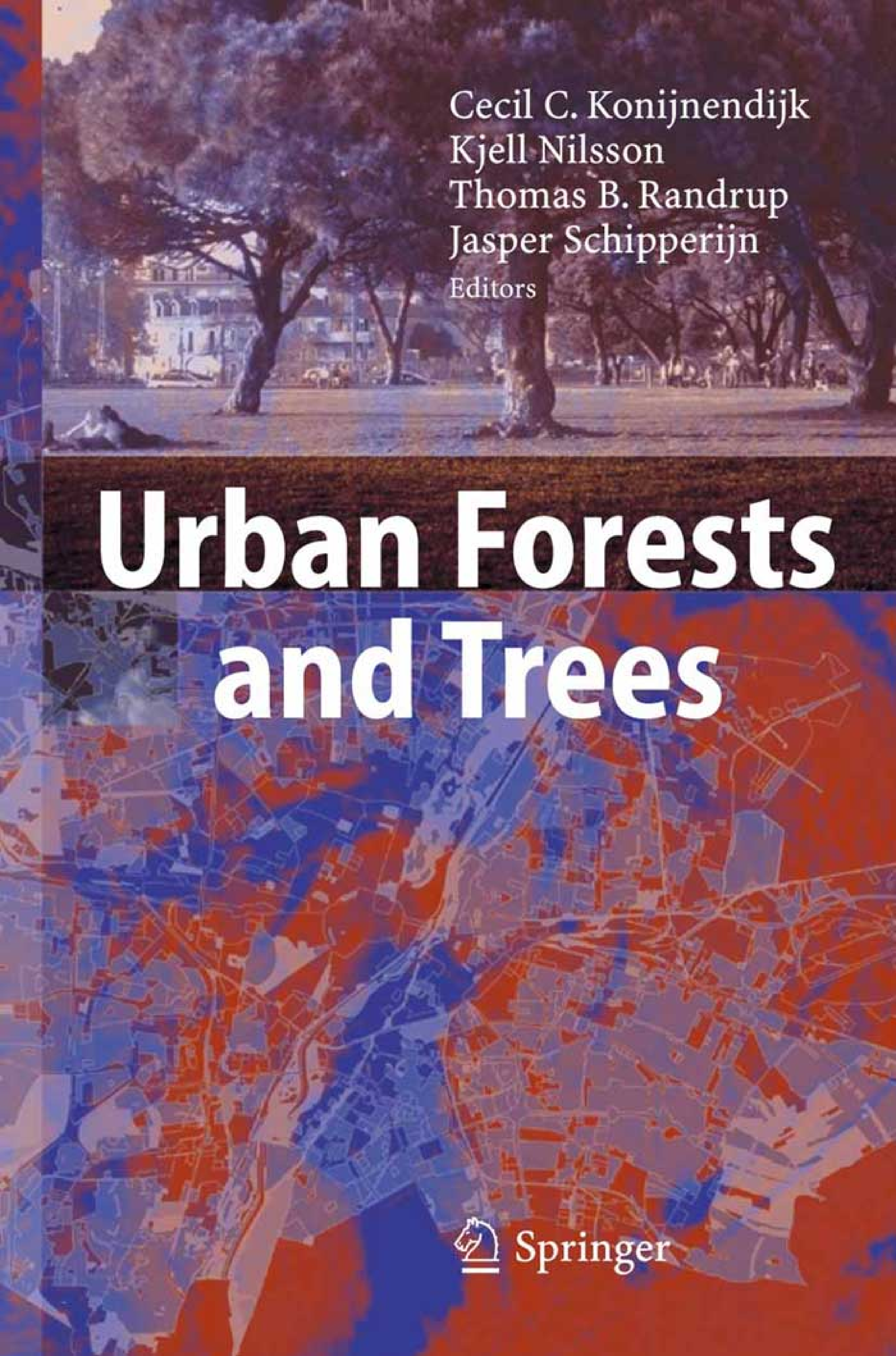

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Urban Forests and Trees

A Reference Book

With 169 Figures and 31 Tables

Springer

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This book was produced by the experts of COST Action E12 'Urban Forests and Trees'.

Library of Congress Control Number: 2004117900

ISBN-10 3-540-25126-X **Springer Berlin Heidelberg New York**
ISBN-13 978-3-540-25126-2 **Springer Berlin Heidelberg New York**

Springer is a part of Springer Science+Business Media
springeronline.com

Printed in The Netherlands

Cover design: Erich Kirchner, Heidelberg
Typesetting: Büro Stasch, Bayreuth (stasch@stasch.com)
Production: Almas Schimmel
Language editing: Bobster Falvey, London
Binding: Stürtz AG, Würzburg

Printed on acid-free paper 30/3141/as – 5 4 3 2 1 0

Preface

This publication is the result of more than six years of hard work by a dedicated group of European urban forest and tree experts. The editors are indebted to the national experts of COST Action E12 'Urban Forests and Trees' and to the others who have contributed to the various chapters in this publication. Ultimately, 59 authors from 21 European countries feature in this book. The European Cooperation in the field of Scientific and Technical Research (COST) and in particular its Secretariat deserve our gratitude for their support in establishing an active European community of urban forestry experts.

In our work to prepare this publication, we have been assisted by Karen Sejr, who provided crucial editorial support. We are also grateful to Jette Abel, Birgit Brynjolf, Jette Alsing Larsen, and other colleagues at the Danish Centre for Forest, Landscape and Planning, KVL. Without their contributions, the work could never have been completed. Words of gratitude also go to the publisher, Springer, who have supported the idea to publish a first European reference book on urban forests and urban trees from the very start, and who showed patience during the long production process.

Finally, we would like to thank the following reviewers whose critical evaluations of draft texts have considerably improved the quality of this publication: Thorbjörn Andersson, Sweden; Anna Behm, USA; Rien van den Berg, The Netherlands; James R. Clark, USA; Laurence R. Costello, USA; John F. Dwyer, USA; Mary Forrest, Ireland; Jason P. Grabosky, USA; Roland Gustavsson, Sweden; J. Roger Harris, USA; John A. Helms, USA; Andy Kenney, Canada; Nerys Jones, UK; J. Bo Larsen, Denmark; Greg P. McPherson, USA; Robert W. Miller, USA; Kjell Nilsson, Denmark; David J. Nowak, USA; Liz O'Brien, UK; Ib A. Olsen, Denmark; Stephan Pauleit, Germany; Werner Pillmann, Austria; Cotton Rondall, USA; Dan Rydberg, Sweden; Fabio Salbitano, Italy; Wayne Smith, USA; Anna Steidle-Schwahn, Germany; Alan J. Simson, UK; Terry A. Tattar, USA; Liisa H. Tyrväinen, Finland; George H. Ware, USA; and Gary W. Watson, USA.

Sadly our good colleagues Ryszard Siwecki and Friedrich Duhme passed away during the term of COST Action E12. Their contributions to the establishment of a European community of urban forestry experts are duly acknowledged.

The editors
Frederiksberg, Denmark
April 2005

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Introduction

Trees for Better Cities

Today more people live in cities and towns than in rural areas. Urbanization continues in an already heavily urbanized Europe, and as more people come or choose to live in towns and cities, the quality of the urban environment becomes increasingly important. Green spaces are a vital part of any urban conglomeration, providing a range of environmental, social, cultural and economic benefits. Trees in woodlands, parks and gardens, and aligning streets and squares are the most important elements of such green areas, yet their benefits are often overlooked and their proper care neglected.

Urbanization does not only concern the inner-city or peri-urban green spaces, as forests and natural resources at large are also affected by it. The dominance of urban values, norms, preferences and use has led to an emphasis on a wide range of forest and nature goods and services. In the case of forestry, for example, in many European countries social and environmental services are now regarded at the same level as timber production, as acknowledged in new forest and nature policies. Recreational use of forest and nature is higher than ever before, and increasing attention is given to the impacts of green space on human health and well being.

As a result of urbanization, attention for the role of forests, parks, trees and other green space in contributing to sustainable and livable cities and towns has increased at the European and national level. The expanding body of scientific literature on urban green resources, their current and potential functions, their appreciation by urban dwellers, and of course the best way to plan, design, establish, conserve and manage them, testifies of this growing importance.

The Urban Forestry Approach

Among the integrative natural resource management approaches that have been developed recently to meet new, urban demands is that of Urban Forestry. It embodies a multidisciplinary approach to the planning and management of all forest and tree resources – ranging from street trees to peri-urban woodlands – in and near urban areas. Originating in North America during the 1960s and 1970s, urban forestry has attempted to bring various professions and approaches together to take a more integrative perspective on the tree-based part of urban green structures.

In spite of its rich heritage in urban green-space planning and management, it has taken Europe some time to develop an urban forestry research community of its own. Initial reluctance to introduce the concept was only recently overcome. This happened when the need for such a strategic, integrative and multidisciplinary approach to urban green-space planning and management in highly urban societies was recognised. Recent years have shown the emergence of a number of initiatives to promote and coordinate urban forestry as a research domain in Europe.

COST Action E12 Urban Forests and Trees

One of the key initiatives in this respect was COST Action E12 *Urban Forests and Trees*. *COST* stands for 'European **CO**-operation in the field of **S**cientific and **T**echnical Research'. Its main objective is to ensure that Europe holds a strong position in the field of scientific and technical research for peaceful purposes, by increasing European co-operation and interaction in this field. It is based on so-called 'Actions', which are networks of coordinated national research projects in fields that are of interest to the different member states. The Actions are outlined by a *Memorandum of Understanding* (MOU) signed by the governments of the COST states wishing to participate in the Action.

COST Action E12, in operation from 1997 until 2002, had as its main objective to improve the knowledge base needed for better planning, design, establishment and management of forests and other tree resources in and near urban areas, and, by doing this, to establish urban forestry as a scientific domain in Europe. The Action developed into one of the largest COST Actions ever with close to 100 individual experts representing 79 institutions from 22 countries, demonstrating the large interest in urban green-space issues. Daily coordination of COST E12 was in the hands of the Danish Forest and Landscape Research Institute (now part of the Danish Centre for Forest, Landscape and Planning, KVL).

The establishment of a comprehensive description of the state of the art of urban forest and tree resources was a key element of knowledge generation and networking. During 1998 and 1999, participating national experts prepared state-of-the-art reports on research on urban forests and trees in their respective countries. Reports from twenty countries describing over 400 research projects were compiled into a report published by the European Commission at the end of 1999 (Forrest et al. 1999). Education is important for newly emerging research fields, and therefore the Action also carried out a review of higher education on urban forests and trees in Europe. The final report of this work, with 28 country reports was published in March 2002, also by the European Commission (Randrup et al. 2001).

The First European Reference Book

As COST Action E12 progressed, and the network of researchers, educators, as well as practitioners expanded, the need for improved knowledge generation and dissemination within urban forestry became clear. The Action's reviews of research and education showed that a significant body of knowledge existed within Europe, but also that a comprehensive overview of this was still lacking.

As a result, it was decided to compile a European reference book on urban forests, urban trees, their functions and use, and their planning, design, establishment and management. The process of compiling and editing, resulting in the book you have in your hands, started during late 2000. Sixty-five of the leading European experts within urban forestry from 21 countries have contributed to the book's contents.

Urban Forests and Trees is the first comprehensive, European reference book on the main aspects of urban forestry. In the first part of the book, information on the form, function and benefits of urban forests and trees is assembled. Chapter 1 sets the stage by providing a conceptual framework for the urban forestry approach, stressing its integrative and multidisciplinary character. The historical roots of the urban forestry approach are described in Chap. 2, which offers insight in the rich history of urban woodland, park and tree planting and management in Europe. The current status of urban forest and tree resources in Europe is the topic of Chap. 3. This chapter shows the richness and diversity in urban forest and tree resources across European cities and towns, and addresses the related difficulties in obtaining a sound overview of the resource base. The final chapter of Part I discusses the many benefits and uses of urban forests and trees, ranging from ameliorating urban microclimates to improving people's health and well being.

Urban forest and tree resources in Europe are extensive and provide urban societies with a large range of important goods and services. How to accommodate the demands of the urban population in urban forestry is the topic of Part II of the book, which addresses the more strategic aspects. Chapter 5 assesses the current status of policy-making and planning related to urban forests and trees, and makes a case for development of strategies and visions to direct urban forestry at various administrative levels. One way of 'translating' these visions into practice is by appropriate design of urban green space. Chapter 6 takes the reader on a European journey of good practice in urban forest design. The many stakeholders involved in urban forestry are the topic of the next two chapters. Examples of partnership approaches, for example involving both the public and private sector, for successful urban forestry projects are provided in Chap. 7. The involvement of people, primarily local residents, in urban forest planning and management is the topic of Chap. 8. A framework for developing participation approaches is given and elaborated through examples of public involvement.

The provision of multifunctional and sustainable urban forest and tree resources starts with the selection of plant material and proper establishment of urban trees. Part III deals with these issues, and describes the very specific growing conditions trees in urban environments face. Chapter 9 discusses the importance of plant quality for establishing trees, and addresses nursery practices. The selection of plant material for urban forestry is the topic of Chap. 10. It intends to be an introduction to the choice of species and a guide to the identification of better plant materials for different urban situations. Main reasons for careful consideration of plant quality and species selection, for example, are provided in the next two chapters. As described in Chap. 11, the abiotic growing conditions for urban trees are complex, different from natural growing conditions, and often harsh. Climatic impacts, hydrology, air and soil pollution, and fire are some of the factors described. Growing conditions are also particular from a biotic perspective, as Chap. 12 shows. Pests, diseases and other biotic threats have been a primary concern for urban foresters in Europe.

Urban forest management, the main topic of Part IV, is the level at which the strategic and operational level need to be aligned. Current practices and innovations within the management of urban woodlands and parks, such as closer-to-nature approaches and the inclusion of social-cultural considerations, are introduced in Chap. 13, while Chap. 15 has the management of individual trees, also known as arboriculture, as its topic. The latter chapter deals with the assessment of trees and the most commonly applied tree care practices: pruning, crown stabilization and wound treatment. In between these contributions, Chap. 14 demonstrates the importance of having accurate information to base management decisions on. Different types of information on the urban forest and tree resource, its use and past management need to be incorporated in comprehensive information systems.

In Part V, the last section of the book, the authors look ahead and attempt to identify developments in urban forestry research, education, and implementation. Chapter 16 briefly assesses the status of research on urban forests and trees in Europe and identifies research topics that need to be prioritized. Chapter 17 argues for the advancement of specific education dealing with the planning and management of urban forests and trees based on the profile of a European urban forester. Finally, examples of innovative urban forestry projects from different parts of Europe, on a local, city-wide and even regional scale, are presented in Chap. 18.

Final Message

This book is the ultimate result of several years of work by a dedicated group of European experts. While not being exhaustive, it represents the most comprehensive European study to date of urban forests and trees, their use, and ways to maintain and develop their multifunctionality and sustainability. A European urban forestry research and education community has emerged partly due to the existence of COST Action E12. This community now has a comprehensive reference for their work; they can place their own activities in a European perspective. The book will hopefully also serve as an important resource for higher education, inspiring both teachers and students. Moreover, policy-makers, managers and other people interested in urban forests and trees can benefit from the information presented.

There are tremendous benefits to be gained from a high quality urban environment. Properly managed forests and trees are essential for underpinning the quality of urban life, enabling European towns and cities to develop as sustainable and enjoyable places for people to live, work, recreate and play. However, European green space is continually under threat due to a wide range of reasons: political and economic dominance in land-use planning, poor growing conditions, pests and diseases, damage during building and road construction, excavation for cables and supply networks and so forth. Problems are worsened by the fragmentation of administrative responsibilities for planning, implementation and management of green space. The legal and policy framework for tree protection is often insufficient. The monitoring, design and management of urban green space lacks the required integration throughout all aspects of city administration.

Thus urban forestry is facing very significant challenges, and the availability and exchange of sound knowledge across cities, regions and countries is crucial, as is the identification of good practice. The editors and authors hope that their efforts have provided an important step forward in this respect.

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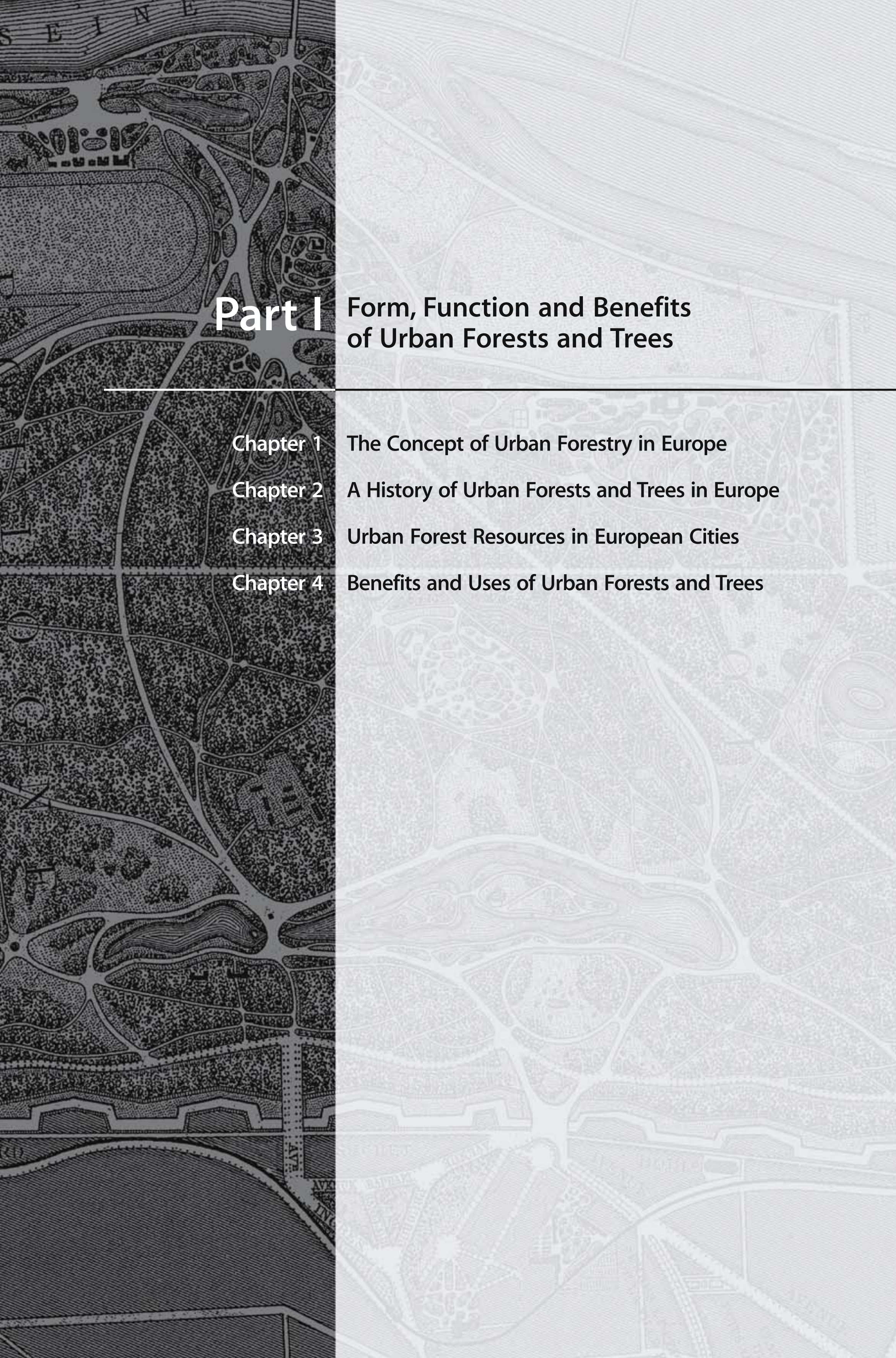

Part I Form, Function and Benefits of Urban Forests and Trees

Chapter 1

The Concept of Urban Forestry in Europe

Thomas B. Randrup · Cecil Konijnendijk · Michèle Kaennel Dobbertin · Renate Prüller

1.1 Introduction

This book provides a comprehensive perspective on the status of urban forestry with a primary focus on Europe. Before addressing various aspects of urban forestry, the applied terminology and definitions should be discussed. This is especially of relevance as the concepts of urban forests and urban forestry are relatively new and subjects of ongoing debate.

The chapter examines the concept of urban forestry from three related aspects. It starts with a general introduction about the use of concepts, definitions and terms in natural resource management and forestry. It then briefly summarizes the development of the urban forestry concept, as well as its definition in a North American context. Next, the implementation and use of the concept in Europe is discussed. As the concept and definition of urban forestry still evoke debate, especially regarding their delimitation from other related terms, the chapter ends with proposing a possible framework for a European definition of urban forestry.

1.2 About Concepts, Definitions and Terms in Natural Resource Management

1.2.1 Concepts, Terms and Definitions

In terminology, which aims at clearly describing and delimiting the meaning of special language in a particular field of knowledge, an important distinction is made between concepts and terms. Concepts are to be considered mental representations of objects within a specialized context or field. They are not bound to particular languages, but they are influenced, as we will see throughout this chapter, by social or cultural backgrounds. Concepts can take the form of terms, appellations, definitions or other linguistic forms (ISO 704:2000(E)).

Difficulties arise when concepts and terms are not related to each other on what would be an ideal one-to-one basis. In practical communication, the usual situation is that there is often more than one term for a given concept, especially if the concept is defined broadly. For example, the concept 'forest' *sensu latu* includes structures such as 'woodland', 'bush', 'rainforest', 'plantation', 'wilderness' or 'urban forest'. It is even more difficult to find precise equivalents of these terms in other languages. The German 'Wald' or 'Forst' (managed forest) is probably not equivalent to the English 'forest.' To keep things simple, this chapter deals only with the English understanding of the 'urban forestry' concept.

To describe concepts clearly we use definitions, i.e., verbal representation of concepts. Definitions identify the characteristics of a concept and permit its differentiation from other concepts.

1.2.2
Forest – A Multiplicity of Definitions

The complexity of the concept–term relationship partly explains why there is not one generally agreed upon definition of 'forest'. Lund (2002) identifies several reasons why experts are not able to agree on a common definition of forest, for example because they believe that the term is commonly understood, because they do not want to be specific, or because the subject is too complex for people to deal with.

Definitions of forest are commonly based on either land use, land cover, or administrative function. Lund (2002) provides a comprehensive overview of national definitions with large differences among countries and sometimes different definitions within one country. The Food and Agricultural Organization of the United Nations (FAO) started a process, together with several other organizations including the International Union of Forest Research Organizations (IUFRO), to assess the potential for a more integrated use of definitions among international conventions, processes, and national understanding of forest-related terms.

Another reason for the development of diverse definitions of a concept is that they change over time as conditions change (e.g., Schanz 1999). Helms (2002) describes that forests previously regarded primarily as a source of wood, are now valued by society for providing a wide range of ecological benefits and societal services. As has already been mentioned, terminology cannot be separated from the culture, history and condition of a nation.

1.2.3
Standardization and/or Harmonization of Definitions

With a multiplicity of definitions for one concept, the need arises to find a single valuable definition for the concept to which reference can be made. Given the complexity of the problem and the diversity in needs, uses, and ownership situations, it becomes clear that such a standardization is difficult to achieve.

A solution is to foster common understanding and harmonization among definitions of core concepts and terms. Harmonization in this context means improved comparability, compatibility and consistency among definitions, establishment of linkages, and description of relationships among terms. The process of harmonization involves documentation of similarities and differences among definitions for which analytical tools can be used (FAO 2002a). In this sense, harmonization is the most important step towards accurate communication, consistent use, and understanding of a particular concept.

1.3
The Development of the Urban Forestry Concept

1.3.1
Forestry Becoming More Urban

The framework for a concept of urban forestry presented in this chapter has a strong focus on the term 'urban'. As will be shown, urban forestry is primarily defined by the (urban) location of trees and tree stands. As such, the concept deals with both the urban location and the urban function of the forest or tree. Thus, it is clear that urban forestry is at least as much about urbanity as it is about forestry.

New concepts and terms have emerged within the field of forestry in line with the changes in society mentioned before. The social side of forestry has become more recognised, for example, as forests provide a wide range of services to society which in some places are even more important than the traditional focus of forestry, i.e. timber production (Kennedy et al. 1998). Social forestry, for instance, could be defined also as forestry catering for social needs and uses (e.g., Westoby 1989). Community forestry has been defined as any form of social forestry based on the local people's direct participation in the production process, either by growing trees themselves or by processing tree products locally (Raintree 1991). Community forestry has been developed in a rural, mostly developing-country context, but is to an increasing extent being applied to urban areas (e.g., Johnston 1997b).

1.3.2
Managing Trees and Green Areas in the Urban Environment

While urban areas expand spatially and in terms of their economic, social, ecological and political influence, more forests become 'urbanized'. Carrying out forestry in an urban setting, however, is not an entirely new phenomenon. Europe has a rather rich tradition of municipal forest ownership and of 'town forestry'. Several of Europe's cities have owned and managed forests for several centuries (Konijnendijk 1999). This fact as well as other aspects mentioned in this and following paragraphs are reflected in the analysis of various definitions in Table 1.1.

While forestry has shown increasing attention for urban areas and issues, other professions have a long tradition of occupying themselves with green areas inside town boundaries. Parks and other green areas have traditionally been designed and managed by landscape architects and horticulturists. Europe has had a long history of designing and developing urban green areas (e.g., Nilsson et al. 2000). Moreover, the need to take proper care of urban trees led to the emergence of the concept and profession of arboriculture as a 'spin-off' from horticulture. Arboriculture is primarily concerned with the planting and care of trees and more peripherally concerned with shrubs, woody vines and groundcover plants (Harris et al. 1999).

1.3.3 Towards More Integrated Concepts

While different disciplines and professions have occupied themselves with the planning and management of urban green areas, cooperation between them has often been limited. Landscape architects, horticulturists, arboriculturists, foresters and others all had their own specific objectives and interests. Recent years, however, have seen an increasing focus on dealing with urban green structures as a whole. The emergence of concepts and policies related to sustainable development and urban ecology (for example based on the work of Duvigneaud (e.g., 1974)) played an important role in this respect. The United Nations' Habitat-conferences and its Conference on Environment and Development (UNCED, held in 1992) stressed that development of cities could only be achieved by incorporating social, economic and ecological dimensions. This would require integration of the efforts of different sectors and stakeholders at the local level.

Thus urban green structures rather than individual green elements have become the focus. To an increasing extent, practitioners, researchers and politicians deal with the contributions of the entire urban green structure to the quality of urban life and environment. Moreover, they have started to realize that more integrated, green-area planning and management are required to meet current societal demands when operating in high-pressure environments. This led to the emergence of new, integrated concepts and approaches. Urban ecology, as urban proponent of ecology, has been mentioned earlier. Urban agriculture is another example. It could be defined, for instance, as agriculture aimed at growing or raising, processing, and distributing a diversity of food and non-food products located within (intra-urban) or on the urban fringe (peri-urban) of a town, city or a metropolis (Mougeot 2000).

1.3.4 The Emergence of Urban Forestry

The concept of urban forestry originated in North America during the 1960s. Jorgensen introduced the concept at the University of Toronto, Canada, in 1965 (Jorgensen 1970). Urban forestry not only dealt with city trees or with single tree management, but also with tree management in the entire area influenced by and utilized by the urban population. Consequently, the 'urban forest' embraced all trees (in stands and groups as well as single trees) in and around urban areas. Jorgensen also stressed the overall ameliorating effect of trees on their environment as well as their recreational and general amenity value. The new concept also caught on in the United States, where the Society of American Foresters initiated an urban forestry working group in 1972 (Johnston 1996).

During the first decades of its history, many different interpretations of the concept of 'urban forestry' have existed and initially considerable opposition from different sides was encountered. Arboriculturists and other green area professionals were hesitant about introducing the term as a way for foresters to extend their domain to urban areas. Foresters themselves, however, were often not convinced of having a mission in managing small-scale green areas or even single trees in urban areas (e.g., Ball 1997; Miller 2001). Nevertheless, gradually, at least, the concept found more support from both sides, e.g., through the efforts of the International Society of Arboriculture (ISA). The government of the United States through its Department of Agriculture's Forest Service recognised the value of the new, integrative concept by establishing a national urban forestry program with strategies and research programs (e.g., Johnston 1996).

What does urban forestry encompass according to the approach developed in North America? Costello (1993) defines urban forestry, in short, as the management of trees in urban areas. Management then needs to be regarded as encompassing planning, planting, and care of trees. By mentioning trees, he refers to individual trees as well as small groups, larger stands, and remnant forests. Urban areas are very broadly defined as those areas where people live and work. The most commonly used definition of urban forestry has much in common with this. In the Dictionary of Forestry (Helms 1998) urban forestry is described, according to the definition developed by Miller (1997), as:

> The art, science and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic, and aesthetic benefits trees provide society.

1.4 The Concept of Urban Forestry in Europe

The concept of urban forestry reached Europe during the 1980s, firstly in the United Kingdom where it found following despite initial disagreement regarding its focus (Johnston 1997a). The first city-wide urban forestry project in the United Kingdom was the Forest of London project, inspired by the work of the TreePeople organization of Los Angeles, United States. This organization used tree planting and management as a tool for social, economic and ecological regeneration of cities. At a later stage, a range of 'Forest of …' projects were initiated throughout the United Kingdom and Ireland. Another important development was the establishment of twelve Community Forests near major urban centers in England aimed at forest establishment and management to generate socio-economic and environmental benefits for local communities (Johnston 1997a). Urban forestry also reached The Netherlands at a rather early stage; in 1984 a group of Dutch urban forestry researchers promoted the concept following their visit to the United States (Heybroek et al. 1985). Ireland initially was another country to follow Britain in embracing the concept of urban forestry. The first national Urban Forestry Conference, held in Dublin in 1991, led to government recognition, for example, via a grant scheme for urban woodland. The first major review of urban forestry in Ireland was carried out in 1994 (Johnston 1997b).

Urban forestry research in Europe as well as efforts to define the concept have benefited from recent international networking activities such as COST Action E12 'Urban Forests and Trees'. The objective of this Action was to promote and coordinate urban forestry research in Europe. It attempted to develop common understanding of what the concept of urban forestry encompasses (Nilsson and Randrup 1997). Other examples of European networking have included the annual IUFRO European Forum on Urban Forestry set up in 1998, and the European Urban Forestry Research and Information Centre (EUFORIC), established as Project Centre of the European Forest Institute (EFI) in 2001 (Konijnendijk 2003).

1.5 Towards a European Definition of Urban Forestry

1.5.1 Diversity in Definitions

During the establishment of urban forestry as a known and more widely accepted concept and term in Europe, substantial debate on its definition has taken place. British and Irish definitions very much adhered to the North American coining of urban forestry (e.g., Johnston 1997a,b). This is reflected in the definition given by the British National Urban Forestry Unit (NUFU 1999), describing urban forestry as a 'planned approach to the planting and management of trees and woods in towns'. In line with this, the 'urban forest' is defined broadly. In a Forestry Commission manual for urban forestry, for instance, 'urban forests' were defined as 'trees grown in and close to urban areas for their value in the landscape, for recreation, and including trees in streets, avenues, urban parks, on land reclaimed from previous industrial use, as well as those in urban woodlands and gardens' (Hibberd 1989). NUFU (1999) provides a similar, comprehensive scope: '(the urban forest) collectively describes all trees and woods in an urban area: in parks, private gardens, streets, around factories, offices, hospitals and schools, on wasteland and in existing woodlands'.

Elsewhere in Europe, however, more debate and confusion concerning the concepts of urban forestry and urban forests has occurred. The term 'urban forest', for example, often already exists in different European languages as referring to 'city woodland' (e.g., Tyrväinen 1999; Konijnendijk 2003). An overview of different national definitions of 'urban forestry' and 'urban forests' carried out by COST Action E12 'Urban Forests and Trees' (Forrest et al. 1999) illustrates the diversity in definitions and perspectives.

Table 1.1 presents results of a literature survey and of a questionnaire sent in June 2002 to all authors of papers and posters at the IUFRO/EFI Conference 'Forestry serving urbanized societies', Copenhagen, August 2002. These experts were asked to define urban forestry from the perspective of their respective countries. Seventeen of them returned the questionnaire. In addition, explicit or embedded definitions of urban forest(ry) and related terms were extracted from 39 printed and on-line documents, including the final report of the COST Action E12 (Forrest et al. 1999). All sources were analyzed in terms of presence or absence of semantic elements of definitions, in order to examine objectives, structural elements, location and benefits and values of urban forest(ry).

Although only a limited number of experts participated in the survey (between one and four for most countries), the diversity in terms of definitions is very significant.

In spite of the traditional, narrow meaning of the term 'urban forest' in many languages, agreement seems to exist on urban forestry's broader scope. Virtually all elements of urban green space have been referred to. Experts and definitions differ in terms of what natural resource elements to include in the scope of urban forestry. Some experts consider that only woodland and forests/forest ecosystems should be included in an urban forest. However, the majority believe that single trees, woody vegetation in general, as well as – in most cases – non-woody structures such as lawns and general green space should also be included. From the limited data provided in Table 1.1, it seems that those who regard an urban forest as consisting primarily of forests and forest systems consider the primary value of the forest to relate to biodiversity and recreational aspects. This paradigm may represent the 'conventional' foresters, who have often regarded the term urban forestry as encompassing all forests primarily managed for the benefit of the urban population, with limited or no production functions (e.g., Konijnendijk 1999). Thus urban forest can be situated in or near urban areas, or even at a greater distance.

In general, however, experts feel that urban forestry deals with individual as well as stands of trees situated in or near urban areas. Where most individuals supporting this generalization agree that aesthetic and recreational aspects are very important, they also believe that a number of other benefits and values, for example environmental services, are associated with urban forests. In the case of the limited survey of country experts, it seems that especially those from less-forested countries and from a background other than (more conventional) forestry support this view.

As seen earlier, the North American approach to urban forestry has a strong link to the forestry profession (e.g., Miller 2001), and is focused on single trees or stands of trees located in or near urban areas. European urban forestry has been more diversified. In the various relevant European networks a number of professions have participated and feel responsible for one or more aspects related to forests, trees and other green space. COST E12's survey of more than 400 research projects dealing with aspects of urban forestry supports this. Although about half of all projects were carried out by forestry institutions, other professions such as landscape architecture, (landscape) ecology, and horticulture were also major players (Forrest et al. 1999; Konijnendijk et al. 2000).

1.5.2
Framework for a European Definition

As described, a long-lasting debate on concepts and definitions has characterized urban forestry. However, in spite of the debate about definitions, many agree on the key strengths of the urban forestry approach:

- It is integrative, incorporating different elements of urban green structures into a whole (the 'urban forest').
- It is strategic, aimed at developing longer-term policies and plans for urban tree resources, connecting to different sectors, agendas and programs.
- It is aimed at delivering multiple benefits, stressing the economic, environmental and socio-cultural goods and services urban forests can provide.
- It is multidisciplinary and aiming to become interdisciplinary, involving experts from natural as well as social sciences.
- It is participatory, targeted at developing partnerships between all stakeholders.

The framework for defining urban forestry within the context of this publication is provided in Fig. 1.1. This 'Urban Forestry Matrix' embodies the integrative and multidisciplinary character of urban forestry in Europe.

