard to environmental protection, the limits stipulated by the Danish Ministry of the Environment (1996, 1998) were used. These limits are: 170 kg N ha⁻¹, 30 kg P ha⁻¹ and 15 tonnes of dry organic matter ha⁻¹. With 2,750 ha. of urban green structure available, the following quantities can be applied in Herning: 2750*170 kg N, 2750*30 kg P, and 2750*15 tonnes dry organic matter.

Information on the actual amounts of different fractions of organic waste produced in the Municipality, the present treatment methods and the end use of products was gathered, and illustrated in a single waste flowchart. The figure shows that the Municipality of Herning uses most of its organic waste to produce energy, so the motivation for using the local urban green structure in the handling of organic waste is small. However, to complete the assessment of the potential for using organic waste, the amounts of N, P and dry matter contained in the urban fractions of organic waste, which was produced annually by the Municipality, were calculated. Approximately 166 tonnes of N, 82 tonnes of P, and 8,459 tonnes dry matter in total are contained in these fractions. Compared to the minimum estimate, the potential for the urban green structure to contribute to the handling of organic waste in non-agricultural fractions by replacing purchased fertiliser and sphagnum is small. It amounts to 5% of N, 2% of P, and 0.2% of sphagnum/organic matter. Compared to the maximum estimate, the available area in the urban green structure just suffices in terms of legal application of organic waste products.

In conclusion, the ongoing consumption of manufactured fertiliser and sphagnum in parks and gardens was unnecessary and could be replaced by compost based on garden and park waste.

Climate and Air
The prevailing westerly wind brings fresh air from the North Sea into the region. Accordingly, protection by windbreaks has been necessary to support agricultural production. Over the years, a network of pine and fir hedgerows has been created. The hedgerows today virtually belong to the perception of the traditional landscape in the region. Within the last few decades, however, these traditional hedgerows have been replaced by deciduous trees and shrubs planted in three, five or seven rows. Since agriculture on poor soils is no longer profitable, some of these areas have been changed again to meadows or have been forested. The Danish Government and the EU give financial support for these changes as part of a general nature protection and forestation policy.

3 How are the character and functions of green structure considered in
land use/landscape planning? How are the character and functions being managed to meet ecological and environmental goals?

**Formal planning instruments - Danish planning regulations**
The Danish planning system was changed radically in the 1970s with a new Planning Act. According to the Planning Act three comprehensive planning levels were introduced in local authorities, based on the principle of framework control. Local authorities have to formulate plans for the total geographical expanse of the particular local authority, including the countryside. Following an amendment to the Planning Act in 2000, an Agenda 21 strategy on environmental issues is now a compulsory part of municipal planning.

Green areas are highlighted in the Planning Act as one possible category of land use within towns and cities. Green structures connecting urban and rural areas are also brought into focus. In the overall structure plan in Herning, green areas and green structures are integrated.

A Green Plan presented by the Parks Department underlines traditional cultural and recreational values, but does not specifically take the ecological potential of green structure into consideration. But the Danish Nature Protection Act also places emphasis on planning activities and an Action Plan on the Protection of the Environment has to be prepared by local authorities. In Herning, such a plan was first presented in 1993 and has since been evaluated and revised several times. Topics in the plan for the period 2001-2006 include: health, noise, air pollution, and the protection of water and soil resources, etc. Tools to support the plan include identifying indicators (birds and fresh water conditions) and subjects of high priority (energy saving in industrial production and transport planning to reduce vehicle movements).

**Informal strategies**
The actual handling of urban landscapes and potential for green structures is defined by economic possibilities and by the experience and skill of the local authority’s specialist staff, where dialogue with citizens also plays an important role.

In the last decade or so, economy and efficiency related to quality in the management of green areas have been a big issue in park departments all over Denmark. Management systems have been developed to help all actors within the profession to communicate and find a common understanding.

The Parks Department in Herning has defined quality criteria expressing different aims in the management of parks and green areas. In relation to environmental goals, the use of pesticides has ceased and alternative methods have been introduced with success. Different standards are also accepted in the maintenance of the green elements. For example, different levels in the maintenance of lawns allow biodiversity to be enhanced according to their natural potential.

From 2003 onwards, the Parks Department is hosting an innovative project, called Holistic Park Management, which is supported by the National Agency for Enterprise and Housing, under the Ministry of Economic and Business Affairs. The project
brings the users of the parks into focus and relates user needs to financial issues and priorities, and to the organisation of green areas and nature.

4 Summary and perspectives

The experience of Herning shows that records on biological and environmental matters are found in different departments within the local authority. This implies that data on parks is held in the Parks Department; that data on green issues as an integrated part of the urban environment is kept in the Town Planning Department; and that data on flora and fauna is found in the Environment Department. Systematic information is not currently collated by the local authority itself, but information on certain subjects of interest, such as birds and botany, is gathered in co-operation with private organisations. This procedure creates problems for the adoption of a holistic approach in relation to sustainable planning and management. This seems to be the case not only in Herning, but generally in Danish municipalities.

The research study in Herning clearly demonstrated that tools to make information available and support interdisciplinary solutions are needed urgently and that the planning process must take care to co-ordinate local plans with the overall goals in planning and management.

In co-operation with the administrators in the Municipality of Herning, it became clear that the green structure does possess the potential for contributing to a more sustainable management of biodiversity in particular, and urban runoff, and to some extent organic waste too. However, lack of adequate information and appropriate methodologies are barriers to the planning process, as well as in the realisation of goals in design and management.

The Municipality of Herning took an early interest in sustainability and formulated goals in local planning demanding sustainable solutions from designers and developers. Much valuable experience was gained and new knowledge was gathered, which have influenced the next steps and have clearly identified the need for new tools and methodologies.

References:


Municipality of Herning: Green plan for Herning and Environment 1996.
11 - Munich

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1. Introduction
Munich is a city with a population of approximately 1.3 million, covering a surface area of 311 km2 (LH München, 1991). It is the centre of a strongly developing region of 2.4 million inhabitants in an area of 5,500 km2. This development puts pressure on the green spaces within the City and the countryside. Results from a European study show that 6.5% of land in the Munich region is classified as natural and that 7.8% of agricultural land was lost due to urban sprawl between 1950 and 1990 (EEA, 2002).

How have natural and cultural factors shaped Munich’s green structure?
Munich is situated in the Munich plain, a glacial and post-glacial outwash of limestone gravel. The City was founded on the western banks of the alpine river Isar and developed in concentric rings around the inner city. The River Isar has its origin 80 kilometres south in the Karwendel mountains (see chapter xx). Other than the Isar floodplain and steep banks of glacial and post-glacial river terraces, natural features have had little influence on urban growth. Figure 1 briefly characterises the main elements of Munich’s green structure. While the groundwater level is 20m. below the surface in the southern part of Munich, it comes to the surface at the northern edge of the City, where extensive fenlands have formed. Therefore, a distinction can be made between the dry and the wet part of the Munich plain. Naturally, deciduous woodlands, predominantly oak, would have covered the gravel plain. Extensive grassy heathlands developed on the shallow soils through sheep grazing. These woodlands and heaths have been mostly cleared to give way to farmland. The Isar floodplain is the major element of the green structure in the City. Parks, including the most famous park of all, the Englischer Garten, were already created in the eighteenth and nineteenth centuries along the river. When the River Isar was controlled in the nineteenth century, it was preserved as a green corridor. It is thus both a natural and a planned green structure.

During the period of strong urban growth in the late nineteenth and the first half of the twentieth century, the City did not develop a spatially coherent green structure such as the ‘green finger’ plans in Copenhagen or Helsinki. Speculative development was very dense. The northern part of the City is characterised by large industrial developments, whereas the cultural landscape, with lakes, woodlands and cultural heritage, is an attraction for recreation and tourism in the south. With the concept of a ‘green belt’, the City Region tries to compensate for the lack of a systematically developed green structure.
Natural green spaces such as woodlands, grassy heathlands, fenlands and wastelands cover almost the same area as the public green spaces, but only a few of them had received the same level of protection prior to the first habitat survey (LÖK, 1983). They are only small remnants of the once predominating natural and cultural landscapes. Natural green spaces are mostly found at the urban fringe, in particular in the northern and northwestern part of the City. By comparison, few natural areas are found in the densely built inner city, but also most of the farmland has a low habitat value. The large wastelands in the north and west of the City partly resulted from infrastructure projects initiated during the ‘Third Reich’ but never completed. The habitat survey was complemented by a survey that provided detailed information on green spaces within urban land uses. The results showed that apart from farmland on the urban fringe, the largest amount of green space can be found in Munich’s residential areas. However, there is strong pressure on residential green spaces from infill densification (Wagner, 1992), threatening mature stands of trees in particular (Jocham, 1988).

