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(Eds.)

Urban Forests and Trees

A Reference Book

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Chapter 3

Urban Forest Resources in European Cities

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3.1 Introduction

In order to protect, manage and develop urban forests, it is essential to know their condition and understand the challenges they face. This chapter aims to give a broad overview of the state of the urban forest resource in Europe's towns and cities in order to identify both common and particular features and challenges. For this purpose, the urban forest will be defined broadly as comprising all the trees and woods within an urban area (see Chap. 1).

The characterization of the urban forest and the assessment of its condition in European cities and towns is a challenging task, as few data exist or have been published. A comprehensive European inventory of the urban forest resource is not currently available. For this book chapter, data on the whole green-space resource, and more specifically, on urban woodlands was obtained from a few existing surveys of selected cities and towns (Gälzer 1987; EEA 1999a,b; Konijnendijk 1999; Pauleit et al. 2002).

Therefore, case studies have been chosen with which the authors are familiar through their own work in order to characterize the urban forest in more detail for a range of large urban areas. The case studies chosen are Oslo (Norway), the Black Country, north of Birmingham (United Kingdom), Munich (Germany), Ljubljana (Slovenia) and Florence (Italy). These case studies represent a geographical cross-section from Scandinavia (Oslo) to southern Europe (Florence). They also comprise different urban situations, with an economically booming city region (Munich), an urban area undergoing a process of economic restructuring (Black Country), a city in a transition economy (Ljubljana) and a prospering city in the south with a famous historical heritage (Florence).

Parameters such as woodland cover and their age and species composition serve as indicators of urban forest provision, structure and quality. Where available, further information is used to assess the health status of the urban forest. Each case study highlights some of the major impacts on urban forests, such as the loss and fragmentation of ancient woodland through urbanization, as well as the threat to street trees. The conclusions of the chapter include general as well as particular challenges for the sustainable preservation and development of European urban forests.

3.2
General Overview

3.2.1
European Setting

As a context to the following discussion of the urban forest resource in Europe, it may be useful to note that Europe is the second smallest continent in the world, but that it is highly varied in environmental, socio-cultural and economic terms. Europe is also one of the most densely populated continents. The average population density per m^2 in Europe is over twice that of North America and Africa and half that of Asia without Russia (Stanners and Bourdeau 1995). Over two thirds of the population lives in urban areas (EEA 1999a). The main corridor of urbanization stretches from the

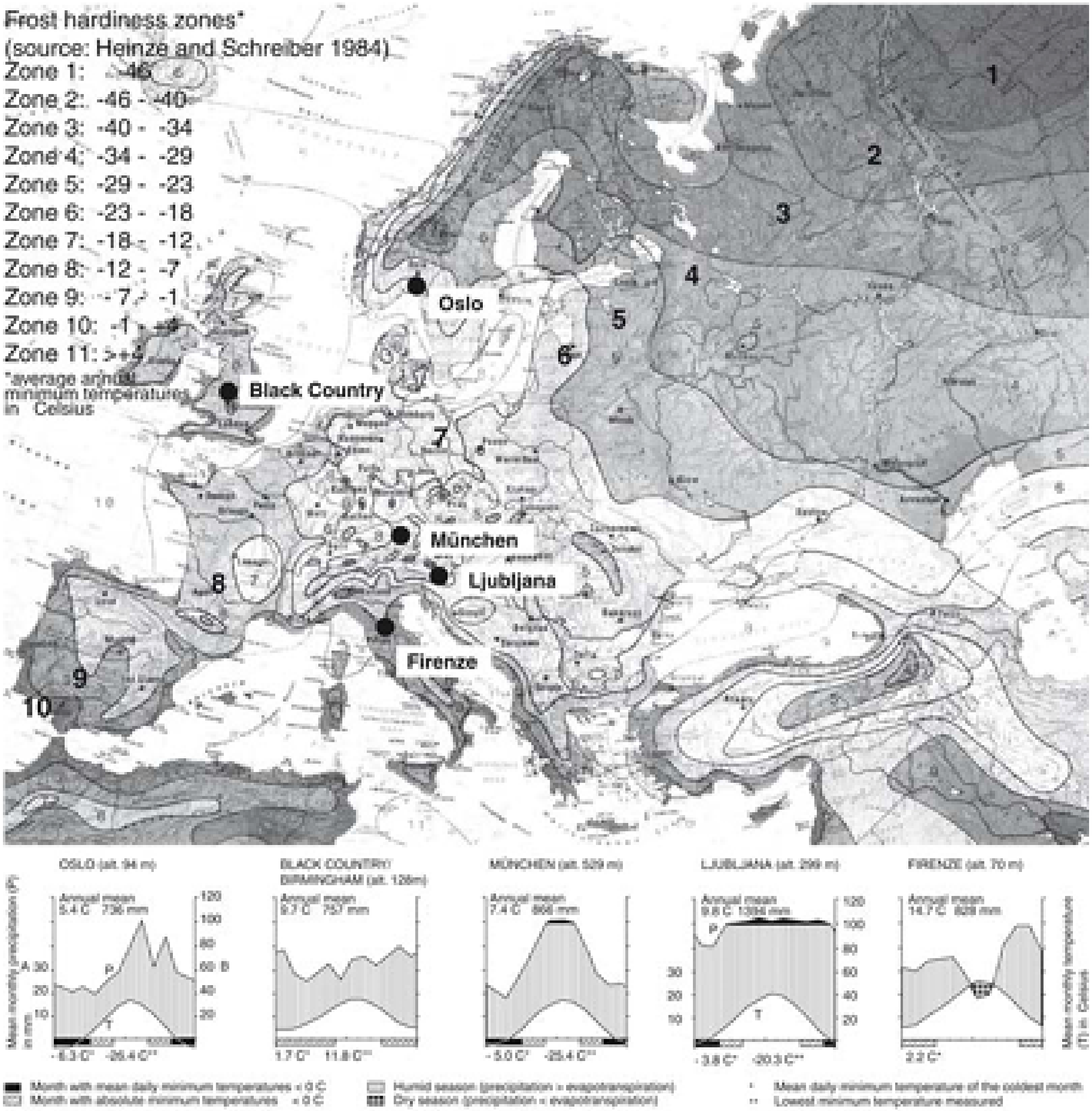


Fig. 3.1. Frost hardiness zones for urban forestry in Europe (based on Heinze and Schreiber 1984) and climate diagrams for the case study areas (Walter et al. 1975)

north of England across the Benelux countries and western Germany to northern Italy, but large urban areas are also found elsewhere in Europe.

Most major urban areas of Europe are located in the plains and along coastlines, except for Madrid, which is situated at an altitude of 640 m above sea level. Climatic differences are particularly important for tree life, for the structure of the urban forest and for the particular environmental benefits which it can bring. The broad pattern here is a gradient from humid north-western Europe to Mediterranean and continental southern Europe, where extended periods of drought occur during the summer. A second major gradient of winter hardiness goes from the north-east of Europe, where trees need to be adapted to minimum winter temperatures well below –20 °C, to the Mediterranean, where winters are generally mild (Fig. 3.1). Winters are also relatively mild in the maritime north-west of Europe.

The natural vegetation cover of the great majority of Europe is woodland, ranging from boreal coniferous woodlands in the north, mainly deciduous woodlands in central and north-west Europe to evergreen broadleaved woodlands in the Mediterranean. However, most of the woodland has been cleared and the urbanized regions of central and north-west Europe generally have particularly low woodland cover as a result (Fig. 3.2).

Fig. 3.2.
Per-capita forest provision in Europe (EEA 1999a)

3.2.2
Urban Forest Cover

According to data from 50 urban areas in Europe provided by the European Environment Agency (EEA 1999a,b), the overall amount of green space in European urban areas can range from only 4% in Athens to as much as 53% in Budapest. However, caution is needed as the data refer to administration units, which in some cases may include countryside around the city. Data based on a method that allows comparison have recently been published for 25 urban areas and six extended urban regions in Europe (for details see EEA 2002). While the percentage cover of forested areas was not listed in this report, data on green-space provision (excluding farmland) again show a wide variance among urban areas. The green-space cover within the urbanized area averages 7%. It ranges from less than 0.5% for Iraklion (Crete, Greece) to 16% for Dublin (Ireland).

Access to green space, measured as percentage of the population living within a 15 minute walking distance to green space, was used as one of the indicators of urban environmental quality in the first Environmental Assessment for Europe (Stanners and Bourdeau 1995). The results showed some significant differences between the urban areas included in the survey:

> In Brussels, Copenhagen, Glasgow, Gothenburg, Madrid, Milan and Paris, all the citizens live within 15 minutes walk from public green space. This is also the case in most smaller cities, such as Evora, Ermoupolis, Ferrara, Reggio Emilia and Valletta. In Prague and Zurich the corresponding figure is 90 per cent, in Sofia 85 per cent, in Bratislava 63 per cent, in Venice 50 per cent and in Kiev 47 per cent. In the majority of European cities, more than half of the population meet this criterion. (Stanners and Bourdeau 1995)

Available information on woodland provision is still very limited. A comparative study of 16 European cities showed that woodland cover ranged from as little as 1% in Amsterdam and Padova to over 20% in Berlin, Arnhem, Joensuu and Freiburg (Konijnendijk 1999). The per-capita provision of forests ranged from less than 20 m^2 in Amsterdam, Padova and St. Petersburg to over 100 m^2 in Arnhem, Freiburg and Joensuu. These woodlands are mostly owned and managed by municipalities or are state-owned forests. However, in some countries such as Germany and Italy, significant amounts of urban woodland are also in private ownership.

Further data on open space and woodland cover was obtained from a study of open space systems in 21 large cities in Europe (Gaelzer 1987). In this study, the open space cover is given separately for three concentric zones around the city centre (0–5 km, 5–10 km, >10 km but within the administrative boundaries). The figures below refer to the total woodland cover within these three zones. In most cases, there is a clear gradient from low open space cover in densely built-up inner urban areas to the urban fringe, which is mostly agricultural or covered by woodlands. The overall woodland cover was analyzed for 18 cities. Here, the variation is even greater, from 0.3% for Copenhagen to 24% and 27% for Zurich and Stuttgart, respectively (Fig. 3.3). 10 out of the 18 cities included had a woodland cover between 10 and 20%, while 6 had a lower woodland cover.

Most woodland is found in the urban fringe. The percentage cover ranges from 1% in Copenhagen to 65% in Stuttgart in the 5 to 10 km ring around the city centre. No geographic patterns between urban areas across Europe can be detected from the figures provided in this survey.