Table 1.1. Analytical presentation of definitions from 39 printed and on-line documents related to urban forest and urban forestry as well as 17 answers to a questionnaire sent in June 2002 to experts in urban forestry worldwide. *Black blocks:* elements explicitly mentioned by the sources; *dark grey blocks:* elements implicitly mentioned by the sources

	Objectives						Structural elements					Location				Benefits and values											
												urban(ized) areas				environmental					sociological			economic			
	Planning, design, landscaping	Establishment, planting	Care, maintenance, cultivation	Management	Conservation, protection	Sustained management	Single trees, groups of trees, woody vegetation	City parks, green lawns, greenspace	Woodlands	Forests, forest ecosystem	All (related) vegetation/organisms	Within cities	Around cities/peri-urban, sub-urban areas/urban fringes	Close to urban areas	Towns, villages/small communities	(Micro-)climate control	Air pollution and noise control	Waste(water) recycling	Biodiversity conservation	Landscape design	Aesthetic/scenic value	Recreation/outdoor activities	Public health/human well-being	Wood production	Non-woody products	Shelter	Fuel/building material
All of Europe									■	■		■		■													
				■												■	■			■			■				
										■		■	■	■													
Austria	▒	■	■	■		■	■	■	■	■		■	■	■		■	▒			■	■	■	▒	▒	▒	■	
Belgium	■	■	■	■	■		■	■				■	■	■		■	■		■	■	■		■				
Croatia	■	■	■					■																			
Denmark	■	■	■	■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Finland				■	■					■									■		■	■				■	
Germany										■												■					
																■	■	■	■			■		■			

Table 1.1. *Continued*

	Objectives						Structural elements					Location				Benefits and values											
												urban(ized) areas				environmental					sociological			economic			
	Planning, design, landscaping	Establishment, planting	Care, maintenance, cultivation	Management	Conservation, protection	Sustained management	Single trees, groups of trees, woody vegetation	City parks, green lawns, greenspace	Woodlands	Forests, forest ecosystem	All (related) vegetation/organisms	Within cities	Around cities/peri-urban, sub-urban areas/urban fringes	Close to urban areas	Towns, villages/small communities	(Micro-)climate control	Air pollution and noise control	Waste(water) recycling	Biodiversity conservation	Landscape design	Aesthetic/scenic value	Recreation/outdoor activities	Public health/human well-being	Wood production	Non-woody products	Shelter	Fuel/building material
Hungary										■		■	■														
Iceland	■	■		■		■	■					■	■							■	■	■		■		■	
Ireland						■	■		■			■	■			▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Netherlands									■	■		■		■													
Slovakia	■	■	■	■			■	■	■		■	■	■			■	■		■	■	■	■	■		■	■	
Slovenia	■	■		■			■	■	■	■		■	■			▒	▒	▒	▒	▒	▒	▒	▒				
Sweden	■		■				■	■	■	■		■		■							■	■					
United Kingdom							■	■	■			■		■						■		■					
	■	■		■			■		■		■	■		■							■		■				
							■	■	■			■	■														
	■	■		■			■	■	■		■	■		■							■		■				

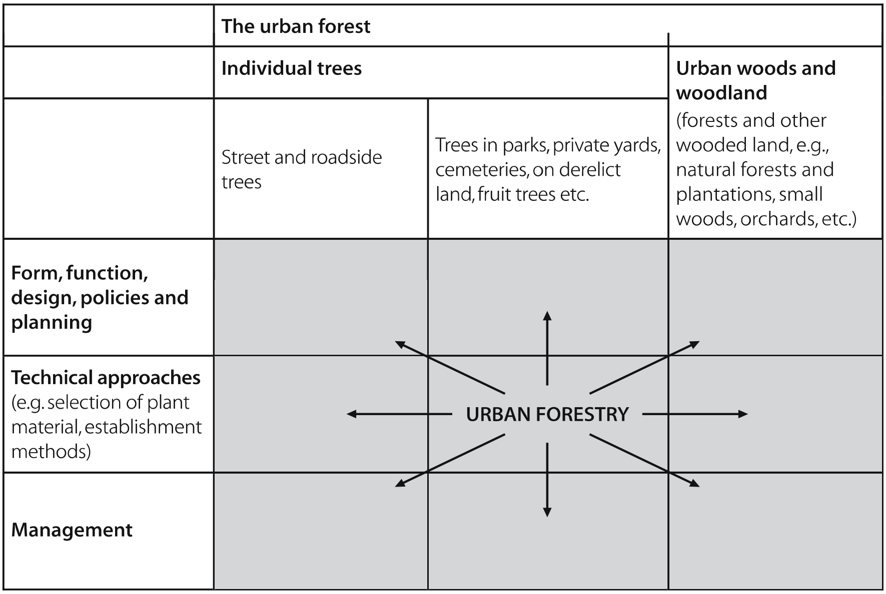

Fig. 1.1. The Urban Forestry Matrix, representing the magnitude and scope of urban forestry

In terms of urban forest resource, the Matrix includes three different types of urban forest locations. The first concerns paved areas, the sites of street trees, trees on squares, lines of trees, rows, and alleys. The second includes individual or small groups of trees growing in gardens, parks, cemeteries, on derelict land and in industrial areas, and others. The third type refers to stands of trees in woodland and shrub vegetation. All three types are to be found in or near urban areas. Moreover, all types relate to woody vegetation elements.

The Matrix also describes how the different tree-dominated structures are dealt with in planning, management, research or any other activity related to the urban forest. There are three categories of activity or involvement: (*a*) overall policy-making, planning and design, (*b*) technical approaches, including plant selection and establishment, and (*c*) management.

Figure 1.2 builds on Fig. 1.1. It places the urban forest (resource) – which includes the three main types of location as described above – centrally as focus of all urban forestry activities, i.e. planning and design, technical approaches, and management. As shown, these activities are all part of an overall and integrated set of actions. In addition, however, Fig. 1.2 stresses urban forestry's multifunctional emphasis, in line with the concept of sustainable natural resource management that incorporates socio-cultural, ecological and economic aspects. Cultural aspects are particularly highlighted due to their importance with regards to urban green space, as for example represented by historical gardens. Figure 1.2 also demonstrates urban forestry's participatory and partnership character through including a range of public and private actors. Urban forestry actors within the public sector include politicians, government officials or civil servants (primarily at the local level), and local public workers. Private actors include consultants, the business sector, user or interest groups, as well as citizens in general.

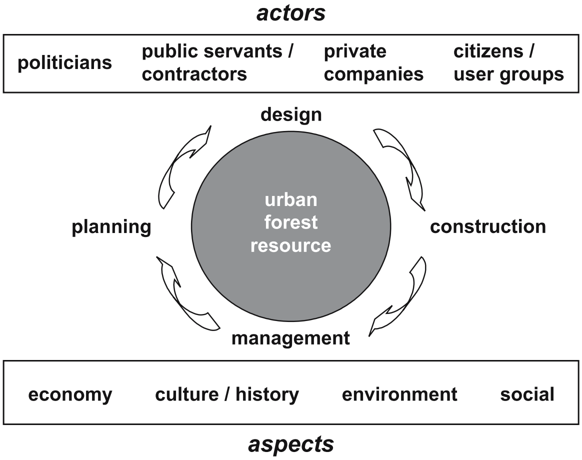

Fig. 1.2. The Urban Forestry Model, representing the actors and activities associated with urban forestry

1.6 The Need for Further Harmonization of Urban Forestry Terminology

The framework presented above has been developed within the context of this specific publication, and builds on experiences from primarily COST Action E12 'Urban Forests and Trees'. It may assist with harmonization of urban forestry terminology in Europe.

Although there is increased recognition among experts that the urban forest encompasses more than only forest stands, the questions which types of green space and which areas (cities and towns, suburban areas, urban fringe, urban-rural interface, rural with 'urban' functions) to include have not been answered unambiguously. The continued use of terms such as 'peri-urban forestry' next to 'urban forestry' testifies of this (FAO 1998).

Harmonization will not only be important in terms of common understanding, but also required for resource inventories and monitoring. So far only the United States has succeeded in carrying out a comprehensive inventory of its urban forest resource, based on assessing urban tree canopy (Dwyer et al. 2000). The main institutions compiling information on the world's forest resources is FAO. According to its definitions widely applied in e.g., forest resource inventories (e.g., FAO 2002b) urban forests include forests and other wooded land as well as trees outside forests as long as these are situated in or near urban environments. The latter have not yet been structurally assessed, nor have FAO assessments had a specific urban focus.

Terminology harmonization is made more complex by related concepts. Earlier the examples of social forestry, community forestry and urban agriculture were given. Other related terms are also in use, such as urban horticulture, and green-structure planning. An example of a related concept that has gradually gained currency is 'urban greening', defined, for example, as the planning and management of all vegetation to create or add values to the local community in an urban area (Kuchelmeister 1998). Although the main difference between urban greening and urban forestry may seem its explicit inclusion of all non-tree dominated vegetation in urban areas (e.g., Konijnendijk and

Randrup 2002), differences between the two concepts are more fundamental. Urban forestry has developed into a science-based approach, and a recognised profession in different countries. This is not so in the case of urban greening, which is a concept, primarily based on activity or philosophy (e.g., Konijnendijk 2003). It was developed mainly in a developing country context, as was the case with community forestry. The growing popularity of the urban greening concept seems to signalize a desire to develop approaches that deal with all aspects of urban green space, rather than for example only with woody elements.

Although Fig. 1.1 and 1.2 provide this book's main framework for defining the concepts of urban forestry and urban forests, focus will regularly shift to urban green space in a more integrated way, including woody as well as non-woody vegetation. Moreover, in practice most urban tree-dominated areas are part of the complex urban structure including buildings, infrastructure, as well as a variety of green structures. Consequently, urban forestry should be seen as only one of a series of strategic, interdisciplinary, and participatory approaches aimed at optimizing planning and management of urban green structures in order to provide multiple benefits to urban societies.

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Chapter 2

A History of Urban Forests and Trees in Europe

Mary Forrest · Cecil Konijnendijk

2.1 Introduction

Trees, woods and woodlands have long been associated with European cities. The London plane, the pines of Rome and Vienna Woods (Wienerwald), for example, indicate how trees have become part of the vocabulary of cities. Cities have expanded to the periphery of woodlands such as Epping Forest in London and the Forêt de Soignes in Brussels. Woodland has been enveloped by an expanding city such as the Bois de Boulogne (see Fig. 2.1) and Bois de Vincennes in Paris and Kenwood in London to become important urban parks. Trees have given their name to streets, for example, the Unter den Linden, in Berlin.

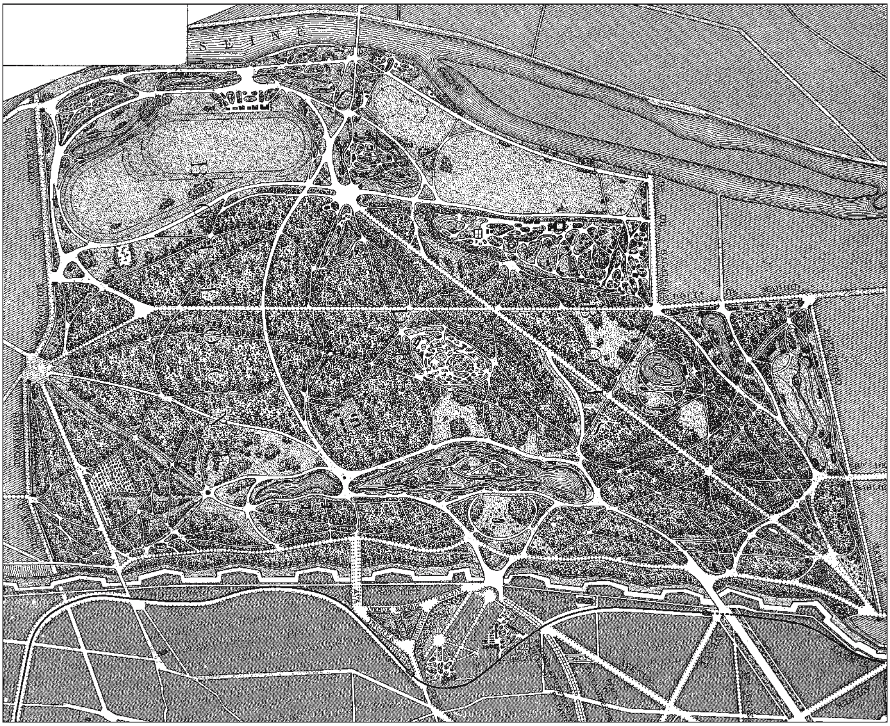

Fig. 2.1. Often woodland became important urban parks, such as the Bois de Boulogne, redesigned 1852–1858 (*source:* Alphand and Ernouf 1898)

When planning and managing Europe's urban forests, one has to consider the rich historical basis of urban woodlands, parks, gardens and trees. Many books have been written about the history of urban planning and the history of designed landscapes. Previous histories of urban forestry by Konijnendijk (1997) emphasized the socio-economic and forestry aspects of the subject, while Gerhold and Frank (2002) and Forrest (2002) have emphasized the arboricultural and aesthetic aspects of the topic. A comprehensive history of what could be translated as urban green ('Stadtgrün') has been given by Hennebo (1979) and Hennebo and Schmidt (sa).

This chapter provides a historical context to the other chapters in this book. It examines, where tree planting occurred in European cities, in what form it occurred and for what reasons it developed. In this review four broad topics are discussed: peri-urban and urban woodlands, tree planting in parks and open spaces, tree planting in streets and developments toward integrated urban green planning and management. The latter was important in the late 20th century development of urban forestry – an interdisciplinary approach to planning and managing forests and trees in and near urban areas.

Examples are drawn from the research literature, from maps, drawings, paintings and diaries of the period concerned. Each topic is described in a more or less chronological order but as will be seen each was dominant in a particular age. Attention is given to areas accessible to the general public rather than to the development of private gardens or royal parks which were associated with cities and towns, except where royal parks and estates were or later became accessible to all people. The concept of urban forestry is discussed in detail in Chap. 1.

2.2 Forestry and Woodland in or near Cities

2.2.1 Forests in Ancient Greece

In Ancient Greece decrees were carved on a stele (not unlike a present day gravestone). Such a stele, some 2 m tall, concerning the planting of fruit trees can be seen in the Archaeological Museum in Kavala (Greece). The planting of vines, figs, olives and other fruit bearing trees and the distribution of profits from these crops between the state and those citizens who planted the trees, was specified by the boule and demos (the governing authorities) of the city of Gazoros. Dating from A.D. 158 the stele is an early example of state support for tree planting.

2.2.2 Medieval Forests

Forests dating from the medieval period remain extant in many European countries and examples from England, France and Belgium are discussed. Britain's Epping Forest in the environs of London, is described by Rackham (1980) as the largest continuous area 1 470 ha of tree-land to retain some semblance of its 12th century state under the Normans. It belonged to many private landowners, in contrast to other forests in Britain and France which belonged to the monarchy. The forest was a wood pasture with plains of grass and tracts of pollards. In Britain forests such as Epping Forest were used as common land for grazing and woodcutting. In Epping Forest the monarch kept deer, commoners and landowners grazed two thousand sheep and a thousand cattle and had wood cutting rights on tens of thousands of pollarded trees. Many others grazed goats and other animals illicitly. The main tree species in Epping Forest were birch (*Betula*), crab apple (*Malus*), hawthorn (*Crataegus*), holly (*Ilex*), hornbeam (*Carpinus*), lime (*Tilia*), oak (*Quercus*) and beech (*Fagus*); though the relative quantities of these genera have altered over the years.

In 1878 the Epping Forest Act stated that the Conservators of the Forest (the Corporation of London) were to 'protect the timber and other trees, pollards, shrubs, underwood, heath, gorse, turf, and herbage growing in the Forest'. The wood pasture became a place of public recreation and has remained so. The annual Dunlop Fair in the Forest, for example, attracted tens of thousands of visitors (Layton 1985).

Ken Wood – now more usually spelled Kenwood (ken is another word for oak) – is situated in the northern suburbs of London beside the 236 ha Hampstead Heath. It is described by Rackham (1980) as a medieval wood except that it has not been coppiced for more than 200 years. From A.D. 1226 Kenwood has been in monastic, royal, private and from 1928 public ownership. It appears on a 1745 Plan of London by John Rocque. In the 16th century the woodland estate was commercially cultivated for timber by leaseholders (Bryant and Colson 1990). In the early 20th century several attempts were made to sell the property for development. Due to much public outcry it eventually was purchased by municipal authorities and became a public park. Since 1986 the woodland and 19th century designed landscape, the work of Humphry Repton, has been subject to major restoration by English Heritage, a conservation organization. Kenwood is now a public park open to the general public.

In France the woods of Fontainebleau and Orleans are remnants of ancient Roman woodlands. Bois de Boulogne and the woods of St Cloud in the environs of the city of Paris were once part of the medieval Forêt de Rouvray (Reed 1954). Marly, Fontainebleau, St Germain and Rambouillet are also close to Paris. The forest at Fontainebleau, 11 km across and composed of oak (*Quercus*), beech (*Fagus*) and lime (*Tilia*), extended to 17 000 ha. It was managed as wood pasture and some oak (*Quercus petraea*) were planted as timber trees. Beech (*Fagus*) trees are now more numerous than oak which had already taken over from lime (*Tilia*). In heathland areas, pines (*Pinus*) dominate. With the development of the railway line from Paris in 1849 it became a public amenity. It was also frequented by the Barbizon school of 19th century painters, named for a town on the periphery of the forest.

Chantilly, also in the environs of Paris, extended to 2059 ha of which 1 323 ha were lime forest. There were also stands of lime–hornbeam, hazel–lime, hazel and oak woodland. In the 17th century the lands surrounding the chateau at Chantilly were redesigned by Andre le Nôtre to become a baroque designed landscape, some of which remains to the present.

In Belgium, Forêt de Soignes on the outskirts of the city of Brussels was known to the Belgian Gauls and to Charlemagne. During the Middle Ages it was a wildlife preserve and all people could use it, unlike other feudal woods of the period which were limited to royalty and nobility. In 1543 Emperor Charles V decreed that each year 126 ha of the 10 383 ha were to be cut selectively. He also decreed that 323 ha were to be reserved for his hunting. By the beginning of the 18th century much of the timber had been felled and a replanting programme commenced. Not later than 1830 the forest was restored to its present condition. In 1822 the Society for the Promotion of National Industry was managing 40 000 ha of forest in Belgium including the Forêt de Soignes. In 1843 it disposed of some lands but 4 369 ha remain intact. During the 20th century walking trails, 20 km of bicycle-ways, 40 km of bridle-ways and 200 km roads were constructed (Roche 1973; Hacque 1987). An arboretum at Tervuren was opened in 1958 and many of its trees are now reaching full stature. In recent years interpretative centers, explaining the flora and fauna of the forest have been built.

Evidence of woodland surrounding towns is seen in paintings of the period. In Pieter Breughel's (1564–ca. 1638) Hunters in the Snow people are walking through a woodland towards a town. His painting Spring (Fig. 2.2) depicts people busy planting a garden in the foreground, while the background houses are surrounded by trees and in the far distance are woodlands.

Fig. 2.2. Evidence of woodland surrounding towns is seen in paintings from the medieval period. Pieter Breughel's (1525/30–1569) painting 'Spring' depicts people busy planting a garden with a background of trees, houses and woodlands (reproduced by J. Cock, 1570)

In the medieval period a category ownership, that of a city owning a forest developed. Municipal participation in the planting of trees and conservation of existing forests occurred in medieval Germany. In 1434 the German city of Nuremberg purchased a public meadow and in 1443 it was planted with lime (*Tilia*) and the area remained in use for 500 years (Hennebo 1979). Artificial seeding with pine, fir, and spruce was undertaken in Nuremberg in 1368 and in Frankfurt in 1420. A view of the city of Nuremberg from 1516 shows a walled city with surrounding meadow in turn surrounded by a broad planting of trees, depicted as dark and pale trees, possibly deciduous and coniferous trees. In 1359 there was a city forest in Erfurt. By 1371 the city of Hannover owned the forest of Eilenriede (Hennebo 1979). In 1741 a principle of sustained yield was adopted in the forests of Göttingen.

City forests were used as places of recreation, as protectors of water sources and as a source of timber for example construction. A main function of forests near cities remained their use for hunting by royalty and nobility. Examples include Bishop's wood near London, the Tiergarten (Fig. 2.3) and Grunewald in Berlin, the Bois de Boulogne near Paris and the Wienerwald adjacent to Vienna (Konijnendijk 1997).

Legal protection afforded to forests and trees also dates to at least the Middle Ages. The city council of Freiburg, Germany, for example started controlling the use and managements of forests surrounding the city at the end of the Middle Ages (Brandl 1985). In 1511 the removal of certain tree-defoliating caterpillars was required by law in Nuremberg (Schabel 1980 cf. Gerhold and Frank 2002).

Fig. 2.3. During the Middle Ages, woodlands near cities were used by royalty and nobility for hunting game, as in the case of Tiergarten in Berlin (*photo:* J. Abel)

Fig. 2.4. Schönbrunn, with Vienna in the background, was redesigned in the 17th and 18th centuries, so that existing forests were transformed to facilitate hunting (*photo:* J. Abel)

2.2.3 Forestry Development in the 17th and 18th Centuries

In the 17th and 18th century existing forests were transformed and new ones were planted adjacent to cities and used by the aristocracy and later the developing class of rich merchants (bourgeoisie) for recreational purposes. In France, the Fôret de Saint-Germain, the Bois de Boulogne and Rambouillet near Paris were redesigned. Star patterns or réseaux étoiles were introduced, for example to facilitate hunting. Similar design patterns were introduced into the Schönbrunn in Vienna (Fig. 2.4) and the Tiergarten in Berlin, among others. Hunting by the monarch had become the major function of the Jaegersborg Deer Park near Copenhagen. The area was fenced and all houses and an entire village within its perimeter were removed. Sometimes new woods were established for a wider public, as in the case of the Haarlemmerhout which was planted as 'recreation forest' for and by the people of the Dutch city of Haarlem (Konijnendijk 1997). Additional protective measures were taken to preserve urban woodland resources. In 1780 the city council of Tallinn (Estonia) declared that the peninsula of Kopli, including the remnants of an ancient oak forest, was to be protected as a 'treasure of the town'. As early as in 1723 all logging was prohibited in the vicinity of the town (Sander 1993).

2.2.4 City Forests in the 19th and 20th Century

Following the Industrial Revolution while many forests were felled others were planted for timber production. Forests in urban areas were increasingly also used for recreation by large parts of urban society. Greenbelts, areas where housing or industrial development could not take place were designated around many cities. Such areas often included forests. The first example of these greenbelts predated this period. As early as 1580 Queen Elisabeth I designated a three-mile (ca. 4 km) perimeter greenbelt around London (Hennebo and Schmidt sa). In 1905 Vienna's city council designated over 4 000 ha of woodland for amenity purposes.

Heske (1938) stated that the function of city forestry was the benefit of forests for the 'spiritual and bodily hygiene' of the urban population rather than a financial return. The management of such forests would entail aesthetic as well as silvicultural and economic issues. After the Second World War some local and national governments were actively involved in the provision of urban woodlands and other large open spaces. These areas provided ready recreational opportunities for an increasing population of urban dwellers. In The Netherlands, for example, a large-scale program aimed at establishing 'green stars', consisting of woodlands, open spaces and water developed close to the main populations (see Fig. 2.5). Sixty years later other countries, including Belgium, Denmark, Ireland, and the United Kingdom embarked on extensive urban afforestation programs. Recreation remained a primary objective for the establishment of peri-urban woodlands, but other functions such as biodiversity, water protection, enhancing the landscape and the creation of attractive environments for housing and economic development became important. Forest-rich countries of northern and eastern Europe had different challenges to address. Urban areas had gradually encroached into nearby forests and techniques to balance the requirements of a sustainable forest environment and urban development were developed (Tyrväinen 1999).

Fig. 2.5. The Amsterdamse Bos, established during the early 1930s, provided inspiration for the post Second World War is development of 'green stars' consisting of woodlands, open spaces and water close to urban centres (*photo:* I. A. Olsen)

2.3
Trees in Parks and Open Spaces

Trees as an element of public parks and open spaces have also been a major contributor to the urban tree cover in European cities.

2.3.1
Trees in Ancient Times

A few ancient authors and inscriptions refer to planting in the Agora (market), an area adjacent to the Acropolis in Athens. Kimon donated Plane trees (*Platanus*) to shade the walks after the Persian Wars had devastated Athens. A marble plaque from approx. A.D. 200 shows Olympos, son of Alexander of Pallene, dedicating plants to the Phosphoroi, light bearers who were worshipped in the nearby Tholos, a temple like building. In 1936 the area around the Temple of Hephaistos was cleared to underlying rock and two rows of rectangular openings in the ground, circa one meter square, came to light. They contained remains of unglazed flowerpots. Cato in his book 'Agricultura' described how they were used:

> To make a shoot take a root while on the tree, make a hole in the bottom of the pot and push the branch you wish to root through it. Fill the pot with earth, press it thoroughly and leave it on the tree. When it is two years old, cut off the branch beneath the pot … shatter the pot and plant the branch in the pit together with the pot. *(cf. Thompson 1963)*

The first planting of this garden probably took place in the early third century B.C. and the garden went into disrepair in the first century. The garden was replanted with myrtle (*Myrtus*) and pomegranate (*Punica*) (Thompson 1963).

In Rome the great public layouts, civic buildings, temples and amphitheatres were framed with trees. The mid-20th century planting of *Pinus pinea* was inspired by the cultural links of species with the Roman Empire (Attore et al. 2000). Plane trees (*Platanus*) were introduced from Greece and used as shade trees (Hobhouse 1992). Inner courtyard gardens of town houses in Rome were planted with fruit trees, vegetables and flowers. From the first century B.C. Roman nobles constructed buildings and surrounded them with public parks (Carroll 2003).

2.3.2
Medieval Period

In the Medieval period people would have used Commons and Greens, lands used by the common people, for recreation and there is little evidence of the construction of public parks. Open spaces within the city walls were primarily used for growing vegetables, fruits, herbs and for drying laundry. Trees were mostly within the walls of private gardens, e.g. of monasteries (Lawrence 1993).

2.3.3
Development of Urban Parks from the 17th Century

Prior to the Industrial Revolution a large number of royal forests and parks were opened to the public, so that many citizens had opportunities for outdoor recreation. Several new public parks were also laid out.

Fig. 2.6. London's Hyde Park was opened to the public in 1635. It was often used for royal celebrations (*photo:* J. Abel)

An aerial view of Paris (from 1615) by Mathieu Merian shows the gardens of Les Tuilleries on one side of the river Seine, with other less formal gardens on the other bank. It also shows an area with a formal planting of trees on either side of an avenue, le Palmail, presumably where the game of pall mall was played.

Green Park and Hyde Park (Fig. 2.6) in London were open to the public from 1635 and were used for royal celebrations. Kensington Gardens was laid out in 1828 by John Nash, an architect, on the site of an existing 17^{th} century landscape design by the brothers, Mollet. At Greenwich Park, the site of the Greenwich Observatory, formal rows of 400-year old sweet chestnut (*Castanea sativa*), are now veteran trees in a senescent state.

In 1682 the Amsterdam city council laid out a recreational area known as the Nieuwe Plantage, which was divided into fifteen squares, each lined with a double row of trees. The squares became allotments (for the cultivation of vegetables) and people strolled on the broad walkways. A painting dating from 1725 shows an avenue lined with tall pleached trees, not unlike those in the Schönbrunn Palace in Vienna today. In 1746, Frederick V opened the Jaegersborg Deer Park north of Copenhagen, to the general public. In 1775 Emperor Joseph II laid out the Augarten in Vienna for public use. The Prater park in the same city was opened to the public from the 1780s. In Berlin the Tiergarten, originally a royal enclosure was opened to the public from 1772. The Englischer Garten (Fig. 2.7), an English style landscape park located on the banks of the River Isar in Munich, was funded by an American Benjamin Thompson and designed by F. L. von Sckell in 1789. In France, during the Intendency of the Marquis of Tourny (1743–57) promenades of trees were planted around the city of Bordeaux and a public garden was constructed (Girouard 1985).

Fig. 2.7. The Englischer Garten in Munich, an English-style landscape park, was funded by an American Benjamin Thompson and designed by F. L. von Sckell in 1789 (*photo:* J. Abel)

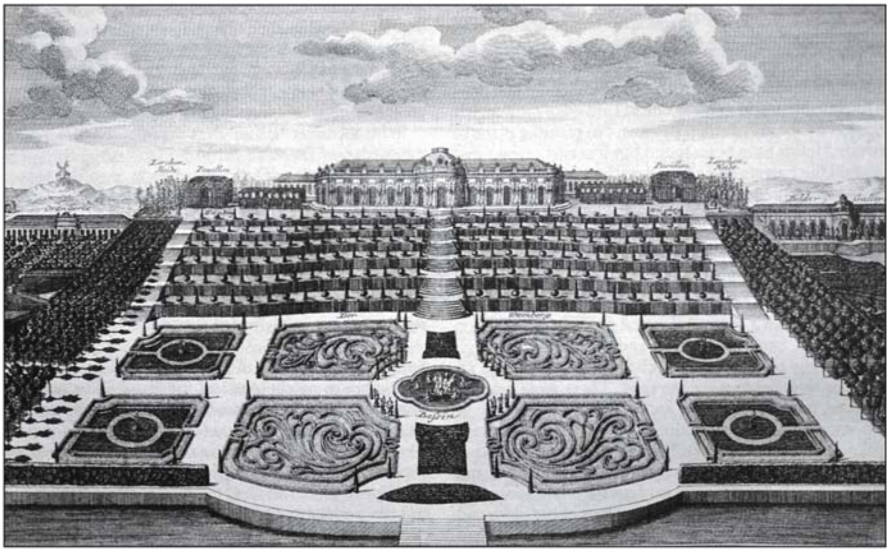

Fig. 2.8. During the 19th century governments and city authorities appointed staff to oversee the development of urban woods and parks. In Potsdam, Germany, Royal Garden Engineer Peter Josef Lenné (1789–1866) laid out the Sans Souci royal garden during the second half of the 18th century (*source:* Alphand and Ernouf 1898)

It is interesting to note that by the 19th century government and city authorities had appointed staff to oversee the development of woods and parks. John Nash, who was employed as an architect in the Department of the Chief Commissioner of Woods and Forests in 1806, designed plantations of woods with tree lined paths and open spaces in the new Regents Park in the developing suburbs of north London. In 1864 Des Cars was director of parks in Paris. In Potsdam, Germany Lenné, the Royal Garden Engineer, laid out the Sans Souci royal garden (Fig. 2.8), now a public park. At Magdeburg 50 ha of fortifications were planted for public use by Peter Josef Lenné (1789–1866). Lenné was also responsible for the development of public parks in Berlin. At Friedrichshain in the east of the city, Lenné prepared schemes for the remodelling of the Tiergarten (formerly a Crown property) in 1818 and 1832. Two of Lenné's most forward looking schemes seem to have been forerunners of the park-system idea, his Verschönerungsplan (embellishment plan) for Potsdam in 1836 and his Schmuck-und-Grenzzüge proposal for Berlin of 1840. The latter seems to have aimed at a ring boulevard linking an elementary park system. This idea was seen later in the work of Frederick Law Olmsted in Boston, United States and Holger Blom in Stockholm (Chadwick 1966).

2.3.4 Post Industrial Revolution

Public Green Space and Public Health

In many continental cities disused fortifications or old city walls were used for extensive promenades, public parks and encircling belts or rings of vegetation. In Cologne in 1881 two green rings totaling 4 166 ha, formerly fortifications, were secured for the city (Chadwick 1966). In Denmark the first public parks in Copenhagen were laid out on the site of old fortifications about 1870 (see Fig. 2.9). In 1866 Van Niftrik, city engineer in Amsterdam prepared an 'Uitbreidingsplan' (extension plan) for the city of Amsterdam in which a pattern of city parks was included. The Vondel Park remains from this period. The British House of the Commons set up a Select Committee on Public Walks. Their report in 1833 was in favor of public walks and open places where people could take fresh air, walk in comfort with their families, and where the mixing of 'middle class and humbler classes' would lead to improved behavior among those who frequented such places (Chadwick 1966).

In Britain many public parks owed their inspiration to the 18th century English Landscape Movement, which emulated nature and created a romantic rather than a formal Baroque landscape. Britain was among the first countries to develop municipal parks. By the middle of the 19th century the census showed that half the British population lived in cities and towns. By 1911, 80% lived in cities. Those who advocated public parks considered that city parks would improve the physical health and moral well being of city dwellers. Parks were seen as 'green lungs' for cities, especially those in the industrial Midlands and North of England. Trees suffered in the industrial pollution and those that could survive were grown. A lot of trees were already cultivated in Hampstead Heath when it was purchased for the public in 1872. Tree planting also occurred in the wealthier suburbs as in Princes Avenue in Liverpool, which linked Princes Park with the city centre (Bradshaw et al. 1995).

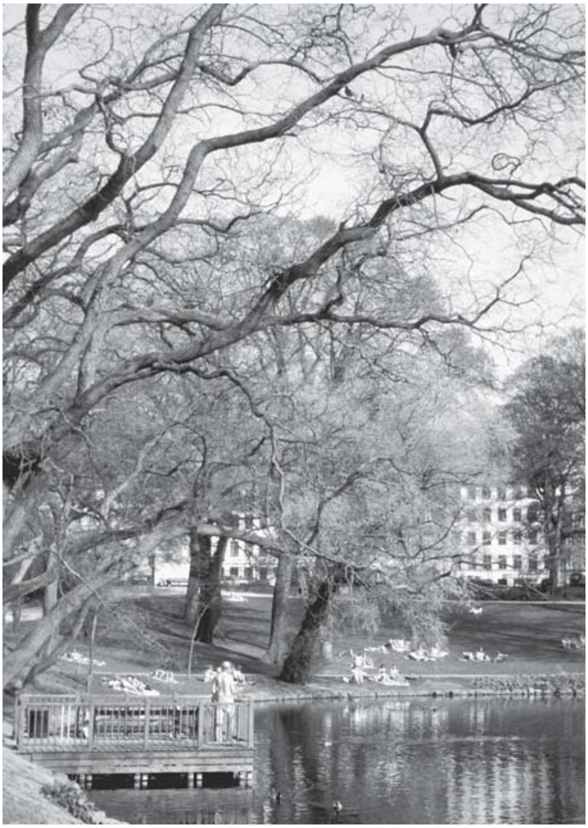

Fig. 2.9.
The H. C. Ørstedspark was laid out on the site of the old fortifications of Copenhagen as one of the city's first public parks in approximately 1870 (*photo:* J. Abel)

Botanic Gardens, Zoological Gardens and Cemeteries

While botanic gardens and zoological gardens were mainly developed in cities for scientific purposes, they also contributed to the number of trees in urban areas. Botanisk Have, Copenhagen (established on its initial site during 1600; later demolished), Jardin des Plantes Paris (1635), Royal Botanic Garden, Edinburgh (1670) and Royal Botanic Gardens, Kew, London (1759) are examples of such gardens. The architect Decimus Burton designed Dublin Zoo in 1821 and London Zoo in 1826.

In many cities cemeteries have and continue to contribute to the urban tree population. In Paris, Picpus Cemetery dating from 1647 is described as a shady park of sycamores (*Acer*) and ash (*Fraxinus*). Père-Lachaise Cemetery dates from 1804 and is described as the largest green space in Paris with remarkable trees, including species of yew (*Taxus*), american walnut (*Carya*) and beech (*Fagus*) (Le Dantec and Le Dantec 1991). Highgate Cemetery (Fig. 2.10), London, was laid out in 1834 in a picturesque manner with winding-paths and groups of trees. In many English cities, such as Reading, cemeteries were planted with what have become fine specimens of weeping beech (*Fagus sylvatica* 'Pendula'), yew (*Taxus baccata*) and deodar cedar (*Cedrus deodara*). In some present day cemeteries, such as the Garden cemetery by Gunnar Asplund in Stockholm (Fig. 2.11), trees and woodland planting are to the fore.

Fig. 2.10.
Cemeteries are important contributors to the urban tree population. Highgate Cemetery, laid out in 1834 in a picturesque manner with winding paths and groups of trees, is an example of this (*photo:* S. Guldager)

Fig. 2.11.
In some present day cemeteries such as the Garden Cemetery in Stockholm by Gunnar Asplund, trees and woodland planting are the leading principle (*photo:* K. Sejr)

2.4 Street Trees

Through the centuries trees have been planted on public spaces such as walks and promenades, alleés and boulevards, walls and ramparts, in city squares and private gardens (Forrest 2002). In 1552 King Henry II of France issued an ordinance for the planting and maintenance of trees in Paris. Trees were part of the urban fabric as seen in several paintings. In 'View of Delft' dating from 1660/1661 by Johannes Vermeer, trees appear among the buildings of the city. A similar picture, 'Long View of London', by Wenceslaus Hollar (1647) shows buildings with gardens and trees on the banks of the River Thames. Trees are seen among the buildings of the city of Bruges in 'The Seven Wonders of Bruges' attributed to P. Claessens, the Elder ca. 1550.

In the 17th century roads leading in and out of Paris, such as those leading to the Tuilleries palace, the Cour de Vincennes and the town of Versailles, were constructed and lined with trees. They were later enveloped by the developing city of Paris. In the early 17th century town councils in the Low Countries already had some sort of public tree policy. For example tree planting was ordered as part of the expansion plan for Amsterdam (Lawrence 1993).

In 16th century Rome *Ulmus minor* was used by Pope Sixtus V to embellish access roads leading to churches and the species became a symbol of Papal Rome. In the late 19th/early 20th century *Platanus* × *acerifolia* was widely planted by King Umberto I to enhance the capital city of the newly formed Italian state. During the period of Fascist rule in the mid-twentieth century *Pinus pinea* was commonly planted on streets. In the 1960s *Robinia pseudoacacia* was widely used in the developing suburban areas of the city. In the period 1898–1998 city authorities undertook four censuses of street trees (Attorre et al. 2000).