2 What are the benefits of Munich’s green structure for biodiversity and the environment?

Biodiversity
Munich has a good information base on habitats for wildlife due to biotope mapping and subsequent studies on individual habitat types (LÖK, 1983 and 1990). The city of Munich is surprisingly rich in higher plant species, with over 1,200, when compared with the intensively farmed agricultural land and the plantation woodlands beyond (LH München, 2002). The habitats identified in the habitat survey particularly contribute to this biodiversity. These are mainly natural woodland types, heathlands and fenlands but also wastelands and extensively managed grasslands in some parks such as the Englischer Garten, Nymphenburg Park and Olympiapark. Intensively managed parks and other green spaces have a low conservation value.

Many of the natural green spaces are very small in size and isolated from one another. For instance, woodlands are split up into 153 sites and 79% of these are smaller than 5 ha. Protecting them individually will not suffice to preserve the City’s biodiversity. Moreover, many habitat sites were found to be in a degraded state due to changes in ecological conditions (for example, lowering of water tables in the fenland areas), lack of proper management and negative influences from the surrounding land uses. Significantly, the survey of ecologically important sites was complemented by a survey to characterise ecologically important features or urban land uses for the whole city area. For each of over 3,500 land use units, data on green space provision and more detailed information, for instance on tree density, are available. The survey showed that green space in urban land uses such as residential and commercial areas can have a species-rich flora and fauna. In particular, low density housing areas with a high coverage of mature stands of trees, and wastelands in industrial/commercial areas and along railway lines, where unmanaged grassy vegetation can develop, were
identified as important for wildlife. These vegetation structures were considered as corridors for wildlife in the city (LÖK, 1990, Duhme and Pauleit, 1992).

<table>
<thead>
<tr>
<th>Green structure patterns</th>
<th>Main green structure elements</th>
<th>Status</th>
<th>Main challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural units: glacial &amp; post-glacial terraces of gravel deposits, river Isar flood-plain</td>
<td>Variety of natural woodland, fenland and heathland types due to the fine grained pattern of natural conditions and adapted historic farming practices</td>
<td>Natural conditions were largely ignored during main phases of urban development</td>
<td></td>
</tr>
<tr>
<td>Streams, canals and artificial lakes</td>
<td>River Isar is Munich’s most important green corridor with natural woodlands and large parks with high ecological value. Also smaller streams</td>
<td>Restoration of river Isar and smaller streams (W, rm, fenland streams, historic canals)</td>
<td></td>
</tr>
<tr>
<td>Wetland habitats in fenland</td>
<td>Mostly converted into intensive farmland. Only tiny remnants of wet grasslands and woodlands left. (grey shaded: original extent of fenland areas)</td>
<td>Restoration of ecological conditions (hydrology/soils), extensification of farming</td>
<td></td>
</tr>
<tr>
<td>Woodlands</td>
<td>Important remnants of natural woodlands. Large plantation woodlands (spruce, pine) south of the city (not shown)</td>
<td>Natural woodlands mostly small and fragmented. Conversion of plantation woodlands into naturalistic woodlands</td>
<td></td>
</tr>
<tr>
<td>Heathland and wastelands</td>
<td>Remnants in the north, partly protected or used as military training ranges. Wastelands in industrial areas and along railway lines. Losses in the last decades due to urban development projects</td>
<td>Restoration and linkage of heathland in the north together with neighbouring municipalities. Management of heathlands</td>
<td></td>
</tr>
<tr>
<td>Parks &amp; public green spaces</td>
<td>Along river Isar and scattered in the city. Mostly lower habitat quality due to intensive management and use but exceptions are old parks such as Englisher Garten</td>
<td>Creation of more greenspace in the inner city, linking of greenspaces, management for nature in existing greenspaces</td>
<td></td>
</tr>
<tr>
<td>Low density housing</td>
<td>Largest green space resource within the built area. Mostly intensively managed but dense stands of trees in low density housing areas can have important habitat function</td>
<td>Protection of greenspaces, in particular trees, from infill densification</td>
<td></td>
</tr>
<tr>
<td>Farmland</td>
<td>Intensive farming</td>
<td>Landscape restoration in particular in the fenland areas</td>
<td></td>
</tr>
<tr>
<td>Railways</td>
<td>Large open spaces, important corridors in west &amp; east direction. Habitats and environmental functions</td>
<td>Availability of former railway areas for development with potential for development of greenspace corridors but also threat of habitat destruction</td>
<td></td>
</tr>
</tbody>
</table>
**Environmental benefits**

The potential of green space to improve the urban climate, reduce air pollution, and manage water flows has not been studied in the same systematic way as their habitat function. For instance, air quality is regularly monitored, but the function of green spaces to improve air quality is not known.

However, a pilot study has shown the important climatic and hydrological functions of green space (Pauleit and Duhme, 2000). Surface temperatures were correlated with the provision of green space, and particularly that of trees and shrubs (See Figure 1 in Chapter xx). Surface temperatures were highest in the densely built-up inner city, but significantly lower in well-greened neighbourhoods. A similar relationship was established between green space provision and the capacity to infiltrate surface rainwater runoff within the urban area. Theoretically, most of the rainwater runoff can be infiltrated within the study area. Overall, the results from this pilot study provided evidence that green spaces can significantly improve urban environmental conditions, but that sufficient provision of green space is required for this purpose. Therefore, the current pressure on green spaces within the City from infill densification will have a negative impact on the City’s environmental performance.

**How have ecological goals been set out to influence the planning, design and management processes?**

Public parks and green spaces, woodlands and also many of the habitats identified in the habitat survey are protected under different forms of designations such as nature reserves, protected natural landscape elements or protected landscape areas. However, the habitat survey clearly shows that protection of ecologically important sites alone cannot preserve biodiversity, because these habitats are often too small and fragmented for the long-term survival of species. Moreover, environmental benefits such as water infiltration depend on all green spaces, both private and institutional. Therefore, green structure planning and management need to cover the City’s whole area. Both formal and informal instruments for green structure planning are used in Munich for this purpose. Formal instruments are the landscape plan for the whole city, green structure plans at the level of master plans, and green space plans at the site level. Both landscape and green structure master plans need to be integrated into the general land use plan and overall master plans, to become legally binding.

Key elements of this strategy are habitat corridors and specific targets for ecological green structure planning in urban land use zones. It is thus a strategy that aims to integrate urban ecology into land use planning.

Ecological goals for green structure planning have been defined in the city’s urban development strategy Munich Perspectives. This strategy is subtitled ‘compact – urban – green’, thus aiming to create a city that is densely built to minimise further urban sprawl, but at the same time that offers a high quality of life within the built environment. Supplementary Ecological Guidelines detail the ecological goals. These ecological goals are based on a spatial strategy for nature conservation that requires
the development of habitat corridors between ecologically important sites and defines specific goals and targets for the provision of habitats in urban zones (Figure 2).

Implementation of ecological green structure planning is challenging in a city where pressure on open space is so strong. A Species and Habitat Action Plan outlines measures for the management of the different habitat types (LH München, 2002). In order to implement the Ecological Guidelines, priority is given to:

- reducing green space deficits in the densely built-up inner city and improving connectivity between green spaces. In particular, big development projects such as the conversion of the former airport into a new neighbourhood are used to create new green spaces. The conversion of disused areas along the main railway lines provides an opportunity to create corridors in an east-west direction. Overall, the role of ecological goals is less important than recreation, but climate considerations have also played an important part, in particular in relation to the railway corridor to the east of Munich and the conversion of the former airport into a new mixed neighbourhood (See Figure 5.2 in Chapter 3. climate and green structure planning).
enhancing and improving the landscape around the city. Key projects are:

‘One greenbelt for all’, a project to create a multifunctional greenbelt around the City. An ecological land-banking scheme has been created for fenland restoration, including the restoration of small streams, on farmland owned by the City in the fenland area to the northwest. Compensation measures from different development projects can be combined to upgrade a larger area, instead of scattering them in many small areas across the City. Developers pay the total costs for the creation of habitats in these areas, including costs for planning, management and monitoring over 20 years, as well as interest rates, so the City is able to implement measures in advance.

This greenbelt project has also established co-operation with farmers. Currently, 45 out of 100 full-time farmers co-operate with the City to implement ecological measures such as extensive management of pastures and restoration of small streams. Co-operation with the neighbouring municipalities in the northern part of the Munich plain in the so called Heathland Society and the Fenland Society to restore and enhance these important landscape types. In particular, the Heathland society has been quite successful in restoring and reconnecting remnants of this habitat type. Currently a new project of the Heathland Society aims to promote a programme for the development of the landscape north of Munich through setting goals for the enhancement of landscape character and ecology.

3 Conclusion: Is there evidence that ecological goals influence the planning processes in Munich?

Two key challenges for green structure planning in Munich were identified in this case study: adaptation of the green structure within the city to provide environmental benefits such as rainwater infiltration and preserve the City’s biodiversity; and the protection and restoration of the landscape surrounding the City that is acutely threatened from urbanisation and already degraded from intensive farming.