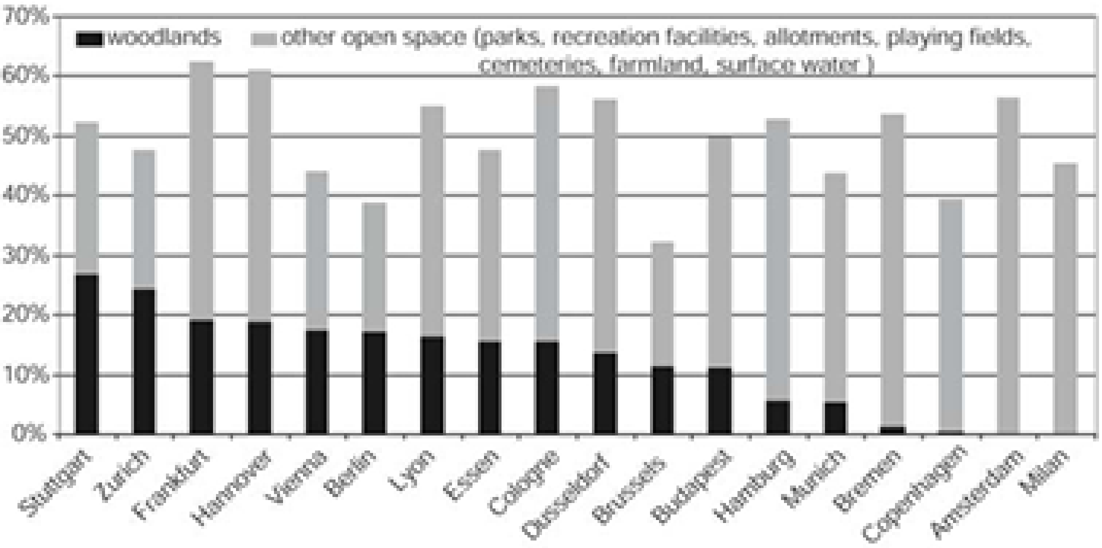


Fig. 3.3. Woodland and open space cover in European cities (Gälzer 1987)

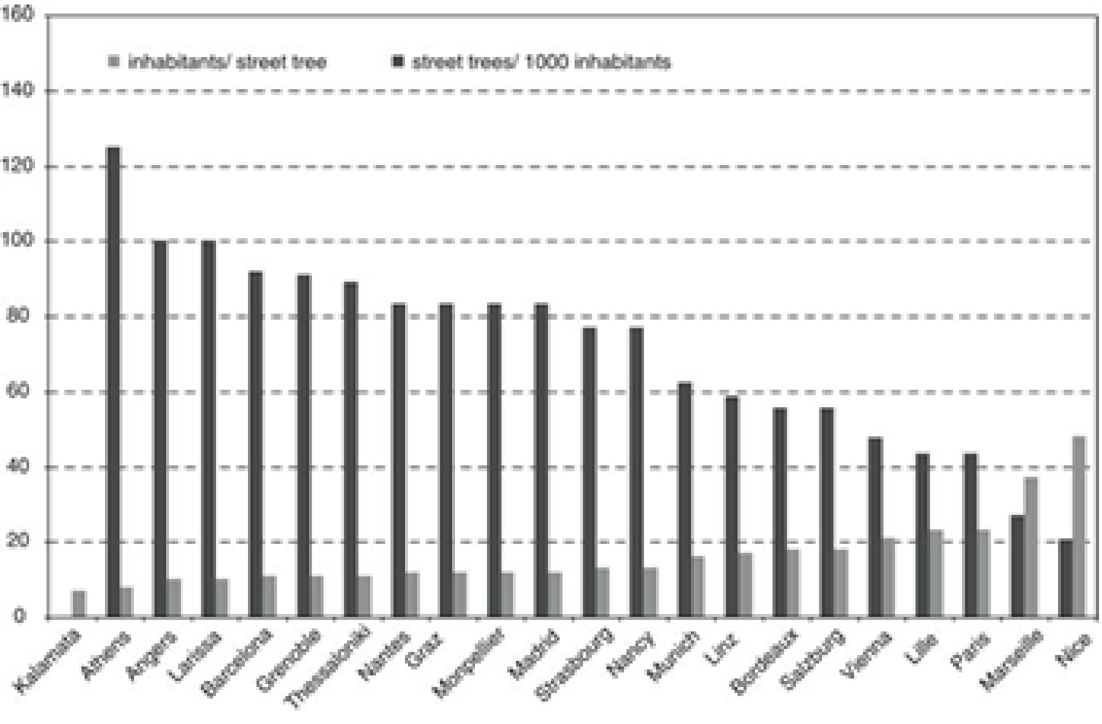


Fig. 3.4. The relation between street tree provision and population in selected urban areas in Europe (Pauleit et al. 2002)

In a recent European survey on the practice of urban tree establishment and aftercare (Pauleit et al. 2002), figures on the relative extent of tree cover varied largely from below 2% for Kópavogur in Iceland to 62% for Kuopio, a Finnish town which incorporates large woodland areas. All of these figures need to be treated with caution, however, as the administrative boundaries of the municipalities may include varying amounts of the surrounding countryside. Therefore, these statistics are not very comparable and the quality of the information can differ greatly. Generally, the most reliable information is available for true woodlands, whereas the stock of trees on private and institutional land is often not recorded in urban statistics.

The stock of street trees may be related to the urban population (Fig. 3.4). Using this comparison, Angers in France had as many as 100 street trees per 1 000 inhabitants, whereas in Nice the number was only 20. Most of the cities were in the range of 50–80 street trees per 1 000 inhabitants, but no clear geographic pattern could be observed.

The inverse ratio is a measure of how many people have to share each street tree. It can also be interpreted as an indicator of human pressure on trees. France reported the number of inhabitants per street tree ranging from 10 to 48, whilst in Madrid, Spain the ratio was 12 inhabitants per tree. In Austria, the number of inhabitants per street tree ranged from 12 to 21. While this ratio seems to be an interesting indicator for comparison, it needs to be noted that the figures do not reflect other important issues such as the quality of the tree stock, the size, health and age of trees.

3.2.3 Species Composition

Only a limited range of observations on the general pattern of species composition of the urban forest can be included in this brief summary (see Chap. 10 for more details). Overall, the choice of tree species is clearly determined by the prevailing climate. However, within the same climatic region, the selection of urban tree species can considerably vary due to planting policies. The survey of European tree selection and establishment practice showed that the range of different tree species planted varied greatly from one city to another (Pauleit et al. 2002).

Northern European cities and towns have a low diversity of tree genera and species due to the harsh climatic conditions and a traditionally narrow choice of species. In Reykjavik (Iceland), over 90% of newly planted street trees were black cottonwood (*Populus trichocarpa*), while lime trees (*Tilia* spp.) account for 40–70% of all new street tree plantings in Norwegian cities (Pauleit et al. 2002). In urban woodlands, species from the natural flora predominate with a high percentage of coniferous species such as spruce (*Picea abies*) and pine (*Pinus sylvestris*).

In central and north-west European countries, a comparatively broad choice of species is used. For instance, 167 species were recorded in a survey in the city of Cologne (Kunick 1987), only 22 of which were considered as belonging to the natural flora. The species richness varied within the city and was correlated with the percentage of the total areas covered by vegetation. Species in urban woodlands largely reflect the natural range of deciduous tree species such as oaks (*Quercus robur*, *Q. petraea*) and beech (*Fagus sylvatica*) but plantations of locally non-native species can also be common.

While there may be great overall diversity of tree species in central and north-western European cities, three to five genera usually account for over 50% of the overall stock of street trees. The most popular tree genera for street planting are traditionally lime (*Tilia* spp.) and maple (*Acer* spp.). In all five urban areas surveyed by Kunick (1987), these two genera together accounted for approximately 50% of the street trees. In The Netherlands, on the other hand, elm (*Ulmus* spp.) is still the second most frequently planted tree species although severely threatened by Dutch Elm Disease.

A tree survey in the city of Munich revealed that some of the tree species which had proved to be very successful up until the 1930s had not been used since then (Duhme and Pauleit 2000). At the same time, some of those species which have continued to be most frequently planted, such as lime, maple and horse chestnut, show particularly severe symptoms of stress and decline. Cultivars of these species are now commonly specified for urban tree planting – selection often being based on appearance alone. However, such a basis for selection does not necessarily take account of the basic genetic limitations which make some trees unable to cope with urban environmental conditions and adverse site factors such as air pollution, soil compaction and drought stress.

Mediterranean towns and cities often use introduced species which are frost sensitive, such as *Citrus* spp. or palms. The European survey of tree selection and establishment practice showed that a great range of species are used in the Mediterranean (Pauleit et al. 2002). Plane (*Platanus* × *acerifolia*) often predominates in public open space. However, this species is increasingly threatened by pests and diseases (Tello et al. 2000). In Marseille, for instance, plane trees are now largely replaced by southern hackberry (*Celtis australis*).

Attorre et al. (2000) documented the change in the composition of street trees over the last one hundred years for the city of Rome, and particularly noted the trend towards the planting of smaller tree species such as *Ligustrum japonicum*, *Nerium oleander*, *Citrus aurantium*, *Albizzia julibrissin*, *Cercis siliquastrum*, *Hibiscus syriacus* and *Lagerstroemia indica*. This trend is likely to be observed in other European regions as well.

Urban woodlands in the Mediterranean are often characterised by native oak species (*Quercus ilex*, *Q. suber*, *Q. pubescens*, *Q. frainetto*), pines (*Pinus halepensis*, *P. brutia*, *P. pinea*, *P. nigra*) and many other species of the native woods and scrublands characteristic of the Mediterranean and sub-Mediterranean (e.g., Attorre et al. 1997).

3.3 Urban Profiles: The Forest Resource and Its Challenges in Selected Urban Areas

3.3.1 North Europe: Oslo, Norway

The Urban Forest Resource and Its Challenges in Oslo

Oslo is the capital of Norway. The city is located at the northern end of the Oslo fjord. It has 510 000 inhabitants and covers 454 km^2. Compared to its surroundings, the local climate in the city is characterized by relatively warm summers, low precipitation and mild winters. The geology consists of Cambro-Silurian rocks in the built-up area and this also contributes to good growing conditions. The city ranges from the relatively low-lying plains of the inner city to the surrounding hills. Most of the significant commercial woodland (pine forest) occurs at medium and higher elevations.