2.4.1 Promenades

Promenades, together with public parks and pleasure gardens, were places where citizens walked, a fashionable exercise of the period. The Cours-la-Reine, a 1500 m promenade planted with four rows of elm trees was created in 1616 along the banks of the Seine in Paris. It is considered as the first example of a promenoir, an artificial or constructed walkway. Marie de Medici, a member of the Florentine family who became queen of France, introduced the idea of carriage riding for pleasure to the French nobility. Old plans show the avenue with three rows of trees and a semi circle for turning carriages. Over the years, access varied from free access to authorized access. In 1723 it was replanted. Another public promenade, the Champs-Elysées (Fig. 2.12) with its triumphal arches, was developed from 1670–1723. An imitation of the boulevards in Paris was seen in Toulouse and Bordeaux. In Lyons and Montpellier two esplanades were planted in honor of King Louis XIV. In Strasbourg, as early as 1681, a *Tilia* avenue was planted. Few tree-lined avenues in urban areas existed before 1700. However there are examples such as Cours Mirabeau in Aix en Provence, originally planted with *Ulmus* and later with *Platanus* which remain today. The Canabiere in Marseilles and Place de la Carriére in Nancy are other examples. A study of Brittany records that 54 prom-

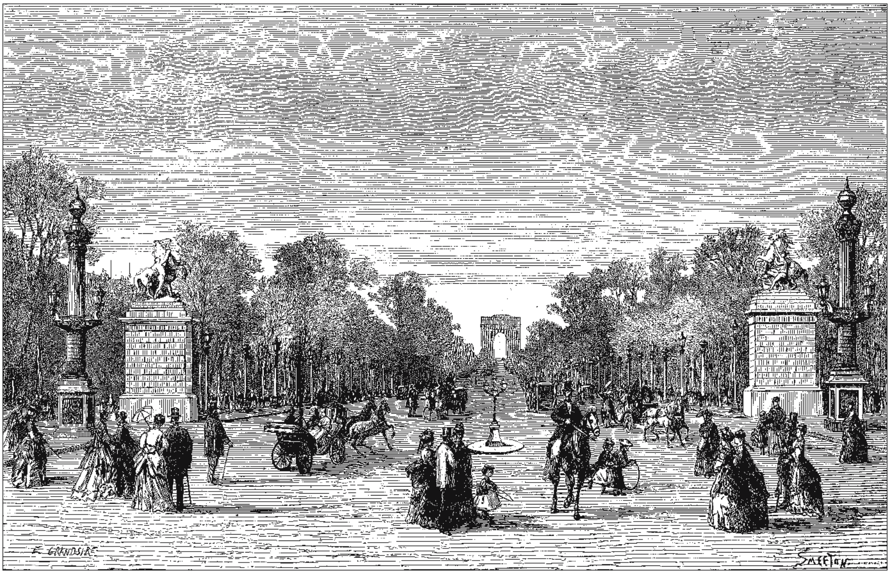

Fig. 2.12. The promenades of the 17th century were places were citizens walked, such as the Champs Elysées in Paris (Alphand and Ernouf 1898)

enades were created in 28 towns in the province from 1675–1791 (Stefulesco 1996). The practice of promenading was also popular in 16th century Spain. In Seville a promenade or parade area known as a paseo con alamos, a parade with poplars (*Populus*) was described in 1583 (Girouard 1985).

2.4.2 Ramparts and Bastions

With the exception of Lucca (Fig. 2.13), Italy where the ramparts were planted in the 16th century tree lined promenades were not introduced until the 18th century in Italy. Examples of these were to be found in the cities of Turin, Parma and Naples (Rabeau 1991). In the late 16th century ramparts rather than city walls were constructed around some European cities. In provincial French towns, ramparts no longer necessary for military purposes were planted with trees. Trees planted on ramparts with people sitting beneath them looking at the festivities are seen in 'Carnival on the ice, outside the walls of Antwerp' by Dennis van Alstoot. In an engraving by Mathieu Merian (1646) 'View form the quay at Frankfurt-on-Main', a row of trees on a rampart is evident. A later painting 'Rampart Walk at Vienna' by P. D. Raulino (1824) shows rows of poplar like (*Populus*) trees on ramparts with people promenading beneath.

In the 16th century, after the Reformation, the Swiss city of Geneva constructed bastions and 'courtines' close to the medieval ramparts. These areas were planted with elms, limes, ash and walnut. Towards the end of the century under the influence of their French neighbors, promenades became important in the city. Dating from 1516 the promenade of the Treille is considered to be one of the oldest walkways in city. De-

Fig. 2.13.
The tree-lined promenades of *Platanus* in Lucca where the first Italian ramparts planted during the 16th century (*photo:* J. Abel)

tailed information about mid-16th century tree planting on this promenade is given in Silva (1996). Limes (*Tilia*) and elms (*Ulmus*) were planted to be later replaced by horse chestnut (*Aesculus*). Silva also describes the role the Promenade had in the life of the city as described in Church documents and by writers of the day. From 1808 a tradition developed. Once a particular tree known as 'Le Marronnier officiel de la Treille' came into leaf then Spring had arrived officially (Silva 1996); an example of the cultural role that a tree can play in the life of a city.

Promenades were also laid out in London. In 1597 the Benchers of Gray's Inn (then and now one of the centers for the legal profession in Britain) paid 'Mr. Bacon for planting of trees in the Walkes'. Mr. Bacon was Francis Bacon, later Lord Chancellor and author of the influential essay 'Of Gardens'. For two hundred years the 'Walkes' was a fashionable promenade in London 'open to the air and the enjoyment of a delightful prospect – for many years much resorted unto by gentry of both sexes' (MacLeod 1972). An example at Moorfields was developed from 1606 and 1616, with gravelled walks, benches and avenues of elm (*Ulmus*) (Girouard 1985).

In the 17th century the waterside promenade developed in the Low Countries. A prime example of this was the 'Plan of Three Canals' constructed in Amsterdam in 1615, where houses of the wealthy and rows of elm lined the canals (Girouard 1985). A relief map of 1663 of the city shows tree lined canals and rows of trees planted near the Oude Kerck and the Nieuwe Kerck. Tree lined canals are evident on present day photographic aerial views of the city. A birds eye view of Amsterdam by Flonsz van Berkenode in 1625 shows trees planted on the banks of the canal Nieuwe zydts voor Burchwal and in the precincts (kerkhof) of the Nieuwe Kerk.

The tree lined avenue Unter den Linden in Berlin (Fig. 2.14) which extends from the Brandenburg Gate to the Opera House and the Humboldt University and is one of the set pieces of city tree planting in Europe. Approximately one kilometer in length it had been planted with walnut (*Juglans*) and lime (*Tilia*) trees in 1647 (Girouard 1985). Bird's eye views of Berlin dating from 1652 and 1688 illustrate an avenue of parallel lines of trees. A later illustration from 1737/1938 shows the Unter den Linden with four rows of trees and a broad central median, along with tree lined streets in neighboring parts of the city and trees planted in gardens. Views dating from 1748 and 1772 show six rows of trees. An illustration from the 1800s show four rows of trees (Gandert 1985). The trees were replaced on two occasions during the 20th century (von Krosigk 2002).

A similar area for promenading occurred at the Jungfernstieg in Hamburg. This was a tradition which continued to the 19th century as evidenced in the painting 'The parade on the Jungfernstieg' Hamburg ca. 1820 by Christopher Suht, which shows people boating and walking beneath trees.

Fig. 2.14. Planted with walnut and lime trees in 1647, 'Unter den Linden' in Berlin is one of the prime examples of city tree planting in Europe (*photo:* J. Abel)

2.4.3 Town Squares

The town square, place or piazza had its origins in 16th century Italy, where they were left unplanted. However as this architectural form was translated into other European cities they were planted with trees. In the Swiss city of Basel the square was planted in 1572. In Germany squares in Cologne and Frankfurt were planted from 1572 and 1580 respectively. 'A street scene in Cologne' ca. 1670 by J. van der Heyden (1637–1712) shows street tree planting with a square in the foreground and buildings in the background.

In a general view of the Palais Royal, in Paris (Fig. 2.15), built in 1780–1784, the square has been planted with formal rows of trees, a feature which continues to the present time. The painting by Monet, 'Saint Germain L'Auxerrois' painted in the summer of 1866 shows horse chestnuts (*Aesculus hippocastanum*) in bloom in a square adjacent to the Louvre. Five large trees dominate the painting 'The Grote Markt at the Hague' by Paulus Constantijn La Fargue (1729–1782). They obscure views of the houses surrounding the square and shelter buyers and sellers of market produce. Celia Fiennes, writing in her diaries of her visit to Tunbridge Wells (England) in 1697, describes the market area in the town. 'The walke (sic) is between high trees on the market side for shade and secured with rows of buildings on the right which are shopps (sic)' (Morris 1982). A walled square (Place Verte) with trees planted on two sides of the square are prominent in 'Widow processing in the Groenplaats by the cathedral, Antwerp' ca. 1600 by an anonymous painter. A square is extant on this site.

In the 18th century squares planted with trees and shrubs were a feature of some residential areas of London, Dublin and Edinburgh. These squares were, and in some cases remain, the private gardens of those whose houses overlooked the square.

Fig. 2.15. Italian town squares were originally left unplanted during the 16th century. But as architectural form of squares was transferred to other European cities, these were planted with trees, as in the example of the formal rows of trees at Palais Royal, Paris (*photo:* J. Abel)

2.4.4 Tree Planting in Industrial Areas

One of the few early examples of tree planting in industrial areas of a city is seen in 'The Howland Great Wet Dock near Deptford, London' ca. 1700. This engraving of a large commercial dock was in use from 1703. In an otherwise agricultural landscape with fields and animals, the rectangular dock an associated buildings are lined with a double row of trees.

Table 2.1. Evidence of early 19th century tree planting in selected European cities (from Branch 1978)

Cities	Evidence of tree planting
Antwerp	1832: Trees were evident on the Quai Vandyck and in the square, Place Verte (Groenplaats) close to the Cathedral (see earlier text)
Brussels	A tree lined boulevard, Boulevards du Regent and Waterloo and Rue Royale encircled the city with the Forêt de Soignes to the south-east
Vienna	Planting occurred on the banks of canals and the grounds of the Prater. The broad Ringstrasse (ring road) was developed on the ruins of the Renaissance fortifications. A design competition for public and residential buildings, a 'ringstrasse' and public parks was arranged by Emperor Franz Joseph and was won by Ludwig von Förster
Bordeaux, Marseilles, Paris and Toulon	Tree lined avenues, trees in cemeteries and formal planting in squares occurred
Dresden	The contrast of the old and new cities with the Neue Anlagen (New Landscape) was strongly influenced by ten tree-lined avenues radiating from a central circle, reminiscent of French Baroque design. Planting also occurred on the ramparts
Frankfurt	Planting occurred on the ramparts and on streets. A public area on the north-west with walks, parade grounds, similar to the design of contemporary public gardens in England
Geneva	Rue sous la Treille described earlier and planting on the ramparts were shown on the plan of 1841
Genoa, Milan, Parma and Turin	Planting on bastions was evident and in Parma and Turin planting occurred on boulevards
Madrid	Tree lined boulevards occurring on the periphery of expanding city to contrast with the closely packed streets of the older city. Campo Grande, a park with formal avenue of trees was also planted along the Rive Manzanares
Warsaw	Some evidence existed of a radial pattern in the environs of the Zamek Ujaz and Castle of Ujazclow
St Petersburg	Surrounding woodland was evident in the plan of the city
Stockholm	Surrounding woodland was evident in the plan of the city
Rome, Florence, Dublin, London and Lisbon	Tree planting was conspicuous by its absence in the plans of these cities

2.4.5
Tree Planting in Some European Cities

A book of plans, 'Comparative Urban Design Rare Engravings 1830–1843', provides an early 19th century view of principally European cities (Branch 1978). The plans first published by the Society for the Diffusion of Useful Knowledge in London are discussed in some detail by Branch. While their main purpose is to show urban design they also provide an interesting view of trees planted in streets and parks. Some surrounding woodland can also be seen. These maps also corroborate much of the information derived from paintings and written sources. A brief description of tree planting in some of the cities is provided in Table 2.1.

2.5
Towards Integration in Open Space Planning and Design

Development of Parks and Open Spaces in European Cities

In the 19th century, tree planting as part of the integrated development of parks and open spaces, city squares and boulevards became evident. This was the case, for example of the rebuilding of Paris by Emperor Napoleon III between 1848 and 1870. The work of Haussmann in Paris to improve traffic circulation, the appearance and amenities of the city of Paris and enhanced military access, included the development of parks and gardens and the planting of boulevards. Precedents for his work can be seen in the development of the 17th century formal baroque designed landscapes of André le Nôtre for King Louis XIV at Versailles.

Ownership of the Bois de Boulogne passed from the Crown to the City of Paris and was planned to rival Hyde Park and other Royal parks in London. It extended to 833 ha, to include a pine forest, several oak groves, the gardens of the Bagatelle (Fig. 2.16), two large lakes, the Longchamps racecourse and a zoo. The dates of redevelopment were 1852–1858. Haussmann also designed and developed a park to the east of the city, the Bois de Vincennes (1860). This had been an existing woodland and extended to include new plantations, three lakes, buildings and a racecourse as in the manner of the Bois de Boulogne. The two parks were linked by tree-lined boulevards and a series of smaller parks, similar to city squares in London. Buttes Chaumont in the north and Parc Montsouris to the south with 24 garden squares between the boulevards and blocks of houses were also developed. The Champs Elysees was remodeled by Baron Haussmann in 1858. In that period some 85 000 trees were planted, primarily Plane (*Platanus*) (41%) and Chestnut (*Aesculus*) (15%) (Hennebo 1979). Some 110 000 trees, a higher figure given by Stefulesco (1996) were planted along 236 km of streets. Alphand, the Director of the Promenades Service, said 'It is no exaggeration to say that the Promenades service has completely renewed the appearance of Paris.'

Among paintings and engravings there are many examples of trees as part of the city of Paris. An engraving by Aveline 'The Cours la Reine' shows four rows of trees with carriages and people. An aerial view of the 'Cours on the Boulevard St. Antoine' dating from the mid-18th century shows a double row of trees on either side of the boulevard. The artists Claude Monet's 'Boulevard des Capucines' (1873) and a view of the 'Avenue de'Opera'

Fig. 2.16. In the years 1852–1858 the gardens of the Bagatelle were developed as an extension to the Bois de Boulogne in Paris (*photo:* J. Abel)

by Camille Pissaro 1898, demonstrate the place of trees in the life of the city of Paris in the late 19th century. Aerial views of the city prepared for the Paris Exhibition of 1889 show the tree-lined boulevards stretching into the horizon. A birds eye view of Parc Monçeau in Paris shows the surrounding streets lined with trees. A view of the Square des Arts-et Métiers shows people and kiosks beneath a canopy of trees. The trees have a tree guard in the shape of a crinoline skirt. An illustration in Chadwick (1966) shows the Square des Batignolles with a double row of trees planted on the periphery of a park located by the side of a railway station.

In Brussels a similar scheme was undertaken by Victor Besme on the instructions of King Leopold II. From 1866 broad avenues and new districts were created in the city, with many of the roads leading to the surrounding countryside. The avenue Louise dates from 1870 and the avenue Tervuren from 1897. The principal species planted were plane (*Platanus*), lime (*Tilia*), horse chestnut (*Aesculus*) and sycamore (*Acer*) (Moreau sa).

Large-scale and planned planting of trees for amenity purposes as street trees and in forest and woodland is primarily a feature of the late 19th and 20th century. Several concepts guided open space development during this period, among which those of the Garden City and the Volkspark.

Garden Cities

Ebenezer Howard's 'Garden cities of tomorrow' (first published in 1902) proposed the idea of a 'garden city', where a city would be laid out in concentric circles with gardens and greenery to the fore (Howard 1946). In 1902 a Garden City Association was founded in Britain. Letchworth, the first garden city was constructed in 1902–1903. Hampstead garden suburb was developed in 1908 and Welwyn Garden City (Fig. 2.17) in the 1920s.

Fig. 2.17. Welwyn Garden City, England constructed during the 1920s with housing development going hand in hand extensive woody vegetation (*photo:* J. Abel)

A similar movement in Germany, Deutsche Gartenstadt-Gesellschaft, was founded in 1902 and in Barcelona, the Societat Cívica la Ciutat Jardí was founded in 1912. In Finland the garden suburbs of Kulosaari and Munkkiniemi in Helsinki date from the 1910s. This idea was further developed in Finland where 'forest towns' such as Tapiola were constructed in the city of Espoo in the late 1950s (Tyrväinen 1999).

Volkspark

The need to provide increasing urban populations with sufficient green areas for healthy and socially acceptable types of leisure led to the establishment of many public green areas. The era of the so-called Volksparks emerged. These were large scale, public areas which combined open space, water and wood, with opportunities for sports and family activities (Hennebo 1979). The Dutch developed many parks in line with these principles, including The Zuiderpark, The Hague, a park of 110 ha dating from the 1920s, and the Amsterdamse Bos. Dating from the early 1930s the Amsterdamse Bos or forest-park, is situated 5 km from the city centre. This site of ca. 920 ha comprises 166 ha water, 416 ha woodland, with the remainder devoted to meadows, paths, cycle tracks, car parks and other infrastructure. Species planted were *Quercus*, *Fagus*, *Tilia*, *Betula*, *Fraxinus*, *Acer*, *Populus*, *Alnus*, and *Salix*.

In the work of Lamprecht Migge, who undertook several park designs in Germany in the years prior to the First World War, function began to create form, a change from the picturesque style of John Claudius Loudon in Britain and Frederick Law Olmsted in the United States. Planting was used to delimit spaces rather than to frame a series of views. From 1936 onwards a semi circular belt of parks was developed in the west of Copenhagen, known as the 'Nature Park' Utterslev Mose (Fig. 2.18) and Damhussøen.

Fig. 2.18. Utterslev Mose west of Copenhagen is part of a semi-circular belt of parks developed from 1936 (*photo:* J. Abel)

Together with the so-called 'Finger Plan', aimed at conserving/developing green 'fingers' or wedges between built-up areas, these provided a framework for conservation and development of green areas in the Danish capital (Jensen 1990).

Unlike many examples of new town development where tree planting followed the construction of houses and roads an example from The Netherlands reversed that custom. From 1978, as part of the overall master plan of the city of Almere-Buiten, a large-scale network of greenbelts was developed. It provided a framework for outdoor recreation facilities, schools and housing and a clear visual connection between the town center and greenbelts (Vroom 1992).

Wider Participation in Tree Planting

Prior to the late 19th century most tree planting was undertaken by landowners in their forests, private parks and gardens or by order of the monarch or government. In the late 19th century and early 20th century local people promoted the planting of trees in woodland and in city streets, and partnerships for tree planting involving local interest groups were set up.

Between 1897 and 1908 public beautification committees in Prague undertook major reforestation projects (Gerhold and Frank 2002). In Britain, the Midland Reafforesting Association was established in Birmingham in 1903. The aim was to encourage the planting of wastelands in the Black Country and other parts of the midlands. Two earlier restoration projects had been undertaken in 1810 at Wrens Nest and Castle Hill in Dudley, both of which are still in existence. The Association with some 300 members, issued pamphlets, organized lectures and tree planting in their own grounds, on council land and in school grounds. They saw that much land lay in waste and thought pit heads and spoil banks from mining were ugly. They realized that these sites would support tree growth, which in turn would provide profitable timber and increase the value of land. They also considered that the presence of trees was pleasant to the eye, refreshing to workers and improved the health of the district. By 1924, 40 ha had been planted on 32 different sites. Most sites were small but some were as large as 14 ha. The species grown at the time were alder, *Alnus glutinosa*, *A. incana*; poplar, *Populus* × *euramerica* 'Serotina'; willow, *Salix* spp.; elm *Ulmus glabra*; birch *Betula pendula*; ash *Fraxinus excelsior* and sycamore *Acer pseudoplatanus* (NUFU 2000).

The Roads Beautifying Association published 'Roadside Planting' in 1930 and the Irish Roadside Tree Association published 'Roadside Trees in Town and Country' in 1935. Both books were illustrated and outlined the function of trees in streets and country roads and their selection and planting and listed suitable species (Fitzpatrick 1935). These associations were willing to give advice to County Councils and other authorities about tree planting.

Development of Arboriculture and Urban Forestry

Arnold Foster (1948) in his book 'Shrubs for the milder counties' wrote about of the role of trees in the post war development of towns and countryside in the aftermath of the Second World War. In 1946 the United Kingdom Ministry of Town and Country Planning issued a circular to local planning authorities concerning tree planting along roads and streets in urban and suburban areas, an example of a government policy which supported urban tree planting.

Street tree planting was an issue brought to the attention of engineers in Britain and Ireland in the 1920s and 1930s. In 1928, Wm. Dallimore of the Royal Botanic Gardens, Kew, presented a paper on roadside trees to the Institution of Municipal and County Engineers. In 1934 the same Institution held a Public Health Congress in London. One of the speakers, Wm. Balfour (1935) presented a paper entitled 'Planting and Care of Roadside Trees' in which he discussed the planting, selection and pruning of trees (Balfour 1935).

Arboriculture as a discipline with associated educational courses developed in the 20th century. However in previous centuries there were several proponents of the subject. John Evelyn (1620–1706) an Englishman wrote 'Sylva: or a Discourse of Forest Trees' in 1664. This work was revised and reprinted several times. In later editions he concluded with 'some encouragements and proposals for the planting and improvements of His Majesty's Forests, and other amenities for shade and ornament'. He demonstrated an extensive knowledge of trees and their management. In 1828 Sir Henry Stuart differentiated the cultivation of individual trees for purposes other than fruit or timber; what became known as arboriculture. His 'Planters Guide' included recommendations about transplanting trees. (Campana 1999). John Claudius Loudon (1783–1843) was a horticulturist and publisher. His books 'An Encyclopaedia of Gardening' published in 1822 and his eight volume 'Arboretum et Fruticetum Brittanicum' described the cultivation of trees and shrubs in Britain and other parts of Europe in the early 19th century. The titles belie the breath of material in these books, including the areas of arboriculture, forestry and garden history.

In the 20th century professional associations for arboriculture developed such as the Arboricultural Association in the United Kingdom and International Society of Arboriculture. When links between arboriculture and other elements of green area management became more integrated, the concept of urban forestry emerged. Chapter 1 describes this development.

2.6 Conclusion

> Men seldom plant trees till they begin to be Wise, that is till they grow Old and find by Experience the Prudence and Necessity of it. When Ulysses, after a ten years' Absence, was return'd from Troy, and coming home, found his aged Father in the field planting Trees, he asked him why (being now far advance'd in years) he would put himself to the Fatigue and Labour of Planting that which he was never likely to enjoy the Fruits of? The good old man (taking him for a Stranger) gently reply'd: I plant (says he) against my Son Ulysses comes home.

These words of John Evelyn written in the early 17th century and quoted by Dawn McLeod (1972) in her book 'The Gardener's London' capture the affinity that people have had with trees from ancient times.

As more people continue to migrate from the rural to the urban environment, the urban dweller and municipal authorities must continue the example of Ulysses' father so that the 'treed' urban landscapes of our forebears described in this chapter will continue through the 21st century and beyond.

Acknowledgments

Ragnhildur Skarphéðinsdóttir, Nerys Jones and Klaus Seeland, colleagues in COST Action E12 Urban Forest and Trees are thanked for their useful information and helpful comments. The authors are indebted to Jette Abel and Karen Sejr for assisting in illustrating the chapter. The archives of the Royal Veterinary and Agricultural University (KVL) of Denmark kindly provided many of the illustrations used.

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Chapter 3

Urban Forest Resources in European Cities

Stephan Pauleit · Nerys Jones · Signe Nyhuus · Janez Pirnat · Fabio Salbitano

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

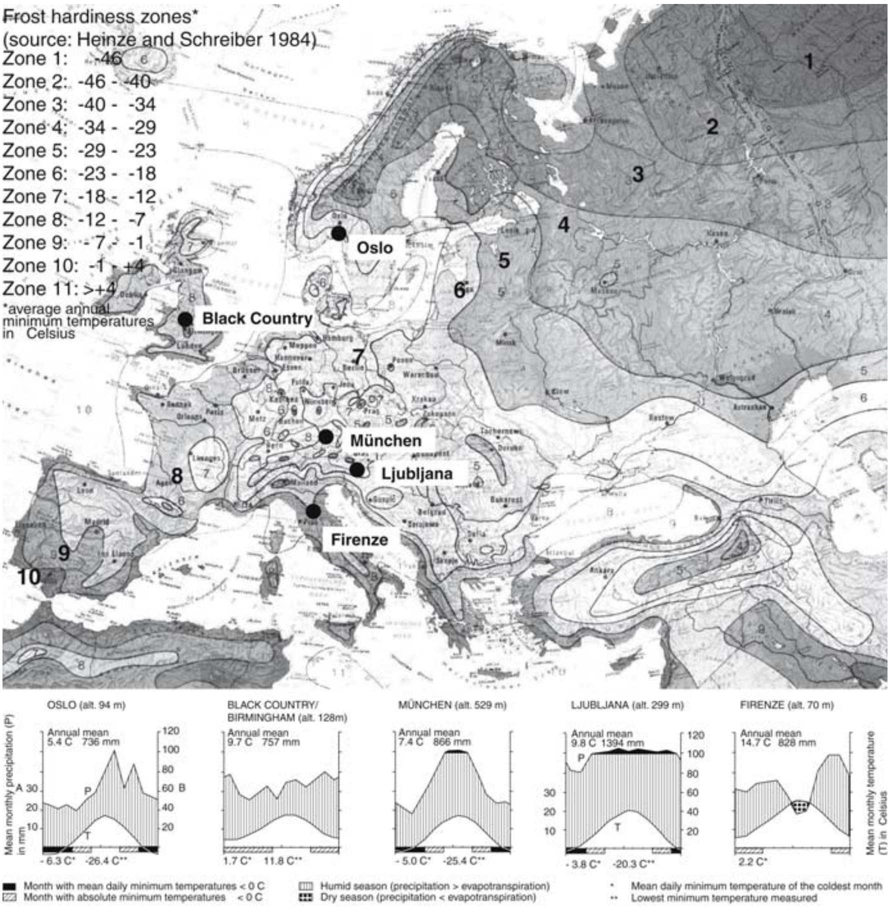

Fig. 3.1. Frost hardiness zones for urban forestry in Europe (based on Heinze and Schreiber 1984) and climate diagrams for the case study areas (Walter et al. 1975)

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).

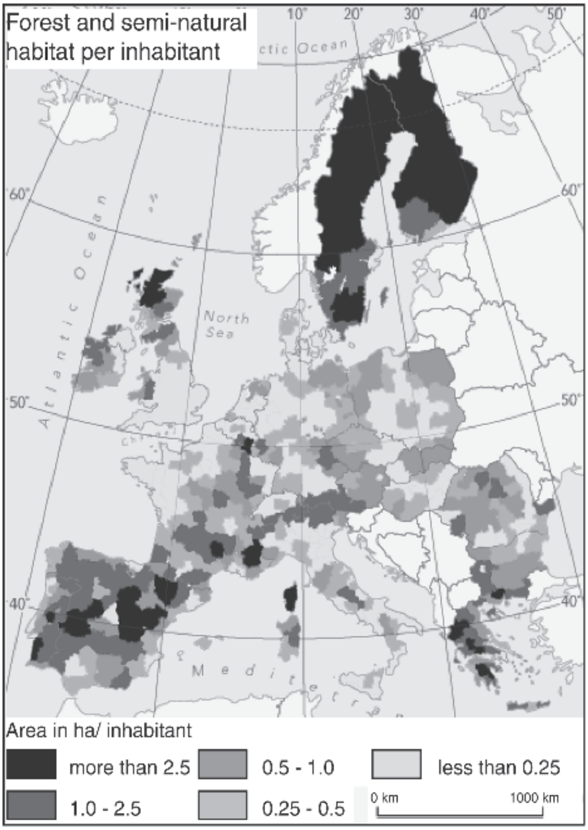

Fig. 3.2.
Per-capita forest provision in Europe (EEA 1999a)

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.

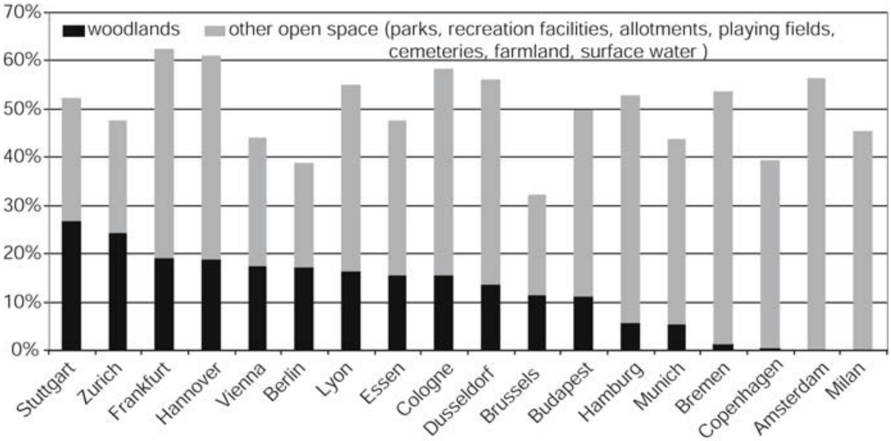

Fig. 3.3. Woodland and open space cover in European cities (Gälzer 1987)

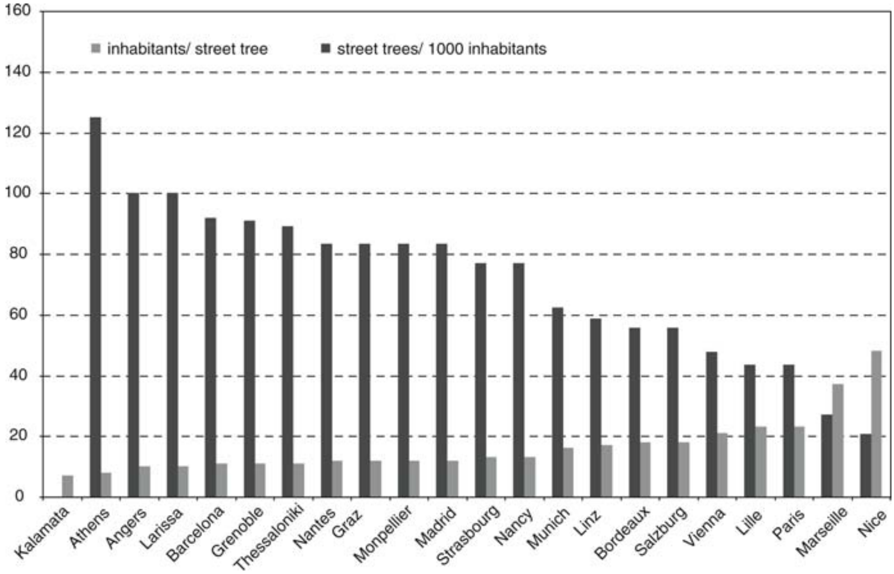

Fig. 3.4. The relation between street tree provision and population in selected urban areas in Europe (Pauleit et al. 2002)

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

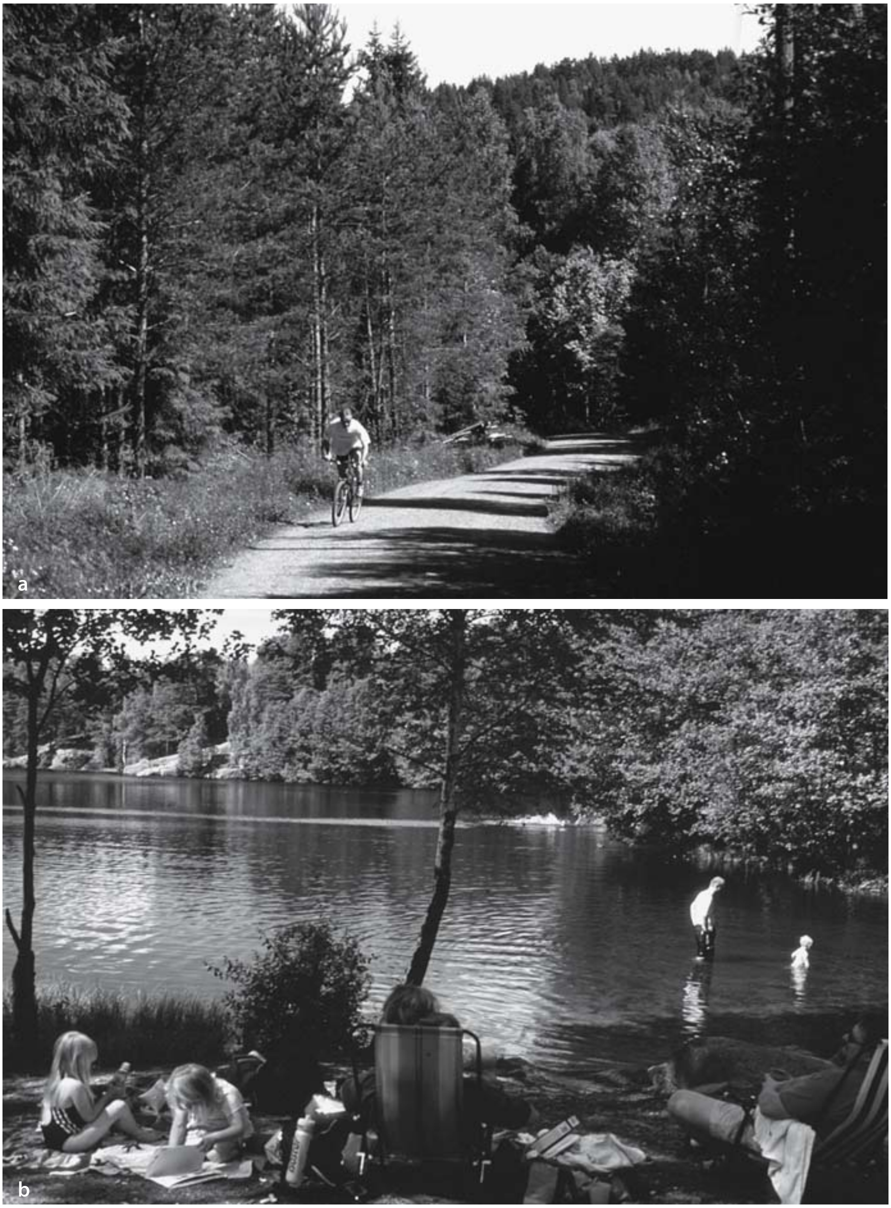

Fig. 3.5a,b. The large woodlands surrounding Oslo are intensively used for recreation (*photo:* S. Nyhuus)

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

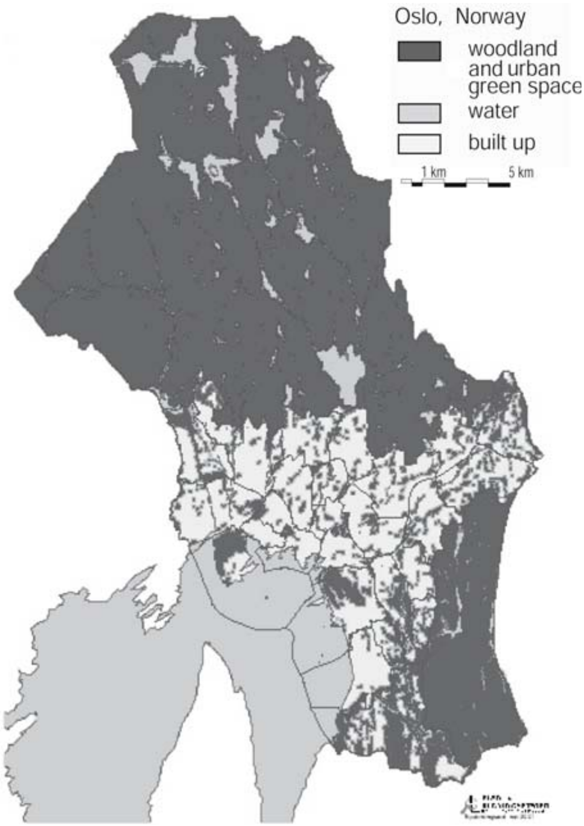

Fig. 3.6.
Oslo is strictly divided into two main categories: urbanized land and forested land. Note the green structure within the urbanized area (*source:* Municipality of Oslo)

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.