Munich is strong on information on the provision and ecological quality of greenspace throughout the City. Species data is more difficult to obtain, and generally it does not cover the whole City. On the basis of the habitat survey, an ecological strategy for green structure planning has been developed and adopted, with distinct goals for habitat corridors and land use zones, but there is no equivalent green structure strategy with goals for climate and water management. Such a strategy could promote the linkage of green spaces by corridors to enhance natural processes in the City and help to protect residential green space that is under pressure from infill densification.

Implementation of the ecological goals defined in Munich’s nature conservation strategy is a challenge in a city that is already densely built up and continues to grow. Formal instruments of green structure planning and green space protection are important, but there is a shift towards approaches that seek to find solutions through co-operation with land owners (for example, farmers), by providing incentives for adopting ecological measures and/or by implementing these measures through large

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development projects such as Messestadt Riem. Moreover, the Heathland and Fenland Societies foster co-operation and co-ordination between neighbouring municipalities regarding landscape restoration and management. However, despite these positive efforts, there is real pressure on green space and large-scale losses of valuable habitats for wildlife have been observed since the completion of the first habitat survey in 1983.

The ‘Greenbelt – one for all’ project aims to link recreational objectives and measures with landscape measures (cycle routes through attractive farmland) and to link these with conservation goals and measures (such as the restoration of the fenland). Green space planning for the new neighbourhood Messestadt Riem is an example at the project level where equal weight has been given to recreational and ecological objectives in the planning of the green spaces. Yet, the concept of ‘multipurpose’ landscapes and green spaces may find its limitations in the inner city, where green space is very scarce. Optimising environmental functions within small leftover green spaces that have also to serve for recreation may not compensate for further loss of green space due to infill densification. Moreover, the loss of green space within the City cannot be compensated by landscape restoration through the land-banking scheme in the urban fringe. Overall, the dilemma to plan for a compact and a green city seems not be resolved, as the loss of green space due to infill densification shows.

References
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Introduction
The municipality of Oslo (454 km²) is located in the inner part of the Oslo Fjord in South Eastern Norway. Approximately two thirds (307 km²) of the municipality is covered by forest, waterways and agricultural land, and one third (147 km²) by a building zone that includes residential, commercial and industrial areas. Approximately 30 km² or about 20% of the building zone is covered by mixed boreal forest and deciduous trees. Since 1995 Oslo has been the fastest growing city in the Nordic countries with the creation of 69,000 jobs and an immigration of 46,000 people to the city in the period 1995-2000. (Oslo municipality, 2003).

1 Green structure development and pattern
Compared to its surroundings the local climate in the city is dominated by relatively warm summers, low precipitation and mild winters, with the city itself located in a south-facing valley. The terrain slopes gently upwards from the sea to the forested hills around the city (up to 700 metres above sea level). Cambro-Silurian limestone and shale, rich in calcium, folded in the Caledonian era, make up the central parts of the city and westwards along the fjord. The Oslo region is a result of an extended depression of earth covered by sea and slowly filled with sediments. The age of the rocks varies from Cambrian to Permian (600-250 million years ago). Remnants of the Pre-Cambrian rock, mainly of gneiss and granite, are exposed in the southern and eastern parts of the municipality (Dons, 1996). The vegetation in the Oslo region mirrors the local variations in precipitation, temperature and rock. Thus the broad-leaved trees such as wych elm (Ulmus glabra), small-leaved lime (Tilia cordata), Norway maple (Acer platanoides) and common ash (Fraxinus excelsior) grow mainly on the Cambro-Silurian limestone in the building zone, while the Scots pine (Pinus sylvestris) grows in the south eastern part on the Pre-Cambrian rocks where there is a slightly drier local climate. In the northern part of the city, Norway spruce (Picea abies) are dominating. Here the precipitation and altitude are higher than in the central and south eastern parts of the city.
The town was first located around the outlet of the Alna river around the year 1,000 AD. Most of the urban development has taken place since the Second World War. The built-up area of Oslo is still one of Europe’s least densely populated and the rate of development today is, according to some politicians, not high enough in order to meet the rising demand for housing. A comparative study of several European cities (Oslo, Stockholm, Copenhagen, Helsinki, den Haag, Bristol, Birmingham, Hanover, Bremen, Gdansk, Zaragosa and Barcelona) carried out by the University of Oslo at
the request of the municipality, shows that Oslo was the largest in area, but only 27% of the area was developed, the remaining areas being forests and green structure. (ProSus & GRID-Arendal, 2002).

Table 1 shows different land use and greenspace categories within the built-up area of the municipality. The category ‘forest’ in the table describes a mix of pine and deciduous trees, wych elm being the most common, followed by small-leaved lime in the built-up area. Scots Pine covers the eastern forest and Norway spruce the north western forested area.

Table 1. Distribution of area categories in the study area

| Categories                          | Area (km2) | Area in %
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential area</td>
<td>64.0</td>
<td>43.6</td>
</tr>
<tr>
<td>Other developed areas2</td>
<td>14.1</td>
<td>9.6</td>
</tr>
<tr>
<td>Allotment gardens and cottages</td>
<td>2.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Industrial/storage areas</td>
<td>8.1</td>
<td>5.5</td>
</tr>
<tr>
<td>Areas for traffic purposes</td>
<td>21.3</td>
<td>14.5</td>
</tr>
<tr>
<td>Forest</td>
<td>30.0</td>
<td>20.4</td>
</tr>
<tr>
<td>Parks and graveyards</td>
<td>3.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Agricultural areas</td>
<td>2.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Water</td>
<td>1.0</td>
<td>0.7</td>
</tr>
<tr>
<td>Total area</td>
<td>146.9</td>
<td></td>
</tr>
</tbody>
</table>

1. Area as percent of total area
2. Offices, commercial/service, public buildings, sports centre/sports ground

The pressure on the green structure within the built-up area is strong due to the preservation of the forested area surrounding the building zone. A large part of the population of Oslo is used to living in green surroundings and an awareness of the threat to green structure due to the ongoing densification process has emerged over the last 20 years. An analysis of the reduction of green structure in Oslo from 1952-1990 revealed a significant impact on three categories due to land use changes from natural areas to residential, commercial and industrial space (Nyhuus & Thorèn, 1996). The same study stated that there has been a strong fragmentation of green open spaces, on average a 50% reduction from 1950-1990, which resulted in more numerous, but smaller areas of green open spaces. The same trend might well have continued from 1990 to the present day, but for the introduction of the Green Plan (Oslo Municipality, 1993), the Green Poster (Oslo Municipality, 1997) and The Biodiversity Report to the City Council, which are useful tools to combat the increasing pressures on greenspace.

The separation of the forest and built-up area has been on the agenda for many years. After the Second World War when city planning was resumed, the politicians decided that all new development should take place within a border between the forested area and the area that was defined as the built-up area. This border has stayed the same since then, even though now and then newly elected politicians have suggested
building in the forested region called Marka. The forest and the management in Marka differ from the vegetation types and management evident within the built-up area. However, both types are multifunctional. Figure 1 shows how the municipality of Oslo is divided into a building zone with its own internal green structure and the surrounding forests.

Oslo - green spaces

Figure 1. The distribution of green open area within the municipality of Oslo
2. Green structure and biodiversity

Due to a mild local climate, calcium-rich soil, varied topography and a short gradient between sea level and the surrounding boreal forests, the city of Oslo is very rich in biodiversity in relation to its location and latitude. The different nature types recorded in the municipality are shown in Figure 2. The richest biotopes of natural vegetation are on the Cambro-Silurian layers up to approximately 220 metres above sea level. Furthermore, Oslo has an international responsibility for these biotopes due to the very specialised vegetation (rich broad-leaved deciduous forest, calcareous woodland and calcareous rocky shores), species richness and the high number of red-listed species. This vegetation is uniquely found in the building zone and on the islands and the need for preservation and in some cases management becomes even more urgent, since these vegetation types are not found in the forested areas outside the building zone.

![Figure 2. The distribution of the main biotopes within the municipality of Oslo](image)

Two main features of the green structure are highly significant for biodiversity: the size of the open spaces and the quality and management of them. The City Government has adopted the work carried out on biodiversity in Oslo. The City Government has provided the City Council with an overview of the status of valuable natural habitats and biological diversity in Oslo, the threats that they face and the basis for the work to preserve and develop this biodiversity. Furthermore, information is provided on the work that the City Government has done and plans to do in order to safeguard the existence of valuable habitats and biological diversity in Oslo.