295 km^2, corresponding to 65% of the city's overall area, is productive forest. This figure includes the smaller areas of woodland within the built-up area. The forest is used intensively for recreation and outdoor activities (Fig. 3.5a,b). Eighty-nine per cent of Oslo's people live within 300 m from a green area larger than 1 ha. Oslo is strictly

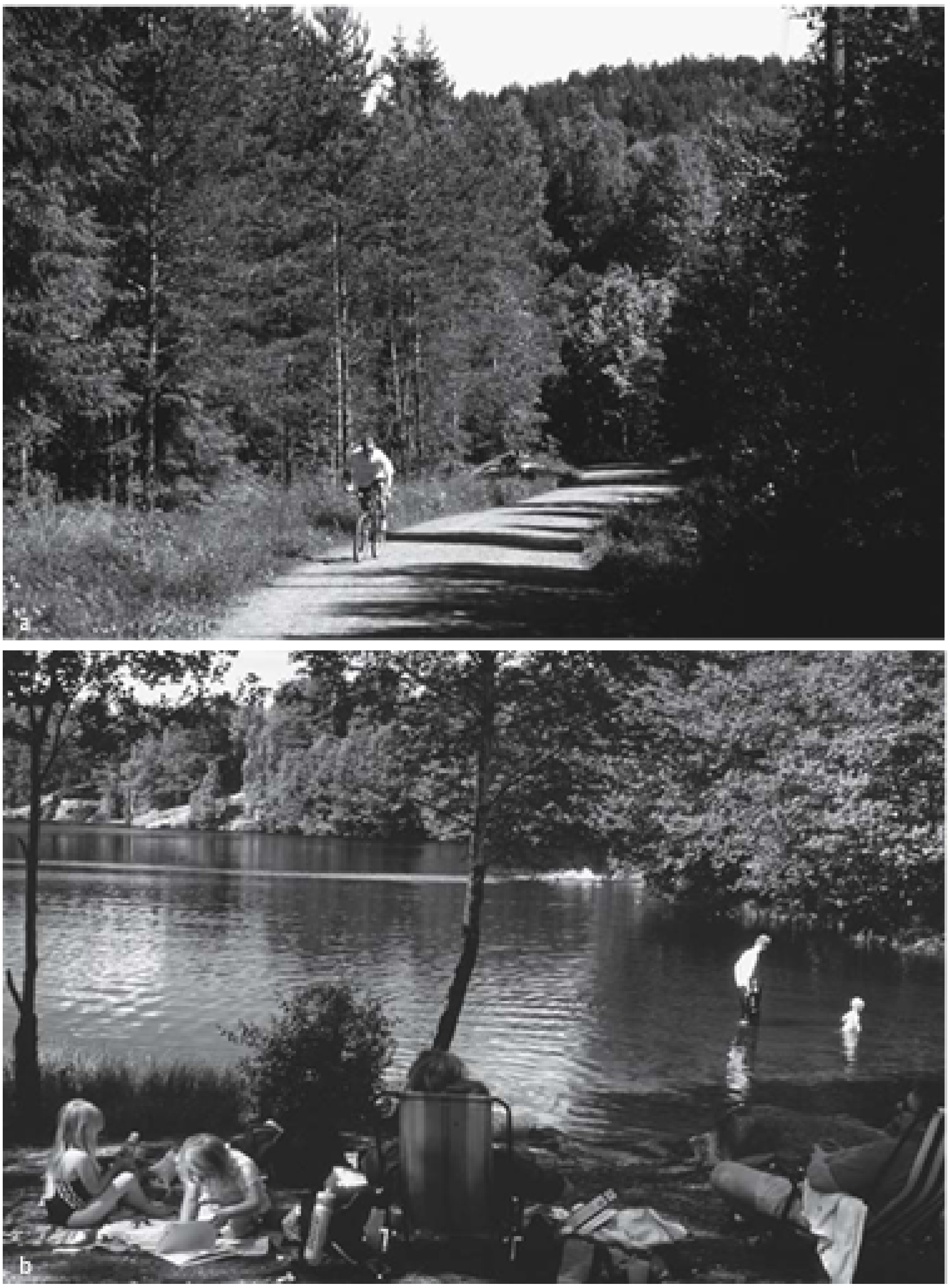


Fig. 3.5a,b. The large woodlands surrounding Oslo are intensively used for recreation (*photo:* S. Nyhuus)

divided between the urbanized core and a wooded sector called '*Marka*' which surrounds the city (Fig. 3.6). Many decades ago, it was 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. Since then, this border has remained unchanged, even though

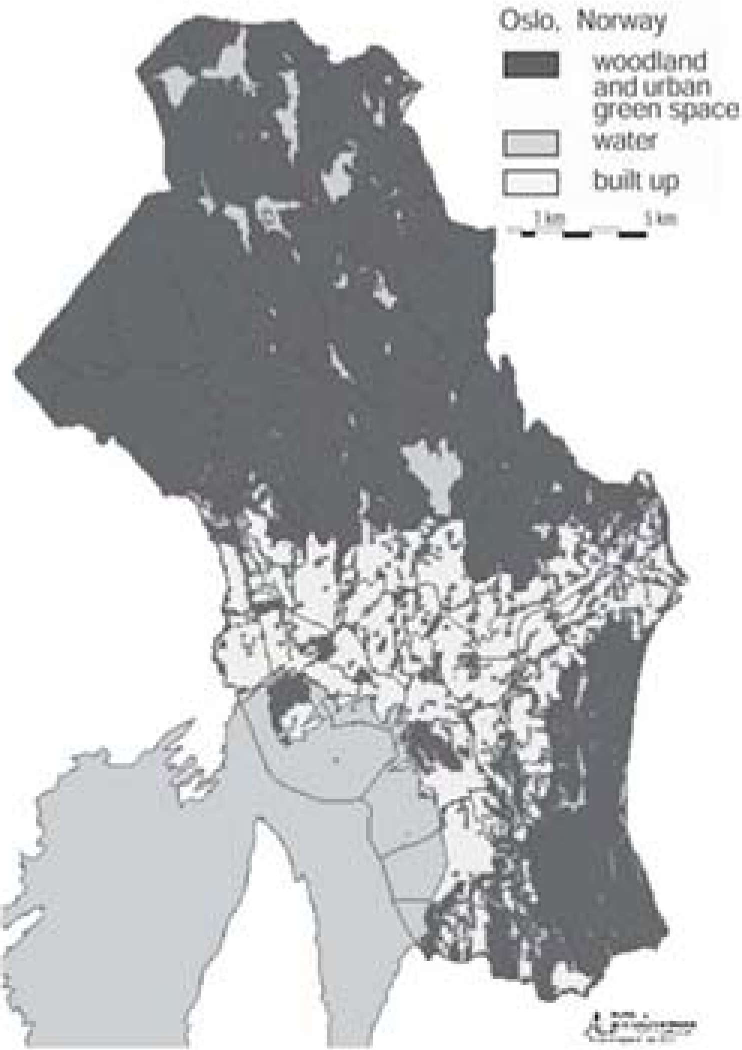


Fig. 3.6.
Oslo is strictly divided into two main categories: urbanized land and forested land. Note the green structure within the urbanized area (*source:* Municipality of Oslo)

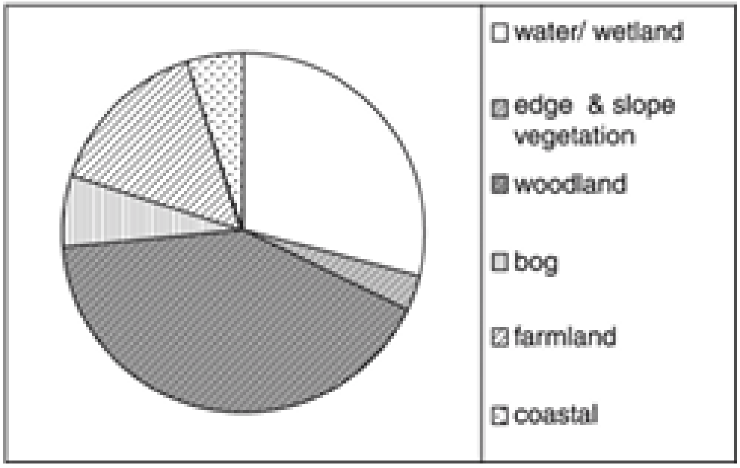
politicians occasionally propose building on virgin land. The vegetation/forest type and the management in *Marka* differ greatly from the vegetation types and management within the built-up area. However both types are multi-functional and are described below.

Marka

The woodland outside the built-up area covers 3 060 ha. In the north and north-east, spruce (*Picea abies*) predominates, while Scots pine (*Pinus sylvestris*) predominates in the east. The differences in species mirror the differences in geology, local climate and altitude. The amount of timber harvested has been constant since 1994, due to a management plan that was proposed at the beginning of the 1990s and which was finally adopted by the City Council in 1996. The overall goal is that the management of the forests should be mainly for recreation and nature conservation.

However, ownership is a problem, since the municipality only owns small parts of the northern spruce forest. A dialogue with the private owners has been going on for many years with NGOs as active participants. This dialogue has led to the adoption of a multifunctional management approach.

Fig. 3.7.
The proportion of principal natural and semi-natural landscape types within the municipality of Oslo (*source*: Municipality of Oslo)



The Built-up Area

Within the green structure of the urbanized area of the city, a great variety of vegetation types exists, including woodlands of a different type from that in the *Marka*. The reason for this difference is that the urbanized area is located on the lower plateau of Cambro-Silurian rocks and has a milder local climate than Marka. The small woodlands in the built-up area are dominated by elm (*Ulmus glabra*) but also other tree species can be found there, in particular lime (*Tilia cordata*), ash (*Fraxinus excelsior*), and oak (*Quercus petraea*, *Q. robur*). Oslo contains about two thirds of Norway's plant and animal species and is therefore regarded as a pool for biodiversity.

Since there is an urban intensification policy in Oslo, due to the shortage of land for new housing, the woodlands are under constant threat from fragmentation or even total disappearance due to new development. Weather records show that there have been milder winters during the 1990s. In Oslo, this change in weather has meant a higher degree of freezing and thawing during the winters, which might have had an influence on trees. However, this hypothesis has yet to be investigated.

The Norwegian government has declared that all municipalities should record their sites of nature conservation interest by 2005. Oslo was in the middle of this work by the time of writing. Figure 3.7 shows the relative share of the main nature types found in the municipality. Forests constitute almost half of all sites of nature conservation interest. In preparing an inventory of the natural green spaces, statistics of single trees, avenues and smaller woodlands will also be included. Previously this task had been given a low priority, since the green spaces were under relatively low pressure.