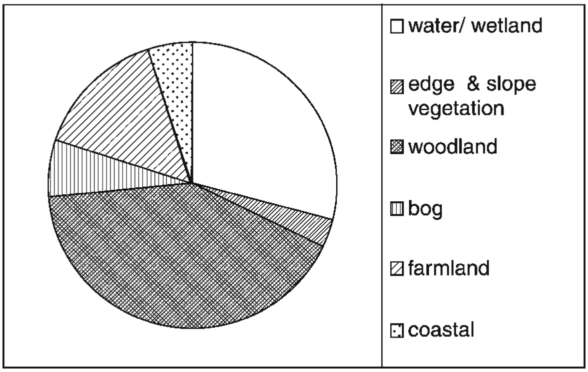

Fig. 3.7. The proportion of principal natural and semi-natural landscape types within the municipality of Oslo (*source:* Municipality of Oslo)

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

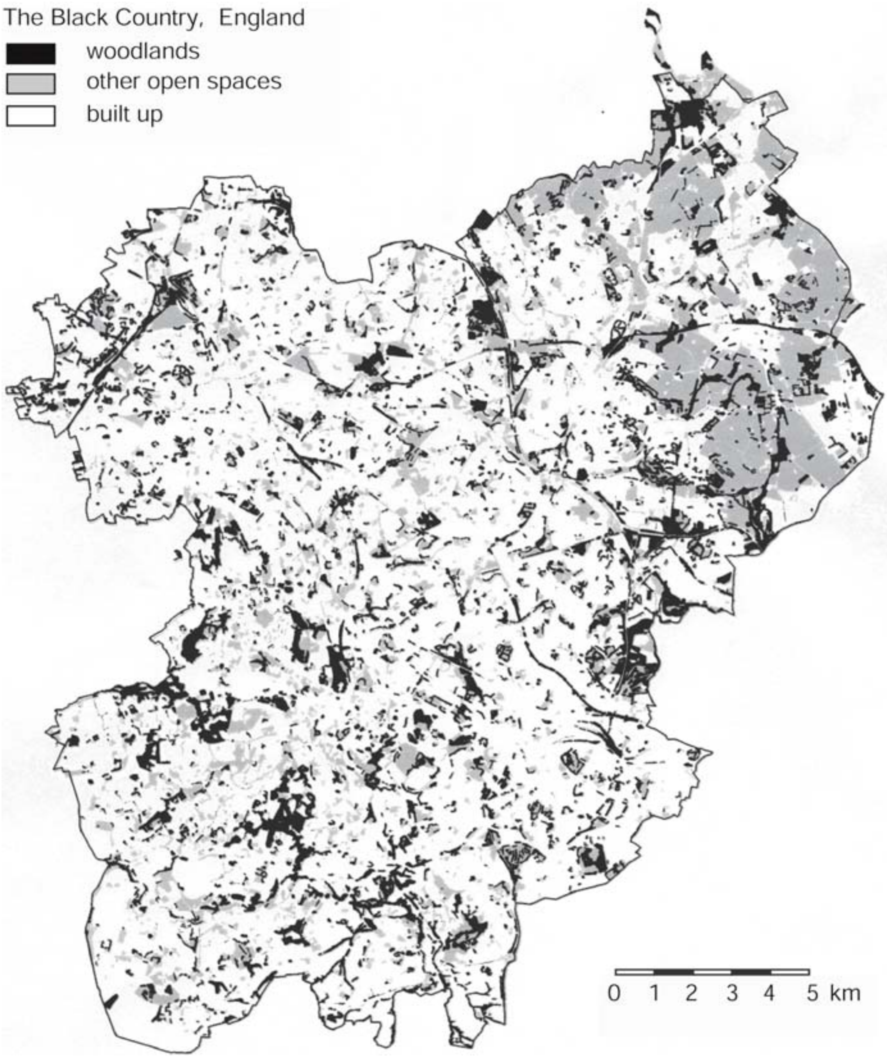

Fig. 3.8. The spatial pattern of the urban forest in the Black Country, England (Map provided by National Urban Forestry Unit, Black Country Urban Forest Millennium Programme)

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,

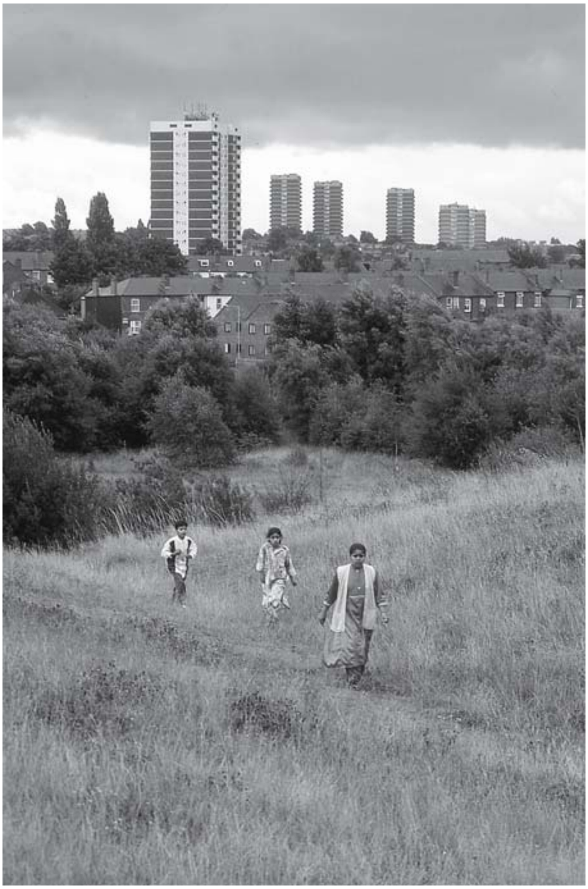

Fig. 3.10.
Children in informal landscape. Woodland close to home provides important recreational opportunities (*photo:* Woodfall Wild Images)

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-

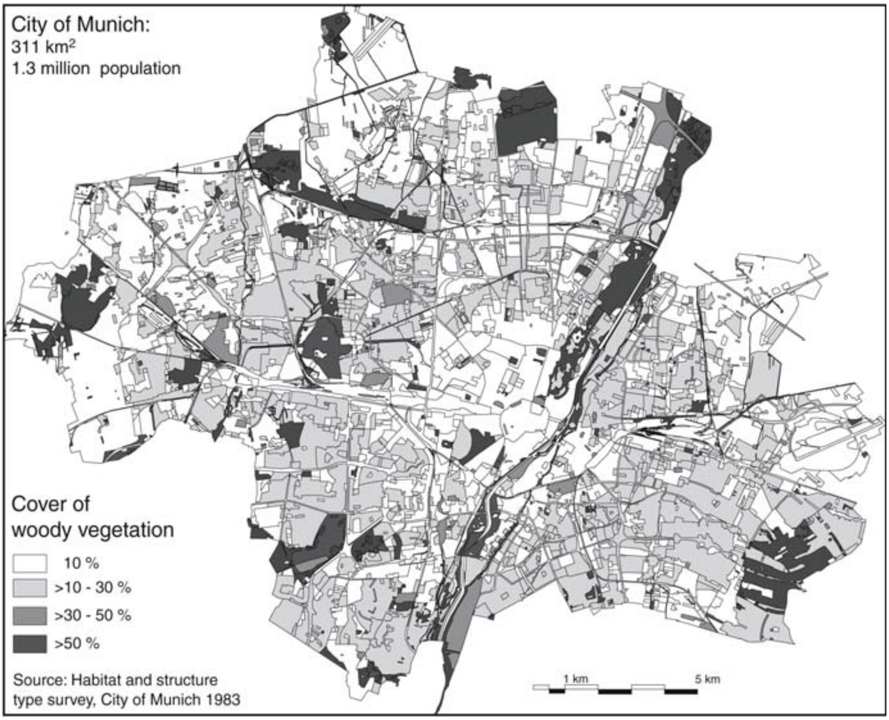

Fig. 3.11. The spatial pattern of the urban forest in Munich (City of Munich 1983)

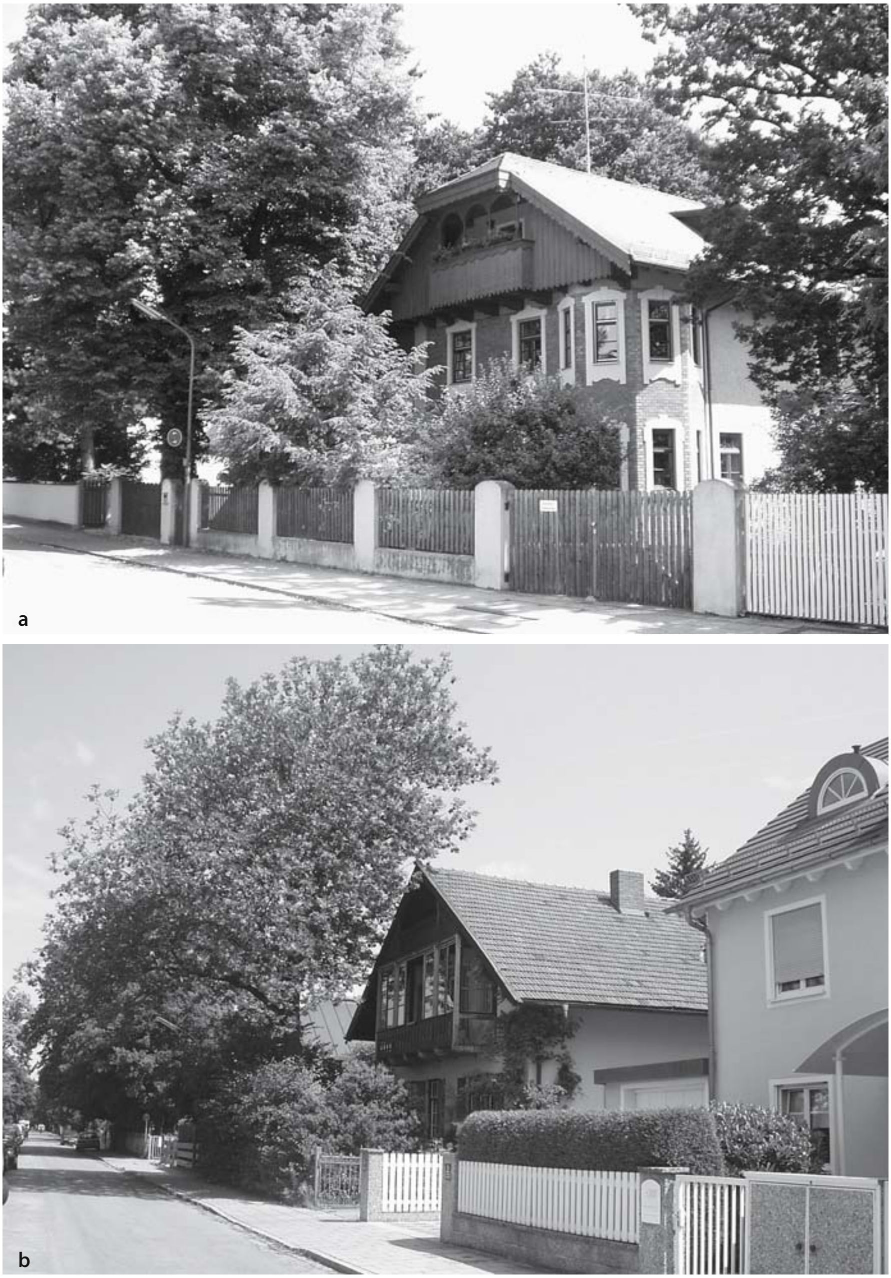

Fig. 3.12. Mature stands of trees in residential areas are an important element of the urban forest. They make a positive contribution to urban character and improve the environment (**a**). However, these trees are under strong pressure from infill development (**b**) (*photos:* M. Rauh)

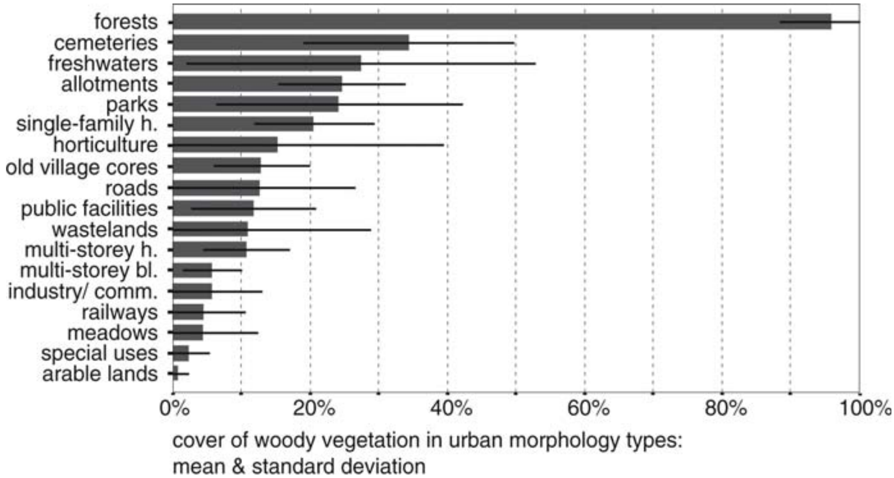

Fig. 3.13. Percentage cover of woody vegetation in urban morphology types in Munich (Pauleit 1998)

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).

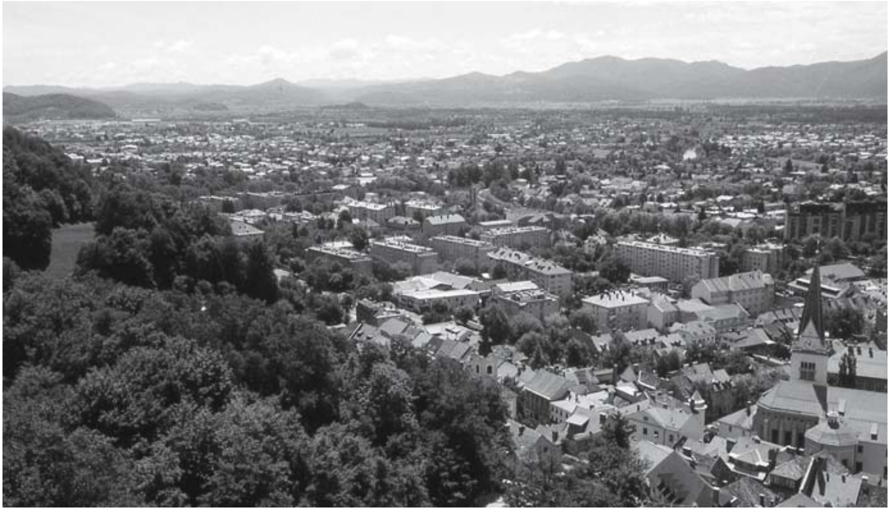

Fig. 3.15. View over Ljubljana: A woodland on a hill within the city in the foreground, extensive stands of trees within the settlement area, and small woodland fragments in the urban fringe (*photo:* N. Jones)

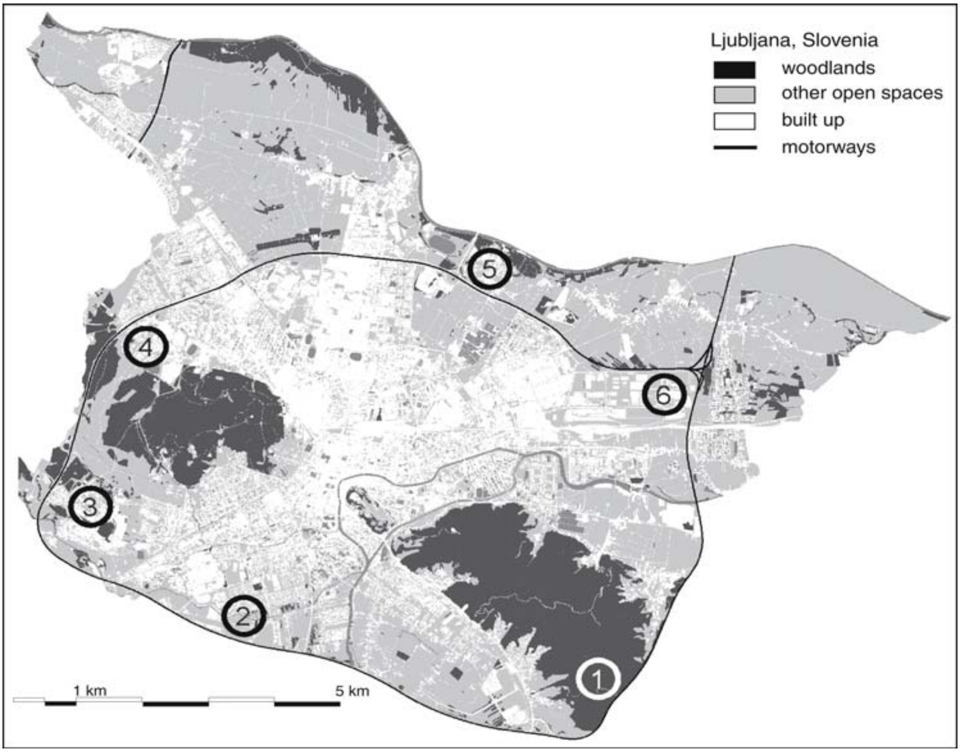

Fig. 3.16. The spatial pattern of the urban forest in Ljubljana (Pirnat 1997)

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 km^2 (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.

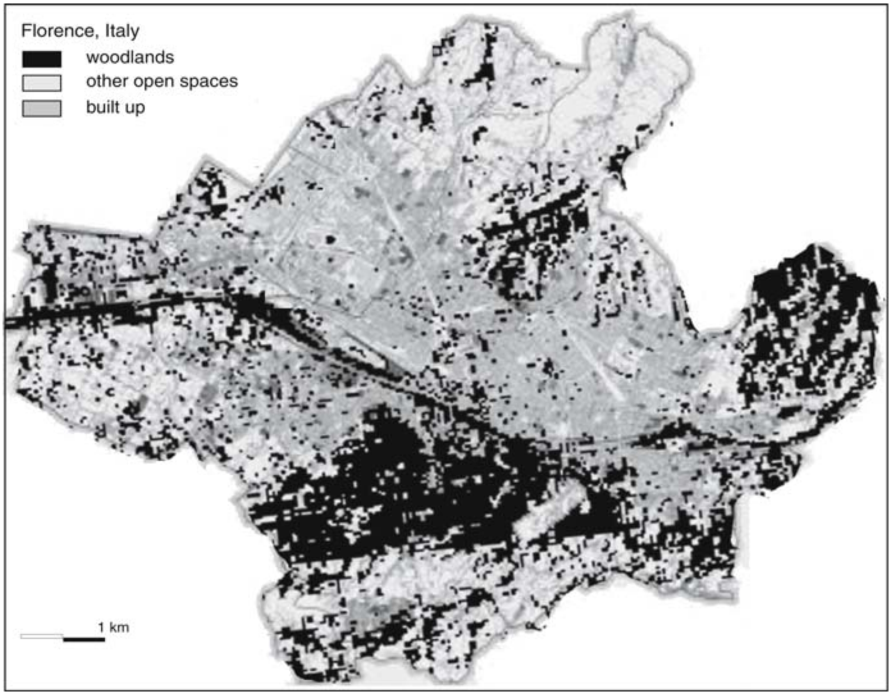

Fig. 3.18. The spatial pattern of the urban forest in Florence (F. Salbitano)

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:

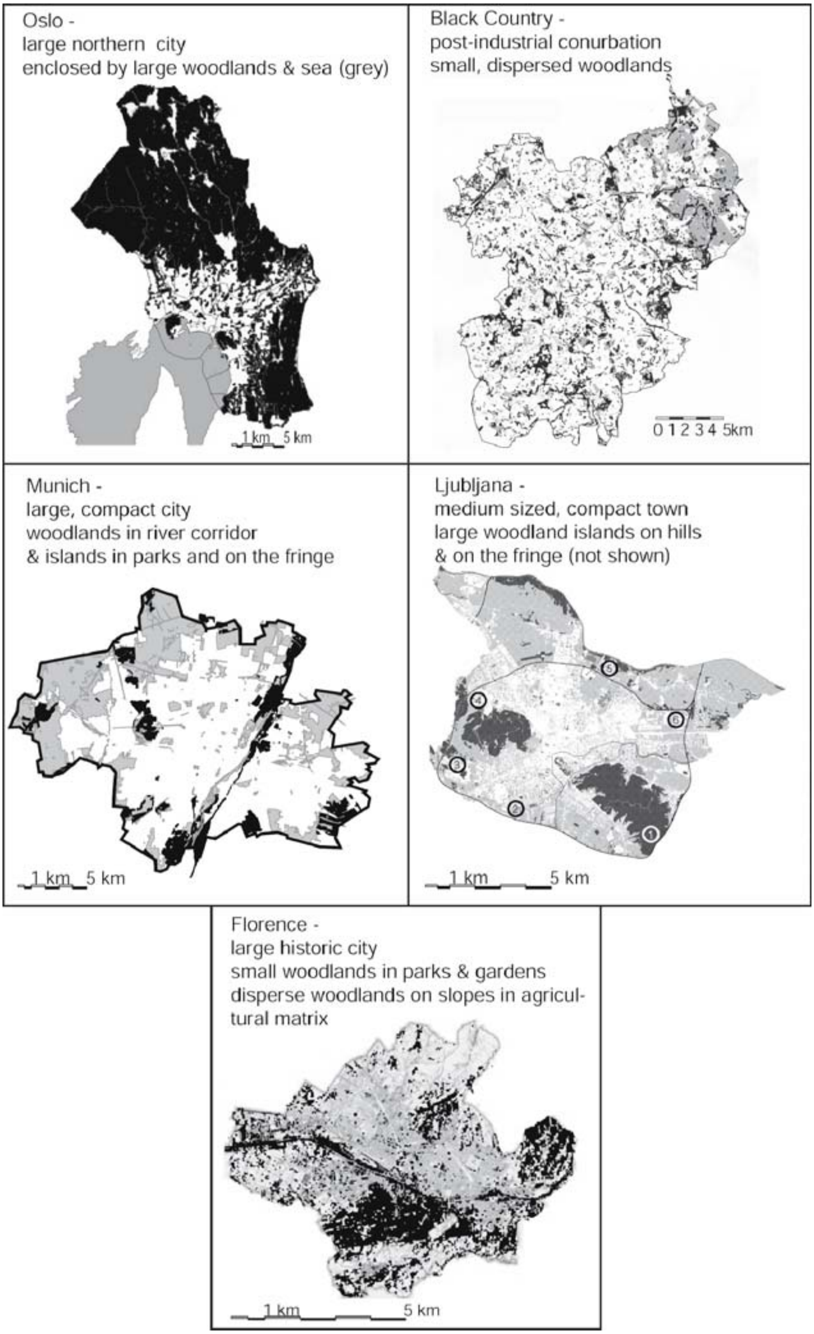

Fig. 3.21. Comparison of urban forest types of the case study areas: woodlands are shown in black, other open spaces in gray, built-up areas in white (F. Salbitano)

- 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.

Acknowledgments

The constructive comments of Drs. Kjell Nilson and David Nowak on a draft of this chapter are greatly appreciated.

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Chapter 4

Benefits and Uses of Urban Forests and Trees

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4.1 Introduction

Trees and forests are, because of seasonal changes and their size, shape, and color, the most prominent elements of urban nature. Their benefits and uses range from intangible psychological and aesthetic benefits to amelioration of urban climate and mitigation of air pollution. Historically the main benefits of urban trees and forests relate to health, aesthetic and recreational benefits in industrialized cities. Moreover, green areas have provided people with subsistence by providing food, fodder, fuel, wood and timber for construction (see Chap. 2).

Today, woodland, woods and trees are important to people especially through symbolizing personal, local, community and cultural meanings. They provide aesthetic enjoyment and create a pleasant environment for different outdoor activities. Woodland can provide an experience of nature in the middle of urban life. In particular, old woodland with big trees may provide urban people with the opportunity to recover from daily stress, revive memories and regain confidence. There is also an important educational value of urban forests. Contact with trees, in particular for children, can help people learn about nature and natural processes in an otherwise artificial environment.

Urban trees and woodland also contribute to an attractive green townscape and thus communicate the image of a positive, nature-oriented city. Indirectly, urban trees and forests can promote tourism and enhance economic development. At the local level trees contribute to the quality of housing and working environments and their benefits are reflected in property values. The same urban woodland areas and trees may have multiple benefits that reinforce each other. Recreational woodland, for example, also reduces wind speed and traffic noise as well as improves the landscape in a nearby residential area. To a certain extent the distinction between different categories of benefits is artificial. However benefits have their own special features and therefore can be presented separately (Table 4.1).

While these benefits of urban woodland, other tree stands and individual trees are not new they are still insufficiently recognised in urban planning and development processes (see Chap. 5). There is need to provide more knowledge on the role of urban woodland and trees in improvement of the environment and relate this to their social functions such as fostering mental and physical health.

This chapter aims to give insight into the current state of knowledge about benefits and uses of urban forests and trees in Europe. This is a difficult enterprise due to the complexity of the European continent. Urban forest research is largely national or even

Table 4.1. Benefits and uses of urban forests and trees (adapted from Tyrväinen 1999)

Social benefits	Recreation opportunities, improvement of home and work environments, impacts on physical and mental health. Cultural and historical values of green areas
Aesthetic and architectural benefits	Landscape variation through different colors, textures, forms and densities of plants. Growth of trees, seasonal dynamics and experiencing nature. Defining open space, framing and screening views, landscaping buildings
Climatic and physical benefits	Cooling, wind control, impacts on urban climate through temperature and humidity control. Air pollution reduction, sound control, glare and reflection reduction, flood prevention and erosion control
Ecological benefits	Biotopes for flora and fauna in urban environment
Economic benefits	Value of market-priced benefits (timber, berries, mushrooms ect.), increased property values, tourism

local, and results are often only disseminated in the national language (Forrest et al. 1999). Moreover, the benefits of woodland and trees can differ widely between European cities and towns due their different environmental and socio-cultural background. The recreational and aesthetic benefits are traditionally important especially in the Nordic countries, whereas the protective and climatic uses of vegetation are more emphasized elsewhere in Europe. Furthermore, while the use of trees to shelter from strong winds is an important issue in the north-western part of the continent, shading is a more important concern in hot climates, for example in the Mediterranean. In practice, management of the urban forest is a challenging task not only because of harsh growing conditions but also because of various, often conflicting, demands and goals. Therefore, this chapter will also address geographical and socio-cultural differences in benefits and uses between European regions.

4.2 Social and Aesthetic Benefits of Urban Forests and Trees

4.2.1 Urban Woodland and Parks As a Recreational Resource

One of the generally acknowledged functions of in particular urban woodland and parks is the provision of recreational opportunities. Urban green-space recreation was a genuine phenomenon of the mid-European bourgeoisie culture of the early 19th century. In earlier times, royal and aristocratic parks as well as urban woodland were used as deer parks and hunting grounds to display the splendour of court life. Tree alleys, promenades, malls and the king's way represented the power of the political system (Poëte 1913; Chap. 2). As well in countries with a long democratic tradition such as Switzerland, the role of trees, parks and alleys has been remarkable. In Calvinist Geneva, for instance, there was literally a tree cult from the 16th century onwards and spring was officially announced when the buds of a particular tree appeared and were seen by a state employee (Silva 1996).

The French Revolution put an end to many aristocratic privileges in all spheres of social life and citizens gained free access to parks and forests across the countries. During the Napoleonic wars and in the era of political restoration, the lifestyle characterized by bourgeois values was spread all over mainland Europe. This also paved the way for outdoor recreational use that had so far been unknown. Industrialization led to a massive transfer of labor from the agricultural sector to the newly established centers of industry and mass production. Insufficient hygiene, poor housing conditions and long working hours were major threats to millions of people who had either no access to, time for or interest in green-space recreation (see also Chap. 2).

Only in the late 19th century and in the first half of the 20th living conditions of the urban working class improved. A sports and outdoor movement emerged that used urban green space for recreation. Leisure time, being once a luxury good of the upper class, became more common among other social classes. The formal separation of a person's life time into working hours and leisure time made recreation an explicit social demand. The provision of green space in and around cities became a representation of middle class values. Its design and function became an attribute of urban culture itself and were spread all over the globe. In the post-industrial era of the late 20th century, parks with a postmodern design emerged in large central European cities like Zurich. This has been a remarkable trend as the municipal area of Zurich has a green-space cover of no less than 43%, even with real estate prices higher than the average in central Europe.

Today, outdoor recreation is a type of activity many people participate in, all across Europe. Participation in the most common recreational activity, walking, stands at about 81% in Finland (Pouta and Sievänen 2001) and 74% in The Netherlands (Statistics Netherlands 1997). Many of these recreationists have considered natural environments more attractive as activity settings than built-up areas. Among natural areas, forests are considered one of the more attractive types of nature. In Italy, 96% of the population participates in recreation activities involving the forest (Scrinzi et al. 1995). In Denmark, this proportion is about 91% (Jensen 1999). There are, however, large regional differences in the supply of forests in and around cities. For example, in Finland forests cover about 86% of the land areas and they are also the prevailing type of urban green area, whereas in The Netherlands forests cover only 10% for the total land area. If we look

Fig. 4.1.
Recreationists in the Helsinki urban forest (*photo:* City of Helsinki, Environmental Centre)

at the amount of forest per capita, the differences become even larger: 51 000 m^2 in Finland versus about 220 m^2 in The Netherlands (Sievänen et al. 2000). The attractiveness of forests as a recreational environment is also evident from the distance that people are willing to travel to visit a forest. According to Scrinzi et al. (1995), Italians travel about 32 km (single distance) to a forest visit. This is about the same distance that residents in the western part of The Netherlands – the most urbanized and "forest-poor" part – travel to their most often visited forest site (De Vries 2000).

Accurate information on the actual level and type of recreational use of forests is still relatively scarce for most countries. In Italy a first national study was carried out in 1995 (Scrinzi et al. 1995). For the German-speaking countries a review study including articles from more than 60 periodicals in forest sciences gives a good overview for the period between 1960 and 1995 (Schmithüsen et al. 1997). Moreover, an overview of the recreational use of forest in the Nordic countries has been provided by Jensen (1995). Participation frequencies derived from interviews or mail surveys may not always coincide with figures obtained through observations of actual forest visits; in retrospect respondents tend to exaggerate the number of visits they have made to forests (Jensen 1999). In Denmark, the average annual number of forest visits is somewhat less than 40 times before correction, and about 13 times after correction. In Italy the average frequency of visits is only four times a year, however, the average duration of a visit is almost four hours. Finland scores much higher with an estimate of between 72 and 110 visits per year. The duration of a visit is usually from half to one hour (Tyrväinen 1999). It is unclear to what extent this high frequency is due to the abundant supply of woodland in Finland or caused by different measurement methods. Therefore, more systematic research and international comparisons are needed.

In urban forests walking tends to be the most common recreational activity. Other common activities are cycling, jogging, picnicking as well as picking berries and mushrooms (Fig. 1). However, there exist clear differences between European countries. Cycling within forests is not that common in Italy. Picking berries and mushrooms is relatively infrequent in Dutch and Danish forests, while cross-country skiing in winter is very common in Finland, Sweden and Norway. These differences are related to the recreation possibilities that the nearest forests in one's environment offer, in combination with the forests' proximity. Using a forest environment for daily physical exercise takes place only if such an environment is available nearby (Tyrväinen 2001; De Vries and Goossen 2002).

Experiences that are sought after are predominantly enjoying the natural scenery, and peace and quietness. On a scale from wilderness to developed natural areas, forested areas tend to be located closer to the developed side, although still less developed than urban parks. This is partly a consequence of proximity to a large concentration of inhabitants. If open to the public, recreational use tends to be rather intensive. The Dutch State Forest Service suggests approximately 1 000 visits ha^{-1} yr^{-1} to be common for this type of forests. This implies that there are likely to be other people present during one's visit. Although this is not likely to contribute to experiencing quietness, forests have a relatively large 'social capacity' per hectare, i.e. because of the trees there can be many people present without the area feeling crowded. This makes forests a relatively efficient type of resource for nature-based recreation, compared to for instance agricultural areas. The perception of crowdedness obviously also depends on visitor expectations. Although many urban forests are unlikely to be selected as a destination for the opportunities they offer with regards solitude, during some days and time points they might actually provide this experience. However, people's recreational motives vary and different user interests often lead to conflicts. For example, those who want to go for a walk in a quiet and natural environment may feel disturbed by others, who pursue hobbies such as horseback riding and mountain biking (e.g., Seeland et al. 2002).

A rapidly growing segment of the population in many European countries consists of ethnic minorities. Often very little is known on their desires and use of urban green space. Language problems have frequently prohibited their participation in surveys, unless special measures are taken. In the few studies that are available, Dutch ethnic minorities (predominantly people from Turkey, Morocco, Suriname and The Netherlands Antilles) appear to be more focused on recreation in urban green areas than in the countryside (e.g., Jókövi 2000). The social aspect of recreation, being together with family and friends, seems to be more important to them than to the indigenous population. The common Dutch activity of bicycling is less popular among the people from these ethnic minorities. However, the composition of this segment is rapidly changing, due to the large influx of asylum seekers originating from different countries. It is even less clear what the needs and desires of these new groups will be regarding urban greenery and outdoor recreation.

From social demands regarding the type and amount of forests it seems to be only a small step to demands based on ecological motives such as conservation and biodiversity. Most visitors appreciate the idea of the naturalness of an urban forest, and the importance of ecological management has increased during the past decade (Tyrväinen et al. 2003). However, the relation between the ecological and the social function is not a simple one. On the one hand, appreciating nature may lead to increased support for ecological goals, but on the other hand, recreational usage may endanger fragile ecosystems. To many people, however, rare animals and plants are not especially important in selecting a destination area. Some people will not even pay attention to or recognise them during the visit. Environmental information and education, however, can increase the awareness of residents and help them appreciate urban flora and fauna. Furthermore, people like to have easy access to the forest, whereas ecologists prefer to minimize disturbance. For urban forests the primacy of the social function is essential. By offering people ample and high quality recreation opportunities nearby, they will be less inclined to visit ecologically fragile environments located further away. However, even for urban forests with a predominantly social function, some ecological preconditions have to be taken into account, to provide a sustainable recreation environment.

4.2.2
Health Benefits of Urban Forests and Trees

Urban forests and trees contribute to a better quality of living environment in cities, for example by improving air quality and consequently the health of urban residents. The leaves of trees can take up many pollutants, e.g. ozone, nitric acid vapor, nitrogen dioxide, ammonia, sulfur dioxide and particles (aerosols and dust). Some of these pollutants can cause serious health problems. Trees also provide valuable shading from the sun. An individual tree can provide a Sun Protection Factor (SPF) of 6 to 10, which means a level of exposure to ultraviolet radiation of one sixth to one-tenth of full sun (NUFU 1999).

There are also other ways in which urban forests may improve public health. By offering an attractive environment for recreational activities, urban forests may seduce people with a sedentary life style to become more active during their leisure time. Activities such as recreational walking and cycling already have a positive effect on one's health. It has indeed been shown that more green space within the living environment leads to people visiting natural environments more often (e.g., Grahn and Stigsdotter 2003). However, a higher number of visits to green areas does not necessarily mean that these people are more physically active. For example, people living in a less green environment may still walk often, but do so more frequently in a built-up area.

Nearby urban forests and parks are especially important for elderly and young people who are restricted in their capacity to move. The most active users of neighborhood forests are probably children. There are also programs that try to stimulate people to become physically active within the local natural environment, for example in the United Kingdom (Ashcroft 2002). When they do go for a walk, a lack of nearby nature-based opportunities tends to increase the number of people using a car and subsequently leads to driving longer distances to visit an attractive natural area (De Vries 2000). The key factor for active use is easy access to the areas, preferably within walking distance from home. In a survey study in Salo, Finland half of the respondents noted that the main reason for not using urban recreation areas was the distance (Tyrväinen 2001).

An important positive effect of natural scenery on health is its stress reducing effect. Research similar to original studies in the United States (Ulrich et al. 1991) has led to similar results in Sweden (e.g., Hartig et al. 1996). Just visually experiencing a natural setting reduces stress. Stress relief, as measured through muscle tension, blood pressure and electrical brain activity, can be demonstrated within some minutes of exposure to a green environment (Ulrich et al. 1991). Moreover, viewing or visiting natural environments (compared to built urban environments without natural elements) after stressful or mentally fatigued situations, produces greater physiological changes toward relaxation and faster recovery of attention-demanding cognitive performances (Parsons et al. 1998). Research has shown that even quite ordinary urban green areas have a stress-reducing influence in everyday life. In Sweden, Grahn and Stigsdotter (2003) demonstrated that the more often one visits green areas the less often one reports sickness from stress.

It is unclear to what extent the mechanism behind this restorative effect is evolutionary in character and/or cognitively mediated. As a consequence, also very little is known about how to design and maintain urban green spaces in such a way as to optimize their health benefits. A high aesthetic quality may not be required for a stress reducing effect, but might be helpful to attract people to the green area. One precondition, however, is quite generally thought to be important for restorative effects: safety. The (assumed) presence of dangerous others will diminish positive health effects. As mentioned before, common motives for visiting forests are experiencing solitude, peace and quietness. These qualities may also be conducive to the stress-reducing effect. However, crime statistics, for example in the United Kingdom, show that physical attacks are rare in woods, and that such concerns are often based on perceptions rather than reality. One of the key factors for security is visibility, which requires active management of the understorey, and giving the impression that the area is controlled (Tyrväinen et al. 2003).