The work has produced a management tool that consists of a database with an accompanying digital map. Using this tool, all those involved in land use planning and management can gain access to information on sites that are of value for biological diversity. The database thus gives the city a very good foundation for ensuring that biologically important sites are protected. The ongoing work is divided into four main fields:
1. Implementation, operation and maintenance of the nature database
2. Additional registration in and updating of the management tool
3. Safeguarding of the sites that are of a high biodiversity value
4. Information to the public, developers and other interested groups

The biotopes recorded are classified according to the national classification system developed by the Directorate for Nature Conservation. Following defined criteria, biotopes are put into categories of great importance, of importance, or of regional importance. Figure 3 shows that in Oslo registered biotopes are divided almost evenly within the categories of importance.

![Figure 3. The recorded biotopes in Oslo are classified according to the national High/Low Importance classification criteria](image)

By 2006 all agencies in the municipality of Oslo are supposed to introduce an Environmental Management System following the so-called Demings-Circle (Deming, 1950 and 1986). This model is widely used in the environmental planning certification process relating to both private and public businesses. When conducting an environmental certification such as EMAS, ISO 14001 or Environmental Lighthouse (a Norwegian certificate), businesses have to follow the so-called PDCA circle or Demings-Circle (Plan, Due, Check, Act). Goals and plans for biodiversity should be included in the considerations undertaken by all the relevant agencies according to the PDCA circle. The use of such a process ensures that the steps are conducted in a well-planned way (Pedersen et al., 2004). The GIS tool and the implementation process will be evaluated within the framework of the revision of the Report to the City Council 1/2003 (Oslo City, 2003).

3. Environmental benefits of green structure

**Blue-green structure**

Eight rivers and/or streams run through the built-up area of Oslo, starting from lakes...
in Marka having their outlet in the inner Oslo fjord. However, 60% of the streams are canalised under ground. When the City Government came into office in 2000 two main environmental tasks were put on the agenda. One was to strengthen the public transportation system; the other was to restore the blue-green structure of the city. About 100 years ago attention was paid to one of the largest rivers in Oslo, the Akerselva. More recently a land use plan including management principles were developed in the 1980s and action was taken. This work has changed the Akerselva from a grey polluted river into a nice and quite clean salmon river containing sweet water insects and ‘bottom’ animals that have returned to the ecosystem. The upper part is very popular for swimming and thus the status for this river is multifunctional.

Today the other main river, the meandering River Alna, has priority. Both the Alna and Akerselva were adversely affected by industry and became outlets for chemicals and other kind of pollution. However, the industries have more or less moved out of the city or ceased to exist and housing development has taken over as the main pressure on the remaining green river banks. Two other important rivers, the Ljanselva and Lysakerelva, are in good shape containing several fish species, while the smaller ones are in a rather bad shape.

During the 1990s Oslo experienced flooding, especially along the Akerselva. This has had both environmental and economic consequences, since the river runs through the most developed and urban part of the city and it has illustrated for the management system how valuable green river banks are in order to handle the water load. Action has now taken place to preserve and restore the blue-green structure. Following an initiative by retired politicians now working in an NGO, the Oslo River Forum, the City Council has formed a municipal forum, the Co-operative Organisation for the Rivers and Streams in Oslo, where both municipal and state officers and NGOs are represented. During the summer of 2004 a new natural swimming basin will be opened along the upper part of the River Alna. This will bring recreational opportunities to the vicinity of several thousand inhabitants of the District of Grorud.

**Organic compound**

Organic waste from parks and other public spaces and graveyards are being composted at assigned places within the city. Soil from composted matter is then sold to the public. There are very few farms left within the built-up area except for some District farms where the public can visit and experience animals such as horses, goats and ducks, etc. Organic waste from these farms is composted on the farm. Oslo has an area of small-scale agricultural landscape left, but this area has been assigned for development. For the time being plans have been developed to show how this new District will be placed in the landscape.

Clear cutting is forbidden and the Management Plan from 1996 is currently being revised, recreation and ecology being the most important issues. Pluck felling of trees and the resultant removal of organic waste is a matter for discussion.
Introduced species as pests

Pests in terms of introduced species that represent a threat to local natural species are a problem in Oslo as in most other cities, since species do not respect human borders. The Recreation Authority has developed a strategic plan for the management of and counteraction against alien or introduced species. The focus today is particularly on two plant species which threaten nature in Oslo: giant hogweed (Heracleum mantegazzianum) and Himalayan balsam (Impatiens glandulifera). The strategic plan includes several courses of action from recording, providing information to prohibition. Also included are suggestions for other initiatives relating to species that are of lesser importance. These include species such as Canada goldenrod (Solidago canadensis), common lilac (Syringa vulgaris), Acer pseudoplatanus, introduced species of stonecrop (sedum), Vincetoxicum, Fallopia and butterbur (Petasites hybridus). The plan also describes the management costs involved in keeping those species that are identified as pests in the Oslo flora under control.

Conclusion

The policy for green structure planning and biodiversity is described in the Report to the City Council no. 1, 2003: Strategy for Sustainable Development. Environment and Sustainability Status 2002. Urban Ecology Programme 2002-2014. Chapter 3, Oslo will conserve and strengthen its blue-green structure, includes goals, indicators and time limits for biodiversity and green structure planning. Indicators are measured once in each election period (every fourth year) in order to identify progress. The Recreation and Leisure Service, which has the responsibility for most issues described in that chapter, is due to report to the Commissioner for Transport and Environmental Affairs when the report to the City Council will be revised in 2006 at the earliest.

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Introduction

Urban development and landscapes

Currently the city of Utrecht has approximately 250,000 inhabitants who live on a surface area of 91 sq.km. On its western edge is the so-called Green Heart, a 60 km. wide meadow-landscape that is the open centre of a horseshoe of cities: the Randstad, with 6 million inhabitants (Figure 1). To the east, Utrecht borders on a wooded hill ridge pushed up by glaciers in the ice age. South of the city, the big rivers belonging to the Rhine delta dominate the open meadow landscape. Peat mining by means of dredging created a landscape of lakes north of Utrecht where recreation is today’s leading activity. Most of the green land around the growing city is still in agricultural use. The city has grown in a concentric way. The river Leidsche Rijn to the west has given its name to the latest large urban expansion, now under construction. The new district will have 30,000 dwellings and the same number of jobs.

Its central position in the country made Utrecht an important road and railway junction...
tion. Green planners and residents suffered a traumatic experience when, after a battle of more than ten years, a new motorway was built in the early 1980s to the east of the city, cutting right through the woodland of the popular Amelisweerd estate. Here, indeed, urban development was the enemy of nature.

2 Green structure

The green structure of streams
Meandering rivers, more than anything else, give structure to the green areas in the city. Two thousand years ago the Romans founded the city and called it Ultrajectum, the last bridge. In those days it was a real effort to cross the river that was the northern boundary of the Roman Empire. In the centuries that followed, the river Rhine transferred the bulk of its flow to more southerly channels. In the middle ages the Utrecht branch of the Rhine was cut off from the main stream. The tamed river became a convenient waterway and the high banks became a place for warehouses and workshops. Today, there is only a small stream that meanders through the city where it splits into two branches. These streams shaped the urban street pattern. From these streets, pedestrians can walk down the steps and sit in the outdoor cafés and restaurants along the river banks. Richness in the details of nature and culture, such as wall vegetation and sculptured lantern consoles, contribute to the typical Utrecht river profile that is not found in any other Dutch city (Figure 2). In the surrounding countryside, towpaths along the river now offer nice walks with beautiful views. Within the city, the rivers turn to greenways with parks and trees.

Figure 2. River branches have shaped the old city

The green structure of defence works
In the 19th century, the earthen defence walls of the city became redundant. Starting in 1827, landscape architect Jan David Zocher turned these walls and what was left of the ramparts and towers into a beautiful English landscape-style park with a walk around the inner city, the so-called Singel. The defence of Holland was taken over by the New Holland Waterline that included a series of inundation works and fortresses east of Utrecht. For military reasons, this area stayed green until 1948. Therefore, the city first expanded to the north and west and it was not until the 1960s that urban growth took place on the eastern side. Even then, the fortresses stayed green and became the carriers of the urban green structure.
The citizens of Utrecht can still walk in the inner city courtyards of churches and monasteries planted with elms and lime trees in the Middle Ages. In 1673 the city created its first public recreation area: the one kilometre long Maliebaan, a green allée with six rows of trees made for the students who liked to play the malie (mall) game. It was not until the late 19th century that public parks were considered to be a real need for the city and became a regular feature of urban development. In some cases old country estates with gardens became part of the growing urban area and were transformed into public parks. Most of them, however, are green islands not connected by greenways.

The green structure of transport networks
Along the banks of the old and new canal, which stretches from Amsterdam to Germany, cyclists and pedestrians find attractive greenways. Their technical design, however make them unattractive for wildlife. The railway verges are quite the opposite. They offer excellent habitats and corridors that contribute to the ecological network. Cyclists, however, usually prefer other greenways. The motorway verges are not so special, whereas the motorways themselves create serious barriers between built-up and green areas.
Green structure and biodiversity

Surveys in the 1970s revealed that the flora of Utrecht (91 km²) amounts to approximately 700 species of native plants. This number is high compared to the 938 species found in a survey of the whole Province (2,000 km²). The number of bird species breeding in the city is 93. Amateur biologists have collected data about butterflies, amphibians and reptiles. These surveys do not cover the whole of Utrecht, but they provide excellent information for the protection of species.