3.3.2
North-West Europe: The Black Country

The Urban Forest Resource

The Black Country is the name for the area to the north-west of Birmingham in the West Midlands region of England. It is a metropolitan area, comprising the administrative districts of Wolverhampton, Walsall, Sandwell and Dudley and it includes a number of industrial towns and urban villages, interlaced with an extensive canal

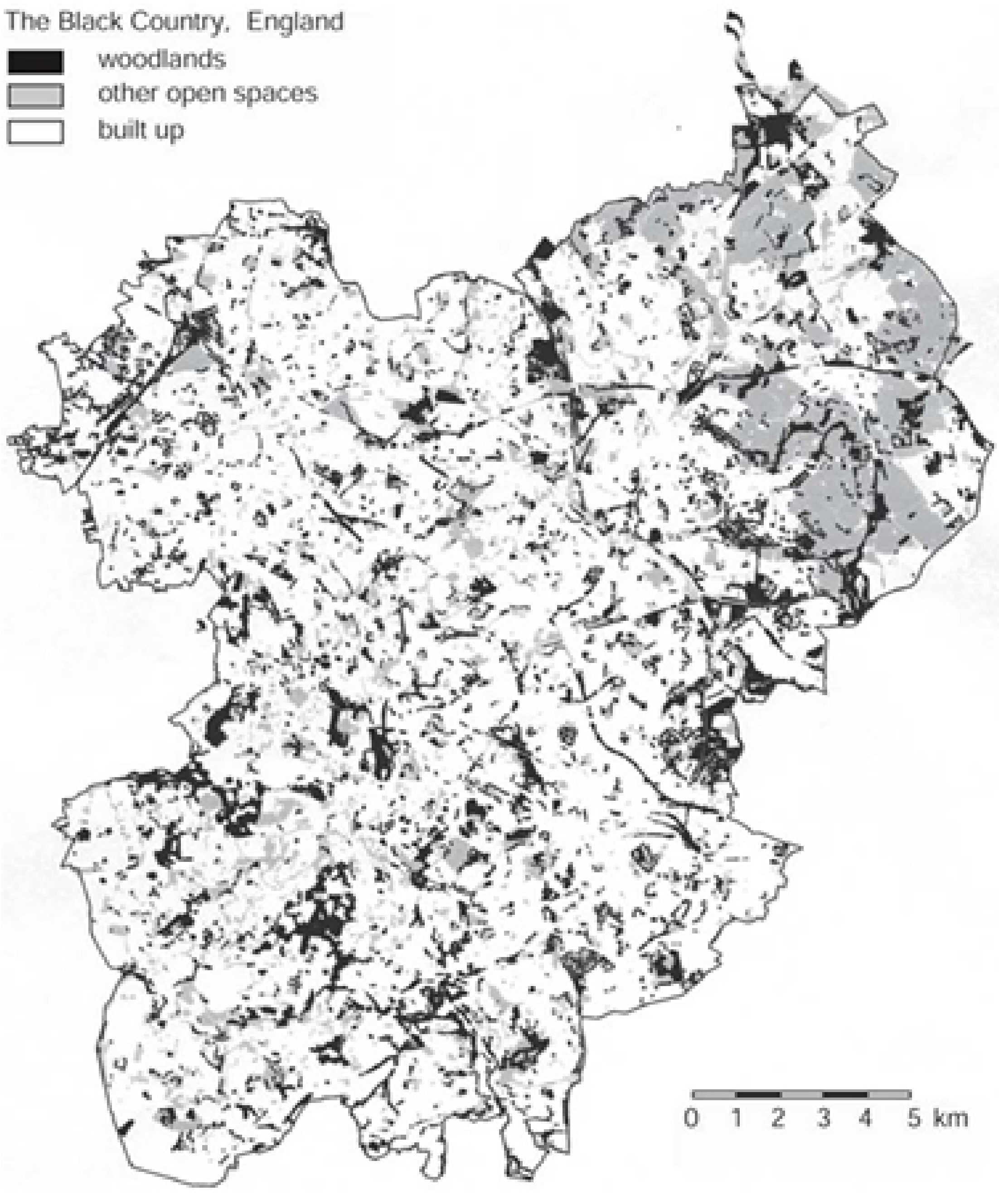


Fig. 3.8. The spatial pattern of the urban forest in the Black Country, England (Map provided by National Urban Forestry Unit, Black Country Urban Forest Millennium Programme)

network and a significant amount of enclosed countryside (Fig. 3.8). The Black Country has a population of 1.1 million people and it covers an area of 357 km^2.

The region has been industrialized for over 200 years and until the 1980s the economy was largely based on extractive industries (coal and limestone) and metals based manufacturing (chain and nail making, and precision engineering, including locks and parts for the motor industry). These industries have left a legacy of vacant and derelict land which is gradually being reclaimed as the sub-region undergoes regeneration and adapts to changing economic pressures.

Fig. 3.9. Hawthorn in flower: Much of the Black Country Urban Forest is made up of naturally colonizing woodland such as this (*photo:* National Urban Forestry Unit)

The Black Country's urban forest includes some very important remnants of ancient semi-natural woodland (dominated by *Quercus* spp.), the largest of which are protected by designation such as *National* or *Local Nature Reserve* status or as *Sites of Importance for Nature Conservation*. Such woodland comprises less than 1% of the total area of the Black Country. Overall, the woodland cover is estimated as just under 10% of the land surface of the sub-region, mostly in pockets of land of 0.25 ha to 1.0 ha. Around 40% of this is emergent woodland, formed through natural regeneration (*Betula pendula*, *Salix caprea* and *Acer pseudoplatanus* dominate mainly of the disturbed post-industrial sites, whilst *Crataegus monogyna* and *Quercus petraea* are the principal pioneer species of neglected grasslands) (Fig. 3.9). Recently planted woodlands are predominantly located on public land: open space, in school grounds, playing fields, parks and recreation areas. The canal, motorway, and railway networks help to create a strong linear pattern within the forest.

Challenges for the Urban Forest in the Black Country

For well over 100 years, public parks and landscape planting have been used to help counter the impact of industry in the Black Country. As long ago as the beginning of the twentieth century, the Midlands Reafforesting Association, a community-based organization, planted over 40 ha of new woodland on areas of industrial spoil in order to reclaim the land and to help clean the air.

Since the 1970s, there has been a succession of greening initiatives that have aimed to enhance the nature conservation potential of the region and help to provide a more attractive setting for economic investment. The most recent and comprehensive of these,

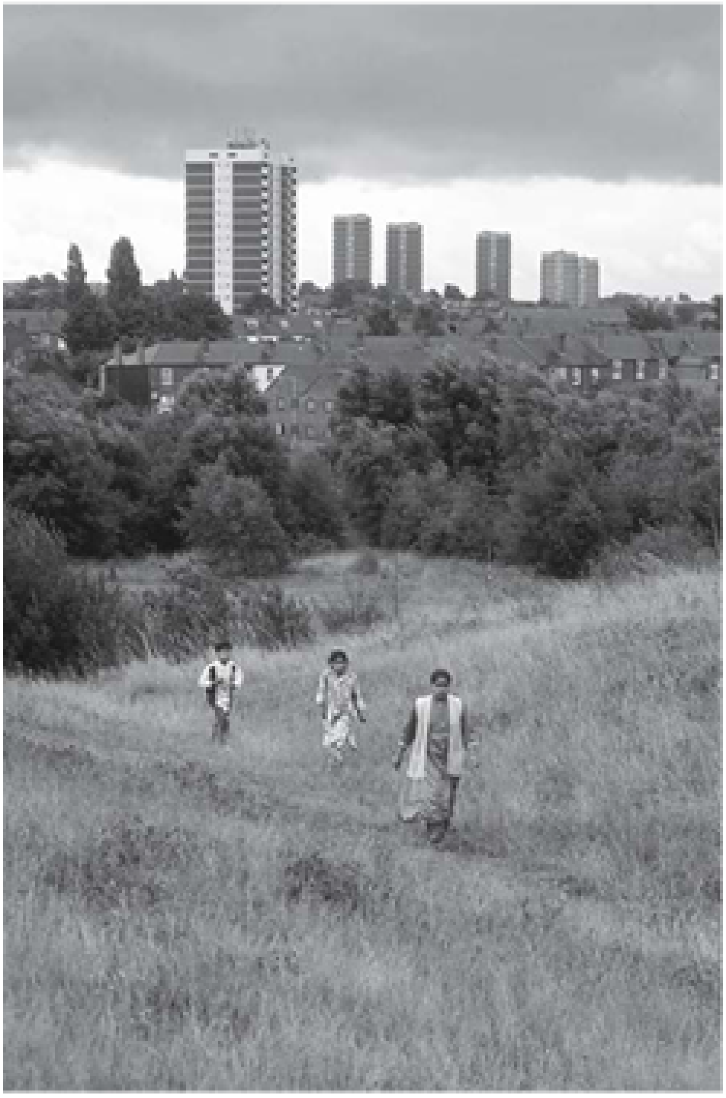


Fig. 3.10.
Children in informal landscape. Woodland close to home provides important recreational opportunities (*photo:* Woodfall Wild Images)

the Black Country Urban Forest initiative (part-funded by the National Lottery in the late 1990s) has served as an important model for the development of urban forestry elsewhere in the UK.

There is a formal strategy for the promotion and development of the urban forest agreed upon among a variety of agencies in the public and voluntary sectors (Black Country Urban Forestry Unit 1995). Despite this agreement, there is still a shortage of resources for on-going maintenance and management, a lack of expertise in managing the urban forest and some public concern that woodland poses a threat to personal safety. Much of the so-called *brownfield* sites have become important wildlife habitat and informal open spaces and these sites are under continual development pressure (Fig. 3.10). The legacy of mature street trees is also severely threatened by the expansion and upgrading of underground utilities, such as piped water, gas and cable communication. However, the Black Country's urban forest is gradually being recognised by politicians, planners and local people alike for the valuable contribution it is making to economic recovery, by improving the region's image and enhancing its environmental quality.

3.3.3 Central Europe: Munich

The Urban Forest Resource

The city of Munich is the centre of a prospering urban region with a population of approximately 2.5 million. The city covers some 311 km^2 and the population within the municipal boundary approaches 1.3 million. The city region has a high percentage of highly paid jobs in the information technology, services, banking and the insurance sector, and one of the lowest unemployment rates in Germany. The city, and particularly the city region in the northern Munich plain are still growing significantly.

In the city region, there is a sharp contrast between the south of Munich, which is largely covered by woodlands, and the northern part of the Munich plain where woodland cover is low. Most of the industrial development has taken place in the northern Munich plain and military training ranges, waste tips, wastewater treatment plants and the new airport infrastructure also occur in this area.