Another possible mechanism relating nature to health is that of social interaction and cohesion. While European research in this topic is still scarce, several studies conducted in Chicago, USA suggest that green space, especially trees, may help to facilitate (positive) social interaction with neighborhood members (Kweon et al. 1998). This is suggested to reduce feelings of social isolation, which is a risk factor related to depression. Although it is still unclear what are the most relevant mechanisms behind the health effects, recent Dutch research has shown that the relationship between the amount of green space in the living environment and self-reported health is positive, even after controlling for relevant socio-demographic and socio-economic characteristics (De Vries et al. 2003).

4.2.3 Social Potential and Trends in Urban Forest and Tree Benefits and Uses

Nowadays, different sections of urban society tend to share more collective values regarding sound management of the environment, including the importance of green space for the well-being of growing urbanized societies. Ongoing social change and increased pressure on the different types of green spaces is a challenge for traditional concepts of maintenance. Conflicts and maintenance problems have developed during recent decades due to a lack of information about the social needs and expectations of various user groups. Due to this limited knowledge, urban greening projects are often designed according to architectural and aesthetic standards which have little reference to the local population with its specific needs.

The demographic development in the service-oriented societies of central and other parts of Europe shows a trend towards further urbanization, a remarkable increase in the number of elderly people and groups with special demands for a certain social infrastructure (e.g., disabled people, asylum seekers, unemployed people, drop-outs, and so forth), a decreasing tolerance to car traffic, and a desire for close-to-nature recreation in or near cities. With regard to these trends, the need for detailed information on urban woodland, parks and trees on public and private land will only increase. The key issues related to the future benefits of urban forests and trees include what is demanded and perceived by whom from urban green spaces, and to what extent and how green spaces could be preserved in and around cities during modernization of cities.

Beautification of the city with gardens and parks for the sake of an image of splendour and generosity was an important aspect of greening cities throughout the feudal and bourgeoisie eras. To have one's recreational needs served within the living environment was a privilege of only few and closely connected with the location of housing quarters. With an increase of urban population and particularly the middle class, entertainment, sport and recreation went along with a daily or weekly visit to urban green space to counterbalance stress and compensate for the lack of private home gardens. Large private parks in the core cities were often opened up for public use and thus a democratization of green space private property became widespread all over central Europe.

Today, event-culture is provided where attractive entertainment is expected; and this applies to the media as well as to open-air events in public green spaces. What common access meant to the middle and lower classes of an emerging urban society in the 18th and 19th century has become a rising public demand for fun-parks and entertainment facilities at the beginning of the 21st century. Apart from dense networks of paths and other recreational infrastructure, there are often special attractions in urban forests such as zoos, amusement parks and platforms for open-air concerts. Green space with related amenities and social and cultural services to make it more attractive seems to be the demand of today and probably even more for tomorrow.

Although a close-to-nature living environment seems to be a desire to many people, at the same time cities and towns have become more compact. Migration studies (e.g., Willaert 1999) point out a steady flight from Flemish cities with relatively low amount of green areas, especially since the late 1980s. Also in sparsely populated countries such as Finland, nature and peaceful environment attract people from urban areas to more rural surroundings. Compact city policies and 'infill' in existing housing areas has resulted in an increasing demand for land within city limits and demands to build on land allocated to green spaces. This means decreasing amount of green spaces within the easy daily access for residents as well as increased use pressures on the remaining green areas, which often leads to overuse, congestion and the depletion of nature.

In general, as lifestyles in Europe have become more urban, the demands for urban woodland and trees become more diverse. Although urban forests are places for social contacts and bringing people together, at the same time many users are looking for solitude and peace and quiet. Moreover, awareness of the importance of ecology and preserving urban biodiversity is increasing among the residents. Compact city policies, however, provide less green areas resulting in decreased possibilities to maintain natural vegetation in urban areas. In addition, parallel to traditional ways to use urban nature, more adventurous and active forms of recreation have increased including mountain biking, skateboarding, survival games and paintball. In this respect, the social carrying capacity of urban open green areas depends on the type of use.

In conclusion, public green spaces have multifunctional purposes such as those mentioned above practically all over Europe. There is an increasing need to define and promote the socially integrative potential of woodland, parks and trees and to integrate people with specific needs and demands, deriving from their social status age, gender and ethnic background (German-Chiari and Seeland 2004). Due to an increase in the multicultural set-up of urban populations in the wake of European political integration and the influx of non-European immigrants and asylum seekers, and the increment of the number of singles among the urban population because of the fragmentation of families, socializing on the occasion of urban outdoor events (e.g. open-air concerts, summer festival weeks etc.) gains momentum. To meet people outside their homes and working places has always been a major purpose of urban green spaces. Be it urban woodland, parks or trees, there tends to be fewer differences and more commonalties in globalizing societies. Public green space offers a great opportunity for all sections of an urban society to meet in an arena that can be designed and used in a participatory way to benefit all. Public, open green space matters the more where informal social conventions increase. This trend of social inclusion among the younger urban generations is perhaps a counter-current to more and more cyber-based forms of communication and access to reality.

4.2.4
Architectural and Aesthetic Benefits

Architectural benefits deal with the use of vegetation in urban planning and development (see also Chap. 6). The main purpose of trees and forests is to improve and to restore constructed townscapes. Vegetation is used in defining open space and inte-

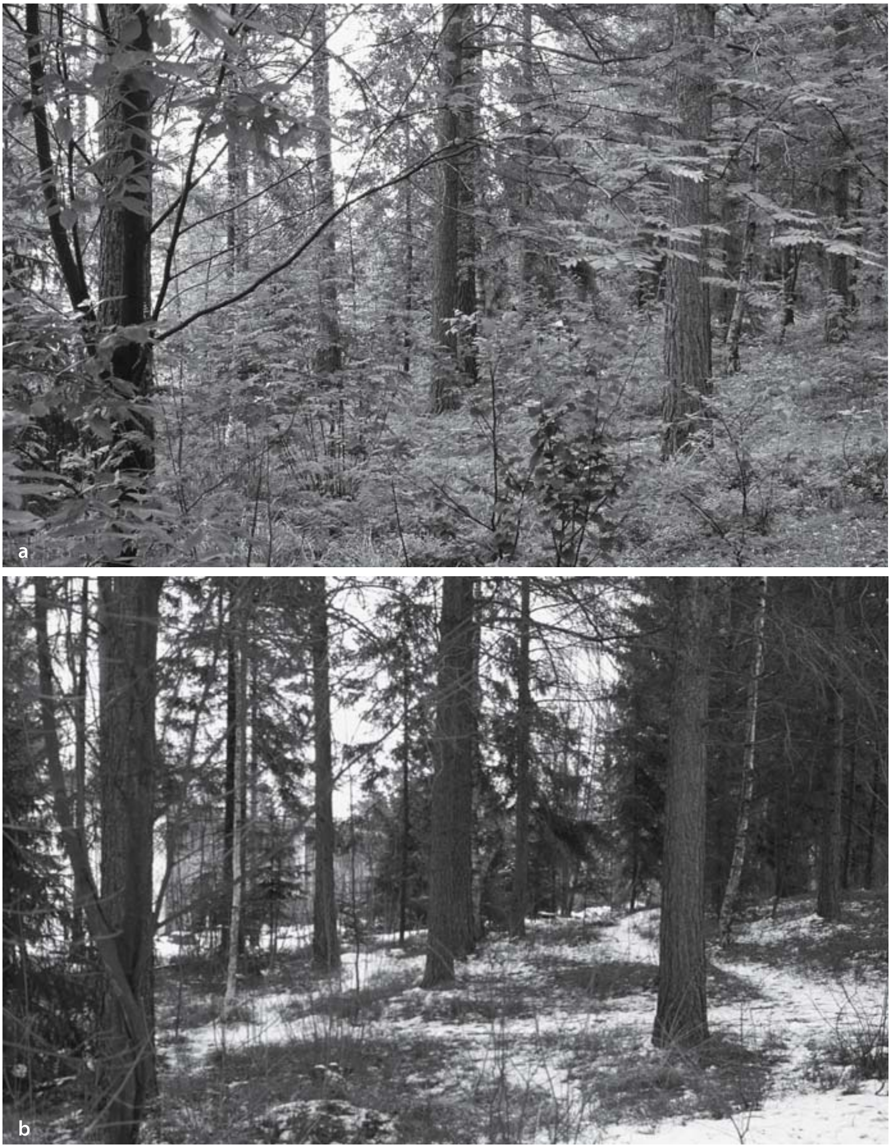


Fig. 4.2a,b. Seasonal variation in urban forests (*photos:* E. Oksanen, Metla)

grating the buildings to the surrounding environment. According to Robinette (1972) plants form walls, canopies or floors of varying heights and densities; these are architectural characteristics. Landscape variation is created through different colors, textures, forms and densities of plants. Urban trees can direct vision, break up large spaces, and define space. They can be used to frame scenes and to provide foreground and backgrounds for landscape features.

Aesthetic benefits relate to people experiencing different colors, structure, forms and densities of woody vegetation (Fig. 4.2). Much of the aesthetic experience is subjective in nature and has impacts on people's mental and emotional state (e.g., Kaplan and Kaplan 1989). Even a single tree carefully placed can make an important contribution to the aesthetic quality of the location. A great deal of the consumption of amenities occurs indoors through a window or from a car or bicycle. Visual variation is often stressed as being a key factor for aesthetic experiences (e.g., Axelsson-Lindgren 1995).

In landscape research there are many different research paradigms dealing with aesthetic values including psychophysical, cognitive (psychological), experiential (phenomenological) and expert approaches (Zube et al. 1982; Daniel and Vining 1983; Lothian 1999). These different research approaches produce different type of information for design and management of urban forests. The psychophysical and expert approaches provide information more easily applicable for practical purposes than other approaches. Psychophysical research has tried, first and foremost, to analyze and rank the preferences of people related to various types of urban forest environments (Daniel and Vining 1983; see also Karjalainen and Tyrväinen 2002). The cognitive approach (Kaplan and Kaplan 1989) has provided a framework for preferences and their links to cognitive aspects of the environment. The most common concepts derived from this knowledge base applied in practical planning guidelines in urban woodland have been diversity, scale, visual accessibility, stewardship, naturalness-continuity and coherence (Ode and Fry 2002).

In preference research aesthetic values are thought to be linked to the evaluation context as well as respondents' characteristics such as education, recreational activity, nature relationship, age and gender. Preference studies mainly from North America have shown that attitudes towards the wooded environments differ between children, teens and adults (Kaplan and Kaplan 1989). Youths appreciate the wild, dense, and hidden forest more than cultivated and open forest. Moreover, adults and children appear to value open-forest landscape more than dense forest. For children, structurally diverse natural places have been stressed as being more inspiring and imaginative, even compared to a well-organized playground (Kaplan and Kaplan 1989; Grahn 1997).

The visual quality of urban forests and people's preference can be examined through various approaches. Verbal information has been shown to have an effect on people's acceptance of various management actions in a recreational forest area (Jensen 1999). The main part of aesthetic perception occurs through the sense of sight and therefore, visualization of landscapes is a central part of forest landscape perception and preference research. Today digital image editing (Fig. 4.3) and in the future virtual landscape simulators offer the most sophisticated means of visualization for landscape research (Karjalainen and Tyrväinen 2002).

People's within-forest landscape preferences correlate strongly with the characteristics of the forest stand. People prefer stands of tall trees, but the preferred tree spe-

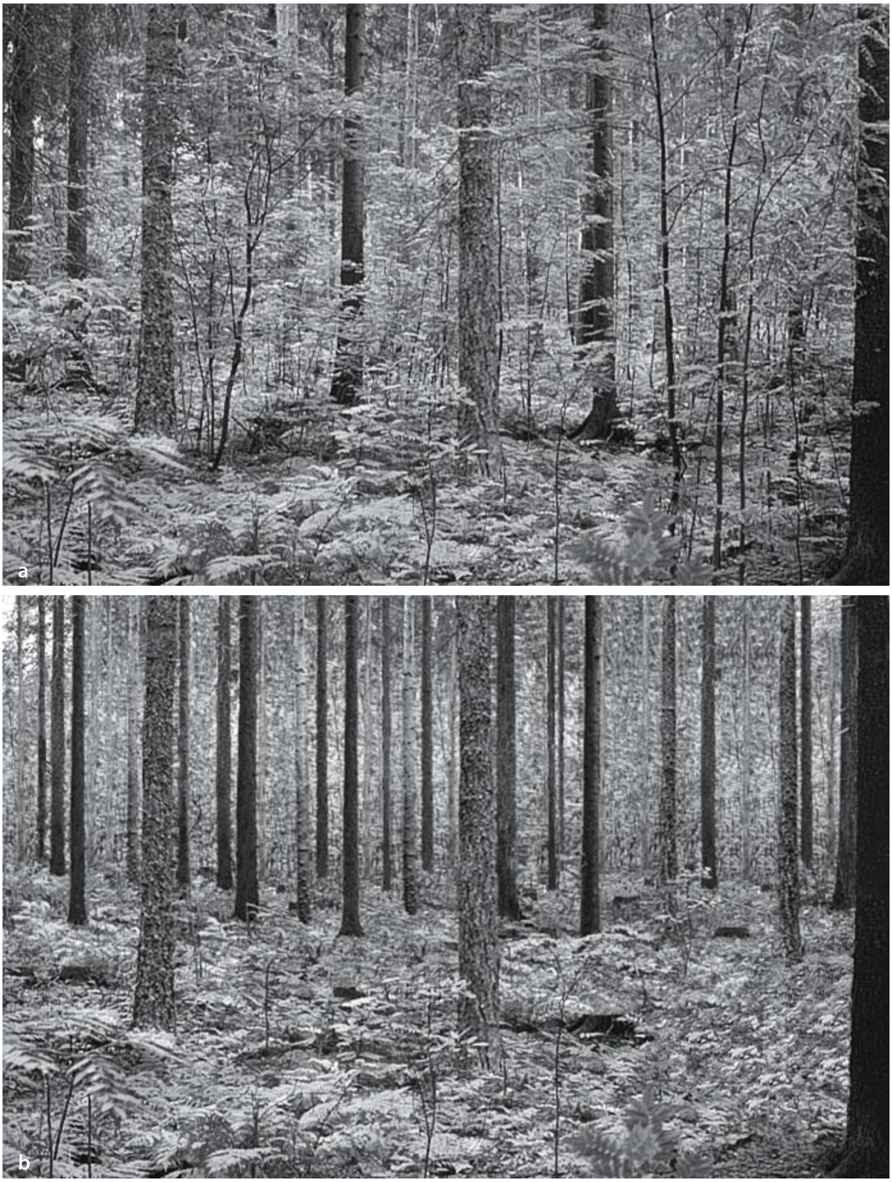


Fig. 4.3a,b. Pair of slides produced by photo manipulation illustrating different management options (*photos:* E. Oksanen, Metla)

cies relate to the specific geographical region in question. In Finland, for example, the most appreciated species in woodland are Scots pine (*Pinus sylvestris*) and silver birch (*Betula pendula*). Furthermore, in urban woodland the within-forest visibility should be relatively good. In general, old and mature forest stands are preferred over young and small trees, but small trees, if they form the lower canopy layer of a two-storey stand, are considered to improve the aesthetic value of the stand. Variation is greatly appreciated, not only due to mixtures with other types of trees, but also combination of trees with fields, meadows and, in particular, water elements (Schmithüsen et al. 1997). In particular, forest edges, which are many in urban settings, are essential for human aesthetic experience and visual perception. A well-designed edge consists of mixture of bush and tree species, which have not only aesthetic but also ecological importance (Lucas 1991).

Moreover, the aesthetic valuations may partially change over time and are influenced by trends, cultural system and knowledge. Studies on forest management preferences show that regeneration, in particular clear-felling, is visually the least acceptable management practice (Ribe 1989). Thinning treatments affect the stand's scenic beauty less than regenerative cuttings. Moreover, the length of time since the treatment has been found to correlate positively with the stands' visual quality (Silvennoinen et al. 2002).

An increasingly important question is whether people find managed forests more attractive than unmanaged ones. Previous forest preference studies conducted mainly during the 1980s suggest that residents prefer managed forests if traces of human activity are not visible. Although both types of results exist, many studies suggest that areas that are thought to be in a natural condition are perceived to be more beautiful than if traces of human activity are visible (e.g., Axelsson-Lindgren 1995). Furthermore, logging residues, dead snags and decayed wood left in the forests are not appreciated. Today, the importance of ecology has increased and values related to woodland are more conflicting than earlier (e.g., Seeland et al. 2002). On the one hand, management is needed because of security aspects and aesthetic reasons, while on the other hand there is an increasing demand for unmanaged areas based on ecological arguments.

In practice, preferences for urban forest management may be rather different among user groups. In a study in Helsinki, Finland, the majority of residents preferred managed forests probably because of security and cultural reasons (Tyrväinen et al. 2003). The most disliked stands were unmanaged forest vistas where young coppice limited sight and accessibility. In general, residents also disliked dead or decayed trees left in the forest. However, younger, higher educated residents and active urban forest users preferred more ecologically-oriented management compared to older, less-educated residents and less active users. Also, housing type was connected to the preferences of urban forests. Residents living in one-family or terraced houses preferred to have managed forests more than residents living in blocks of flats (Tyrväinen et al. 2003).

Forest landscape preferences have a strong cultural dimension. Nordic residents have a relatively abundant supply of woodland within their living environment, but in many densely populated countries in central Europe the daily contact with natural woodland is less frequent. In a study conducted in Redditch, United Kingdom (Coles and Bussey 2000), open structure woods were found to be preferred over woods with a dense canopy cover, in particular because of security concerns but also as open woodland offers a more varied environment. Interviews revealed that escape from urban life and activities was considered the most important motive to visit a wood, in order to seek a sense of tranquillity. Whether the woodland was a plantation or a natural woodland did not appear to matter. Woodland visitors described "natural" mostly as a contrast to the urban setting, and every sign of urban intrusion reduced the pleasure of experiencing nature. Rubbish, signs of vandalism, and management were seen as particularly negative impacts.

Physical design parameters for urban woodland were also investigated by Coles and Bussey (2000) in Redditch. A size of 2 ha was identified as the smallest wood that people wish to visit regularly. Small woods could be attractive when linked together by footpaths. Shape became particularly important in small woods of less than 5 ha in size. Blocks of woodland that allow circular walks were preferred over narrow belts.

4.3 Climatic, Engineering and Ecological Benefits

The urban forest can play a major role in improving urban environmental conditions and safeguarding biodiversity. Environmental benefits do not relate solely to areas of woodland, however; smaller groups, avenues and isolated trees can equally improve environmental conditions in urban areas.

4.3.1 Air Quality

Improving air quality has been an imperative of environmental policies throughout the 20th century. Installation of filtering devices in power plants, the switch to less polluting fuels and other technical measures have achieved significant improvements in this respect. Yet air quality remains a major concern. While the concentration of air pollutants such as sulfur dioxide has been successfully reduced in urban areas, other – mainly car induced – pollutants such as nitrogen oxides, ozone and volatile organic compounds are of increasing concern. Climate change is likely to add further to these air quality problems because rising air temperatures and higher levels of radiation can lead, for instance, to higher concentrations of ozone in the air. Particular attention also needs to be paid to ultraviolet radiation, which can cause skin cancer, in the southern parts of Europe.

A particular challenge lies in the fact that the sources of air pollutants are often diffuse. In this context, the role of urban green space and in particular that of the urban forest in removing air pollutants in urban areas has become of interest. Green spaces and trees are widespread in urban areas and thus could provide an effective means to improve air conditions locally and provide shelter from ultraviolet radiation. A number of studies in the United States have shown the potential of the urban forest for improving air quality (e.g., McPherson 1994; Nowak et al. 2002).

In Europe, evidence is still limited but results of previous studies clearly show that trees have an important role to play in removing air pollutants in urban areas. A woodland in Nottingham was estimated to reduce concentrations of sulfur dioxide and nitrogen oxides in the air by 4–5% (Freer-Smith and Broadmeadow 1996). More important, however, is the function of trees to capture dust. Evergreen tree species, and in particular conifers, filter more dust than deciduous species, but conifers are also more sensitive to damage caused by air pollutants (Däßler 1991; Beckett et al. 1998).

Single trees filter less dust than groups or rows of trees. Trees capture air pollutants most efficiently when they are planted close to the source of emissions. Woodland canopies are more effective than other vegetation types at trapping particle pollutants because of their greater surface roughness (Manning and Feder 1980). Studies in North American cities have estimated the overall removal of air pollutants by trees (McPherson 1994).

While there can be little doubt that the urban forest has a largely beneficial effect on air quality, the emission of volatile organic compounds (VOC; Beckett et al. 1998) as precursors of ozone has recently gained attention. This may be an issue in hot climates with intensive solar radiation such as are experienced in Mediterranean cities. Also, the production of pollen from tree species such as birch needs to be carefully considered when tree species are selected for urban plantings, because of its allergenic effect.

A recent large-scale study in the West Midland region of England estimated the overall removal rates of air pollutants by the urban forest (Stewart et al. 2001). The study was based on a sample of over 30 000 trees. An air quality model was developed to assess the potential of the urban forest to remove air pollutants such as ozone, nitrogen oxides and carbon monoxide and also to estimate potential emissions of volatile organic compounds. At the time of writing, results had yet to be published in their entirety. However, the data that are available suggest that planting additional trees on land theoretically available for this purpose could lead to a significant reduction in concentrations of airborne particles in the West Midlands once these trees have matured. Planting of all available land could achieve a reduction of up to 25% of small airborne particles.

4.3.2
Urban Climates

Thermal imagery has been widely used to assess thermal conditions and develop climate strategies on a city level (e.g., Nachbarschaftsverband Stuttgart 1992). On these images, urban woodland and trees are consistently among the coolest surfaces during hot summer days. On these hot summer days, air temperatures within large parks can be 2–3 °C lower than in the surrounding built-up areas. A significant climatic function can only be expected when park size exceeds one hectare, while a size of 10 ha is required to lower air temperatures by 1 °C (Kuttler 1993). The results from extensive studies in Göteborg, Sweden clearly show the climatic impact of green space (Eliasson 2000). Air temperatures were significantly lower inside parks as compared to the surrounding built areas, but temperatures were also reduced in a transition zone outside the parks. However, even large parks lower the air temperatures in adjacent built-up areas only to a distance of approximately 200–400 m on the windward side on days with low wind speed when the urban heat island effect is strongest. Therefore, it is important to protect the vegetation within urban land uses and to create a dense network of publicly accessible green spaces. An ideal urban climate would offer a great range of different microclimatic conditions within walking distance (= 150 m; Mayer 1990), while avoiding climatic extremes.

Trees are the most effective vegetation element for reducing overheating in urban areas. Figure 4.4 shows the mean surface temperatures for urban surfaces in Munich (Pauleit and Duhme 2000a,b, see also Chap. 3). Open space types, and in particular those with a high percentage cover of trees and water surfaces, were the coolest areas in the city. An increase of tree canopy cover by 10% reduced surface temperatures on average by 1.4 °C

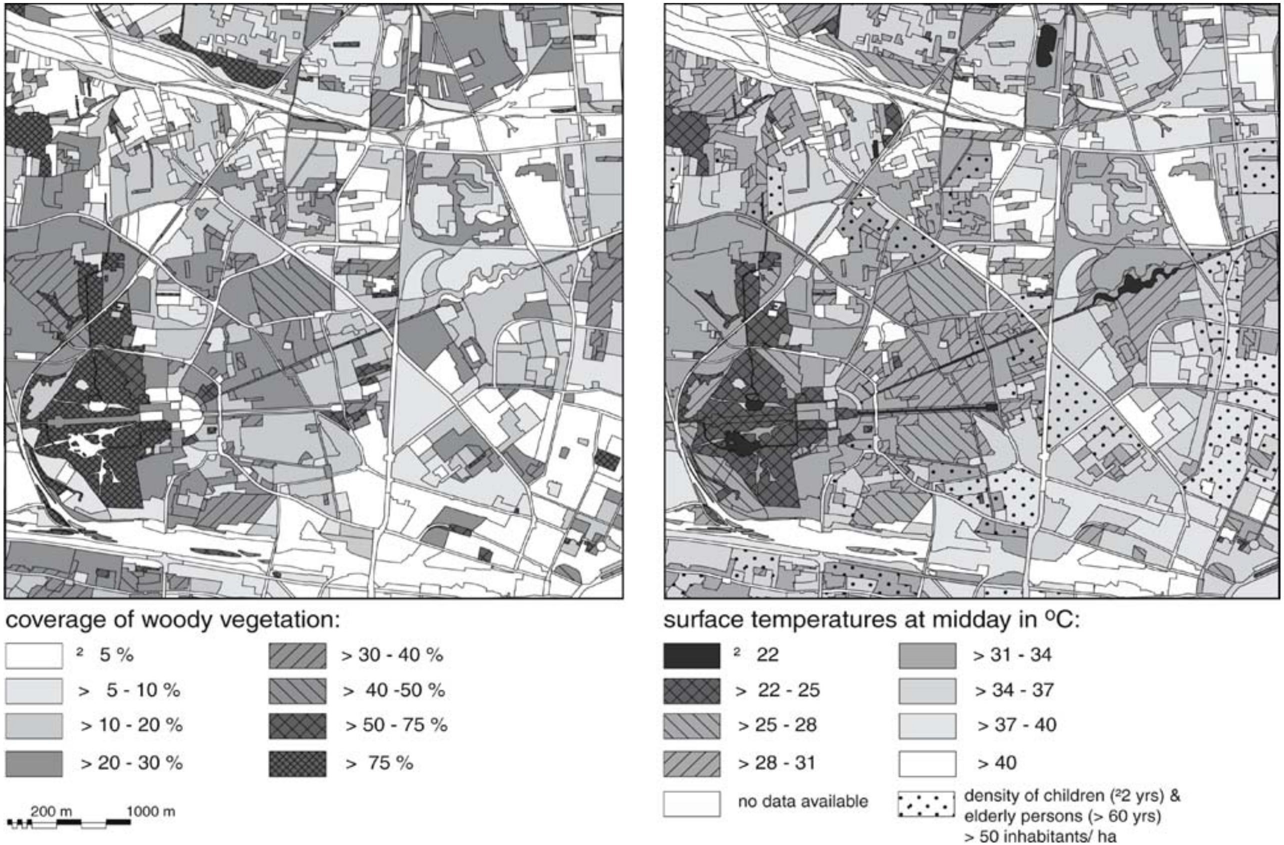


Fig. 4.4. Mean surface temperatures in urban morphology units and cover of trees ands shrubs for the example of Munich, Germany (adapted from Pauleit and Duhme 2000)

during daytime on a hot summer day. Low density residential areas were characterized by a cover of trees and shrubs greater than 20%. These areas were significantly cooler during hot summer days than densely built-up housing and commercial areas.

Temperature reduction by trees is mainly caused by two factors: direct shading and evapotranspirational cooling (Oke 1989). On a hot summer day, for instance, a significant decrease of air temperatures by more than 2 °C could be observed during daytime under trees on a car park as compared with sun exposed sites in front of south facing walls (Brahe 1974). Airflow, on the other hand, can be significantly reduced through tree plantings. This reduced airflow can decrease energy demand of adjacent buildings for heating and air conditioning but it can also have negative impacts, as air pollutants may concentrate under the tree canopy, and sultriness may increase in hot-humid climates (Givoni 1991). Therefore, plantings schemes are required that reduce overheating but maintain good ventilation.

An example of climate conscious planning is the redevelopment of the former Munich airport as a new mixed neighborhood (Burkhardt and Duhme 1996, Fig. 4.5). Approximately one third of the neighborhood was dedicated to green space. A big park of 200 ha size in east-west direction fulfills important climatic functions as a corridor enhancing ventilation of the inner city and the neighborhood (Fig. 4.5, level 1). Green wedges within the built-up area will allow country breezes from the south to penetrate and thus improve air quality as well as reduce air temperatures on hot summer days (Fig. 4.5, level 2). For access streets in east–west direction, it was suggested to plant trees in front of the north facing fronts of the houses (Fig. 4.5, level 3). This would allow good air exchange due to circulation driven by small-scale temperature differences. Planting trees on the north facing side would also avoid strong shading of south facing windows. However, in hot climates such as the Mediterranean, plantings should be preferably made on the south-facing front to avoid excessive temperature loads on the buildings while temperature differences with the north side of the street would still allow for small scale circulation.

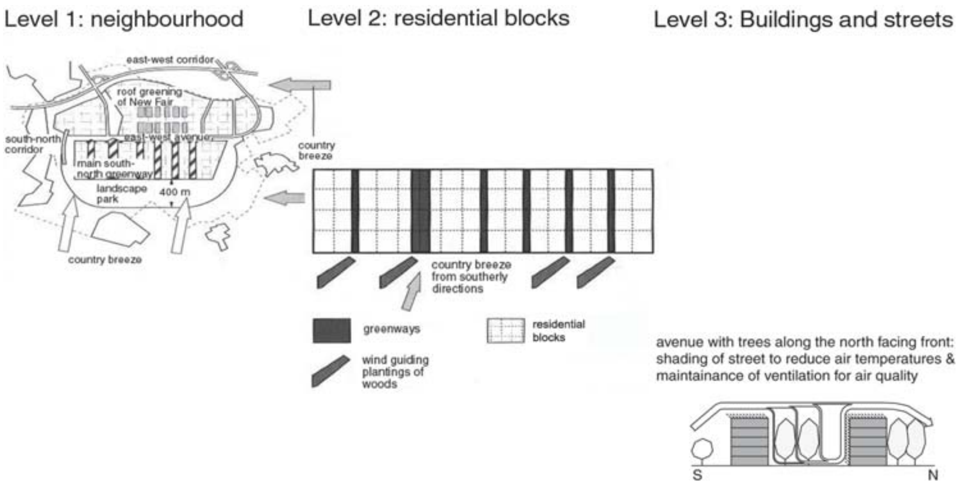


Fig. 4.5. Principles for climatic planning on the levels of residential area, block and street in the new neighborhood of Riem, Munich (*source:* Burkhardt and Duhme 1996)

Deciduous trees with open crowns such as black locust (*Robinia pseudoacacia*), honey locust (*Gleditsia triacanthos*) or Japanese pagoda tree (*Sophora japonica*) would be particularly well suited for this purpose.

Climatic modeling is becoming increasingly available to assess the bioclimatic conditions on urban places and in street canyons (e.g., Matzarakis 2002; Maye and Matzarakis 2003), yet its application in climate planning is still limited (Eliasson 2000). These models assess the effects of trees on air temperature and thermal comfort of pedestrians, and thus provide tools for climate planning from a small scale to the city level.

The role of trees to improve climatic conditions in cities and towns differs across Europe. Overheating of inner cities during summertime is in particular an issue in the countries in the south, south-east and to some extent also in central Europe. In urban areas in the north and north-west provision of shelter from cold winds will be of greater importance, even under climate change scenarios.

4.3.3 Hydrology

Hydrographs show how urbanization increases the peak flow intensity and quantity during rainfall events. Urban forests and trees can reduce surface runoff and thus alleviate the strain from the urban sewage system and dampen peak flows of streams. The main ways that individual trees reduce runoff are by

- the interception of precipitation, which is stored and/or evaporated from the tree (Xiao et al. 2000),
- the increase of rainwater infiltration into the open soil under the canopy,
- an increase of water storage capacity of soils through evapotranspiration,
- the reduced impact of raindrops and consequently less soil erosion and pollutant wash-off.

Protection of riparian woodland can be of particular importance for surface water quality. The hydrological function of urban woodland and trees is increasingly stressed as protection of drinking water resources. For example, in Denmark new woodland areas established close to cities consider this function as a primary one next to recreational benefits (Jensen 1995).

Open spaces covered by trees and other pervious surfaces enable infiltration of rainwater and thus recharge the groundwater in an otherwise sealed urban area. However, no models are currently available to assess these effects quantitatively on the level of cities, neighborhoods or single sites in European cities and towns.

The role of vegetation in reducing surface runoff was estimated using a standard curve method in 11 residential areas for the Merseyside conurbation, England (Whitford et al. 2001). The results show a clear inverse relation between green-space provision and rainwater runoff. A simple approach based on empirical coefficients derived from several studies was used to estimate the hydrological impact of green spaces in Munich (Pauleit and Duhme 2000a). Different runoff and infiltration coefficients were assigned to land cover types. This exercise provided only very rough estimates and would need further refinement and verification. However, the results show clearly how well-greened

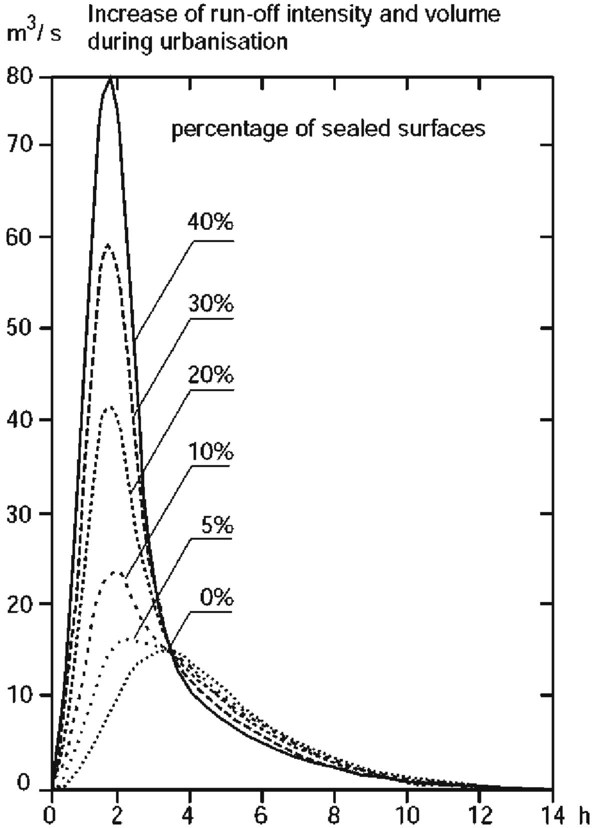


Fig. 4.6.
Runoff curves in urbanized catchment areas (*source:* Emschergenossenschaft/ Lippeverband, 1979, in: SRU 1987, p 299)

urban areas and particularly woodland reduce surface runoff and increase rainwater infiltration compared to built-up areas, as can be seen from Fig. 4.6. In a next step, the amount of pervious surface required to infiltrate the surface runoff completely within the land use unit was calculated. On this basis, the need for green areas in general and urban forests in particular for a more sustainable urban hydrology was quantified.

4.3.4
Energy Demand and Carbon Sequestration

While some North American research has studied the reduction of energy demand through shading of houses in summertime and shelter in winter (e.g., McPherson 1994), no comparable studies have been performed in a European context. Energy studies have concentrated mostly on the built environment. The overall direct carbon sequestration by urban trees accounts for less than one percent of carbon emissions from urban areas (McPherson 1994). Still, more important will be the indirect effects of trees in reducing energy demand of buildings. It has been estimated that, for Sacramento County, California, the urban forest of approximately 6 million trees sequesters 238 000 t of CO_2 per year. The urban forest further reduces energy consumption indirectly as carbon dioxide emissions from the local power plant are avoided by an estimated 75 600 t CO_2 yr; this is because the presence of trees leads to reduced demands for household heating and air conditioning (McPherson 1998).

In Liverpool, United Kingdom, carbon sequestration was estimated for four residential areas with a different provision of vegetation (Whitford et al. 2001). With up to 0.13 t ha^{-1} yr^{-1}, well-treed areas sequestered more than double the amount of carbon than those areas with a poor provision of green spaces. Even more striking were the differences in carbon storage between residential areas. Carbon storage could be as high as 17 t ha^{-1} in a residential area with a mature, dense stock of trees, whereas it was below 1 t ha^{-1} in an area with an overall low provision of green space and almost no trees.

Moreover, the use of wood as a biofuel could substitute for fossil fuels. Modern biofuel and power plants would allow for a wider use of wood without unacceptable impacts on air quality. This could be an interesting alternative in particular for smaller settlements where sufficient land is available for growing energy crops such as poplar plantations or coppice woods.

4.3.5 Biodiversity

The biodiversity of urban woodland in European cities and towns is relatively well investigated (Gilbert 1989; Sukopp and Wittig 1993). The main factors that influence biodiversity of woodland are:

- Woodland origin and naturalness, with a gradient of species richness from relics of primary woodland, over secondary, naturally developing woodland to recently established and managed woodland. Even after several centuries, secondary woodland could be still distinguished from primary woodland by a lack of species of low colonizing ability (Peterken 1974).
- Size: large forests offer more different habitat types as well as habitats for species with larger area requirements. In a study in The Netherlands, only woodland areas of at least 10 ha in size harbored interior woodland birds (Van Dorp and Opdam 1987), but much larger woodland areas would be required to accommodate more demanding wildlife ($\gg$100 ha).
- Intensity of interventions through management and use: Intense recreational activities may have a negative impact in particular on breeding birds and other disturbance sensitive species (Van der Zande 1984). Monoculture woodland mainly planted and managed to produce timber is less biodiverse than naturalistic plantations.