Green structure Planning may create or protect conditions for biodiversity. It is therefore important to discuss different categories of conditions. A first condition is the surface of green areas. The built-up area covers about 70% of the municipal territory, agricultural land takes up 24%. Roads cover 4% and only 2% is forested. The built-up area, however, includes parks, cemeteries and private gardens. Within these public green areas, the level of maintenance is an important condition for biodiversity. Best conditions for wild plants and animals are found in the rough woodlands (18.1% of the total green area), and rough grass (18.6%) categories. As maintenance costs are low for these areas, their surface increased in the 1980s, a period of budget cuttings. In residential districts, however, the rough maintenance categories met with resistance. Wild was seen as the result of neglect and in socially problematic areas the wild bushes were soon perceived as unsafe. This led to a preference for higher maintenance levels within the districts. It is easier to create conditions for natural plant and animal life in the main green structure between residential districts.

Connecting corridors between green areas are vital conditions for crawling animals and for the dispersion of seeds they carry with them. The role of green corridors therefore has become an important issue for urban ecologists. In their preparatory study of the Utrecht Green Structure Plan, Farjon et al., 1987: 87, point to the following dispersion zones requiring attention in planning and maintenance:

- river zones
- railways
- canals and ditches with unpolluted water
- greenways with pedestrian and cycle tracks
- green zones along the canals.

All of these corridors are part of the main urban green structure. The Province developed a method of biotopes and ecological groups with indicator species and the municipal Department for Green Areas further elaborated on this approach and generated maps for six ecological groups, indicating the desired corridors. Corridors only create ecological conditions for biodiversity if they connect habitats. Habitat qualities related to abiotic factors play a key role in this context. Gradients at the landscape level between high and low, dry and wet, sand and clay, create a frame for diversity. At the level of the urban landscape a key factor is upward seepage of
clean, nutrient poor groundwater that occurs at the foot of the Utrecht hill ridge. Gradients at the level of road verges and river banks are the focus of habitat-creation programmes in all parts of the city.

**Green structure, health and pests**

Research about the use of green areas in Utrecht revealed that 65%-86% of the residents of different urban districts frequently visit a park and 67%-87% frequently visit a recreation area outside the city (Hinssen, 1993: 27). The Wilhelminapark in the city and Amelisweerd, just outside the city, both attract approximately one million visitors per year. The inner city parks and the outer green areas are not exchangeable. People love them for different reasons.

The history of the Griftpark is a paradox in the context of health. The highly contaminated soil of the old gasworks could not be completely purified. Therefore the area was considered too unhealthy for residential development. As a result, a beautiful park emerged in the heart of the city: unhealthy if you were to grow fruit trees and eat the apples; very healthy, however, for the stressed office workers looking for a quiet park to have lunch in.

Recently Van Bronswijk (1999) pointed out the risk that more natural ecosystems in urban areas could improve conditions for rats and mosquitoes. She even warned of a possible revival of malaria as a result of climatic change combined with the presence of natural wetlands in Dutch cities. The reaction from experts in the fields of entomology, epidemic diseases and health was clear: there is no evidence of such a threat (Takken et al., 1999: 836). Rather, the opposite is more likely. The more natural parts of green structure will improve water quality and this will create less favourable conditions for pests. There is no reason for panic, but there is a case for sound maintenance practice based on urban ecology.

**Urban water and climate**

Earlier attempts to link green structure and water planning (Tjallingii, Spijker & de Vries, 1995) had only a limited impact. The gap between the two sectors in municipal administration was too big. The new Leidsche Rijn development, however, combines green and water planning in an elegant way. In the Leidsche Rijn plan, surface water will circulate from the built-up area into a lake in the adjacent green ‘lobe’ that is part of the urban green structure. Here, the water will pass through the wetland that will care for sedimentation and nutrient uptake. The purified water will then re-circulate into the built-up zone.

The role of green areas and street trees in moderating urban climate is clear in general terms, but apart from some incidental discussions about the need for a windbreak for cyclists, climate is not an issue in Utrecht, nor in other Dutch cities.
Use of green resources
Inside the city, 150 hectares of green areas are being used as allotment gardens. Around the city, dairy farming on meadowland is the dominant land use. In 1985 there were still 47 farms, but many of them were small hobby farms with part-time farmers. Full-time farmers increasingly face the need to industrialise and expand their enterprise and this is extremely difficult in the urban fringe that is full of uncertainties about urban expansion. Several zones in the western and eastern Utrecht fringe area are not yet urban and yet are no longer rural. Urban residents enjoy the meadows of the open countryside, but do not pay for its maintenance. In the Noorderpark, a 5,700 ha. rural area just north of the city, farmers are being paid for landscape maintenance tasks under the legislation of the 1975 Memorandum on the Relationship between Nature and Agriculture.

Surveys and monitoring
Utrecht has a long tradition of volunteer ecologists who explored the ecological treasures of the city (Maes, 1984). In the preparation of the 1990 Green Structure Plan, Farjon, Harms and Scheffer (1987) carried out the first systematic analysis of present and potential plant and animal life in the city. In the 1990s, the focal point of green structure planning shifted towards improving and establishing ecological corridors. Green structure planning was further made operational by a project implementation plan that included budgets for an ecological survey prior to major building projects and for monitoring specific habitat improvement activities. At the regional scale, the Province carried out a grid survey of native plants that was published in 1984. The km2 grid, however, is inadequate for planning purposes.

4 Green structure Planning
Figures 7 and 8 demonstrate the two levels of green structure planning in Utrecht. An assessment of green structure planning practice in the city has been published (Tjallingii, 2003). The 1990 Green Structure Plan (Gemeente Utrecht, 1990) presents the core areas and the corridors that connect them. The plan is primarily a strategy to protect and develop the green frame of the city. Figure 8 presents some key images of the Singel Restoration Project that restores a missing link in the green structure around the inner city and is realised as an element of a huge renewal scheme involving a shopping centre, railway station and offices.
Figure 7. The 1990s Green Structure Plan
References


Websites: www.groenstructuurplan.nl; www.utrecht.nl/herstel singelstructuur utrecht
Introduction
The City of Vienna has 1,615,438 inhabitants and it covers a surface area of 415 km² within its administrative boundaries. Green spaces cover 49% of the city area in Vienna, compared with 33% as the built-up area and 14% traffic area. More than one third of the green space is covered by forests, another third is farmland (arable land, horticultural land and vineyards) and 11% are meadows (mainly for recreational use, on the Danube Island and in the Wienerwald). Only 5% of the green space are parks (Realnutzungskartierung, 1997).

How have natural and cultural features influenced the development of green structure in the urban environment?

Vienna is situated at the intersection of different landscape types and climatic regions. From the Wienerwald in the west a series of terraces descends like steps to the Danube, where the centre of the city is situated. In the south, Vienna is bound by the hills of the Wienerberg and the Laaer Berg, and in the north by the Bisamberg. In the northeast, Vienna extends into the plain of the Marchfeld. Climatically, Vienna is situated in the transition zone between central European, Pannonic and Alpine climate. Correspondingly, the natural vegetation in Vienna consists of mixed deciduous forest (mainly beech, maple, oak and hornbeam) in the western part of the city and of Pannonic vegetation with dry grassland and oak forests in the east.

Vienna originates from the Roman military camp Vindobona. Around 1150, when the Austrian margraves from the Babenberg dynasty transferred their residence to Vienna, it developed into a veritable town. In the sixteenth and seventeenth centuries, palais with baroque gardens, which were connected to the city by avenues, were built outside the mediaeval town, which was enclosed by town walls and glacis. In the mid nineteenth century the old military fortifications were razed and the city expanded by incorporating the suburban zones. On the former glacis, the Ringstrasse was built, a broad, imposing boulevard lined by administrative buildings, museums, theatres and parks. In the nineteenth century, Vienna grew tremendously fast. The parts of the city originating from the second half of the nineteenth century are laid out in a dense rectangular pattern of blocks of buildings, streets and places, with few green structures. In 1905 the Wienerwald, which had been endangered by the rapid expansion of the city, was made a protected green zone by decree of the Vienna City Council. In the
1950s to 1970s, the large forest areas of the Lobau, the Bisamberg and the Lainzer Tiergarten were opened to the public. In the 1970s the Danube Island, an elongated man-made island, which is very popular as a recreation area today, was created in the course of the restructuring of the hydraulic regulation of the Danube. In 1996 the Lobau, a large (2,900 ha.) natural riverside forest on the southeastern bank of the Danube, was declared a national park, together with the adjacent riverside forests in Lower Austria (Auböck and Ruland, 1994; Opll (www.wien.gv.at/history)).