Munich is listed as one of the most densely built-up urban areas in Germany. The city's green-space resource was comprehensively assessed in a habitat and urban mor-

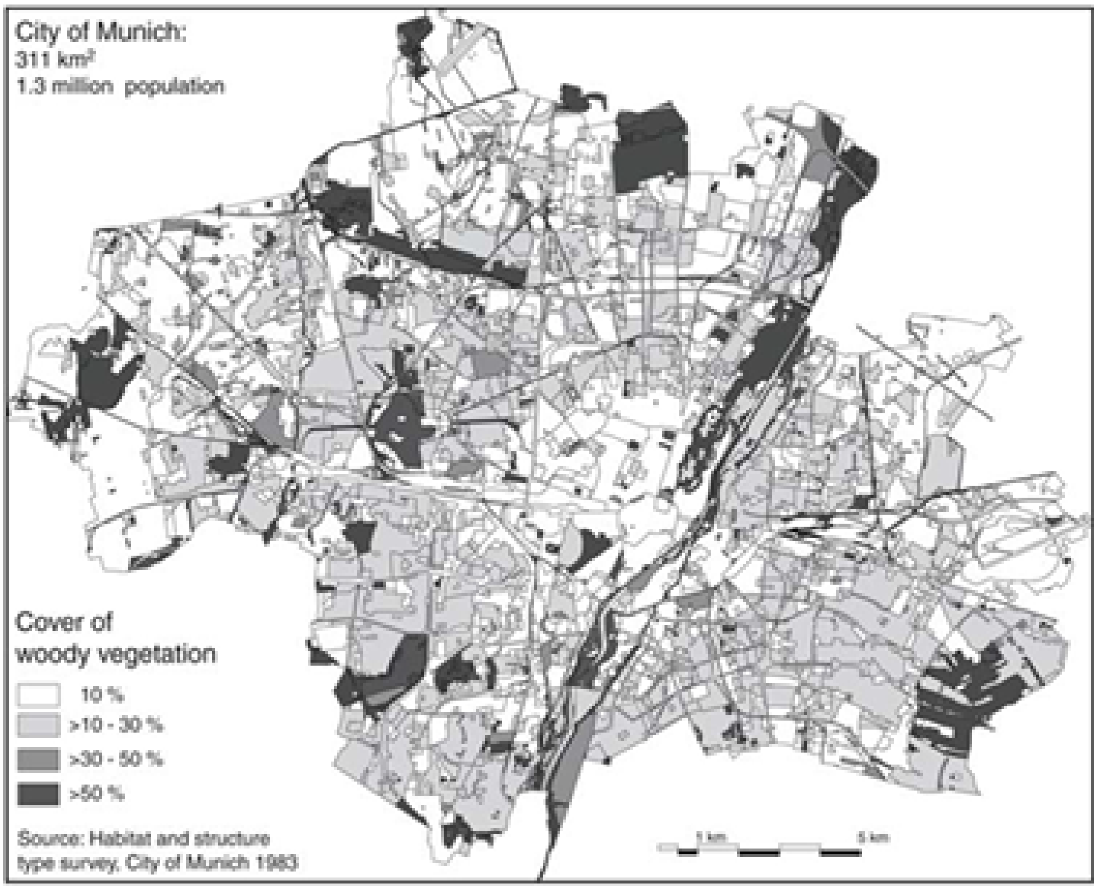


Fig. 3.11. The spatial pattern of the urban forest in Munich (City of Munich 1983)

Fig. 3.12. Mature stands of trees in residential areas are an important element of the urban forest. They make a positive contribution to urban character and improve the environment (**a**). However, these trees are under strong pressure from infill development (**b**) (*photos:* M. Rauh)

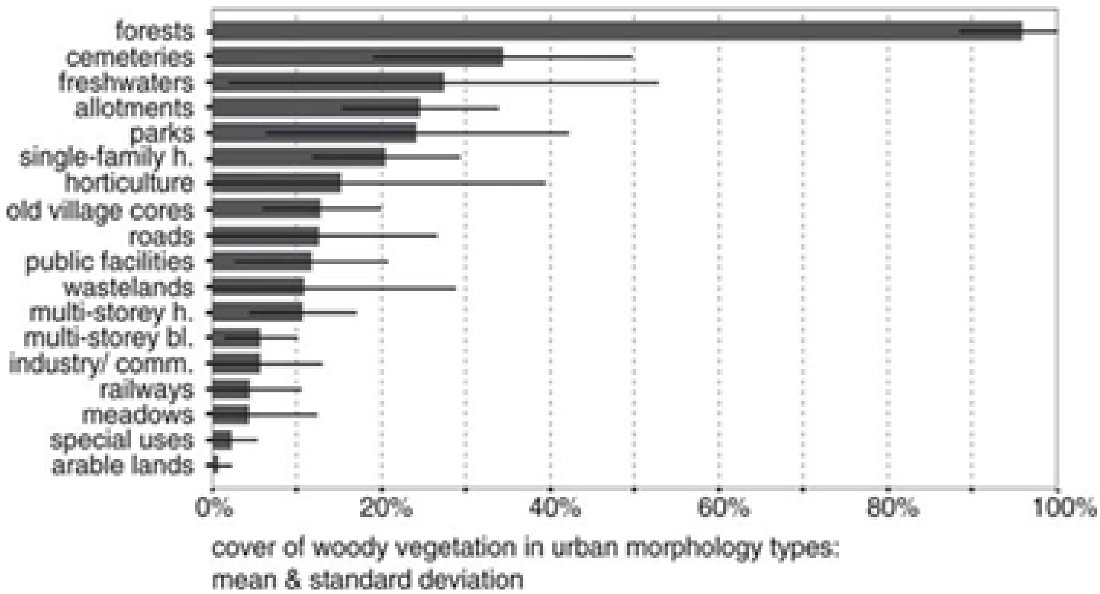


Fig. 3.13. Percentage cover of woody vegetation in urban morphology types in Munich (Pauleit 1998)

phology survey in the 1980s, and this was later repeated for a smaller test area (Pauleit and Duhme 2000). Over 3 500 morphology units were delineated by using aerial photographs and classified into 18 morphology types. The proportion of land cover types was estimated for each unit. Emphasis was placed on a detailed survey of green space where the cover of trees, shrubs, grasslands, and flowerbeds were separately recorded. The cover of trees and shrubs as well as the maximum age of trees were estimated for each of these urban morphology units.

Overall, woody vegetation covers 17% of the city surface. This amount compares with 18% building cover. Together buildings and other impervious surface cover 34% of the city. The spatial pattern of the urban forest is closely linked with the general zoning of land uses. Woody vegetation is abundant in the broad ring of low density housing areas around the inner city, in parks and along the River Isar floodplain (Fig. 3.11).

The densely built-up inner city and neighboring 19th century developments are the most deficient areas of green space. The floodplain of the River Isar forms a natural green backbone throughout the Munich plain and within the city. Large parks occur in a circle outside the inner city and contain some of the most valuable natural woodlands within the city (Fig. 3.12a,b).

According to a habitat survey (Duhme and Pauleit 1992), overall urban forest cover equals 2 097 ha, corresponding to 6.7% of the city's surface area. Historic remnants of natural woodland cover only 4% of Munich, but these contain 18% of the woody vegetation. These woodlands are split up into 153 wood lots, 79% of which are smaller than 5 ha. Public open spaces (parks, cemeteries etc.) and single-family housing contain over 30% of Munich's woody vegetation cover. The mean per cent cover of woody vegetation in detached housing areas is 22% (Fig. 3.13). In the very densely built-up inner city trees and shrubs are rare, with the exception of a few small parks and open spaces (Fig. 3.14). In these areas tree cover falls to below 5%. The cover is also low in farmland areas on the urban fringe and in industrial areas.

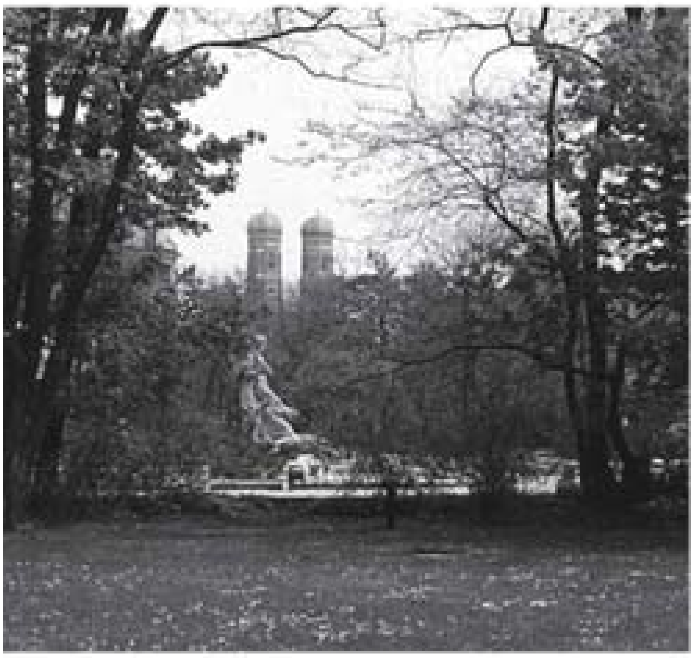


Fig. 3.14.
Alter Botanischer Garten. Small parks provide a habitat for trees in the densely built-up inner city (*photo:* M. Brunner)

Major Challenges for the Urban Forest in Munich

Large scale development projects on land identified in the habitat inventory as particularly important for nature conservation demonstrate the pressure on open land. For instance, over 220 ha of dry heathland and wasteland on which woodland had developed were lost due to the construction of a freight railway station and a motorway between 1983 and 1988.

New developments, such as the conversion of former army barracks into housing areas, can provide opportunities for the creation of green space and urban woodlands, but the overall impact of development is increased intensification of land use and further compaction of the city. On balance, there has been an overall loss of green space.

Further major threats to urban trees include infill development in residential areas and poor growth conditions in streets. Trees of a certain size (>80 cm dbh) are strictly protected on private land by a tree preservation order (TPO). However, results from a study (Jocham 1988) show that, on average, infill development causes the loss of one third of protected trees because of irreversible damage suffered during construction works. Only when the distance between construction works and the tree is greater than four meters there is a reasonable chance of retaining the tree.

Results of a vitality survey (Ammer and Martin 1989), which included almost 30 000 trees across all land uses, show that two thirds of the trees in the city have been damaged with one quarter of all trees damaged significantly. Trees are more heavily damaged in the densely built-up inner city due to unfavorable site conditions, such as restricted rooting zones, environmental pollution and lack of water. Older trees showed higher levels of damage than younger trees. Repeating the survey in 1991 demonstrated that approximately 5% of trees had been removed in a period of 3 years. 55% of these trees were located in residential areas. It is likely that these trees were lost because of construction works or were felled in gardens in order to reduce shading.