Moreover, single old trees in parks can be an important habitat for birds, bats and invertebrates. Habitat surveys and floristic and faunistic studies have shown the importance of tree cover in urban land uses such as residential areas for biodiversity. Tree crowns can provide habitat for birds and invertebrates in otherwise intensively managed and used gardens. Density of tree cover, overall extent of stands of trees and age of trees are especially important factors influencing biodiversity. An overall tree cover of at least 20% was proposed as a target for urban forestry planning for residential areas on this basis for the City of Munich (Duhme and Pauleit 1992). In fact, the biodiversity in urban areas is in part high because of human influence and due to many exotic species. This richness of species in urban nature could be used more for educational purposes, i.e. to show the residents that city nature has its own special features and diverse values (see Chap. 8).

While the importance of urban areas for biodiversity is increasingly recognised, there is a significant lack of guiding models for biodiversity planning on the city and neighborhood level. One approach is the linking of individual sites, through wildlife corridors or green corridors into a "green network" of wildlife sites and open spaces (Barker 1997). Whilst research findings are calling into question assumptions about the functioning of ecological connectivity within urban environments (Dawson 1994), there is little doubt that both people and wildlife benefit from connections to the overall landscape. Urban woodland is a major component of green networks. This requires strict protection of existing natural woodland that cannot be recreated. Furthermore, although in North-Europe woodland areas preserved from natural forest vegetation are common they are often intensively managed. For example, in Finland there is an increasing demand to leave unmanaged areas also in urban forests to create habitats for old growth forest species in the long run. In practice, the more the urban forests become fragmented in a city structure the more difficult it will be to reach the ecological objectives.

Furthermore, increasing attention needs to be placed on successional woodland on post-industrial land. These areas offer significant opportunities for the creation of urban woodland (Perry and Handley 2000), providing valuable habitats and creating a new landscape character. Therefore, the model of compact cities and the redevelopment of brownfield sites (i.e. abandoned former industrial sites) needs to be carefully balanced against their value for recreation, biodiversity and landscape character. Landscape ecology also stresses the importance of patch shape and boundaries (e.g. hard or soft, straight or curved) for biodiversity. An overview of landscape ecological principles for the design of woodland is provided by Bell (1999). Finally, the Munich study shows how targets for urban forests within urban land uses can be developed based on habitat surveys (Pauleit and Duhme 2000).

4.4 Economic Benefits of Urban Forests and Trees

4.4.1 Economic Values of Urban Forests

In environmental economics a specific taxonomy of values related to natural resources has been developed, although definitions of these values seem to be somewhat unclear or overlapping (Turner et al. 1994). The values attached to public environmental goods are usually classified as use values and non-use values. Use values are divided further into consumptive and non-consumptive use values, while non-use values are often divided into option, quasi-option, bequest and existence values.

The consumptive use values of forests include values of market-priced products such as timber, game, berries and mushrooms. Timber is traditionally seen as the most important market-priced product of forests in many rural areas across Europe. However, the values of timber production and of picking mushrooms and berries in urban forests are lower than in rural areas. This is because the environmental conditions for growth are limited due to pollution, fragmentation of forests and trampling effects. In addition, the net revenues from timber are usually fairly small if any, because management of areas is relatively expensive due to small-scale management practices. Moreover, the market price of berries and mushrooms reflects their true value only partially, as the recreational value of their picking is excluded. The value of game is also unimportant as hunting is often not allowed in urban areas.

In fact, the main values of urban and peri-urban forests have no market-price. These values are termed as non-consumptive use values and include benefits derived for example from a pleasant landscape, clean air, peace and quiet, as well as recreational activities (Fig. 4.7, Tyrväinen 1999). This category also includes benefits such as reduced wind velocity, balanced microclimate, shading, and erosion control, the economic value of which may be determined through for example reduced costs of heating or cooling or alternative costs of environmental control.

The non-use values (option, bequest, existence) may be less important in urban than in natural forests but still worth taking into consideration. The possible motives for these values are altruism, heritage or existence, but theoretically the different value categories have not been consistently defined. Option value is defined as individual willingness to pay (WTP) for ensuring the future availability of a particular amenity. These values can be attached for example to well-known public parks such as Central Park in New York or Bois de Boulogne in Paris, which can be expected to have importance for people other than residents of the city. A related form of value is bequest value, a willingness to pay to preserve the urban forest as a resource, not for the current valuators, but for a potential future use by their descendants (Turner et al. 1994). Many parks have, among other values, this type of cultural and historical importance. Moreover, the existence value is derived from the knowledge that the resource continues to exist and it is often connected to extinction of species. There are species, for instance, that have found suitable habitats only in urban environment.

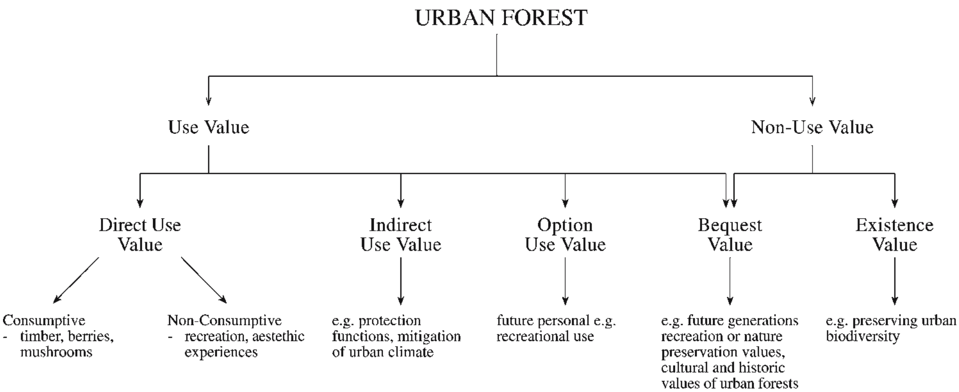


Fig. 4.7. The total economic value of urban forests (Tyrväinen 1999, adapted from Turner et al. 1994)

4.4.2 Quantifying Amenity Benefits in Monetary Terms

The economic value of urban forest can be estimated in different ways. Traditional methods include opportunity costs, estimation of maintenance costs and of the production value of forest. These methods are based on valuing market-priced goods and therefore their use in urban forests is limited (Tyrväinen 1999). The quantification of amenity values of urban forests is complicated, because these are not sold and bought through markets. The urban forest resource can be viewed as a public good, but not a pure one. Usually municipalities are in charge of providing the services, excluding urban trees on private property, and in principle everyone has a possibility of consuming, for example, the pleasant wooded landscape. However, households also have an option of paying for the environment as a joint product with a job or a house by, for example, choosing a house close to a public park.

The methods used in estimating non-priced benefits of forests include the contingent valuation method (CVM), the hedonic pricing method (HPM), and the travel cost method (TCM). Furthermore, approaches such as tree pricing and environmental benefit valuation have been applied in assessing urban forest benefits (Tyrväinen 1999). The methods have different abilities to capture different benefits (Table 4.2). For example, hedonic pricing mainly captures recreational and aesthetic benefits of green areas, whereas environmental benefit valuation focuses on air quality and the energy saving function of trees.

In the first approach, *CVM*, hypothetical markets for the environmental goods are created, i.e. the respondents are asked what they are willing to pay (WTP) for the preservation/establishment or improvement of urban forests. The researcher can then estimate the monetary value of the asset by calculating the average WTP of respondents and multiplying this by the total number of consumers (Mitchell and Carson 1989). In Germany, Elsasser (1996) applied the CV method for valuing the recreational use of two large urban fringe forests in the Hamburg region. The

Table 4.2. Methods of estimating the amenity value of urban forests in monetary terms (Tyrväinen 1999)

Method	Types of values	Suitability	Constraints
Hedonic pricing	Use values (option value)	All green spaces	Data restrictions, difficulty in defining environmental quality variables
Contingent valuation	Use and non-use values	All green spaces	Hypothetical, assumptions on peole's behaviour
Travel cost	Use values on-site	Parks or recreation areas	No or small travel costs to neighbourhood parks, time excluded
Tree pricing	Use values	Individual and groups of trees	Not suitable for forested areas, mitigation effects of climate excluded
Environmental benefit valuation	Part of non-consumptive use values	All green spaces	Aesthetic values excluded, data restrictions

data set was exceptionally large (3 500 respondents). The mean WTP/year for the use of the forests was around €42 person^{-1} yr^{-1}. In Finland, Tyrväinen (2001) asked people's willingness to pay (WTP) for forested recreation areas in two study towns, Joensuu and Salo. More than two-thirds of the respondents were willing to pay for use of the recreation areas. Good location and active management raised the average WTP. The average use value per visitor in different recreation areas ranged from €5.2–12.7 per month.

In the second approach, *hedonic pricing*, the value of the urban forest amenities for people is observed through housing market transactions. If a household wishes to enjoy a view onto a forest or a park or to have easy access to wooded recreation areas, it will buy this type of property and pay a premium for it. A hedonic price model can be computed from data concerning the prices and different features of properties (Palmquist 1991). The main advantage of the method is that it relies on actual market data rather than hypothetical valuations. In Finland, Tyrväinen and Miettinen (2000) demonstrated that a one kilometer increase in the distance to the nearest urban forest area led to an average 6% decrease in the market price of the dwelling (Fig. 4.8). Furthermore, dwellings with a view onto forests were on average 5% more expensive than dwellings with otherwise similar characteristics. In The Netherlands, Luttik (2000) found that a pleasant view alone leads to a considerable increase in house price (6–12%), particularly if a house overlooks water or open space. Proximity of public parks, however, yielded ambiguous results; only when water was a distinctive feature in the park could a premium on the house be demonstrated.

However, it is worth noting that proper maintenance of urban forests is essential to sustain the flow of green benefits. A deteriorated park, for example, may become a negative externality within a neighborhood, and may also prompt decision-makers to consider it for non-park development options. Moreover, social congestion caused by a heavy use of public parks may cause negative externalities to adjacent houses and may even decrease their prices.

The basic idea of the *travel cost method* is to estimate the demand for recreational benefits using the costs of travel, which are used as a proxy for price. The method is problematic in urban settings because there are usually no or only small costs involved in traveling to the site (e.g., Tyrväinen and Väänänen 1998). However, the method is useful in a setting where large urban forests within city limits are scarce and people have to travel further to reach the areas.

Tree pricing assumes that the tree value is based on several factors such as size, expected age, aesthetic value, location, form and other special features (Table 4.3). The method is based on a cost depreciation approach, and it is widely used in many large European cities due to its practicality. Determining prices for single trees has been necessary for estimating the compensation of injuries to the landowner caused, for example, by vehicles or construction. This is, however, based to some extent on subjective judgment. Tree pricing has typically been used for single or groups of trees, but it is not suitable for forest areas. Moreover, it does not explicitly account for environmental services such as shading and adsorption of pollutants that trees provide.

Table 4.3. Example of a tree pricing formula used in Danish cities (Randrup et al. 2003)

VAT 03 – Valuation of Trees – a Danish model, developed in 2003			
Locality		P_n = price, new tree	
Species		C_n = circumference, new tree	
Date		C_d = circumference, damaged tree	
Reg. no		E = establishment costs	
		a: actual age (years)	
		b: expected age (years)	
		Average is given with two decimals	
		Result is denoted in 100 Kr.	
		If $a < b/2$, then $A = 1$	
Basis value (*B*) $= E + (P_n/C_n) \times (C_d - C_n)$			$B =$ ______
Health (*H*)		**Location (*L*)**	
Give points (0–5, with 5 as highest)	Points	Give points (0–5, with 5 as highest)	Points
Roots	....	Adaptation	....
Stem	....	Architecture	....
Main branches	....	Aesthetics	....
Smaller branches	....	Visibility	....
Twigs, leafs, buds	....	Environment	....
Total / 25	$H =$ ______	Total / 12.5	$L =$ ______
Age (*A*) $\sqrt{\frac{(b-a)\times 2}{b}}$			$A =$ ______
Value of the tree $= B \times H \times L \times A =$ ______ Kr.			

Valuing the environmental benefits of trees aims at quantifying the impact of trees on urban climate (shading, evapotranspiration and air flow modification). These benefits can be valued through the alternative costs of environmental control, such as people's WTP for air pollution control and noise abatement, or directly through, for example, energy savings in heating or cooling (McPherson 1994). Nowak (1994) found that a 5–10% improvement in localized air quality was possible in areas with relatively high tree cover. In 1991 the researcher estimated the value of pollution removal to be US$1 million for trees in Chicago. Furthermore, the potential of trees to reduce the residential heating and cooling energy was investigated. An increase in tree cover of 10% (approximately three trees per building) could reduce heating and cooling energy by 5–10%. Although the approach is suitable for valuing all green areas, many countries have insufficient quantitative information on the impacts of trees on urban climate.

4.4.3
Cost–Benefits Analysis in Urban Forestry

Frequently, the amenity benefits of urban forests are not well enough articulated in land use decisions and green-space policy-making. In many cities there are increased pressures to convert urban forests to other use, as well as financial problems related to management of the areas. If the socio-economic value of ecological factors can be demonstrated, for example through a premium on house price, this strengthens the position of existing green areas in the policy decision process. Today land-use planning procedures and greening projects do not include any systematic quantitative assessment of the benefits of green areas (Tyrväinen 1999). Decision-makers compare economic factors like contribution to the tax base and employment or the value added to the local economy against the value of environmental factors. By expressing the latter in monetary terms they become comparable to the former. This will put more weight on environmental factors in the decision making process, although by no means all environmental values can be put into monetary terms (Luttik 2000).

Economic estimates of benefits of urban forests and trees are useful in decisions regarding town planning, urban forest policy and budget allocation. The application possibilities include an assessment of lost benefits due to 'densification' or 'infill' of town structure and reduced tree canopy as well as economic gains of establishing new green areas. At the municipal level it is necessary to assess whether the provision of recreation services is in balance with the demand. The analysis also provides information for assessing cost efficiency and alternative management structures. The use of economic analysis in decision-making has different levels. At a minimum level it might stimulate public and policy-makers' awareness of potential values. At the project level, it could influence or identify decisions through cost–benefit analysis.

Frequently, the costs of urban forest management are poorly documented in cities and towns. A study in Munich, Germany, addressed the question of how to optimize management costs of the urban green structure. An economic approach was used to structure the quality of urban forests in relation to necessary maintenance to get this quality. Information on resources and average time spend on certain management tasks in different areas was gathered. An optimization model was applied to plan the use of management resources (Steidle-Schwahn 2002).

The total value of a green area depends on its location, size, quality, use intensity and the amount of available substitute areas. In general, the scarcer the resource becomes, the higher the value per hectare. Moreover, the value of single trees in a city is not the same, even if trees are identical and in the same location. The law of decreasing marginal benefits applies to aesthetic and recreational values of trees: the first tree in an open area makes the biggest difference after which every additional tree counts for less.

So far, research seeking to determine the amenity benefits in monetary terms has been limited in Europe, although the level of activity and the results have more or less passed the demonstration stage. There are cultural differences in attitudes towards the urban forests and the supply of the green areas varies. Therefore, results are not easily transferable. More research is needed to create feasible models for assessing the benefits in practice. By monetary valuation methods it is possible, however, to create local or regional estimates for the economic value of green areas.

4.4.4 Tools for Decision-Making

Valuing Benefits of Urban Woodland

Property Value Models

The next example shows how a property value model can be used to calculate the value of an individual urban forest park indirectly. The idea behind this procedure is (*1*) that the total value of the forest/park views is determined and (*2*) that attention is given to the effect of the distance to the forest park. Here the calculation is illustrated by using the property value model (Tyrväinen and Miettinen 2000) presented in the previous section (Fig. 4.8). In this example it is assumed that size of the forest park is one hectare and it is circular. Given the average yard size of 400 m^2, the number of dwellings next to the park is 35. The total value of these apartments is approximately €2.24 million, and the value of the forest view is 4.9% of the total value of dwellings, which is €110 000. Here, the average size of an apartment is 90 m^2 and the average unit price was at the time of investigation €710 per m^2.

Moreover, according to the semi-logarithmic model an increase in distance of one kilometer reduced the average price of a dwelling by 5.9% (Fig. 4.8). Here the price effect is calculated only up to 600 m, because it is the case of a small park. The total value of apartments within 600 m from the park is €76.35 million. The aggregate value of the park reflected to dwelling prices is €3.73 million and can be calculated geometrically using the price model. When the value of the view is added to this figure, the total value of the park is €3.84 million. If conversion of the park into other use is considered,

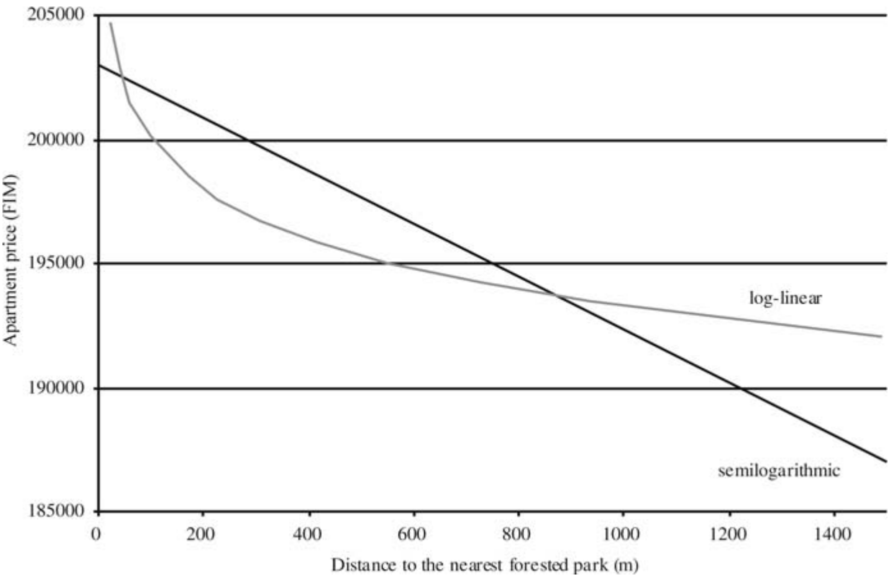


Fig. 4.8. Effect of distance to the nearest forested area on apartment price (1 FIM = €0.168) (Tyrväinen and Miettinen 2000)

this value should be compared to increased costs when providing the building sites somewhere else. A more detailed calculation example is presented in Tyrväinen and Miettinen (2000).

In this example it was assumed that the park was the only one influencing the apartment prices within 600 m. If the construction intensity is higher (i.e. there would be mostly blocks of flats), the estimated value of the park would also be considerably higher, approximately €11–15 million. Here it should be stressed that the social and ecological carrying capacity of the green area are limited. After a certain limit, the high use of the park becomes also a nuisance and may decrease property values.

It should also be noted that hedonic models express only the benefits associated with housing. Excluded are recreational benefits by others than residents in the area. The residents may not be aware of other benefits such as rainwater and erosion control. Therefore, the approach capitalizes only a portion of urban forest benefits to nearby properties and the method gives just a minimum value for the areas.

Use of Economic Estimates from CV Studies

The next examples demonstrate the use of economic estimates derived form CV studies. The cases deal with urban fringe woodland and therefore it is relevant to compare the amenity value of the areas with timber production benefits. In this analysis information on forest stock (inventory data) and timber values is needed. On the cost-side information on annual maintenance costs of vegetation and recreation facilities is required. Moreover, the costs should include opportunity cost of land, i.e. reduction in timber values due to management adjustments such as prolonged rotation period and small-scale management units required by the recreational use. In the Nordic countries, usually the loss of timber production value in recreation areas compared to commercial forests is between 10–30% (Tyrväinen 2001). On the benefits side, the aggregate amenity benefits can be estimated by calculating the average WTP of users and multiplying this by the total number of consumers.

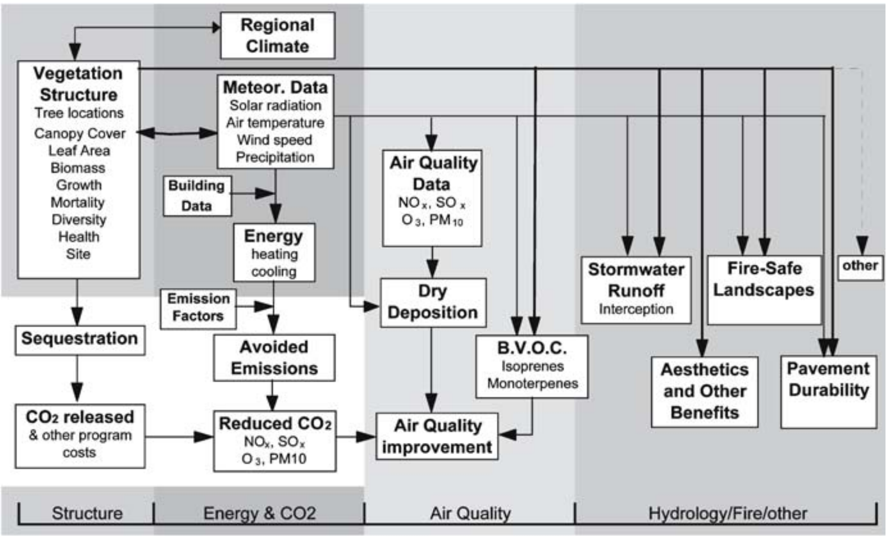
Tyrväinen and Väänänen (1998) estimated the present timber value of the study area (46 ha) in Joensuu, Finland to be €0.19 million and the residents' total WTP for keeping it in recreational use was €1.38 million (1997) using a 5% interest rate. On this basis the amenity value of urban forests was 7.3 times higher than the value of the area in timber production. It has to be kept in mind, however, that the recreational use of the area does not completely exclude timber production, but rather decreases the received economic benefits and vice versa. Furthermore, Tyrväinen (2001) also showed in a comparative study that amenity benefits of various recreation areas in two study towns were clearly higher than their current management costs. The estimated aggregate recreation value was 7 to 26 times higher than the total costs of providing recreation services in the area depending on their characteristics, management and use intensities.

Moreover, the infill of existing housing areas may lead to a considerable loss of amenity benefits of urban forests experienced by the local residents. In the study of Tyrväinen and Väänänen (1998) people were willing to pay most for the green space where the development scenario meant condensing the housing area. The aggregate total WTP for preserving this urban forest was €1.38 million. It exceeds the value of similar size, unimproved land area by €120 000. This sum can be used to cover the increased costs of infrastructure when building elsewhere, for example, at the urban fringe. This example suggests that infill of present housing areas is not always worthwhile from the point of view of society, if the losses of green-space benefits are taken into account.

Valuing Benefits of Street and Park Trees

Recently, some large research projects, most of these undertaken in the United States, have studied the benefits of the urban forest, for instance to improve urban climates and abate air pollution (McPherson 1994). American Forests, a non-profit citizens' conservation organization, has developed a geographical information system, which allows rapid assessment of the benefits of trees on urban green space (CITYgreen 2003). This kind of information system informs planning and decision-making on the role trees and woodland play in the urban environment.

CITYgreen is a GIS-based software product, which has been used to analyze the local ecosystem and to calculate the benefits from urban forestry in Garland, Texas, United States. Ten sites were selected to represent a broad spectrum of land use and land cover, including single family residential, commercial and industrial sites. The main problem in the town was storm-water management. The computer software package calculated the effects of urban tree cover and impervious surfaces on forest health, air quality, carbon sequestration, energy use and storm-water runoff. An important characteristic of the software is the ability to put dollar values on all these effects. The software can calculate the financial benefits from tree cover (compared with a zero tree cover situation).



Conceptual approach to modeling urban forest benefits. Information on vegetation structure is primary input for modeling functions such as energy savings, atmospheric CO_2 reductions, air quality improvement, stormwater runoff reduction, aesthetic and other benefits.

Fig. 4.9. Conceptual approach to modeling benefits or street and park trees (McPherson and Simpson 2002)

A study by McPherson and Simpson (2002) analyzed the benefit–cost ratios of street and park trees in two cities, Modesto and Santa Monica in California, United States. The approach considered functions such as energy savings, air quality improvement, storm-water runoff reduction and atmospheric CO_2 reductions and aesthetic benefits (Fig. 4.9). The estimated benefits of trees were 1.85 to 1.52 times higher than the actual costs. The aesthetic and other benefits accounted for a large part, 50–80% of total benefits, while pruning accounted for half of the maintenance costs.

4.5 Conclusions

Nowadays, urban woodland and parks in or in the vicinity of large cities serve as areas for recreation and entertainment, as well as space for biodiversity to compensate for the built parts of the city. It is therefore important to emphasize the multifunctional use of trees, green spaces, parks and woodland and draw the attention of city dwellers towards the maintenance of biodiversity, of plant succession and the dynamics of low-cost ruderal places. This may allow them to develop a more conscious attitude towards nature in their immediate surroundings. In this context, more research will have to be done on how wilderness is perceived and accepted or demanded by urban dwellers. So called 'loose-to-fit' green spaces, where people can participate to design public green space according to their own taste and recreational preferences will have to be given more attention. Increasing maintenance costs of intensively managed parks with flower beds and urban woodland with a neat infrastructure will favor a trend towards low-cost greens.

Most of the research on the recreational function of urban green space has not yet been translated into generally accepted practical guidelines and criteria, or into other types of policy and management instruments. Partly this is due to the normative content that is almost inherent to such guidelines and criteria: they fall within the domain of the policy-maker as much as within that of the researcher. Suitable guidelines and criteria depend on the goals that have been set. What is an adequate local supply of outdoor recreational opportunities measured both quantitatively and qualitatively, however, is still unclear. Although a start has been made (see e.g., Van Herzele and Wiedemann 2003), more work remains to be done before empirically founded policy making and planning with respect to urban greening is put into practice.

In the future, a comprehensive picture about the perception and acceptance of trees should be obtained. Today, there is considerable loss of trees in urban areas due to pollution, vandalism, traffic damage, use of de-icing salt, storm events, lack of adequate space to grow and over-aging. Substantial research on these topics has been done representing a need and strength of the technical and green-space management sciences. Economical valuation studies have brought about many valuable insights into the benefits and costs of urban green spaces and their management at the end of the 20th century that was previously not available.

There is also an increasing need to define and promote the socially integrative potential of woodland, parks and trees and to integrate people with specific needs and demands. Parks and woodland areas at the peri-urban belt of large agglomerations are important social meeting places for elderly people, youth, ethnic minorities of different cultural background and disabled citizens, to mention only a few. The role of cities as focal points of cultural life has been supplemented by providing their inhabitants with green spaces designed close to nature. Multicultural residential areas showing a preference for certain tree or other plant species and outdoor amenities are particularly important.

The results from various research studies stress the importance of the quality of the near-home environment and encourage the maintenance and establishment of new green areas near homes. Economic valuation studies indicate that on social grounds urban forests are a cost-effective concept. Although there is increasing evidence also of the environmental benefits of the urban forest, most of this evidence is gained indirectly, for instance more generally investigating the urban climate and the role of green space therein. There are few studies in Europe on the environmental performance of forests, and the different advantages and disadvantages of spatial forest patterns and types of tree plantings. The information available is mostly limited to a few urban areas; there is a significant lack of comparative information of cities across Europe. There can be little doubt that the environmental functions and benefits of the urban forest will vary widely between cities in southern, central and northern Europe, depending on regional climates, the specific structure of the urban forest (Chap. 3) as well as local needs. Yet, until now these differences have not been explored. As a consequence, there is a lack of guiding principles for urban forest planning specific to the different regions of Europe.

The particular challenge for the future will be to establish links between the environmental, social, economic and aesthetic functions of the urban forest, for instance to assess how mitigation of heat island effects and the improvement of air quality are related to human health. This agenda has only recently become addressed (NUFU 1999, 2002) but there is still a significant lack of information. Collecting this information will support the development of urban forest policies on a strategic level and the setting of clear targets for provision of trees and woodland in urban areas.

In many countries innovative means to raise public awareness and also funding for management and establishment of green areas are needed. Concretizing the amenity benefits of urban forests and trees through various types of research contributes to raising the decision-makers awareness of the consequences land use alternatives and compact city policies. Moreover, this will produce more information on the benefits that people actually receive from various types of green areas for practical planning. The amount and quality of urban forest is, in the end, a political question and a matter of whose interests are to prevail in decision-making. Given many residents' high appreciation of urban forest benefits, it is worth to fully account for urban forest benefits and elaborate more detailed criteria for green-space development in European cities.

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Part II Planning and Design of Urban Forests and Trees

Chapter 5

Urban Forest Policy and Planning

Andreas Ottitsch · Max Krott

5.1 Introduction

The main objective of this chapter is to provide an overview of the status of urban forest policies in Europe. In the context of this chapter 'urban forest policies' encompass the full range of policies aimed at management and conflict regulation of relevance for urban forests as including all woodland and tree resources in and near urban areas (see Chap. 1).

In English language texts from the field of policy science three distinct terms are used in order to describe different objects of interest, which in everyday language are commonly referred to as being in the domain of 'politics' (e.g., Glück et al. 2001a). *Polity* refers to the institutional dimension at formal (e.g. constitution, laws, taxes, parliament) as well as informal (e.g., tradition) levels. *Politics* refers to the procedural dimension, looking at the dynamics of political processes (e.g., will formation, interest mediation, bargaining, and communication processes). *Policy* finally refers to the substantial or normative dimension, which includes issues and objectives as well as outcomes of the political process. In the context of this standard terminology this chapter is therefore focusing on 'policy', while also taking into account the 'polity' aspects of the field. Some other issues related to 'politics' are only marginally touched here and are being taken into account in other chapters, namely Chap. 7 and 8.

The chapter first introduces a theoretical conceptualization of urban forest policy and planning based on the policy scientific conceptualization of economical and political powers at play in today's urban areas. It then focuses on the specific aspects of policies in the context of urban forestry, as opposed to national forest policies. This stems from the hypothesis that urban forestry policy networks and arenas are determined by different interests than 'traditional' forest policy networks and arenas. As urban forestry is a multidisciplinary domain in which forestry is one among different actors, this is understandable. In addition, the chapter will try to determine to what degree 'national forest policies' of certain countries in Europe are approaching or already coinciding with 'urban forest policies'.

Next, some main 'tension lines' or underlying factors that shape urban forest policy to a large extent are outlined. This will assist with identifying some of the main characteristics, challenges and opportunities in urban forest policy-making. After this, empirical results from 14 towns and cities are then presented to introduce the situation of urban forest policy in different parts of Europe. The examples will also serve as illustration of the more theoretical perspectives presented in this chapter.

The final sections of this chapter discuss some of the major issues of relevance for urban forest policy and planning today. Moreover, they search for a theory of urban forest policy. The theory is based on general theory of policy-making but selects most relevant hypothesis covering the important factors driving the urban policy process.

As a result, the political dynamics of the problems urban forestry is facing today could be understood and used to design a more comprehensive, task-oriented approach.

5.2 Urban Forest Policy and Urban Planning

5.2.1 Theoretical Conceptualization of Urban Forestry and Urban Forest Policy

Looking down from a landing airplane onto an urban area makes it immediately clear what urban forest policy embodies. One sees urban trees and green islands floating within an ocean of housing and traffic lines. The urban socio-economic framework determines the options for green areas. Consequently the definition of urban forestry and the associated theories most usable for explaining the development of urban forestry and forest policy have to be grounded in theories about urban areas.

Trees and forests are important elements of urban green structures. As described in Chap. 4. they contribute to the high ecological and aesthetical significance of green elements for the quality of life in densely inhabited areas. The impact of trees and forests comprises benefits in the field of atmosphere, hydrology, noise reduction, wildlife and biodiversity (e.g., Nowak and Dwyer 2000). Furthermore trees provide aesthetic surroundings and significant emotional and spiritual experiences that are important in people's lives and can foster a strong attachment to urban areas. But there exist also great pressures on urban space resources (Nilsson and Randrup 1997). New buildings and traffic lines are devouring green areas. Harsh air and soil conditions are threatening the health of plants. Users not respecting ecological limits cause heavy damages to trees and soil. The competitiveness of potential users of green areas for different recreational types as well as competition with other users cause additional conflicts and stress. Due to the high population density maintenance of trees and forests in urban areas has to cope with specific problems. From this experience the concept of urban forestry was developed.

Managing a complex subject like urban forests is by no means a simple task. Inventorying and monitoring, techniques of treatment, planning, implementation, funding and responsibilities are very demanding. Facing these problems and looking for solutions created the concept of urban forestry as well as various innovative solutions to the different challenges (for example, Grey and Deneke 1992; Konijnendijk 1999, 2000; Kuser 2000). Treatment seems to be as difficult as the inventory. Techniques must be oriented toward specific products and needs. Handling conflicts in recreation does not only require appropriate ecological and recreation facilities but also psychological skills in convincing and guiding people. Planning is aimed at coordinating management in order to meet the objectives the community would like to see met. These objectives are as diverse as the interests in urban communities. Thus it is not surprising that urban forestry programs insist on strong organization and a stable budget. The key funding for this public has to come from the municipality. In addition, other public and private funds are necessary. The responsible organization and the funding have to be reliable to maintain sustainable urban forestry for the benefit of the entire community.

Based on this Programme urban forest policy can be defined as follows:

> Urban forest policy is the social bargaining process for the regulation of conflicts related to interests in the utilization and protection of forests and trees according to urban forestry programmes.

Urban forestry programs focus on trees and forests within urban areas. Therefore the use and conflicts within urban areas are the most relevant for urban forest policy. Conflicts are caused by different users within urban areas and driven by their interests and power. The high density of uses and conflicts and the strong dynamics of social bargaining within urban areas are very challenging for regulating efforts. Nevertheless, urban forest policy does not follow the strong interests only, but sways the conflicts in favor of urban forestry's goals formulated in programs. Forest policy needs both a clear orientation toward public goals and the means and strategies to influence users. Whether and how a small program like urban forestry can have any impact on the overwhelming forces of urban areas is the domain of the theory of urban forest policy.

5.2.2
Key Distinctions between 'Urban Forest Policy' and 'National Forest Policies'

Issues and Objectives

Studies on forest-resource related conflicts at national and international levels (e.g., Humphreys 1999; Hellström 2001) have shown that political issues taken up by the political administrative system have mainly been conflicts between timber production and ecological interests (management practices and zoning of reserves), and timber production and other economic interests (for example the *Waldsterben*-debate of the 1980s, the loss of forest resources to other land uses). Social issues, including cultural and religious ones, have entered the debate only marginally, usually alongside ecological issues, for example in the case of rights of indigenous populations in debates over the use of forest resources in their environment.

Urban forest politics, however, have shown a slightly different development. As can be seen from the case studies presented elsewhere in this chapter, as well as from other recent work in this field (e.g., Forrest et al. 1999; Konijnendijk 1999), urban forest and green-space management has been less focused on raw material production and more on amenity values. This can even be claimed for those cases where urban forests originated from hunting reserves for the nobility, as these were mainly established and managed for representation and entertainment purposes rather than for the production of venison.

Table 5.1 (adapted from Glück et al. 2001a) provides an exemplary overview of the common forest policy fields. These can be defined based on the three groups of interests (social, economic, and ecological) and the most common conflicts arising from them. The main fields of urban forest politics are highlighted in bold print in the table, based on, for example the case studies introduced in the following parts of this text, and the case studies compiled by Konijnendijk (1997, 1999). The purpose of this table is to illustrate the difference between the type of conflicts typical for 'forest policy' in general, and the specific nature of 'urban forest policy', thus illustrating the legitimateness of dealing with the latter as a separate field of analysis, also from a forestry perspective.

Table 5.1. Overview of general forest policy fields, with highlighted in bold print the main issues of urban forest policy fields

Interests conflicting with	Interests		
	Social	Ecological	Economical
Economical	▪ **Forest recreation** ▪ **Forest aesthetics** ▪ **Soil and water protection**	▪ Nature conservation conflicts ▪ **Emissions into forest land** (emission reduction policies) ▪ CO_2-fixation	▪ Multiple use forestry/joint production problems ▪ Employment markets ▪ Timber markets ▪ **Protection and increase of forest cover** ▪ Forest fires
	Spatial planning of forests and forest land uses (at regional levels)		
Ecological	▪ **Ecological problems of recreation** ▪ **Carrying capacity**	▪ E.g., Biodiversity vs. closeness to nature ▪ **Cultural vs. natural landscapes**	
Social	▪ **Recreation conflicts** ▪ **Land ownership/public access to greenspace**		

Actors

The distribution of roles between different actors in 'general' and 'urban' forest politics corresponds to that of issues and objectives as described above. Until the 1970s and in some countries even longer, national forest politics have been dominated by a trinity of state forest service, private owners and wood processing industries, and the institutions set up for and by these actors. During recent decades new actors have entered this arena. These represent the interests mostly in conflict with 'traditional' forestry, which had primarily been oriented towards the sustainable production of timber. Accordingly, the role of environmental institutions and especially that of environmental NGOs has become increasingly important. This is not only true at the national level, but especially also at the international level, where large international NGOs are nowadays recognised as being an important factor in the political process.