The agricultural land mainly consists of intensively used arable land on the urban fringe, which was cleared of many of the hedges surrounding fields in the past, so that it represents a rather monotonous landscape, which is unsatisfactory both regarding agroecology and nature conservation and regarding recreational use (Maurer et al., 2002).

3 What does this green structure mean for biodiversity, environmental services and management of flows?

Biodiversity
The flora of Vienna, with 2,187 wild plant species and subspecies, can be considered very rich in species. This is mainly due to the location of Vienna within the border region of several large floral regions (Central European, Alpic, Pontic, Pannonian and sub-Mediterranean), comprising substantial proportions of near wilderness areas (natural forests, wetlands along the Danube, formerly extensively used steppe pastures), as well as arable land, meadows and planted forests. In addition, man-made sites typical of large cities, such as ruderal vegetation, wasteland, settlement areas, traffic areas (railways, docks, streets, channels) and industrial derelict areas (including for commercial and business usage) play an important role (Müllner et al., 2000).

58 species of mammals, 134 species of butterflies and 72 grasshopper species are living currently in Vienna. Species which inhabit natural woodland, river banks, dry grassland or other well-structured landscapes are endangered because these types of biotopes are diminishing and the remaining biotopes are often isolated. A further reason for the endangering of many species is the use of pesticides (Sieber and Ulbel, 1998).

Management of flows
Water: Vienna’s drinking water supply originates for the largest part from mountain springs in the eastern Alps. Only around 3% of the drinking water comes from groundwater. The groundwater in the city is mainly used for industrial and agricultural purposes. There are projects aiming at increasing infiltration of rainwater from the roofs of residential complexes in order to replenish the groundwater and to reduce the amount of storm water going to the sewage treatment plant. About 70 streams and rivers used to flow from the eastern flanks of the Wienerwald forest through the city and into the Danube. Many of them have been overarched to protect the adjacent riverbank properties from flooding and have disappeared completely from the
cityscape. Today several of them have been restructured and their riverbed gradually re-naturalised (www.e-lisa.at).

**Air**: In Vienna, windy weather is very common, with the main wind direction being west to northwest. As the natural landscape of the city opens to the Marchfeld plain in the east and the Danube provides a natural corridor in this direction, the natural preconditions for a good ventilation of the city are very favourable, so that smog rarely occurs in Vienna.

**Organic matter**: In order to close the ecological cycle of nutrient flows, the organic fraction of household waste is collected separately in Vienna (90,423 tonnes in 2002). Applying constant quality control, this waste is then transformed through an open windrow composting process; this compost conforms to high standards. The largest part of the compost is used in agriculture on the municipal agricultural estates, which has enabled some of the estates to change over to organic farming (www.bestpractices.org).

4 **How are the ecological and environmental functions of green structure considered in land use/landscape planning? How are the functions being managed to meet ecological and environmental goals?**

The **formal planning instruments** in Vienna are the building regulations: the comprehensive community development plan and the legally binding land use plan. These two plans are amalgamated into one document. Vienna does not have regional planning legislation, so the regulations for city planning are to be found in the building regulations.

The community development plan and the land use plan provide detailed guidance for the future pattern of land use in an area by ascribing the area to a certain zone. There are four kinds of zone: green space, building areas, traffic areas and special areas. Vienna’s nature conservation law consists of several categories with varying degrees of protection and there is also a tree preservation law.

**Informal planning instruments**, which are not established in law, are the Urban Development Plan 94 (Stadtentwicklungsplan 94, STEP 94), the plan Greenbelt Vienna 1995 and the Strategic Plan for Vienna (1999).

The Urban Development Plan 94 is based on a resolution of the City Council. It provides the framework for the optimum development of land. The STEP 94 defines 11 growth axes, along which the city expansion should take place. Between the growth axes, large green areas, which are connected into a web of green structures, should be preserved. In order to implement the ideas of the STEP 94 plan, a number of more detailed plans for the green structures were developed. The plan Greenbelt Vienna 1995 shows the network of green areas, which should form a belt around the built-up area of the city. These green areas are linked by green corridors and by areas in
agricultural use.

Certain measures have been drawn up to protect the green areas mentioned in the plan Greenbelt Vienna 1995. Designating green areas as ‘protected zones in the greenbelt’, laid down in the community development plan/land use plan, is the best possible protection. In such a zone, no building activities are allowed. At present, only part of the designated greenbelt is ascribed to ‘protected zones in the greenbelt’. Large areas are ascribed to rural areas, in which certain building activities are allowed. There is a great deal of pressure to change the pattern of land use as designated in the community development plan/land use plan of some of these areas into building areas. Green areas are also protected under the nature conservation law. Another means of protecting the areas of the greenbelt is to develop them into woods or parks. Since trees are protected under the tree preservation law, such areas become protected green spaces. This measure is used extensively. Furthermore, it was intended that the City Council should protect some green areas by purchasing them, which has happened in a few cases.

The Strategic Plan for Vienna (1999) calls again for the realisation of the Greenbelt 95 plan. It identifies the measures to be taken and the persons responsible for their implementation. It also calls for the provision of public and additional private funding for the purchasing and developing of green structures.

Figure 1. Greenbelt Vienna 1995 (greenbelt shown in black.
Source: City of Vienna Dept.18)
5 What is presently recorded about ecology in the case study area, by whom, and how?

The Municipal Department for Nature Conservation (MA 22) has commissioned numerous studies on environmental and ecological aspects of the city (www.wien.gv.at/ma22/pool/). Biotope mapping studies in the built-up areas were conducted in the late 1980s (Punz, 1990). Habitat surveys covered vegetation and important groups of fauna, such as mammals, birds, reptiles, lizards, beetles, butterflies and grasshoppers. A nature conservation strategy for Vienna and concepts for the conservation of species and their habitats were drawn up (Kutzenberger, 1994). In the 1990s, a biotope-monitoring study was conducted using aerial infrared photography (1991; 1997; 2000). Infrared photographs of the total city area were analysed in detail for the green structures and the results were included in the digital city map using GIS (Kellner et al., 1999). In a study ‘Ecological-functional types of structures’, the total area of the city was divided up according to ecological-functional criteria and was allocated one of eight ecological-functional types; this formed the basis of a first proposal for taking differential conservation and development measures (Brandenburg et al., 1994).

Energy levels, materials (in particular carbon), water balances for anthropogenic and natural flows, and nutrient balances for agriculture have been calculated (Brunner et al., 1996; Maier et al., 1997; Erhart et al., 2002). The status of agriculture in Vienna today has been evaluated from the ecological, economic, social and planning points of view and options for its future development have been defined (Maurer et al., 2002).

6 How have ecological goals been set out to influence the planning, design and management processes? Is there any evidence that these goals have influenced the planning processes within the study area?

The Urban Development Plan 94 (STEP 94) and the plan Greenbelt Vienna 1995 provide guidelines on how and where to preserve and extend greenspace in Vienna. Since 1995, the areas Bisamberg (275 ha.) and Flugfeld Aspern (35 ha.) in the north and the Goldberg (270 ha.), a refuge for endangered plant and animal species in the south of the city, have been preserved by designating them ‘protected zones in the greenbelt’ in the community development plan/land use plan. Other green areas have been protected by their development as forests, or parks. However, the pressure to expand the industrial and traffic areas poses great challenges for the successful protection of the greenbelt in Vienna, particularly in the south of the city.

A new instrument, the Strategic Environmental Assessment (SEA), is being used to take account of environmental aspects in city planning. At present, an SEA is being conducted for the area in the northeast of Vienna, which is to be developed in the next few years (www.wien.gv.at/stadtentwicklung/supernow). The Local Agenda 21 was started as a platform for sustainable district development and citizen participation in the fields of ecology, social affairs and economy. Within the framework of the Local
Agenda 21, citizens also participate in the process of developing green spaces in their
district (www.agenda21.or.at).
The first steps to implement the nature conservation strategy for Vienna and the pro-
grammes for the conservation of important species and their habitats have been taken
at district level (www.wien.gv.at/ma22/netzwerk.htm).
Several approaches aim at implementing ecological goals in agriculture. In the
municipal estates, 50 km. of windbreak hedges, which reduce wind erosion and
provide habitats for many species, were planted. Farmers are encouraged to change
over to organic farming through the programme ‘Eco-food’, which increases the use
of organically-grown foodstuffs to 30% in the City’s institutions, such as kindergar-
tens, schools, hospitals and old people’s homes. The Contracted Nature Conservation
Programme, Biotope Farmland, rewards farmers for converting farmland into nature
conservation areas by applying appropriate management measures.