Finally, over 50% of Munich's woodlands are coniferous plantations of mostly spruce and pine. These were originally planted for timber and the major challenge will be to convert them into truly multifunctional woodlands, primarily for recreation and the enjoyment of nature.

The urban development strategy *Munich Perspectives* (City of Munich 1999) is subtitled "*compact, urban, green*", thus endorsing the concept of a "compact city" whilst still aiming to preserve the city's green space. The strategy includes a landscape ecological strategy to protect and enhance woodland corridors and create woodlands in the farmland on the urban fringe. However, implementation of the strategy is a challenging task in this booming city where development pressure on non-built land is high. Munich uses a mix of both formal and informal planning instruments to address these challenges. Moreover, most woodlands are protected under one formal designation or another. Whilst loss of woodland still occurs overall, the existing woodlands are now quite well protected. By contrast, trees in residential areas appear to be less well protected.

Development pressures are highest at the regional level and this is where the landscape is most threatened. A *Heathland Society* and a *Fenland Society* have been created to improve the condition of these particular kinds of landscapes. However, whilst these societies are successfully restoring habitats, their remit is limited. A wider approach is required in order to coordinate development between Munich and its neighboring municipalities and for the development of a coherent green structure for the emerging regional city, including the creation of new woodlands. This approach is important not only from an environmental perspective but also from a recreational one, as the majority of people live in the north Munich plain, but over 90% of recreational trips are made to the south, to the Alps and the lake region which lies adjacent to them.

3.3.4
South Central Europe: Ljubljana, Slovenia

The Urban Forest Resource

Ljubljana is the capital of Slovenia and also its largest city, located in the middle of the country. Its elevation ranges from 285 to 310 m above sea level. The total residential population of Ljubljana is approaching 340 000 inhabitants. Data on current (1997) land use were obtained from Ljubljana municipality sources and corrected using aerial photographs. Within the overall 87 km^2 of Ljubljana city area, forests cover 16%, buildings, yards and paved areas cover 33%, agricultural land 47% and other public open space (parks, playgrounds, cemeteries, water) cover 4% of the total area (Pirnat in press; Fig. 3.15).

The spatial distribution of forest areas is highly irregular. There are just three forest areas larger than 100 ha, two of them in the southern part of Ljubljana and one of them in the extreme north. These three areas represent 77% of the total forest, the remaining 23% of the forest area being distributed in 10 woodlands of between 5 and 100 ha and 49 woodlands between 1 and 5 ha. Less than one per cent of the forest vegetation occurs in areas of less than 1 ha, including scattered forest remnants, and wooded corridors on wastelands. The two largest areas in the south of Ljubljana form a green corridor in a NW–SE direction, making a link between neighboring landscape units (Pirnat 1997, Fig. 3.16).

Fig. 3.15. View over Ljubljana: A woodland on a hill within the city in the foreground, extensive stands of trees within the settlement area, and small woodland fragments in the urban fringe (*photo:* N. Jones)

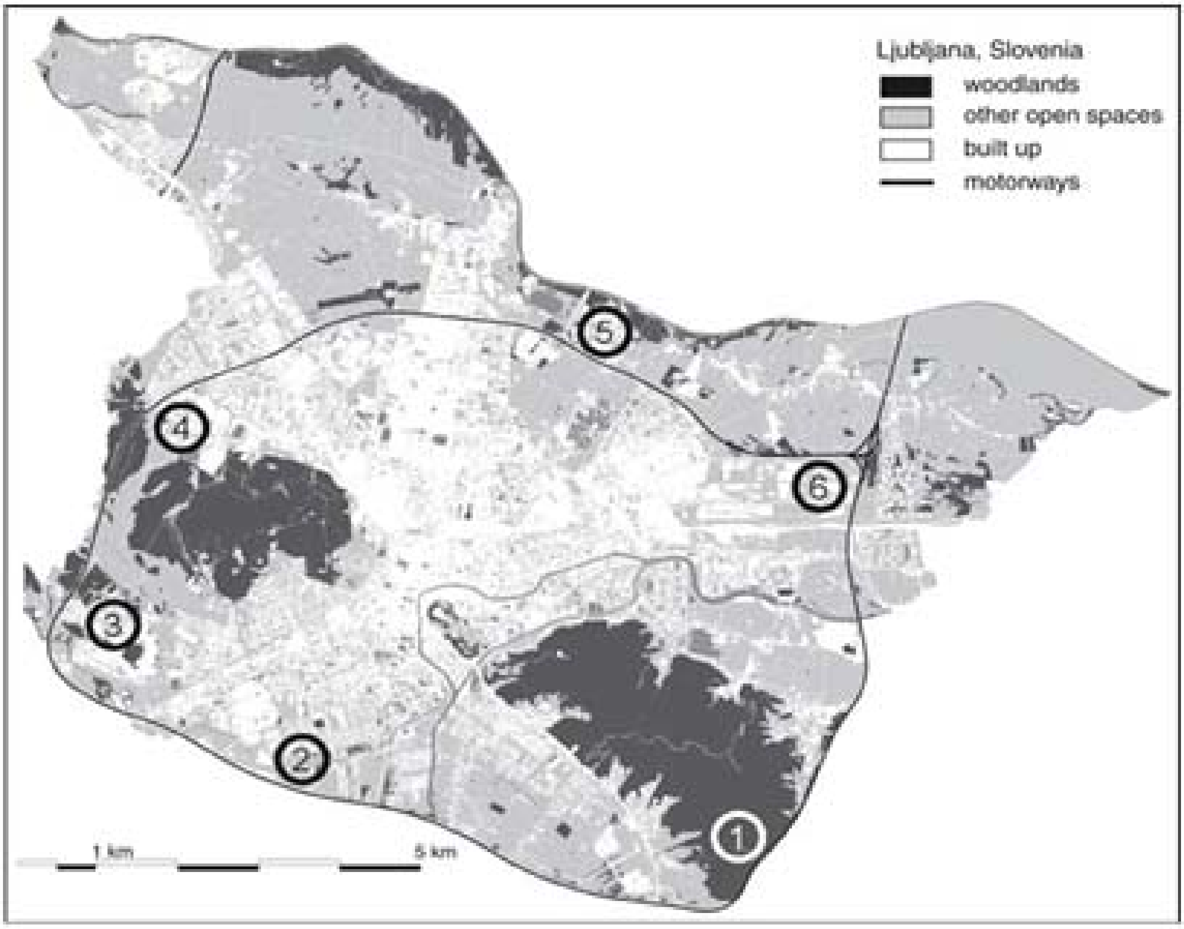


Fig. 3.16. The spatial pattern of the urban forest in Ljubljana (Pirnat 1997)

Challenges for the Urban Forest in Ljubljana

Some of the major challenges for the urban forest in Ljubljana are summarized here. Firstly, there is a lack of information on the current state and condition of urban woodlands and trees, and rational planning and management of the urban tree resource is difficult to achieve without this. Monitoring at regular intervals is required to obtain information how urban woodlands and trees change over time. This information is particularly required as both trees in public open space and woodlands are under pressure. Street trees are forced to grow in harsh conditions. They suffer from a high frequency of mechanical wounds on stems and roots, poor pruning techniques, as well as summer drought, winter water-logging and de-icing salt concentration (Oven in press).

There is increasing pressure on open space, and particularly on woodlands due to economic growth and development of Ljubljana. A new system of road by-passes around Ljubljana covers almost 100 ha of open space, 48 ha of which used to be woodlands. As a consequence of these development pressures, woodlands are increasingly fragmented. For instance, the construction of a motorway led to the dissection of a 47 ha woodland into two remaining areas, whilst 6 ha of the woodland were destroyed (area 4, in Fig. 3.16). Other woodland areas were fragmented correspondingly or completely destroyed. When the system of bypasses is finished, an additional 14 ha of urban forest will be lost in the north-east part of Ljubljana (area near No. 4, Fig. 3.16).

Another major challenge is that nearly 80% of all woodland areas are in private ownership. The large number of small private woodlands represents a serious obstacle for long-term forest management. The ownership structure is also a potential source of conflict between private and public interests.

The urban forests of Ljubljana are managed, regulated and protected according to a range of different legislation. The Slovenian Forest Service is responsible for the maintenance of urban woodlands and the municipality of Ljubljana is responsible for the maintenance of public green space and public trees. Major goals of the urban forestry management strategy are:

- accessible nature and multi-purpose management
- free access to all woodlands regardless of ownership
- prohibition of deforestation
- compensation for privately owned urban woodlands
- protection of larger trees, regardless of ownership

Future work in the field of urban forestry should concentrate on the protection, planning and management of the existing woodlands. Appropriate levels of management in urban and suburban woodlands are required to protect and enhance their functions for recreation and nature conservation. Development of remote sensing-based inventories will make the management of the urban forest easier (Pirnat in press). The state forestry service and the local municipality need to work more effectively together. The municipality will need to develop a long-term financial framework for managing and sustaining the urban forest in the context of built development. The maintenance of landscape integrity to counter the fragmentation caused by road construction and urban development is a prime area of concern in this respect.

Finally, the planning and management of trees in public green space and streets is as important as the protection of woodlands. Ljubljana has a rich heritage of trees in public open spaces, and these trees need to be sustainably managed. Moreover, planting programs for protected trees, parks and street trees are required to maintain the stock of trees and increase it whenever possible.

3.3.5
Southern Europe: Florence, Italy

The Urban Forest Resource

Florence is situated in central-northern Italy, on the western side of the Apennine mountain range. It is the capital of Tuscany and the municipality covers a surface area of 102 km² (Fig. 3.17). In the year 2000, the city of Florence had a population of 380 000, but the whole city region, consisting of 12 municipalities, had a population of almost 900 000. While the population within the municipality of Florence has declined slightly in the last decade, it has been stable or even slightly increasing across the wider city region.

The city region is the most densely populated part of the plain of the valley of the River Arno. The land rises from an altitude of 30 m, beside the river to 343 m in the hills that surround the built core. These hills cover roughly 60% of the city's surface area and form a kind of "green crown", where parks, ancient and new woodlands merge into agricultural land.