While state-owned forest enterprises have often been managed by public administrative institutions, such as a national or regional forest services the management models of public forestland are being changed. In most countries these are or already have been subject to restructuring and reorganization. In accordance with the general tide of public opinion and policies the role as managers of public land is being questioned and in many instances handed over to institutions, which are separate from authority administration. In some case, these can even by private entities, at least as regards their legal form (e.g., AssiDomain/Sweden, Bundesforste AG/Austria, Staatsbosbeheer/Netherlands).

This general trend towards a 'privatization' of public forestlands at the national and regional levels has not taken place at the municipal level to the same extent. Sometimes municipal administrative institutions have taken over the management or even the property of former national forest land in order to integrate it into their green-space planning.

In the urban context special 'green-space organizations' (i.e. park and garden services, municipal forest services) appear most prominently in their role as managers of public areas, and to a lesser degree also by exercising public authority over private lands (supervision of public regulations, and so forth). The management of parks and forests (i.e. woodland) is mostly divided among separate administrative units. Following the general patterns of institutional interests, these separate institutions are also competing for an increase of their respective fields of competence as well as additional resource allocation. Apart from organizations especially instituted for 'green-space administration' other institutions within the public municipal administration are also of relevance. The most prominent example for this are public road and public works administrations.

In most countries, this trend toward an increasing importance of the private sector has not (yet) been followed to the same extent in urban forestry. Municipal forest services and other green-space institutions have been quite successful in extending their activities and fields of influence over time (see e.g., Chap. 2). Having been relatively free from the obligations of economic profit they have had a much easier task than their national counterparts when it came to defending the costs of managing public lands. From the start most municipalities that acquired forest, land and other green space had done so explicitly for social objectives such as recreation and improvement of the urban environment. Due to this difference in objectives municipalities have also been less allied to the traditional actors of forest politics. As timber management and profit orientation was of minor importance they had it easier to achieve compromises with conservation interests, for example in abandoning controversial management practices such as the use of chemicals or clear-cutting. Similarly, municipalities are also more likely to be interested in voluntary activities such as certification of forest management and forest products. Usually, municipalities have opted for the FSC (Forest Stewardship Council) label (e.g., Konijnendijk 1999). FSC is an initiative by environmental NGOs (mainly WWF) and some forest industry actors (e.g., AssiDomain). This has also happened in countries where other public and private owners have been reluctant to accept the FSC-initiative and preferred the PEFC-system (Pan European Forest Certification System – an initiative by forest owners' institutions).

The role of private landowners in urban forest and green-space politics has been relatively minor, as primarily public land has been used for the implementation of urban forest and green-space policies (e.g., Krott and Nilsson 1998; Konijnendijk 1999). Municipalities have employed a 'property strategy' of transferring green space within their boundaries or within their otherwise described spheres of interest to municipal property. Policies used in this context include the conscious provision of 'land-buying funds' and the decreeing of first-buyer's rights for municipal authorities for land-transactions. Another policy has been the shrewd use of opportunity when in times of economic hardship some larger scale land-owners were willing to part with properties which could be used to cover for financial obligations in other areas, or which had primarily served representative functions no longer affordable by the owner.

Due to these developments in the context of urban forest and green-space politics, private land property nowadays plays a role mainly in the form of private non-productive lands. These include private gardens and to a lesser extent private or semi-private parks, as in the case of sports and recreation club properties. Apart from the restriction of land use, change and some general tree protection laws or regulations on hazardous materials, the owners of such areas (often owning a very significant share of all green space) are relatively free with regards to their management objectives. Type and nature of vegetation (species selection), design aspects, degree of naturalness, and even minor landscaping changes are left to the owner's discretion to a large extent. Conflicts in this field are more likely regulated by civil-law regulations on neighbors' rights and obligations than by public policies.

Non-governmental institutions, on the other hand, play a major role in urban forest politics. The main difference with general forest politics is that local organizations are more important in an urban context (e.g., Konijnendijk 1999). Some NGOs have devel-

Table 5.2. Comparison of role and relevance of most important actors in national/regional and urban forest politics

Actor group	Forest politics at national and regional levels	Urban forest politics
National forest authority (forest service)	▪ Implementation of national forest policies (regulative, financial, informational instruments) ▪ Management of public forest land (in most countries decreasing) ▪ Extension and other services for private land-owners	▪ Mainly supervision role (unless forestry issues have been devoluted/decentralised to the local level)
Municipal forest service and other public greenspace organisations	▪ Mainly defence of municipal interests vs. national authorities ▪ No need for alliances with traditional public or private owners	▪ Implementation of municipal forest and greenspace policies ▪ Management of public lands
Private land owners	▪ Property rights ▪ Financial and other benefits from land management	▪ In most countries not very relevant, with the exception of some forms of 'common' property (e.g., Buergergemeinden in Switzerland); private gardens do constitute an important component of the urban forest, however, e.g. in terms of ecological greenstructure
Wood processing industries	▪ Raw material supply	▪ Mostly not relevant
NGOs	▪ Environmentally sound management practices ▪ Conservation areas ▪ Conflict with land-owners	▪ Environmentally sound management practices ▪ Conservation areas ▪ Less conflicting role ▪ Importance of local groups and single-issue initiatives!

oped out of the large number of single-issue, ad-hoc initiatives, which are also characteristic for urban forest politics. In some cases, for instance in The Netherlands, Denmark, and the United Kingdom, cooperation with local interest groups constitutes a new, special form of public administration. From a theoretical approach this constitutes an implementation of the idea of 'community forest management' – which primarily has developing world roots (Raintree 1991) – to the conditions of urban Europe. In community forestry approaches, responsibility for planning as well as management of public areas is shared with local interest groups. In some instances these are actually charged with specific management tasks (Forrest et al. 1999; Konijnendijk 1999 for examples).

Given the low relevance of timber production objectives in urban areas timber processing industries are practically not relevant as actors in urban forest politics. Table 5.2 summarizes and compares the role and relevance of actors in general and urban forest politics.

5.3
Tension Lines Defining Urban Forest Policies

5.3.1
A Diversity of Traditions – A Diversity of Presences – Segmented Policies?

In many cases urban green-space policy in Europe still constitutes a patchwork of segmented policies, as will also be illustrated by the case studies below. This is mainly due to the fact that present structures have to be seen in the historical context from which they originated. As described in Chap. 2, today's urban green spaces originate from the representation purposes of feudal courts (parks, urban gardens, urban forests), from traditional public forest domains, and from representation related activities of the 19^{th} century bourgeoisie (private gardens, boulevards, alleys). They also have their roots in the concept of 'people's gardens' (*Volksparks*) from the late 19^{th} century, partly instituted by rededication of the former categories. This development has to be regarded within the context of rising labor interests across Europe as related to industrialization and its consequences in changing the social fabric of urban agglomerations. Moreover, green space and green-space policy need to be seen in relation to the more recent concepts of urban planning, resulting in new forms of community forestry, and as a most current development the implementation of local Agenda 21-projects.

In those cases where urban green-space management is based upon a long tradition, the institutions and organizations involved in its management also have such a tradition within the respective municipal administration. As a result of this, different types of urban green space within the same municipality, for example forests and parks, are administered by different organizations. Such an insistence on traditional spheres of influence can be seen as hindering the introduction of new, comprehensive green-space concepts (such as urban forestry, for example). On the other hand this competition between different administrative units can also be used at the political decision level as an instrument to reach cost-efficient solutions, for example by allocating newly created areas to that institution offering the 'best price' for delivering specific objectives.

5.3.2
Urban Green Space – Accepted As a Public Service?

Urban green-space policy is mostly a policy of public property. In most cases existing policy instruments are focusing on areas in public property. Urban green-space policies can be characterized as the policies of specific branches of the public administration. Most municipal administrations have preferred property strategies when it comes to selecting instruments for realizing public objectives in the field of urban green-space policies. This means that while some regulative instruments relevant to private properties may exist, municipal administrations prefer to transfer land into public property if areas are needed for realizing larger scale objectives, especially in the context of urban green-space strategies. This development can be seen as being slightly in contradiction with forest policies or green-space policies in general at national levels. Here, a trend towards the development of innovative financial policy instruments (e.g., conservation contracts, agro-environmental tools, taxation related instruments) can be seen when it comes to realizing public objectives on a wider scale, on private land (e.g., Davies 2001; Hothersall 2001).

In this context it is also interesting to note that relatively little pressure exists from the side of NGOs, who are well organized and especially active in urban regions, on private areas which are not used for agriculture or forestry, and when it comes to realizing public objectives. While there is some criticism in terms of problems regarding freely accessible green space in urban regions, mainly in countries without universal right of access-regimes such as The Netherlands, this criticism does not lead to a demand for changing the legal framework; rather it is voiced in demands for allocation of more resources to enable municipal authorities to buy more land from private owners.

5.3.3
Private or Public Green Space – The Problem of Subsidizing Privileged Groups from Public Funds

A host of studies documents that green space in urban regions is increasing real estate market value, regarding both rent as well as purchase prices (Chap. 4, Tyrväinen 1999). This connection is even recognised in those cases where price regulations have been enforced at least for parts of the housing-market, allowing for ‘raise-factors’ for ‘closeness to green space’. This results in the following paradox: The value effect of green space close to developed land can be used to prove its high value, not just through contingency valuation methods, but even through revealed preferences in terms of market prices. At the same time, the high demand for development land close to green space increases the pressure on this green space. The very factor that makes it possible to ‘prove’ the high value of green space in urban regions is, therefore among the main threats to these green areas. If such green space is private property, this implies that the private owner of green is contributing to the higher value of nearby development land without being able to profit from this. In addition, the owner is facing potential criticism for managing this land for primary production purposes (such as cutting timber). If, on the other hand, a public entity owns these lands, the public is foregoing potential benefits for developing this land, while at the same time only a limited number of people are enjoying the positive effect of living in the vicinity of green space. A minority which most likely will be constituted from rather well-to-do members of the society, as only households with above average income levels will be able to afford renting or buying real estate in the vicinity of green space. In order to solve this dilemma new approaches will have to be implemented, for example through linking real estate property rights with those for surrounding green space (see Chap. 4).

5.3.4 Urban Green-Space Conflicts Develop along New Front Lines

In the context of general forest policies land use conflicts are usually understood as conflicts between timber production and other land uses (non-wood forest products or services) on forestland. While this principle conflict of objectives is also and in most cases even stronger present in urban regions as demographics suggest a higher protest potential in towns and cities, it seems that the institutions involved in urban forest and green-space management have adapted to this fact. This is at least the case as regards their formal and publicly announced objectives.

The results from comparative studies (e.g., Konijnendijk 1999) show that urban forest and green-space conflicts tend to be more among different 'non-timber land uses', with conflicts between different types of outdoor recreation gaining in importance. On one hand the intensity of recreation activities is increasing due to changes in lifestyles and living standards. This mainly results in a higher demand for recreation in general. On the other hand new recreation activities (i.e. trend sports, extreme sports) constitute an additional demand for recreation areas, especially as such new activities – due to their more dynamic nature – often conflict with traditional activities. To illustrate this one just has to imagine a traditional hiking path in a hilly section of an urban forest, which will be in demand by hikers as well as mountain-bikers. Regulating these new conflicts will be one of the main challenges for urban green-space management and has to be tackled on strategic as well as on tactical levels. So far studies focusing on activity-specific carrying capacities have only been introduced at project level and are not already integrated elements of green-space planning concepts. The development of new products based on 'club-good' strategies (Glück 2000) may offer a possible solution. In the context of management of public lands, however, any form of access restriction may prove to be problematic as regards its acceptance by the population.

The regulation of different recreation activities also points to the new and changed role of institutions involved in public green-space management. While in the past the role of managing institutions was restricted to mere access control and supervision of recreation activities in relation to primary land uses such as timber production or hunting, it is nowadays increasingly moving towards *leisure time moderation*. Consequently, the qualification profile for members of such organizations cannot be focusing on ecological and technical aspects of resource use. Rather will it increasingly have to consider knowledge from the field of social sciences and humanities, as well as related methods and techniques (e.g., moderation, mediation).

5.3.5
Forest in an Urban Environment or Urbanized Forests?

In the frame of urban green-space policy-making it is possible to speak of an 'urbanization' of forests and other green spaces, which is shaping the relevant policy processes. The central challenge in this context is not linked to the traditional conflicts between timber production and specific urban demands for various services from forested land. Conflicts rather arise from the variety of demands for urban services to be provided by green spaces and from the competition between green-space land use and other forms of land use, especially development interests.

Forests and green space as part of the urban infrastructure constitute more than just a greening of urban areas. Urban forests and other green spaces have to specifically fulfill urban demands. These demands require more than just reintroducing urban populations to nature and related values. They require urban green-space management to define a specific urban and democratic identity. This will only be possible if it can be liberated from the remnants of rurally inspired resource production objectives, as well as from representation requirements of feudal or industrial aristocracies or 19th century ideas of preserved nature.

In this context, the creation of certificates for specifically urban forms of green-space management would be worth discussing. The current practice that certified urban forest management with labels designed for 'sustainable timber production' has to be questioned in this context, as it could be seen as just another variant of a – nowadays considered to be obsolete – 'Wake Theory' (German: *Kielwassertheorie*, e.g., Glück et al. 2001). This theory expects a sustainable production of specifically urban services and products by certifying a product, which in the context of urban green-space management only plays a minor role.

5.3.6
Urban Forest Policies Instead of Forest Policies?

Issues that are discussed in the context of urban forest policy-making seem to have only few things in common with what is discussed in the context of forest politics, especially at European levels. As timber production is not seen as a primary management objective, there is a much lower level of conflict between timber production and conservation objectives within urban forestry. In addition, as management of urban green space is mostly in the responsibility of public organizations, the strategies of relevant actors are based on different rationales than of those in processes eventually resulting in a new definition of property rights and obligations.

When assuming that the majority of conflicts within forest policy processes result from a general value change within (Western) societies towards post-materialistic values and attitudes – which are also linked to an ongoing process of urbanization of societies – it might be expected that conflicts related to urban forest and green-space politics are but a precursor of what may come to dominate general forest politics in the future. This assumption has proven correct insofar as empirical results show that post-materialistic values have a central importance as regards urban green-space conflicts (e.g., Konijnendijk 1999). On the other hand the central problems and conflicts in the urban green-space policy field are specifically linked with the conditions in urban environments, that is when relating to urban in the context of conditions which can be expressed in terms of population density and development activities. High pressure from different types of recreation activities, and related land-use potential and land-use conflicts as a result of demands from other land uses (either through immediate competition for land resources or negative externalities) are the central themes in urban areas. However, these are only of limited relevance in a more general context of forest politics.

The specific land-ownership situation for green space in urban regions as being mostly public property constitutes a particular situation, at least within the context of the 'old' 15-member European Union. As a result of this specifically urban problems of forest and green-space politics and policy are not treated in general forest political processes. The latter are more focused on the regulation of conservation-related conflicts and the specific problems linked to the domination of private, small-scale property as the main form of forest ownership in Europe. The urban forest policy field can thus be seen as being clearly distinguishable from the general forest policy field. But as the urban forestry concept clearly encompasses more than only forest ecosystems, it is obvious that forest policy only does not suffice.

Specific urban definitions of green-space management still need to be developed. Such definitions have to be more than a mere transfer of natural areas into urban environments, but will have to be developed around specifically urban identities. The result of such developments may differ significantly from what is today understood by many under the term 'urban forest', but may be better suited for fulfilling the demands of urban societies.

5.4 Overview on Urban Forest Policy and Planning in Europe

5.4.1 European Case Studies of Urban Forest Policy and Planning

In order to provide an overview on urban forest politics in Europe case studies are presented here which were undertaken during 1999–2000, by country representatives of COST-Action E12's Working Group 1 'Objectives and functions, planning and design'. The selection of cities within countries was left to national experts.

Within the – more extensive – qualitative part of the survey of selected cities, information on conflicts was collected, together with information on the content of relevant policies and related instruments. Focus was on recreation, as recreation is usually seen as the most important function of urban green space by urban citizens (Ottitsch et al. 1999). A SWOT (Strengths-Weaknesses-Opportunities-Threats) analysis was part of the survey and resulted in a rudimentary evaluation of respective urban forest policies. Moreover, the analysis indicated trends in the field.

Only those responses that provided information suitable for a comparable presentation and analysis of results are presented here. Information comes from fourteen municipalities in eight European countries. While this does not allow for generalization of results at the European level, the results provide an indication of urban forest policies in Europe; for instance, covering the main European regions' respective problem situations. Results are presented from forest-rich, scarcely populated regions of northern Europe, densely populated regions in north-western Europe, urban regions of central-Europe (including densely populated mountain regions of the Eastern Alps), and the Mediterranean areas of southern Europe. With the example of Slovenia, the study also contains one country in transition, albeit one which is usually seen as being on the forefront with regards to adapting to a market-economy and democratization of society.

5.4.2 Summary of Quantitative Indicators for the Case Studies

Table 5.3 provides an overview of data on population size and green space in the studied municipalities.

Table 5.3. Data on green space, total area and population for the selected case studies

Town	Greenspace			Inhabitants[a]
	Total (ha)	% of total town area	m^2 / inhabitants	
Copenhagen	2 030	23	15	1 381 200
Oslo	3 380	67	68	500 000
Ljubljana	4 885	56	173	281 913
Celje	1 510	56	301	50 239
Geneva	369	23	22	171 675
Zurich	3 955	43	118	335 741
Athens	454	[b]	6	734 435
Thessaloniki	350	[b]	9	386 740
Amsterdam	5 884	27	81	718 175
Arnhem	4 286	44	321	133 272
Helsinki	5 509	30[c]	101	546 317
Reykjavik	23 400	10	2 167	108 000
Akureyri	10 000	12	6 667	15 000
Vienna	10 437	25	65	1 608 144

[a] Source: www.population.com, 09/00.
[b] No information provided for this category by national respondents.
[c] Helsinki: percentage refers to land area!
The names which are used are those which are used when reference to the respective municipality is made in English language texts. All quantitative data are usually referring to the area within the municipal administrative boundary (MAB). The actual size of the relevant urban agglomeration is in some cases larger than that, but the distinction had to be made to allow for a better comparability of data.

As the comparison of population data from Table 5.3 shows, the case studies represent a rather wide spectrum of what is usually referred to as 'urban' in a European context. Vienna, Copenhagen, Athens and Amsterdam at the upper-end of the range of population size represent the 'medium' category of European metropolises within this study, especially when taking into account that in the case of Athens and Amsterdam the actual size of the urban agglomeration is by far surpassing the municipal administrative boundaries (MAB). Unfortunately, the study does not include European examples for 'World Metropolises' (e.g., Paris, London, St. Petersburg).

5.4.3
Analysis of Main Issues, Key Functions and Policies Based on Case Study Results

Table 5.4 (see p. 130, 131) provides an overview of the main issues and policies in the selected case studies. The survey studied the relevance of regulative instruments, the importance of different functions of green space, the specific forms of participative processes, and the importance and relevance of NGOs. Also studied were the use of information policy instruments that specifically focused on activities in the field of (public) education and information. The issue of financial instruments could not be covered in detail. However, it is briefly touched upon in the analysis below.

Relevance of Local Legislation in the Field of Regulative Policy Instruments

The case study results indicate the high relevance of local (i.e. municipal) legislation as regards the development and implementation of regulative policy instruments for urban green-space policies. This indicates a high level of devolution within this policy field. It is especially interesting to note that this trend can be seen across all case studies, independent from the general national political framework, as determined by the respective constitution, having a more centralized or more decentralized character when it comes to natural resources policies.

One reason behind this phenomenon is the high importance of municipal land property in the field of urban green-space policies. Strategic decisions, for example regarding the zoning of different functions of urban green space, are mainly made as land owner's decision of municipal authorities on their own properties. Thus a 'property strategy' is applied rather than implementation of public regulations on private lands. Consequently, municipal authorities try to buy land, which is needed for major urban green policies from private owners, rather than attempting to integrate private properties into such projects.

Nevertheless, in most cases municipal authorities also exercise administrative authority over green-space areas in private hands. Having said this, there is a difference between areas that are in use for agricultural or forestry production, and areas that are not used for income purposes (i.e. private gardens or parks). As far as the former is concerned, the usual national or regional regulations (for example for forest land use) apply. Private gardens, on the other hand, are not subjected to very detailed regulations as regards management regimes. Unless such areas fall under forestry-regulations, the owner is to a large extent free as regards individual objectives (e.g. gardening style, plant selection). Usually it is only the general zoning declaration (green space or devel-

Table 5.4. Comparative presentation of case study findings within the context of urban forest policy

	Copenhagen (DK)	Oslo (NO)	Celje (SLO)	Ljubljana (SLO)	Geneva (CH)	Zurich (CH)	Athens (GR)	Thessaloniki (GR)	Amsterdam (NL)	Arnhem (NL)	Helsinki (FI)	Reykjavik (ICE)	Akureyri (ICE)	Vienna (AT)
Relevance of laws and ordinances														
National/federal	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	X	X	X
Regional					X	X			X	X	X			X
Municipal	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Main functions recognised														
Social (recreation etc.)	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Amenity (water/air quality, noise reduction, aesthetic values, living environment)		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	X	X	X
Ecological (conservation for 'its own purpose' – without social objectives attached)	X	X	X	X	X	X			X	X	X			X
Economic (timber)										X	X			X
Structures for public participation														
Representational democracy (city council etc.)	X	X	X	X				X	X	X	X	–	–	X
Institutionalised public participation at strategic level	**XP**	**XP**	**XP**	**XP**	**XA**	**XA**			**XA**	**XP**	**XA**	–	–	
Institutionalised public participation at tactical level	**XA**	**XP**	**XA**	**XA**	**XA**	**XA**	XP	XP		XP	XA	–	–	
Informal de facto participation (activities at grass roots level)		**X**			**X**	**X**		**X**	**X**	**X**		–	–	**X**

Legend: Presence of factor indicated by 'X'; most important factor within each group indicated by '**X**' (*bold print*); '–' indicates that no information was provided for this city; *A* = (*ante*) co-ordination before or accompanying planning process/activities, *P* = (*post*) consultation after planning process/activities.

Table 5.4. *Continued*

	Copenhagen (DK)	Oslo (NO)	Celje (SLO)	Ljubljana (SLO)	Geneva (CH)	Zurich (CH)	Athens (GR)	Thessaloniki (GR)	Amsterdam (NL)	Arnhem (NL)	Helsinki (FI)	Reykjavik (ICE)	Akureyri (ICE)	Vienna (AT)
Interest groups														
Organised interests (e.g., professional associations)	–		**X**	**X**		**X**	**X**	**X**	**X**		**X**	X	X	X
International NGOs	–						X							X
National NGOs	–					**X**	**X**		**X**	**X**	**X**			**X**
Regional/Municipal NGOs	–	**X**			**X**	**X**	**X**	**X**	**X**	**X**				X
Ad hoc groups	–	**X**	**X**	**X**	**X**	**X**		X		X	X			X
Educational Programmes														
Public education activities by managing institutions (forest schools etc.)	–	X	–		X	X	–		–	X	X	X	X	X
Public education activities by other institutions/organisations (e.g., conservation)	–					X	–		–	X				X
Activities by or in co-operation with educational institutes	–	–	–		X	X	–		–	X		X	X	X
Special educational infrastructures (demonstration forests, etc.)	–	–	–		–	X	–		–	X				X
Professional education and research co-operations	–	–	–	X	X	X	–	X	–	X	X			X

Legend: Presence of factor indicated by '*X*'; most important factor within each group indicated by '***X***' (*bold print*); '–' indicates that no information was provided for this city; *A* = (*ante*) co-ordination before or accompanying planning process/activities, *P* = (*post*) consultation after planning process/activities.

opment area) which has the character of a regulative instrument. In addition there also exist laws regulating the management of trees outside of forest areas, primarily tree protection acts or ordinances. These foresee, for example, the need for permits for cutting down trees and obligations for substitute-plantings if trees have to be removed. In general, civil laws governing the mutual obligations of neighbors are more relevant. So far no extensive comparative evaluation exists of the implementation of regulative instruments for urban green space as far as municipal legislation is concerned.

Social Functions As Most Important Management Objectives

The comparison of the importance of different functions of urban green space at local level shows that in general *social functions* are seen as the most important and consequently receive the highest share of attention by policy instruments. This refers especially to recreation. High relevance is also attributed to so called *welfare (or environmental) functions* (water quality, local climate, filtering of air and water), which are usually ranked before *conservation goals* (see also Chap. 4). Only three of the investigated case studies (Arnhem, Helsinki, and Vienna) name timber production as a relevant objective. This ranking of priorities, which is the result of an expert-assessment, is supported by the results of empirical research (for example, Otttitsch et al. 1999) on the preferences of urban citizens in Europe as regards green-space functions. It is interesting to see that obviously nature conservation goals are not ranked first when it comes to preferences for urban green-space management objectives, given the fact that urban populations are usually more supportive of conservation goals than rural citizens.

Supply of and Demand for Public Participation Possibilities

One of the central features of urban forestry is the high importance of public participation possibilities at strategic as well as tactical levels of planning and management (see Chap. 8).

Almost all of the cases show the existence of institutionalized models for public participation, offering levels of democratic involvement in decision-making processes, which surpass the traditional options within representative democracy for legislative and executive institutions.

Public participation possibilities are offered at strategic (development of general plans and *green-space strategies*) as well as at tactical (management plans) levels. The approaches found within the case studies offer participation both as reactive as well as proactive coordination. The former usually constitutes a possibility to comment upon and appeal against concepts designed at administrative levels, whereas the latter involves public opinion already in the phase of program development. Even in the cases where no institutionalized (i.e. legally regulated) possibilities exist for public participation, informal participation has been introduced by members of the public administration. Quite often this had happened as a reaction to preceding incidents of public protest against public policies or management actions.

The case comparison also shows that public protest occurs as well when formal possibilities for public participation are offered by the administration. This means that the full demand for participation by all segments of the public cannot always be satisfied by institutionalized offers for participation. Also in this context the need for scientific evaluation of available participation options and the connection between such policies and actual conflict situations has to be stressed.

Relevance of Non-Public Actors

Within the study research into the relevance of non-public actors, meaning actors from the field of NGOs has been regarded to include the full spectrum from ad-hoc initiatives to semi-public institutions (e.g., mandatory-membership land-owners associations). The study showed that in the context of urban green-space politics local actors are of central relevance. This constitutes a clear difference between the fields of urban green-space politics and general forest policy processes, as in the latter non-public actors are usually present in the form of 'institutionalized interests' (i.e. traditional land-owner associations, trade and labor unions), and national as well as international environmental NGOs.

The Use of Informational Instruments – Information and Education Activities

The study also investigated activities by relevant institutions in the field of education and training. The most common example in this context consists of initiatives by green-space management institutions offering green space-related education to the general public. This is often also done in cooperation with public education institutions, especially schools, often through joint activities such as excursions or more action-oriented events such as tree planting or park clean-up days. Regarding cooperation with scientific institutions, it was reported that most management institutions cooperate with universities and other research institutes through research projects.

These education-related activities can be interpreted in two ways. On one hand they can be seen as a response towards the growing demand for nature-related information from the general public and thus a customer-friendly policy by green-space management institutions. On the other hand these activities also have to be seen in the light of ongoing discussions on the reduction of public budgets in Europe in general. In this context, such activities, which are extending the portfolio of activities of management institutions to new fields, could also be interpreted as an effort to legitimize the allocation of increasingly scarce financial and personnel resources. This is done through the familiar strategy of 'extension of responsibilities' out of the arsenal of traditional strategies of public bureaucratic institutions.

The Use of Financial Policy Instruments in Urban Forest Politics

As private actors are not among the main addressees of urban forest policies, traditional financial policy instruments such as incentives or taxation have only been of low importance. This can partly be explained by the nature of the main objectives and issues in urban forest politics, as well as by the role of different actors or – more precisely – by the absence of a strong representation of private owner interests.

The most relevant, direct financial incentive for private land-owners in the context of urban forest politics are incentives to provide public access to private lands. This occurs in those countries where such access is not foreseen through some sort of universal right in the national or regional forestry legislation.

More recently some financial policy instruments have been developed in several of the covered case studies and also in the context of providing additional nature conservation services. This is done in accordance with a trend in general forest politics to ensure conservation values on private lands outside of major protection areas by individual contract agreements.

If financial instruments are regarded from a broader perspective, however, any financially relevant intervention by the government into a market economic system has to be regarded. This also includes the direct activity of the government on private markets as well as the direct provision of goods and services at no, or below market level, costs. Consequently the 'property policy', which has been identified as being among the most frequently-used approaches by municipal authorities for forest and green-space provision and management, also has to be regarded when looking into the use of financial policy instruments in urban forest politics. This includes the provision of funds for the acquisition of land, as well as the budgeting of public institutions' management activities.

With a few exceptions, precise information on the costs of green-space management could not be obtained within the case studies. The reasons for this are:

- Insufficient information on the extent of green space in private property and therefore on the private as well as public costs involved in the management and administration of these areas
- Divided responsibility for different categories of green space among different public institutions (park services and forest services)
- Problematic allocation of cost positions within public administration units, partly as a result of an insufficient differentiation between the costs for exercising of 'public authority' and 'management' of public lands, partly because of a sharing of resources used for green-space management with other areas of public administration (e.g., street cleaning, maintenance of roads and other infrastructure)
- Restrictive information policies of public administrations on financial issues, especially as regards public personnel

Results of a SWOT-Analysis

Analysis of **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats is aimed at assessing the main current issues, as well as the possibilities for development of urban forest policies in Europe. Table 5.5 (see p. 136, 137) constitutes a summary of responses aimed at showing the main commonalties as well as differences between the cases studies.

Strengths

The most interesting result from the analysis of strengths is that 'the interested public' is mentioned as being the most important factor in this context. This points to the high relevance of activities in the field of public relations and public participation. Such activities have to surpass the level of mere information and advertising, and have to include involvement into decision making processes at strategic as well as at tactical levels, as is also mentioned in Chap. 8. Another factor named as strength in the majority of the case studies is the existence of a comprehensive urban green-space concept or strategy. These issues will be discussed further below. 'Positive attitudes' of decision makers are also mentioned as strengths, although one might suspect that such attitudes should be attributed mainly in those cases where they are supported by political decisions resulting in more or less generous allocation of public resources.

Weaknesses

In line with what was mentioned above, it is interesting to note that in several of the case studies 'positive attitudes from political decision makers', mentioned as strengths, occur together with 'financial cuts/restrictions', mentioned as weaknesses, often accompanied also by 'political power of development interests'. As both of these weaknesses lie within the sphere of policy development and implementation (public budgets and zoning plans) it may be questioned in how far the 'basically positive' attitudes of decision-makers may actually be accounted for as strengths if they are not manifested in according policies. Of course the reason may also be that while green space in principle enjoys the support of (some) political decision makers, other areas of public policy, such as health or social issues, as well as development interests enjoy an even higher support. This is especially true as investments in these fields may provide more tangible results, at least in the short term.

A similar contradictory situation can be seen in the cooccurrence of 'comprehensive green-space concepts' as strengths and 'lacking implementation of existing plans and concepts' as weaknesses. It has to be analyzed in how far such implementation failures may be the results of insufficient planning, more precisely a lack in dealing with conflicting issues through adequate planning mechanisms and thus transferring their solution into the implementation phase.

Opportunities

Three of the issues mentioned in this summary as 'opportunities' lie within the domain of the political process, and more precisely within the phase of agenda-setting. The mobilization of public interest, as well as increased lobbying activities, are seen as suitable tools to bring green-space issues to the urban political agenda. The analysis of original survey questionnaires has shown that the ultimate purpose of such a mobilization is seen in the attempt to result in the allocation of higher resources from public budgets for public green-space management.

Threats

Regarding potential threats to green-space development in the case studies, the situation presents itself as being rather heterogeneous. Among the external factors listed in this context are problems, which can be summarized as being the result of ecological factors. Many of these are linked to climate conditions, including related human activities such as use of de-icing salt, together with other human caused factors, mainly pollution and, especially in Southern-Europe, fire.

Table 5.5. Results of SWOT-analysis

	Copenhagen (DK)	Oslo (NO)	Celje (SLO)	Ljubljana (SLO)	Geneva (CH)	Zurich (CH)	Athens (GR)	Thessaloniki (GR)	Amsterdam (NL)	Arnhem (NL)	Helsinki (FI)	Reykjavik (ICE)	Akureyri (ICE)	Vienna (AT)
Strengths														
Existing 'green plan/strategy' for the city	X	X	X	X			X	X			X			X
Positive attitude from political decision makers	X	X		X	X		X	X	X		X			X
Good tradition of urban greenspace management	X		X		X	X		X		X	X			X
Interested public		X		X	X	X			X	X	X	X	X	X
Administrative reforms (co-operation or merging of different departments)			X	X										
Weaknesses														
Financial cuts/restrictions	X				X	X				X	X			
Political power of 'development' interests		X	X	X										X
Unsatisfactory implementation of legislation/programs/plans		X	X	X		X		X	X	X	X			X
Lack of legal protection for greenspace			X	X										
Pressure resulting from increased use					X				X	X	X			X
Ownership structure (fragmented)			X	X										
Lack of public awareness			X				X			X				

Legend: Presence of factor indicated by 'X'.

Table 5.5. *Continued*

	Copenhagen (DK)	Oslo (NO)	Celje (SLO)	Ljubljana (SLO)	Geneva (CH)	Zurich (CH)	Athens (GR)	Thessaloniki (GR)	Amsterdam (NL)	Arnhem (NL)	Helsinki (FI)	Reykjavik (ICE)	Akureyri (ICE)	Vienna (AT)
Opportunities														
Increasing public interest/participation		X	X					X			X	X	X	X
Innovative methods, technology	X	X		X		X		X	X	X	X			X
Development of public interest		X	X	X	X		X	X		X	X	X	X	X
Political lobbying				X	X	X								
Threats														
Stress factors (e.g., pollution, salt, diseases, poor water supply, wind, harsh climate)		X				X	X	X				X	X	X
Social problems (vandalism, loitering, etc.)	X				X	X	X	X	X					
Urban development pressure	X		X						X	X	X			X
Gaps, lacks in management know-how			X	X				X						

Legend: Presence of factor indicated by 'X'.

It should be stressed that those threat scenarios which are mainly based on social problems, i.e. vandalism and other crimes, seem to occur in countries that represent a rather wide range of political culture and social conditions. Therefore, the reasons behind this have to be investigated in a broader context.

Urban development pressure, which was also listed among weaknesses, was also named in the threat-category.

Summarized Assessment of the SWOT-Analysis

In summary, the following conclusions can be drawn. Positive as well as negative factors are linked intrinsically with the positioning of green-space management within the general urban policy arena and conflict fields. Factors related to the implementation of public relation and public participation contribute both to weaknesses as well as strengths. Improvements or further developments in this field are seen as the major potential for a general improvement of the position of urban green-space policies and management. This connection has to be seen especially from the point of view of managing institutions. These institutions expect an improvement of their position within the general urban administration through higher support from the general public in order to position themselves better in the competition for resource-allocation.

Strengths and potentials have to be seen in close connection with weaknesses and threats. Among the potentially negative factors, competition from other land-uses, especially the development sector, is seen as the most serious threat to urban green space. The major political power of development interests (i.e. the construction industry) is criticized as being one of the major problems for the political positioning of urban green-space planning and management. In accordance with this assessment is also the fact that improved lobbying activities are seen as a possibility to improve this situation. Consequently segments of the general population who are interested in public green space are seen as potential allies who could be activated in order to demonstrate the high political relevance of green-space management to political decision makers. This need for a higher mobilization of public opinion, however, is not seen as urgent in those cases in which institutions involved in public green-space planning and management seem to enjoy a rather powerful position within their respective urban administrations.

5.5 Towards the Development of a Theory of Urban Forest Policy

5.5.1 Analysis of Actors and Processes

After having provided an indicative overview of urban forest policy in Europe, the general political framework for urban forestry can be analyzed further applying the basic assumptions of analytical policy theory (Krott 2002). Actors and processes are analyzed which determine the problem solving. Problem solving by urban forestry needs specific programs for multiple use and users, suitable forestry institutions, and specific strategies for collaboration with the urban stakeholders. The users of urban forests are 'drivers' through their needs, but also in their resources, access to the forests, and organization, as the above case studies have illustrated. They all focus on urban woodland and trees, which are small or few compared with the number of people interested in them. Therefore these ecosystems and vegetation elements in urban areas are exposed to user demands that frequently exceed their ecological potential.