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Introduction
The City of Warsaw has approximately 1,707,400 inhabitants in a surface area of 516.7 km² (www.warszawa.um.gov.pl). Warsaw is the largest city, the only one with a population over one million inhabitants. If the Warsaw Agglomeration is implemented, the population will reach 2,100,000 people. The current administrative structure of Warsaw was established at the beginning of 2003, when the city became an association of eighteen districts. Each district has limited independence and powers. The City Council is a major legislative body that controls the spatial planning process in the city.

Warsaw has a long tradition of green structure planning that extends back to the beginning of the twentieth century. The different concepts with regard to greenspace have emerged since then. Almost all of them have influenced the contemporary green structure of Warsaw, which covers 36% of the total city area (Table 1). The transformation of the Polish political and economical situation since 1989 has made Warsaw into a strongly developing city. As a consequence, the attractive green open spaces

<table>
<thead>
<tr>
<th>Type of greenstructure</th>
<th>ha</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>parks</td>
<td>2895</td>
<td>5.7</td>
</tr>
<tr>
<td>municipal parks</td>
<td>171</td>
<td>0.35</td>
</tr>
<tr>
<td>forest</td>
<td>3838</td>
<td>7.8</td>
</tr>
<tr>
<td>municipal forest</td>
<td>2716</td>
<td>5.5</td>
</tr>
<tr>
<td>residential greenspace</td>
<td>1772</td>
<td>3.5</td>
</tr>
<tr>
<td>allotment garden</td>
<td>1454</td>
<td>2.9</td>
</tr>
<tr>
<td>botanical garden &amp; zoo</td>
<td>78</td>
<td>0.15</td>
</tr>
<tr>
<td>cemeteries</td>
<td>449</td>
<td>0.9</td>
</tr>
<tr>
<td>promenades &amp; squares</td>
<td>175</td>
<td>0.35</td>
</tr>
<tr>
<td>greenery associated with transportation system</td>
<td>1200</td>
<td>2.4</td>
</tr>
<tr>
<td>other greenery</td>
<td>3278</td>
<td>6.75</td>
</tr>
<tr>
<td>Total</td>
<td>18026</td>
<td>36.3</td>
</tr>
<tr>
<td>Total area of Warsaw</td>
<td>49428¹</td>
<td>100</td>
</tr>
</tbody>
</table>

1. The surface area of Warsaw was enlarged from 494.3 km² to 516.7 km² in 2003 but no new statistical data have been published. Contemporary land use structure data are expected this year.
<table>
<thead>
<tr>
<th>Main natural green structure element</th>
<th>State</th>
<th>Plans for development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivers, streams, canals, lakes</td>
<td>The Vistula River is the main element of Warsaw’s green structure. The northern and southern parts of the river are quite natural and present some typical features of a braided river like sandbars. Both banks are covered in part with riparian forest. The Vistula has an unsymmetrical valley consisting of a few terraces on the western and eastern sides, and existing systems of oxbow lakes, streams and canals on the most recent terraces that are also emphasised by narrow strips of riparian forest and bushes. Some of these elements are protected as natural reserves or as historical landscape structures (sandbars, oxbow lake, canals). The Vistula valley has been classified as the European ecological corridor in ECONET – PL and this decision influences planning provisions. But there is still a fight between architects and ecologists about the future of the Vistula River banks, as to whether they should be green or built up.</td>
<td></td>
</tr>
<tr>
<td>Warsaw Escarpment</td>
<td>The edge of the moraine plateau is considered one of the most valuable elements of the natural and cultural landscape. Its course is emphasised by the natural and semi-natural vegetation communities that form a rather narrow but almost continuous structure to the inner city. Its southern and northern parts are connected with large sections of forest. Both are protected because of their environmental value. Its provisions are written in the Study of Conditions and Directions of Spatial Planning. They both regulate and protect the natural geomorphological form and processes, natural or semi-natural vegetation, historical objects and landscape pattern, and aesthetic values.</td>
<td></td>
</tr>
<tr>
<td>Green areas</td>
<td>108 objects - parks, gardens and valuable waste areas (mostly natural lakes and their vicinities) and 27 allotment gardens. These objects are protected against any kind of inappropriate investment and changing their size and status; it is recommended that allotment gardens change their function into public green open spaces.</td>
<td></td>
</tr>
</tbody>
</table>
have vanished, becoming locations for new investments. It these circumstances, the question of the role and value of green structure becomes crucial.

1 How have natural and cultural features influenced the development of green structure in the urban environment?

The green structure of Warsaw today relies on natural and historical landscape elements. Although its dependence on natural structures is weakening as a result of the urbanisation processes, the land relief and hydrological system still create a visible pattern of green areas. The River Vistula, the main green structure axis, provides Warsaw some remnants of elements of the natural landscape such as the system of oxbow lakes and streams, and banks accompanied by riparian forest and dunes, separated by peat swamps or small ponds (Figure 1). Another crucial element of the Warsaw landscape is the Warsaw Escarpment, the edge of moraine plateau that stretches through the city almost parallel to the Vistula. Its southern and northern parts are connected to large stretches of forest. Both are protected because of their environmental value. The northern one, the Kampinoski National Park (one of the largest Polish national parks, totalling 356.55 sq. km.) and the southern part, the Kabacki Forest Nature Reserve, create the framework of regional green structure. They are the main sources of alimentation for both biodiversity and air regeneration. The Warsaw Escarpment was recognised as a crucial natural structure in the localisation of significant historical landmarks such as the Old Town with the royal castle and magnificent residential palaces, parks such as Lazienki, Natolinski or Ujazdowski Parks and gardens such as the Botanical Garden.

The development of Warsaw in the eighteenth century, known as the golden age of city planning and architecture (Kicinska, 1993) left the remnants of two axes associated with green spaces that defined the urban fabric at that time. Warsaw’s investment in the nineteenth century in, for example, military fortifications and railways, has contributed to the development of contemporary green structure and provides important environmental services. Vast unbuilt areas have a positive influence on the city’s ventilation and contribute significantly to the overall hydrological balance, for example, through ground water replenishment areas.

For the major part of the twentieth century Warsaw was located on the western side of the moraine plateau, where the urbanisation processes gradually resulted in the vanishing of the natural landscape, as well as green structure. Only a few patches of forest, small lakes and streams or just their valleys, remain of those previous landscapes. Now, the major spatial development of Warsaw has taken place on the eastern side, because almost every area of land reserve to the southwest has been used. In these circumstances, green open spaces without precisely defined functions became the best source of land for housing development in that part of Warsaw.
Green open spaces cover 36.3% of the total Warsaw area, according to an inventory carried out in 1997 and updated in 2001. Table 1 presents the main types of Warsaw green structure. Three categories of greenery dominate: forests, municipal and national, cover about 14% of the surface area; parks, both municipal as well as owned by the districts, occupy 6% of the city and a further 6% has other greenspace without being precisely defined (Figure 1). The present green structure of Warsaw, together with agricultural land and open water, covers more than 50%. The built-up areas occupy 28% and are continuing to rise. The most vulnerable land on which to build is agricultural (about 29.9%) and such ground has vanished rapidly from Warsaw over the last 12 years.

2 What are the benefits of Warsaw's green structure for biodiversity and the environment?

Biodiversity
The first comprehensive mapping of the real vegetation communities of Warsaw was done at the beginning of the 1980s and then updated in 1998 (Kozowska 1999). It has become an important source of information for nature conservation and protection. This database offers vast possibilities for the analysis needed for proper city nature management, for example, the degree of heterogeneity, the direction of changes of communities because of the eutrophication of habitats (nitrophilous or calciophilous), xerotrophication and still growing influx of alien species. It enables the sequence of vegetation communities to be controlled, from the inner city, where they relate mostly to land use type, to the Warsaw suburbs where the condition is still determined by the natural vegetation pattern (Chojnacki 1991).

Besides vegetation surveys, research has been done on zoocenosis. The history of fauna investigation within Warsaw and its vicinities dates back to the end of the nineteenth century, when the surveys of mammals and avifauna were done (Luniak 1990 and 2001). The last forty years have produced the most intensive and detailed research on this topic. The best information has been gathered for avifauna. In Warsaw, 247 species of birds have been recorded (breeding birds and wintering birds are included) since the mid-1980s, 187 of them occurred regularly and 131 were regular breeders (Luniak 2001). The total breeding population in 1990 was estimated at about 154,000-352,000 pairs, or 300-700 pairs/km2 in the whole Warsaw area. Research carried out for the inner city (52 km2) has shown substantial differences between the number of pairs in summer and wintertime. It varied from 830-1,590 pairs/km2 in summer to 2,500-4,500 pairs/km2 in winter (Luniak, 2001).