Fig. 3.17. The historic city centre of Florence is very densely built-up (*photo:* S. Pauleit)

Table 3.1.
Distribution of tree cover among land use categories in Florence

Distribution of overall tree cover among land use classes	Surface cover (%)
Urban/peri-urban woodlands	32
Formal public parks	21
Roads	15
Historic monuments, parks and gardens	10
Private residential gardens	8
Small public areas	8
Farmland	3
Industrial land	2
Derelict land	1
Total	100

More than 50% of the city region is classified as agricultural land, and 28% as woodland, whereas only 12% is classified as urbanized and 4% as industrial land (CEC 1993; EEA 2000). Within the municipality of Florence, the built up area is much higher (38%). Woodlands cover only 11% of this territory (DISTAF-Ministry of Environment 2002), whereas trees are estimated to cover approximately 20% of the city surface (Town Master Plan, update 23 September 2001) and the estimated population of 80 000 street trees in the city accounts for much of this difference. From the breakdown of tree cover by categories (Table 3.1) it emerges that over 60% of the trees within the municipality of Florence are growing in public open spaces, including historic parks and gardens.

228 different species of trees were identified in a survey (Bussotti et al. 1986), but these included palm trees and also single rare trees of private historic green spaces and the collection in the botanical gardens. It can be estimated that at least 115 tree species (70 introduced and 45 indigenous species) are present in significant numbers in parks, woodlands and streets. The main species of street trees are *Platanus* spp., *Celtis australis*, *Pinus pinea*, *Tilia platyphyllos*, *Quercus ilex*, *Populus nigra* var. *italica*, *Ulmus* spp., *Robinia pseudoacacia*, and *Cupressus sempervirens*.

The spatial pattern of the urban forest of Florence shows three distinct zones (Fig. 3.18). In the historical centre, most trees grow in historic gardens and squares. These are linked to the peripheral zones and the hills, largely due to the gardens of historic villas. On the urban fringe, small to medium sized woodlands can be found growing on both private and public land, and most grow on the north facing slopes (Fig. 3.19). These woodlands are composed of Mediterranean species of pine, deciduous oaks or exotic broadleaves. Scattered single trees, small woodlands, as well as secondary succession by woody species on former agricultural fields can be found on the southern and south-western slopes.

Many efforts have been made since the 1920s to replant woodlands on the hill slopes around Florence. Reforestation programs were carried out until the 1970s aiming to protect the settlements in the floodplain against floods and landslides, using mainly conifer species (*Pinus pinaster*, *P. pinea*, *P. nigra var. austriaca*, *Cupressus sempervires*, *Cedrus atlantica*). However, the silvicultural management of these woodlands has been neglected.

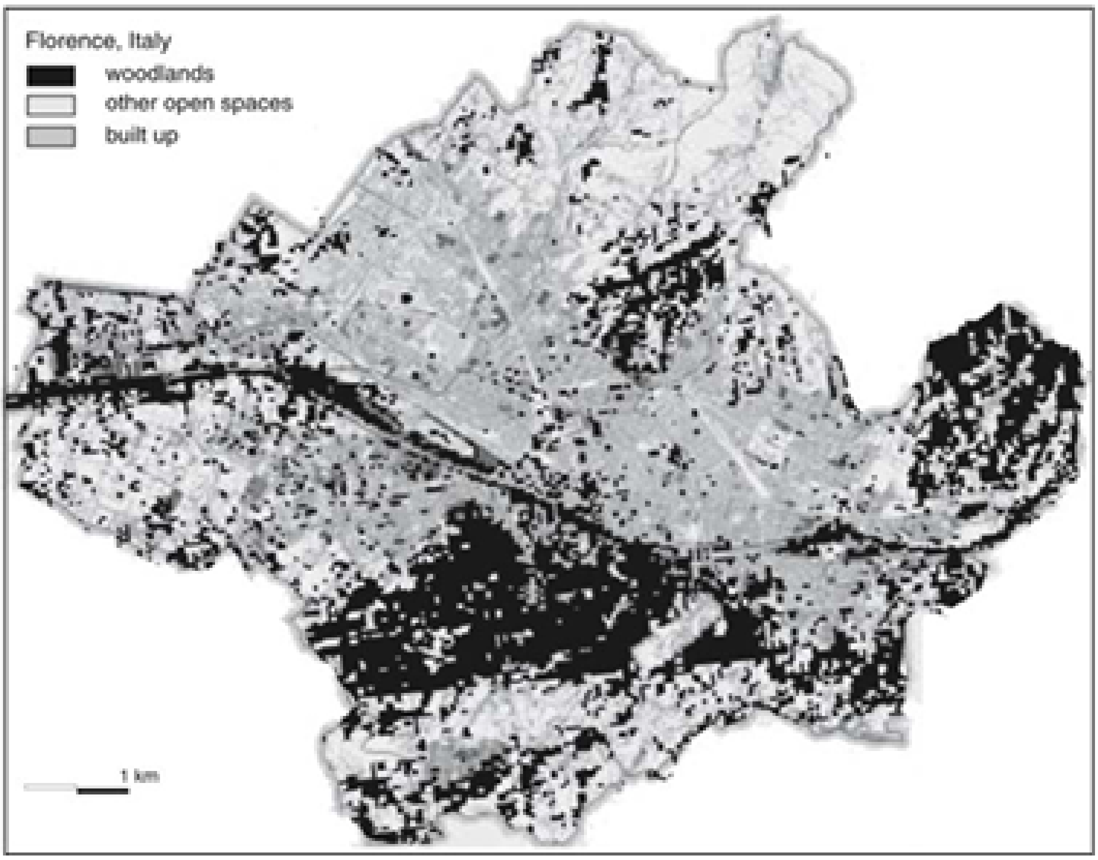


Fig. 3.18. The spatial pattern of the urban forest in Florence (F. Salbitano)

Fig. 3.19. View over the hills around Florence with parks and scattered woodlands (*photo:* N. Jones)

Challenges for the Urban Forest of Florence

The green structure of the floodplain consists mainly of public and private gardens, parks and a few remnants of the former rural landscape. This has been eroded by progressive urbanization. The principal weaknesses of the urban forest of Florence are its fragmentation and its diversification, the lack of public participation in the planning, design and management process, the gap between public (municipal) administration and private woodland owners.

While built-up areas have grown in recent decades, no significant new green spaces have been created within the municipality of Florence itself. The budget and personnel of the municipality in the sectors of green spaces, environment and land use planning have been decreasing in recent years, until the management of the urban forest resource is now largely restricted to pruning of street trees and removal of dead trees. Large urban development projects such as the extension of the airport, a new university campus, industrial and retail centers, the highway and new railway lines pose particular physical threats to the urban forest of Florence. At the same time, the changes in the structure of the city caused by the heavy urbanization process, the need for water for urban uses and the decrease in the permeability of the soil, led to drastic changes in the water table (Calistri 2001). Such changes have dramatically influenced

Fig. 3.20.
Parco delle Cascine is the largest park in the inner city and very popular. Its remnants of floodplain woodland are vulnerable to changes of water level and climate (*photo:* S. Pauleit)

the growth conditions for some water-demanding species in the floodplain woodlands. The largest public park of Florence, *Parco delle Cascine*, is located close to the River Arno, 500 m from the Ponte Vecchio. It is 160 ha in area and 25% of it is covered by remnants of floodplain woodland (Fig. 3.20). This makes this part of the urban forest particularly vulnerable to recent changes in water table and local climate.

The diversity of the stands and the high aesthetic and heritage value of many of the parks and woodlands are particular strengths of the urban forest of Florence. In late November 2002 the Committee of the Metropolitan Area of Florence adopted the plan for the development of a '*Park in the Plain*' to address the challenge of creating a green-space system at a regional level. The project is an attempt to reforest at least some parts of the floodplain in order to re-establish an ecological network throughout central Tuscany. This constitutes a strong challenge for the next decade. Further opportunities arise through the creation of a system of peri-urban parks within the framework of *Local Agenda 21*. At the same time, strategic planning and the design of protected areas continues due to the activity of the recently created "Office for Urban and Peri-urban Parks" of the Municipality of Florence. The management of these areas poses a particular challenge. Some ongoing projects are particularly designed to enhance the participation and communication between the municipal administration, the University of Florence and local NGOs.

3.4 Discussion and Conclusions

The chapter describes the urban forest resource in European towns and cities with the aim of identifying common features and differences. Gaining a complete overview is difficult since there is no common database. Case studies were selected to complement the more general information available, and to provide more detailed insights into the current condition of Europe's urban forests. The case studies are not exhaustive, but they do highlight some characteristic features of the European urban forest resource in a range of different geographical circumstances and in contrasting towns and cities.

3.4.1 Urban Forest Characteristics in European Cities

General figures for urban open space and woodland show a wide variance between different European towns and cities. While the data need to be treated cautiously, as urban areas are defined in different ways (in some cases including woodlands in the surrounding countryside), Gälzer's study (1987) accounted for these differences to a degree by distinguishing equal distance zones around the city centre. The figures, therefore, reflect real differences between the cities included in the study.

While the percentage of cover of woodlands in Europe's urban areas does not seem to be directly related to their geographic location or the size of urban areas, the case studies show that within urban areas distinct patterns of the urban forest can be identified (Fig. 3.21). Four different types of urban woodland could be distinguished, for example:

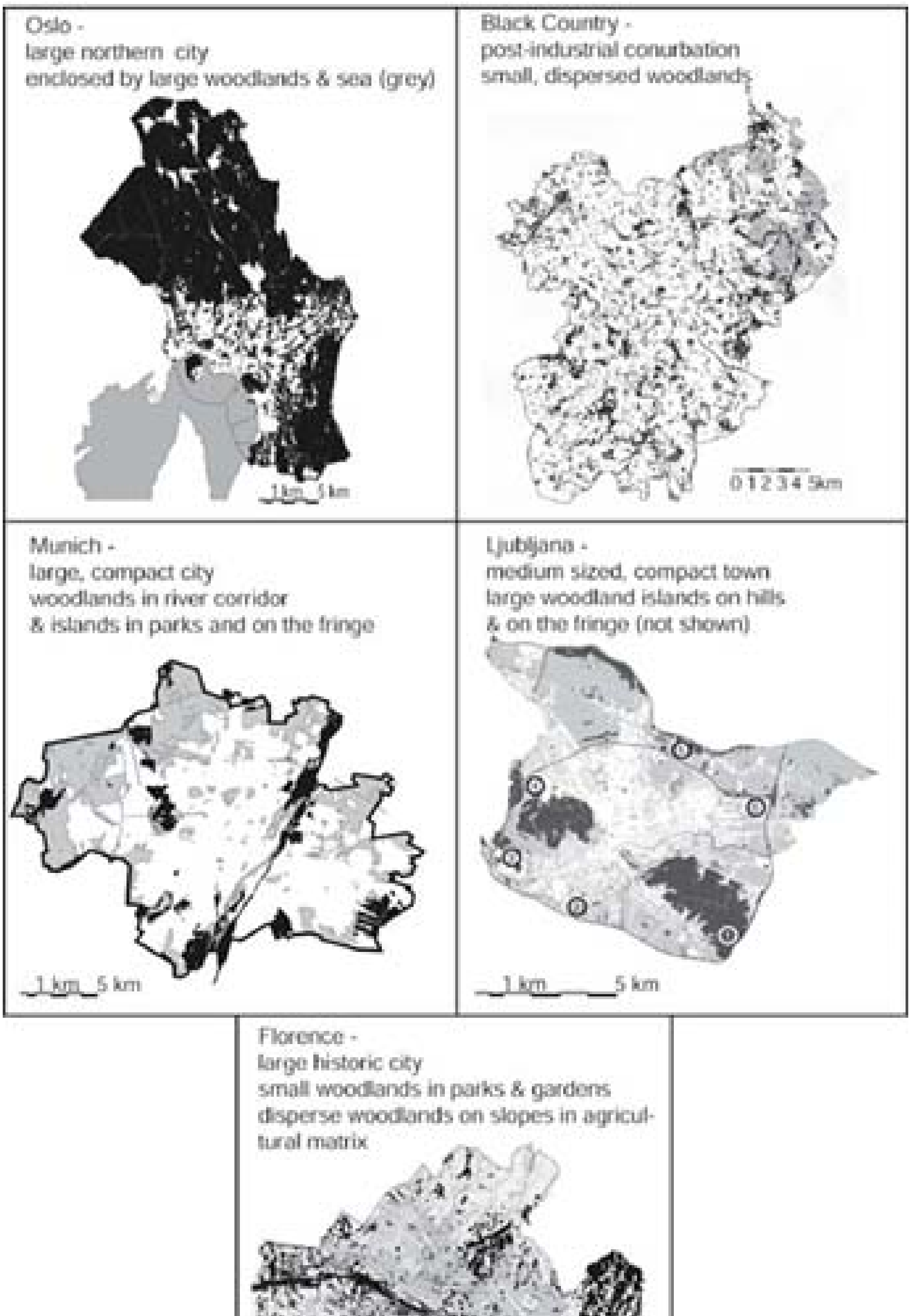


Fig. 3.21. Comparison of urban forest types of the case study areas: woodlands are shown in black, other open spaces in gray, built-up areas in white (F. Salbitano)

- closed woodland surrounding the city (Oslo, Ljubljana)
- woodland islands and belts within the city (Ljubljana, Munich)
- dispersed woodland within an urban matrix (Black Country)
- small woodland areas in parks and gardens within the city; dispersed woodland in an agricultural matrix around the city (Florence)

The overall distribution of trees in urban areas is largely determined by the pattern of land use (Nowak et al. 1996). Woodlands and parks contain a large proportion of all urban trees. In Florence, over 60% of the tree population grows within public open space. However, low-density residential areas can also be an important urban forest resource. In the case of Munich, they contain over 20% of the city's trees and shrubs. By contrast, the densely built-up residential and commercial areas of the inner city generally have low tree cover. Thus, urban forest cover is positively correlated with provision of open space and inversely related to urban density. Nevertheless, in some central European towns, the tree and shrub cover may be as high as the area covered by buildings. Many European cities are more tree-rich than the surrounding countryside. The extent of tree provision and green space may be related to indicators of environmental quality such as surface temperature or rainwater run-off, and biodiversity is also an important influencing factor (Pauleit and Duhme 2000, see also Chap. 4).

3.4.2
Developing Common Approaches for the Assessment of the Urban Forest Resource

The lack of comparable information on urban green space was stressed in the first assessment of the European environment published by the European Environment Agency (Stanners and Bourdeau 1995), and the situation has not improved since then. To advance effective urban forest policies, there is an urgent need to collect comparable information on the urban woodland and tree provision across Europe.

A recently completed survey of forest resources in urban areas of the USA, based on the interpretation of satellite imagery, could serve as a model for this purpose (Nowak et al. 2001).

Land cover data collected under CORINE, the European Union's program for gathering environmental information, could be used to assess woodland cover on a city scale, and aerial photograph interpretation could also be used to estimate the proportion of tree cover within a city. The survey of green space within urban morphology types undertaken in Munich, including detailed information on tree cover, also shows how the urban forest resource within urban areas can be analyzed and linked to its environmental performance by the use of a geographic information system (Pauleit and Duhme 2000). A similar approach was applied to the survey of trees in 66 towns and cities in the United Kingdom (Land Use Consultants 1993). Complementary ground surveys can provide information on the dynamics and condition of urban forests. The health status of rural woodlands is regularly monitored across Europe and a similar approach is also required for urban areas where the majority of people live. The monitoring of urban forests was recently proposed for urban areas in the USA (Nowak et al. 2000).

Indicators such as the per capita provision of trees can be used to benchmark the performance of urban areas and develop targets for urban forest planning. The provision of green space within walking distance of home, as used by the European Environment Agency (1999a,b) in its environmental assessment, provides one useful measure of green space and woodland provision in urban areas. The European Common Indicator Project has now been used to assess the green-space provision in 32 European cities. (The results are published on http://www.sustainable-cities.org/indicators, May 2003). This indicator also appears to be suitable for the development of targets for green space and woodland provision for recreation in the urban areas of Europe.

3.4.3
Identifying the Main Challenges for Urban Forests

From the case studies, it appears that most urban areas in Europe are continuing to experience a loss of green space in general and of trees in particular. Munich, and perhaps to a lesser degree Oslo and Florence, are examples of booming cities where development pressure is strong, both within the city and in the surrounding region. There is a need to balance the high density built element of the "compact city" with the protection of urban green space for recreation and environmental quality. Dealing effectively with these conflicting pressures is probably where the major challenge lies in prospering urban regions.

The case study of Ljubljana highlights another major pressure on the urban forest. In particular, woodlands are lost and fragmented through the construction of new roads and this greatly reduces their value as a resource for recreation and for biodiversity. In Oslo, whilst overall there was a net loss of green space between 1950 and 1990, the percentage of green areas smaller than one hectare actually increased from 68% to 87% (Nyhuus and Thorèn 1996). Protection of the remaining large areas of woodland is therefore particularly important. However, woodland fragmentation occurs across Europe and is likely to increase further, due to the growth of urban areas and their connection by transport networks. The Black Country is probably the only example included here, where there is actually an increase in urban woodlands thanks mainly to the re-vegetation of derelict land. A recent survey showed that in England, derelict land can provide an important opportunity for the creation of new woodlands (Perry and Handley 2000) and that this in turn can increase access to green space for recreation and for environmental improvement. The main challenge here is to establish appropriate levels of management and develop a coherent network of multifunctional woodlands that are accessible to the public.

Finally, surveys provide evidence of the threat to urban trees due to poor growth conditions, in particular in inner cities and along streets. Improving living conditions for trees in urban areas will become even more crucial under a changing climate which is likely to increase the extremes of summer drought, winter rain, and wind storms. The case study of Florence suggests that these changes have already started to occur. Healthy urban forests will be better able to adapt and withstand to these changes.

Trees have to be selected for the specific environmental conditions of the city, such as traffic fumes and drought stress, as well as aesthetic considerations such as crown structure and amenity value. At present, tree selection is often based almost entirely on desirable features of the tree crown alone, but in future much more attention should be paid to the tree's capacity to cope with the relatively harsh environmental conditions of urban areas (see Chap. 10). Systematic surveys in different towns and cities would identify trees that have already proved successful in particular urban situations over long periods.

3.4.4
The Need for New Approaches to Urban Forestry

The planning, design and management of urban forests in Europe are outlined elsewhere in this book. Some ideas for responding to the challenges facing urban forestry are outlined below:

1. This chapter shows that cities and towns can contain significant stands of trees and extensive woodland canopy. In countries where the woodland cover is generally low, urban areas can contain the most important tree resource. The urban forest can fulfill a number of valuable functions: contributing to urban character, aesthetics, recreation, biodiversity, healthy living and general environmental quality (see Chap. 4). This wider value of the urban forest needs to be recognised in the development process if urban areas are to become more sustainable and resilient to local, regional and global change.
2. Even though hard data are difficult to obtain, the case studies showed that the urban forest is mostly in decline. Woodlands are being fragmented and destroyed, trees in residential areas are being removed and in particular street trees are often being badly damaged. Urban green space in general and the tree resource in particular seem to lack the legal protection and professional care needed if they are to fulfill their potential.
3. The case studies show that the structure of urban forests and the challenges they face vary between urban areas and different European regions. Planning systems, urban development trends and cultures also differ between the case study areas. These range from a booming city region such as Munich, where pressure on open space is very high, to a post-industrial region such as the Black Country, which is undergoing considerable socio-economic restructuring. There is no one solution to urban forestry problems: clearly, individual solutions need to be adapted to local conditions and needs.
4. Local authorities need to adopt a strategic approach to the planning of their urban forest resource. Their strategies need to be comprehensive, and to encompass trees on public and private land, as well as taking into account the multiple functions of the urban forest. The urban forest should be considered as an integral component of the entirety of urban green space, i.e. the 'green structure' as it has been termed in, for example Norway and The Netherlands. The case studies also show that there is now an urgent need for strategic approaches on the level of the city region, where urban development pressure is highest.
5. Strategies are only successful if they are put into practice. Urban woodlands and stands of trees can only fulfill their potential if managed properly. They need to be well maintained to be attractive and regarded as safe. Therefore, the delivery of multi-purpose forestry combined with improved access to woodlands, are key tasks for woodland managers. This is well illustrated by the case studies of Oslo and Ljubljana.

6. Most local authorities are facing severe budget constraints. Therefore, it seems important to identify approaches to the management of urban woodlands, which can be successful despite such constraints. Much can be learned from the experience from the Black Country and more generally from England, where local non-governmental groups and national organizations such as the National Urban Forestry Unit promote participatory approaches within a wide social, economic and environmental agenda (National Urban Forestry Unit 1999).
7. While urban forestry is mostly a local authority responsibility, the European Union and national governments can greatly aid their efforts. The role of urban forestry should be fully recognised in the EU and within national policies for sustainable development. The lack of information on the condition of the existing urban forest should also be addressed at a European level. The work undertaken by the US Forest Service (Nowak et al. 2001) shows how this can be achieved on a continental scale. Moreover, there is a need to promote information exchange between local authorities across Europe. The survey of tree establishment practice in Europe (Pauleit et al. 2002) revealed that there is a wide variance of practice. There is an urgent need to promote the exchange of best practice and current scientific knowledge and much of the information needs to be translated into English. The European Union could facilitate this exchange and play a valuable role in raising the standard of planning, design and management of urban forests.

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