Apart from the inventory, detailed research has been undertaken to examine the relationship between biotopes and existing species. As a result their refuges have been identified in central districts and in other valuable landscapes, such as the Warsaw Escarpment or Czerniakowskie Lake (one of the oxbow lakes). This information is
particularly important for the species’ survival. Only the protection of habitats against urban development can guarantee the existence of endangered species. Interesting investigations have also been carried out on other topics, for example, on the behaviour of butterflies (Scarce Large Blue – Maculinea teleius), rarely seen in urban areas (Sielezniew and Stankiewicz, 2001), and on the diversity of insect communities in green areas (Chudzicka and Skibinska 2001). The result of this research has become the basis for protesting against the development of a residential area (in the Bielany district) on the two hectares of meadows. This piece of land is on the one hand a habitat for a rare butterfly species, but on the other hand is seen as a priceless site for development by architects and representatives of local authorities.

**Environmental services and management flows**

The Vistula River is a major source of drinking water supplied to inhabitants. 70% of the water demands of Warsaw are provided directly from the Vistula (Krajobraz Warszawski, 2001). Warsaw has also been tapping deep-well water from the Oligocene formations for more than one hundred years. But the use of this source is restricted nowadays because of a vast decline resulting from wasted use of the Oligocene water in the 1970s. A major threat concerning drinking water is its quality. Only one sewage treatment plant for eastern Warsaw and a lack of sewage treatment, mainly in the Warsaw periphery, have caused significant pollution of the ground as well as surface water.

One of the key roles of green space is to improve water circulation and its quality. Green open spaces slow the water run-off caused by the storm water drainage system and contribute to groundwater recharge. There is no field research on this topic in Warsaw, but some attempts have been made to describe and evaluate the condition for hydrological processes (Kaliszuk, 2003). Results from this type of research can make a good basis for the identification of those areas that are crucial to achieve a proper hydrological balance.

The size and pattern of green structure influences the urban climatic condition significantly. There have been a number of studies on this topic in different areas within the city. The mean air temperature in parks is lower by about 1.40°C than in streets, while the surface temperature in parks with trees is lower by about 100°C than on lawns and about 120°C lower than in granite squares (Czerwieniec and Lewinska, 1996). Thus, green space minimises the negative phenomenon – the heat island effect. Each green open space, except the forest, plays a positive role in the ventilation of Warsaw. Those located on the outskirts enable wind to enter the city, whereas those which are in the inner districts accelerate wind velocity (Kuchcik and Blazejczyk, 2001). Apart from the results of these field studies, Warsaw also has a database of key climatic elements developed in GIS (Kozlowska-Szczesna, Blazejczyk and Krawczyk, 1997).

2. Second sewerage treatment plant for western Warsaw is under construction
<table>
<thead>
<tr>
<th>Urban natural system</th>
<th>Zones</th>
<th>Provisions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ecological zone</td>
<td>This has been divided within the Study of Condition and Directions of Spatial Planning into four categories: protected areas, recreational, recreational and residential, and others. Each of them has their own provisions, according to the particular environmental, ecological, historical and social value. The provisions are written as prohibitions or recommendations. Prohibitions relate to this kind of development, which can cause a deterioration in environmental values; recommendations formulate the most appropriate proposal for development of the ecological zone, with minimum impact on the environment.</td>
</tr>
<tr>
<td></td>
<td>Ecological zone - Auxiliary system</td>
<td>Its role is to maintain links between the spread out green areas, or to act as a buffer zone of the most natural landscapes. Provisions written in the Study of Condition indicate green belts with an established minimum width (along streams, canals and roads) and establish the percentage of greenery for each investment unit, located in this zone to minimise the negative influence on the valuable remnants of the natural landscape.</td>
</tr>
<tr>
<td></td>
<td>Air Ventilation and Regeneration system</td>
<td>Its role is to protect areas which create proper climatic conditions in Warsaw. It partially covers the ecological zones, mentioned above (forests and parks), while wide wasteland, railroads and highways create major ventilation passageways.</td>
</tr>
</tbody>
</table>

Figure 2. The urban-natural system of Warsaw
Note: All maps in this paper are copyright of the City of Warsaw, Architects Department.
The role of linear greenspace as an ecological corridor is also under discussion. There is a lack of data, but this is regarded as one of the most important functions of green areas (Szulczewska, 1996). The Vistula valley has been classified as the European ecological corridor in the net called ECONET – PL (Liro ed. 1995 and 1998). It is not yet legally binding, so it does not strictly regulate planning decisions. Nevertheless it is reflected in almost every planning document and it influences planning decisions.

3 How have ecological goals been set out to influence the planning, design and management processes?

The main challenges for Warsaw’s green structure planning, development and protection

The information about Warsaw’s environment and ecology gathered during different research programs should form the basis for the development and conservation of green structure. There were some attempts to conduct scientific research with a strong practical orientation, and to use them in the Biała__ka district (Szulczewska, 1996). They were fundamental in the development of land use, for example, by laying down the proportion of green structure and housing areas, and they designated areas for green open spaces as well as making recommendations on building design. Unfortunately, they have never been used. Instead of a good example of city development with strong environmental awareness, a new, very dense housing district is being built.

The boom in regional spatial development of Warsaw city started after the political and economical changes of the beginning of the 1990s. To conserve the most valuable natural environment and areas crucial for proper living conditions in the city, the ‘urban natural system’ concept was implemented in the Warsaw Master Plan of 1992. Unpropitious administrative conditions (11 independent boroughs) and ineffective provisions written for the ‘urban natural system’ could not preserve these areas. Some of them have been lost (Szulczewska and Kaliszuk, 2003). In the new administrative circumstances where Warsaw is now one community divided into eighteen districts with limited competition for spatial development, the identification of the ‘urban natural system’ is still an important challenge for the development of green structure in the city. A new version of the ‘urban natural system’ has been identified in a planning document, The Study of Conditions and Direction of Spatial Planning, at the beginning of 2003. It regulates the pattern and function of green structure for the whole city. Three key zones have been indicated: The Ecological Zone (Figure 2), The Ecological Zone - Auxiliary System and The Air Ventilation and Regeneration System.

The ecological zones are based around key structures within the Warsaw landscape, such as the Vistula River valley with its remnant natural hydrological system associ-
ated with meadows and forest, other valuable green open space, for example, parks
and gardens, and the remnant natural forest located on Warsaw’s edges. Each area that
belongs to this zone has its own designated provisions, according to its ecological,
historical and social values. The provisions are written as prohibitions or recommenda-
tions.

The main role of the Ecological Zone - Auxiliary System is to keep the connection
between spread out green areas, or to be a buffer zone of the most natural landscapes
(Figure 2). The third zone, the Air Exchange and Regeneration System aims to protect
areas, creating appropriate climatic conditions in Warsaw.

Besides the provisions written for each ecological zone, a separate study is formulat-
ing groups of prohibitions and recommendations for particular structural elements
of the Warsaw landscape. These are green open spaces, the Warsaw Escarpment, the
sports and recreational system, and also a flood zone (Uchwala No. XXXVIII/492/
2001). The first group of provisions relates to 108 carefully defined areas - parks,
gardens and valuable waste areas (mostly natural lakes and their vicinities), and 27
allotment gardens with a recommendation to change their function into public green
open spaces. These areas are protected against any kind of inappropriate investment
and change to their size and status.

Apart from the Study of Conditions and Direction of Spatial Planning, other docu-
ments, related directly to green structure development, are being developed by the
City Council. The latest one is the Strategic Programme for Warsaw Green Open
Space Development. It was preceded by the Programme for the Protection and
Development of Green Areas (Lisicki, 1996). The green structure inventory for the
whole of Warsaw was undertaken then. The GIS database provides detailed informa-
tion about each green structure element, on what is crucial for its protection, conser-
vation and management. The City Council has recently managed to restore one of the
most important parts of Warsaw green structure - Ujazdowski Park.

Separate regulations relating to development and management have been written
for legally protected areas, nature reserves (eleven indicated up to now), historic
parks and gardens, and flood plain areas within flood embankments. Each of them
has appropriate legally binding acts, which are the basis for developing the protec-
tion plan. The Nature Protection Act of 1991 refers to nature reserves, the Culture
Heritage Protection Act to historic parks and gardens, and the Water Law Act of 2001
to the Vistula flood plain areas within flood embankments.

4 Conclusion

The delineation of the urban natural system in the Study of the Conditions and
Direction of Spatial Planning should be considered an achievement and an oppor-
tunity. The provisions detailed for these areas give guidelines for their development
or even for their protection against any changes of function. However, the same plan

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generates threats in the light of green structure planning. Green areas, missed in the study because of too general a scale or inappropriate methods of the system of identification, may be lost.

The study details only general rules of the city’s green structure development. It is up to the planners how the rules should be applied in detailed land use plans and interpreted for a particular part of the urban natural system. A broad interpretation of the provisions, written as prohibitions or recommendation, bears unexpected fruits, mostly negative ones - sometimes green roofs are considered as greenspace, where the provisions dedicate a certain minimum percentage for such areas. As a result, instead of greeneries associated with residential areas, densely built-up blocks sometimes appear with green roofs.

References:

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