Urban forestry institutions have become part of the municipal administration. These types of administrations differ from administrative institutions at other political levels, such as national or regional. They are forced to play many roles at the same time, as they are entrepreneurs in securing the basic supply for people in terms of housing, transportation, water and recreation. Simultaneously, the municipal administration implements and controls many laws like an authority. Additionally, the administration represents the political organization of urban people, with focus on the mayor, who is at the same time the political representative of the people and the head of administration. Being part of such a dynamic, complex institution offers specific chances for urban forestry institutions.

In the context of urban forestry and other green-space policies and management, municipalities thus act as land-owners, with an interest in gaining benefit from land management. They also have the role of a legislative power, which in the context of land-use decisions is manifest through legally-binding land-use zoning as well as through regulations governing individual land-uses. Municipalities also have executive power within their jurisdiction and are responsible for the supervision of relevant legislation. Institutions dealing with urban forestry and urban green-space planning and management at large are often involved in all these functions. They may have an advisory role in the development of relevant policies, they are in charge of managing green space, and they have to police green-space regulations within the respective autonomy given to municipal governments within the specific national or regional context.

Finally, urban forestry programs and institutions have to deal with the specific stakeholders in urban areas. As seen before, interest groups and the media are very active in urban areas. Citizens, political parties and politicians are aware of the forest, but mainly as a subject and symbol for 'green' politics. The level of conflicts is high but the options for problem solving are rapidly changing. The high dynamics of the political process dominate every urban forestry strategy, but handled in the right way these dynamics could be used for supporting these strategies too.

Political theory offers strong analytical categories and explanations for actors, instruments and processes of urban development, including forestry. A selection of the most relevant factors within the recent urban development guides to four critical factors causing a crisis to sustainable urban forestry on the one hand, and to three factors providing new opportunities for innovative urban forestry on the other.

5.5.2 Factors Causing Crisis

Urban forestry aims for much more than sustainable, profitable wood production. It wants to optimize the protection and use of trees and woodland within urban areas. This goal is in principle a public good, as every inhabitant can benefit from advantages of healthy, multifunctional green areas. The demand for free public goods is very often higher than the supply. Due to this simple economic fact, the demand for healthy woodland and trees within densely populated areas is usually higher than the supply. Urban forest and green cannot be other than scarce, causing pressure on managers devoted to serving urban needs with urban green.

Urban forestry shares the fate of falling behind its own goals with all other public programs aimed at public achievements. The exceptional situation here is that shortcomings will grow beyond the usual stage due to specific factors typical of urban forestry and urban areas:

1. The guiding concept of sustainable urban forestry is unclear. Sustainability of the forest makes sense within a sustainable urban community only; if the town is not sustainable itself, survival of trees makes no sense at all. The strong tendency of area-wide sprawls of housing, shopping centers and industry is seen as the major threat to sustainable cities due to the huge consumption of land and traffic increase causing pollution of water and air (Hesse and Schmitz 1998). If the pressure of growth is overwhelming, it should be concentrated into new centers. The first approach to counter the problem of sprawl aims at designs for the concentration on and restriction to urban centers as a solution for sustainability, and is therefore named 're-urbanization'. The second approach doubts the sustainability of big centers and aims to guide the sprawl of housing, offices, industries and traffic lines into a new structure consisting of decentralized networks of housing, working, consumption and cultural facilities, with main traffic inside the network. The version of 'decentralized networks' would save green space and traffic lines compared with the sprawl caused by centers just expanding into their surroundings ('infill'). Whether the restriction to different centers or the reorganization into decentralized networks is the more promising option for sustainability remains unclear.

   Both versions have completely different implications for future urban forestry and green-space planning. If future development is concentrated within existing urban centers, then green space around these must be strictly protected to ensure a sufficient supply with all the benefits which can be derived from green areas. At the same time, a (re-)greening of centers in the form of street and courtyard green as well as smaller park-like areas should increase the attractiveness of urban centers. If on the other hand a network of smaller urban centers is being aimed at, this would inevitably require the sacrifice of some now peripheral green areas for the creation of new centers of housing and commerce. To a limited degree this might be compensated by the re-greening of older built up areas whose function may become obsolete in the new concept (e.g., former industrial sites in areas with a primary function as living quarters).

   The contradiction between the two concepts of sustainable urban development means that the concepts of urban forestry and urban green-space planning that want to support sustainable cities cannot follow a clear guideline. Having no clear line for the central issue of sustainability is weakening the concepts whenever the necessity of justification of specific needs of urban forestry arises. In some way the concept of urban forestry is still unable to clarify its most important goal!

2. The potential for implementation of well-planned urban forestry is very limited. Let us assume that some time in the future integrated urban planning is able to provide a clear direction for urban sustainability. In this case comprehensive planning for urban forestry could show the way for sustainable management of urban forests. But here the story of success will end. Each step of implementation of the 'green plan' will have to overcome overwhelming economic and political forces. In this regard urban planning as a whole is a very weak partner for urban forestry and green-space planning at large. Urban development is driven by powerful economic enterprises competing on markets. They promise tax revenues and employment to the town. But they also know their value and importance. The town prefers to do accommodate their demands for land and infrastructure within the different development plans. The strength of the enterprises can empirically be seen by the growing sprawl of shopping centers, industry and office complexes in the surroundings of urban areas, which is in contradiction to the different concepts of urban planning (Hesse and Schmitz 1998). Planning does not change much of the market-driven development in which urban green is just a residual factor that has to adapt to new projects and traffic lines. The formal procedure requires coordination of economic development with all other sectors and plans, but in the implementation hardly any freedom is left for implementing a green plan demanding respect for green needs (Roth and Wohlmann 1994).
3. The ecological pressures on urban forests are hidden and unseen to the public and politicians. Forests and trees are changing all the time, but change is slow both in a good and in a bad direction. Worsening conditions of air, climate and soil in cities increase the stress on each tree but the tree does not immediately stop growing. Loss of green areas to buildings or traffic may be small in the individual case, but add up to a huge damage to green potential. Loss of biodiversity within the green elements is even more difficult to detect (Schulte et al. 1997). When trees become older, their vitality decreases, while diseases increase. Renewing and planting new trees is inevitable, but again, new trees grow slowly and the expected positive effects will only be observed decades later. The slow development of urban forests means that 'the reduction of maintenance activities is not readily apparent to city residents in the short run, but may have a tremendous long-term impact on the urban tree resource' (Tate 2000). Major costs of not doing enough today will occur in the future only. Long term damages and costs are weak arguments compared with public budgets. Sectors that can immediately show negative feedback to relevant groups from budget cuts gain stronger support for their needs than urban forestry, which is forced to spend money to prevent long-term negative effects.
4. Funds for urban forestry are shrinking along with the general decline of public budgets. The economic recession during the first years of the third millennium has forced most European governments to employ austerity policies. Even without economic recession, a reduction of taxation levels in order to improve international competitiveness, and the related necessary cut-down on public spending have been the main political credo of the last decade. For long the most important goods and services derived from urban forests and green space have effectively been produced as public goods, free of charge to individual beneficiaries, funded from public funds.

In relation to the above mentioned economic factors, municipal revenues do not match the growing costs for infrastructure and administration. Making debts has provided municipalities with means for active policy, but the amount of obligations has reached its limits in many of them. Like other public entities they are forced to cut back and to focus on the most essential services. Reforming the municipal administration is to a large extent aimed at prohibiting the growth of the public budget. In most towns urban forestry and green-space management is fighting with little success or none at all to save itself from budget reductions, and prospects to cover the growing costs by public funds are gloomy.

As one potential way to solve the dilemma of increasing demands and decreasing public funding economists have recommended – for many areas of public activity – that the private user who has the benefit or who causes the damage should pay personally (Wicke 1994). Ongoing discussions on the introduction of road pricing, which in some inner-city areas is currently being implemented, are but one indicator for this. Unfortunately users do not appreciate such a concept. They are accustomed to free use of the public goods of urban green and are not willing to pay for general damages their activities like housing or car driving are doing to the environment. Science has developed a variety of models of how to establish economic instruments to collect money from users causing externalities, and progress can be made in practice (Mantau et al. 2001; see also Chap. 4). Nevertheless, as long as existing externalities cannot be overcome by economic instruments, urban forestry will suffer from an indisputable lack of income from private users compared with forests that are mainly producing wood for markets.

The four trends discussed above will cause severe problems to urban forestry in the future as well. It will not be easy, even with intensive research, to clarify the concept of sustainability of urban areas and its meaning for urban green. The implementation of green plans within urban dynamics will in practice be nothing more than an exhausting fight against interests mostly stronger than forestry. Selling a preventive strategy against long-term threats for green areas to citizens and politicians will remain an extremely difficult task, and funding will be short of public and even shorter of private sources. It depends on the policy standard chosen for comparison whether the conclusion is that urban forestry as a comprehensive concept is one of the most difficult aims to achieve, or that the crisis of urban forestry is evident.

5.5.3 Factors Offering New Options

Market Driven Development Projects

For weak urban forestry, it makes sense to look for strong allies. An interesting target group could be smaller and bigger urban projects which are driven by profits to be earned on markets. An example for such projects are new urban entertainment centers, new urban housing districts on the urban fringe, renovation of housing districts inside town, new shopping and office centers on the fringe, or transformation of abandoned industrial areas.

The forces behind these market-driven development projects are strong. Investors seek new opportunities to make money. Marketing and management of the projects are professional in the way industry handles its projects. The projects offer tax revenues and employment to gain the support of the politicians. Administration reforms encourage private-public partnerships to use the dynamics of private investors and management. They simultaneously guarantee the influence of the administration to secure public goals.

The economic and political rationale of these projects cannot be discussed here and it is beyond the task and influence of urban forestry. The challenge for urban forestry is to find out how trees and maybe forests can serve the needs of these projects, and to explore new opportunities. Looking at the programs and practice of urban planning, new chances can be identified.

New urban districts have been built at the urban fringe (Wiegandt 1997). Berlin and Freiburg in Germany, for example, designed and implemented building projects on areas of 60 ha and 80 ha, developing housing facilities for 5 000 and 10 000 residents, respectively. The investors are public and small private ones. The entire area is designed by means of a comprehensive concept offering proactive green planning chances to participate. In Freiburg, 25% of the entire green area of 320 ha was used for housing, and the remaining area is envisaged for nature preservation. Architectural variety and the creation of public spaces including green areas provide significantly higher urban development qualities than the sprawl of individual housing fighting its way into the urban fringe.

Another type of project consists of the new shopping malls, sometimes developed in combination with new recreational centers or new office centers in the urban fringe. Projects destroy green areas but at the same time need an excellent design and high amenity value. Trees and forests could play an important role if the aesthetics of integrating trees and buildings are developed further. Offices shadowed by trees might be quite prestigious. The traditional preference for closed forest separated from buildings does not offer innovative options for the needs of such new projects.

Even in city centers trees are very necessary. On the one hand large abandoned buildings of former factories or hospitals, which have been moved to the fringe, are looking for follow-up uses of which recreational facilities with trees could have their share. On the other hand, dense housing in the city needs green elements to become attractive again, combining garden elements with excellent access to downtown facilities (Kühn 1998). There is a need for innovative models bringing green and trees back into existing built up structures.

The discussion among planners and architects teaches urban foresters that within new projects there is need for green elements for which woodland and trees could prove innovative models. Compared with comprehensive green planning, the advantages of such projects are their strong financial basis and their professional management which can be expected to turn the plans into reality.

Symbolic Communication by Forests

In urban areas human activities reach their highest intensity. People meet, cooperate, but also get into intense conflicts, which is a perpetual challenge for maintaining the community. Therefore, maintaining social cohesion is an important task for urban policies.

A stable basis for peace is a sufficient and just supply of basic facilities, such as housing, employment, health care, recreation, and cultural and green sources for every inhabitant. Urban policy is devoted to such public goals, but a shortage of resources and a distribution of wealth, which is determined by the economic system, lead to a result remote from the goals (United Nations Centre for Human Settlement 1996). Policy needs additional instruments to foster the community and keep it in peace.

If the situation is bad, people must have hope. They need a feeling of trust in the town and future development. Municipal politicians play a key role in offering hope to citizens, motivating them to participate in the development of the town or at least to accept the given opportunities. Political communication cannot do this difficult job by means of technical explanations only. The task of urban development is too complex to be discussed in public on a pure factual basis. Communication with the public relies to a large extent on symbolism. This does not explain things technically, but condenses 'into one symbolic event, sign, or act patriotic pride, anxieties, remembrances of past glories, of humiliations, promises of future greatness: some one of these or all of them' (Edelman 1985). Evoking emotions is as important as explaining facts. Symbolic communication has a great impact on the public perception of urban policy, and on the peaceful town life together.

Foresters love forests, but they should know that the public perception of forest in Europe is also full of condensed symbols. The media are sensible to symbolic aspects related to forest. A survey of the press coverage of the Erster Deutscher Waldgipfel (First German Forest Summit), the most important German public forest event in 2001, showed that 50% of all messages about forests use symbols evoking emotions. Most prominent are 'sustainability', 'German', 'recreation', 'forest dieback' and 'home' (Krott et al. 2002). 'Forest' is a suitable symbol for positive feelings like home or sustainability, but it can also signalize huge threats, as in the case of forest dieback.

Combining the highly symbolic contents of forest with urban policy's need for symbolic communication, urban forestry offers the chance to meet a key need of urban policy. Even today the specific urban forests are a significant part of the identity of many cities and towns, for example the Wienerwald in Vienna. Political communication has to continuously renew symbols of identity in order to keep the community together. The message needed is not mainly on what happened in the forest, forest benefits and activities for maintenance, but rather the forest's emotional role in terms of town image to be the best and a unique home to be proud of, with a challenging future full of hope for everybody.

Of course, the public discourse is already full of issues, and the media are oversupplied with news. Active public relations are needed to catch the attention of the media and the public. In addition to communicating events in urban forestry professionally, specific 'produced media events' are a promising technique to take part in the symbolic media discourse (Krumland 2000). A single tree planted by a visiting president is a big step for the forest to become part of the identity of the town, and to strengthen the identity even if the tree is a completely insignificant contribution to the forest in an ecological sense. Producing media events by using the forest to shape symbolic messages is a product of urban forestry, which meets the strong demand of urban symbolic communication.

Due to the hard competition of sectors and stakeholders to become part of the symbolic message and image of the town, only a few produced forestry media events will get through. But whenever a media forestry event occurs, a window of opportunities opens for a short while. In this very moment urban forestry has the attention of the public and politicians. Such support provides one of the few opportunities for urban forestry to achieve the desired decisions. In the long run, being frequently part of the symbolic communication of the town significantly strengthens the position of urban forestry.

Integration of Fringe Groups

Green areas and especially forests are public open areas in town. Most of the time access is free of charge, and although many things are forbidden, the freedom for different uses is larger than in most other public urban areas. Therefore it is not surprising that the forest attracts fringe groups. Due to their incomplete assimilation these prefer activities for which the town does not offer sufficient or affordable facilities. There are, for example, immigrants and ethnic minorities, who are accustomed to open air meetings and activities but live in small flats without gardens, backpackers, homeless people, drug addicts, prostitutes, and so forth. The variety of fringe groups is huge in modern towns.

Taking care of fringe groups is a big issue for urban social policy. Supporting the integration into urban life is a complex issue that cannot be discussed here due to space limitations.

Urban forest policy's task could be a mixture of two basic strategies. Firstly, green facilities can contribute to solving problems associated with fringe groups. If people need a place for a barbecue and have no private garden, forests and parks do offer such places. The management problem is to maintain security and amenity of the area, and to handle conflicts among barbecuing and other activities. This is not a question of discipline only, but a challenge to understand the users' needs and the habits of minorities that differ from the traditional native habits. Difficult problems have to be solved with regard to scarce resources and activities on the borderline to illegal behavior. It is important to understand and solve these problems not as specific forestry problems, but rather as part of the municipality's social and security policy.

Secondly, fringe groups are not clients for social welfare only. They are citizens who have the desire and the right to participate in the political decisions in the community. Due to their deficit in integration their ability to participate in policy-making is very low. Participation in the planning process is a chance which fringe groups are able to use very seldom. The lack of resources, organization and power prevent them from being a genuine partner in these procedures. As they are not much different from other interest groups, they would need some sources of political pressure for successfully promoting their interests. Therefore dealing with fringe groups includes the challenge to support them in finding their own way, building up political pressure and withstanding the guidance of public agencies. Helping urban minorities that meet in green areas is such a difficult task because it includes giving them a voice for fighting for their own interests, which might cause additional conflicts for public agencies.

5.6 Future Perspective for Urban Forest Policy – Task-Oriented Comprehensive Urban Forestry

When combining the political deficiencies of urban forestry with the opportunities mentioned above, a strategy of a 'task-oriented comprehensive urban forestry' seems promising. In spite of stating a contradiction, this strategy might work better within the given dynamics of urban areas than the perfection of a comprehensive urban forestry concept or the concentration on a few issues only.

The concept of urban forestry definitely signifies the multiple benefits and the major need for maintenance of urban trees and forests. But the forces of urban policy do not guarantee sufficient support for the comprehensive concept which could optimize the use and protection of urban forestry. The basic concept of the sustainable city itself is unclear, the impact of planning on town development is very limited, political pressure concerning long-term ecological risks is weak, and public and private funds for green issues are diminishing. These political shortcomings signify that urban forestry is under strong pressure and will not have sufficient political support to implement a comprehensive concept, however desirable such a concept might be.

Nonetheless do the dynamics of urban areas offer three main basic trends in which urban forestry could play a major role. First of all, the development of cities is driven by huge market-oriented projects for new shopping, recreation, office or housing facilities with huge buildings and traffic lines. Such projects cause severe damage to the green area or agricultural belts around cities, but they need to integrate green elements in an innovative way defining the aesthetics of integration of trees and buildings anew. Significant financial sources and political support make it even more important to implement these projects. Secondly, strong symbolic communication, which is full of emotion-evoking symbols, is necessary to maintain the peace among the highly diverse and conflicting urban population. It offers urban forests the chance to frequently become part of this discourse in the media and in public. Any time this happens, a window of support for urban forestry opens. Thirdly, urban forests are important to fringe groups. Urban forestry could be recognised as an important partner for social policy and could even help in letting the voice of fringe groups be heard.

These three opportunities can be met by active and professional urban forestry institutions only. Participation in development projects needs high technical skills and efforts. Professional PR has to become part of the central discourse in town. To contribute to social policy requires new professional abilities of urban foresters. Resources and efforts of institutions have to be focused on these tasks in order to achieve the critical majority required.

At the same time there is the permanent need of comprehensive maintenance of urban woodland and trees. The idea is that success in the new main tasks will spill over and strengthen urban forest institutions in fulfilling their regular tasks as well. Experiences and manpower financed by participating in projects will be available; the good image in public discourse will help in the competition for funding. Social policy thus becomes a mighty new partner.

The spillover-effect will work best if there is a single institution responsible for urban forests. This institution can combine the success in specific tasks with the need to maintain the urban forests in a comprehensive manner. If other institutions focus on one specific 'forest' task only they can easily be successful, but nothing will be left for many other needs of urban forests. The innovation and professionalism of existing institutions managing urban forestry, and the strength of the competing institutions trying to be successful in the few growing forestry tasks, will decide whether the concept of task-oriented comprehensive urban forestry will be implemented in practice.

Acknowledgments

The authors' gratitude is hereby expressed to the contributions of the members of Working Group 1 of COST-Action E12 'Urban Forests and Trees' who made this work possible. Special thanks are hereby expressed to the task force which was active in the development and distribution of the questionnaire, consisting of C. Konijnendijk, K. Collins and F. Salbitano. Further thanks are due to the respondents for the individual city case-studies (in alphabetical order of respective country): P. Aurenhammer (Vienna, Austria), C. Nuppenau (Copenhagen, Denmark), L. Tyrväinen, M. Rautamäki (Helsinki, Finland), A. Hatzistathis (Athens and Thessaloniki, Greece), R. Skarphéðinsdóttir (Rejkjavik, Akureyri, Iceland), C. Konijnendijk, D. Blom (Amsterdam and Arnhem, The Netherlands), K. Seeland (Geneva and Zurich, Switzerland), J. Pirnat, P. Oven (Ljubljana, Slovenia), R. Hostnik (Celje, Slovenia), S. Nyhuus (Oslo, Norway).

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Chapter 6

Design of Urban Forests

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6.1 Introduction

Designers work to change the landscape from its current state to one which better meets society's prevailing needs, while protecting the valuable assets handed down from the past and ensuring that the potential for future generations is also maintained.

The urban forest may already contain a great legacy, the best of which must be conserved, restored and maintained. Other areas may need to be altered to a greater or lesser degree, in part to reflect the changes experienced by the community as well as to reflect the evolving urban structure. Significant new areas of urban forest may also be required, possibly to be established on technically difficult sites. Here the designer may have a relatively clean canvas upon which to create a landscape for the future, responsive to current needs but also looking to advance the frontiers of design, especially in meeting the needs of sustainable cities.

Landscapes of woodlands, parks, and trees in streets and other urban spaces take a long time to develop and mature; such landscapes require vision and perseverance on the part of the designers and managers. This vision needs to encompass scales of landscape ranging from the regional planning level where large-scale green structures are designed to unify several urban areas, such as in the English Community Forests or the Dutch *Randstadgroenstructuur* (Ministerie van VROM 1991) down to the detail of a small park or urban square. It is a tremendous challenge.

This chapter explores the design of the urban forest. Whether the various elements are new to the urban green-space structure, or whether they are existing components which require changes in layout or management due to evolving demands, design has an important part to play. The spatial layout of trees, their composition and structure, interact with the ways people perceive or make use of them and also affect physical and ecological functioning such as shelter, shade and habitat provision.

What are the design elements covered by this chapter and how do they fit together? In Chap. 1 the main focus of this book was set out primarily to include woodlands, parks and street trees. It can sometimes be difficult to be precise about distinguishing between, for example, a park, a woodland, or forest: after all, some places are called 'forest parks'. Street trees obviously include trees in squares and other urban thoroughfares, but what about riversides, canal sides or railways. Where do trees in gardens fit in? These are all part of the urban forest. Some are mainly to be found in the public realm, others in private spaces.

Making the distinction between forest/woodland and park is more complicated in English than it might be in other languages, due to the origins of and historical and cultural associations of these words (Harrison 1992). The term 'forest' originally referred to open, wild areas (usually with a high proportion of tree cover), while 'park' meant enclosed (emparked) areas, set aside to protect deer, eventually becoming the kind of landscape parks around country houses and later, city parks. These terms do, of course, change over time and tend to be somewhat fluid. It is also important that the terms reflect the widest possible application across Europe. For the purpose of clarification and structure, the following definitions are used for the rest of this chapter.

Urban woodland means a forested ecosystem of natural, semi-natural or man-made origin, used for a variety of purposes including recreation, nature protection and, in exceptional circumstances, wood production. It is mainly tree covered, although other elements such as water, wet areas, paths and open spaces of different sizes are often to be found. Woodlands may tend to be more multi-purpose than parks and their design may need to accommodate more uses, some of which may conflict while others are complementary (Fig. 6.1). Examples can be found in and around many cities, such as Losiny Ostrov (Elk Island) National Park in Moscow, Helsinki Central Park (Fig. 6.2), the forests around Stuttgart (Fig. 6.3) and Ljubljana, Epping Forest in London or the Vienna Woods, all original forests absorbed into the city. More recently created examples include the Vestskoven (West Forest) on the edge of Copenhagen and the Amsterdamse Bos, near Amsterdam.

Woodlands may also be more dynamic, changing in layout and structure over time. Many people may consider them to be more wild or natural in character than other elements of the urban forest and this quality needs to be considered in design.

Fig. 6.1. This is a woodland at Sutton Park in Sutton Coldfield near Birmingham in Britain. Many people use this woodland for dog walking, getting fresh air and exercise, and playing impromptu games in summer. People in Britain are not always used to visiting woodlands, which occupy only a small part of the landscape. Shelter from cold winds is important (*photo:* S. Bell)

Fig. 6.2. Helsinki city forest (Central Park) is mainly a forest of native trees, spruce, pine and birch. It is used for similar activities as the British example except that in the long, dark winter there is much more skiing. People in Finland are very fond of forests, which cover much of the country (*photo:* S. Bell)

Fig. 6.3. Stuttgart, in Germany, has extensive forest around the suburbs, much of which is available for recreational use. The continental climate of central Europe means that forests help to keep visitors cool in the hot summers and comfortable during the cold winters (*photo:* S. Bell)

A park is a mainly open space set aside for recreational purposes, both formal and informal, with a significant component of trees to provide visual screening, shelter, shade and aesthetic pleasure (Fig. 6.4). As well as trees, grass is likely to be a major vegetation element together with shrubs, water, surfaced areas such as roads and paths and possibly buildings and other structures provided as amenities for the public. Famous examples of old deer parks that have become city parks include Jaegersborg Dyrehaven in Copenhagen and Sutton Park near Birmingham.

Existing parks often reflect the design movements or styles that prevailed at the time they were designed. These may be national styles, such as the 'English style' or international, such as the Modern Movement. Well-known examples of parks in different styles are Phoenix Park in Dublin, in the English style, the Boboli Gardens in Florence in a Renaissance style, Versailles near Paris in the unique 17th Century French style, or Parc La Villette, a Modern (or post-modern) park, also in Paris (Jellicoe and Jellicoe 1995).

Street trees are planted and maintained in the public spaces within housing areas, between buildings within the urban fabric, along the constructed type of edges of rivers and canals and around lakes, squares, along streets, avenues and boulevards and in association with old linear fortifications. They complement the architecture of the urban area. Such locations may present challenges to the designer because of the practical constraints that often apply. Cities well known for their street trees include The Hague, London (with the famous London plane tree) and Paris with its shady boulevards.

Fig. 6.4. In Lisbon, this park is characterized by the canopy provided by the trees which gives a shady place for activities which, while similar to elsewhere, need more shade in the long hot summer, although they can take place comfortably for much more of the year owing to the milder Mediterranean winter (*photo:* C. Castel-Branco)

Trees can also be important features of private or commercial spaces such as gardens or business premises. As such they may represent a significant proportion of the tree population of a town or city. On the one hand it is difficult to control how trees on private property are used as part of a wider, unified urban design but, on the other hand, they represent a chance for people to express themselves and to develop their own, personal relationships with trees and plants. However, it is important not to lose sight of the need for an overall, city-wide sense of unity in the complete pattern of urban woods, parks, street trees and trees in private spaces.

Often one urban forest element leads into, is connected by or visually links with another to present an overall sense of a city-wide forest. This coherent pattern should be developed strategically, taking the existing elements and planning new ones to fill gaps and establish new connections. It is highly desirable that a city resident can encounter a tree outside their door and through this, feel a connection to the wider urban green-space system, if not the wider landscape beyond (Bell 1994, 1999b).

Chapter Objective

The objective of this chapter is to present an overview of the main issues, concepts and principles concerning urban forest design. The chapter mainly covers the design of trees in public spaces, because this is where the large scale is relevant and where the public benefits are mostly achieved. The design concepts and principles are, however also relevant to the design of private and commercial spaces. Since other chapters of the book deal with many of the physical and ecological benefits of urban forests (e.g., Chap. 4) this chapter will concentrate on the social, experiential and functional aspects associated with people making use of urban woods, parks and street trees.

Urban forestry is a multi-disciplinary subject and this chapter on urban forest design can only deal relatively superficially with a wide range of aspects that form disciplines in their own right, such as forest landscape design, urban park design, urban design, arboriculture or habitat creation. The references listed at the end of the chapter provide a sample covering this diverse, multi-faceted subject.

The chapter is arranged into five main sections. Firstly, the European dimension is presented, reflecting the fact that urban forest design has to relate to very different circumstances around Europe. Secondly, a brief historical review looks at some of the past design aspects that form the legacy found today. Thirdly, a number of main conceptual themes are explored in relation to various design dimensions: social, experiential, functional and ecological. Fourthly, design concepts examine the main approaches to urban forest design found, through practice, to be most successful. Fifthly, design considerations describe the process of design and the detailed aspects that have to be considered under different circumstances. Finally, the chapter considers what opportunities exist for designing the urban forest of the future.

This chapter has been written by a group of experts and it is based largely on their combined experience. The chapter presents a combination of tried and tested approaches together with new visions and ideas for the future. Readers should be able to feel comfortable with most of the concepts and, hopefully, to use them to create wonderful new landscapes.

6.2 The European Dimension

When considering urban forest design across Europe, it is important to ensure that regional differences are highlighted. The character and function of urban woods, parks and trees contain both similarities and differences between, for example, London, Helsinki, Vienna and Florence. People undertake popular activities such as dog walking or jogging, picnicking or kicking a ball about in all four cities. However, the climate, the ecosystem, the cultural history and the character of the people of each country also lead to major differences and it would be inappropriate and undesirable to recommend principles of design that ignore this rich variety.

Between the European-wide and the national or local scales it is possible to detect broad regional characteristics of what might be termed 'forest culture' (Sims and Hislop 1999). These zones, shown on Fig. 6.5, reflect the climatic and ecological differences, the importance of forests in the national economy and as part of the landscape, and the way forests and trees relate to the national culture through traditional uses, forms of recreation, folktales and legends.

The northern forest culture covers Norway, most of Sweden, Finland and the Baltic states. Here the forest is a major element of the landscape, the national economy and in the everyday lives of the people. Cities such as Stockholm, Oslo, Helsinki, Tallinn, Riga or Vilnius, tend to be set within and surrounded by large tracts of forest, which expand beyond the urban boundary. The cities have expanded into the forests and the people go out into them almost as much for mushroom and berry picking as for walking or skiing (Sievänen 2001).

The central European forest culture covers those countries with a mainly continental climate but with milder winters and warmer summers than the northern countries. The landscapes are quite forested but not so heavily as in the north, and the woods

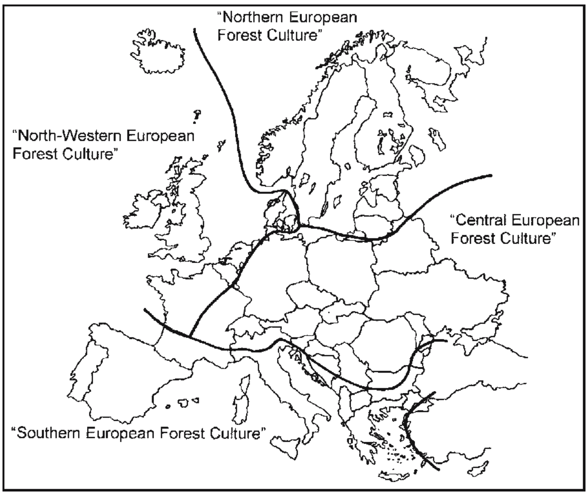

Fig. 6.5. This map shows the division of Europe into four different zones of 'forest culture'. This regional variation should be taken into account in the design of the urban forest (*illustration:* S. Bell)

contain a higher proportion of broadleaf plants and are well managed. Many cities, such as Stuttgart or Vienna possess significant wooded tracts but these lie mainly at the periphery and may be former royal or aristocratic hunting estates with a long history of management and use. The people of the cities use these woods intensively for all kinds of recreation and the woods may be under considerable pressure.

The southern forest culture occurs in the mainly Mediterranean countries, including southern France and Portugal. The Mediterranean climate of hot summers and warm winters means that people live outdoors for a lot of the time, so that street trees, parks, squares and woodlands provide much needed shade. Forests may be significant in mountainous or hilly parts. Close to cities most forests were once reserved as hunting parks and are now used for recreation. In these countries the urban culture has grown apart from the forest culture. Fire is a major threat to forests with a high degree of public use (see also Chap. 11).

The north-western forest culture includes Britain, Ireland, Belgium, the Netherlands, Denmark, southern Sweden, north-east France and Iceland. The common factor in these areas is the loss of most of their forest cover over the last 3–4 thousand years, so that forests now occupy a small percentage of the land area. Many forests are now of plantation origin and are intensively used. In popular culture forests are sometimes seen as alien places, so that urban people are less spiritually connected to them than in the Northern zone, for example. These are also highly urbanized and industrialized countries with dense populations who need space for recreation, but where private land is not always available for public access.

6.3 A Historical Review

6.3.1 Development of Urban Forests

Chapter 2 explores the historical background to urban forests in some detail. However, from a design point of view it is worth noting some major features that continue to have an effect. These form not only a historical legacy of trees in towns and cities but continue to have an influence on urban design.

In Europe, as opposed to North America, cities are often very much older and possess different features. For example, the core areas of many major cities are of medieval origin, with narrow winding streets and they developed 'organically' (Jellicoe and Jellicoe 1995; Bell 1999a). Trees and parks rarely form a significant component of these cities, although, as the cities expanded beyond the lines of walls or fortifications, these redundant defences often became parks close to the old centers. The boulevard rings of Moscow or Riga or the old defences of Copenhagen or walls of Lucca (Fig. 6.6) are examples of this. The outer areas of these cities, as well as many more modern city developments, were often planned and laid out with a structure of avenues, tree lined streets, formal squares and parks designed not only to enhance the city architecture but also to provide aesthetic and public health functions. These often reflect the pre-

Fig. 6.6. The old city walls of Lucca, in Italy, had trees planted on them to help dry out the earth fill and make them stronger fortifications. Their defensive purpose has long ceased to exist, so that they make a very attractive, shady walk right around the old city (*photo:* S. Bell)

vailing style of the different eras in which they were laid out. The New Town of Edinburgh, the 19^{th} century expansion of Barcelona and the English New Towns such as Milton Keynes reflect this approach (Bell 1999a).

As many cities expanded they incorporated already existing parks and forests (Fig. 6.7). Sometimes forest areas remain in their natural state, although subject to increased pressures, others have been modified, either through management or as a result of human use. The idea of parkways or greenbelts surrounding the dense urban area became a design concept where urban forests influenced the urban growth. Helsinki has gradually expanded into the surrounding forest areas and Tapio New Town in Finland was designed to fit into the forest into which it was built. Sometimes the expansion of cities has brought threats, for example the problem of fire in Mediterranean forests close to cities such as Thessaloniki in Greece.

Many post-war city developments right across Europe have been built for mass housing with dense populations living in high or medium rise apartment blocks. Access to green space has often been at a premium but it has not always been either readily available or designed to a good standard, despite the best intentions when they were constructed (Fairbrother 1970). Many of the open spaces around housing blocks, whether in Glasgow or Moscow can be depressing because of the lack of good green structure. Conversely, there have been many examples of ambitious new urban forest programs and developments, those of Amsterdam and other cities in the Netherlands, from the 1930s, Copenhagen, in Denmark, from the 1960s and around a number of cities and towns in the UK over the last 10 years or so being some of the most significant. Public participation in planning, design and management is also increasingly important and will influence design more and more (see Chap. 8).

Fig. 6.7.
This piece of urban forest in St. Petersburg used to be well outside the city, but as massive housing development took place after the war, it has become surrounded by the city. From a woodland managed to provide timber it has become a recreational amenity, with implications for its layout and management (*photo:* S. Bell)

6.3.2
Changing Perceptions, Uses and Management

Urban society is constantly changing and developing, placing new demands on the urban forest. Designs that fulfilled the needs of society 300, 200 or 50 years ago do not necessarily satisfy today's requirements. Designers need to be able to maintain important elements of tradition and cultural heritage contained in the existing resource, whilst at the same time enable it to be managed for changing use patterns. The urban forest takes time to grow: woods planted 10 years ago are only now developing much of a structure; by the time they are mature new demands are certain to be placed upon them (Hodge 1995).

Design is a constant process and should be an integral part of management, so that the developing landscape can change and evolve to meet new challenges. Designers therefore need to seek for universal elements that withstand these changing pressures. One approach, as far as woodland is concerned, is to keep as close to nature as possible and not to become too associated with design styles that quickly go out of fashion as opposed to the long-lasting forest atmosphere. Designers should also use natural processes as the base to prepare the space for human use. The continuity over time of a woodland ecosystem also has important spiritual and aesthetic values that more ephemeral elements lack. This should be considered together with the economic, cultural and social processes driving design and does not mean that the early years of establishment are left entirely to natural processes. Instead, natural processes are fitted into management to produce the design. Having said that, it is also important to develop new ideas and to look forward as well as back.

6.4 Main Conceptual Themes

When considering the design of the urban forest, whether street trees, parks or woodlands there are some key conceptual themes to be considered. These are presented as four interlocking dimensions. Any over-emphasis on one dimension to the exclusion of others may cause an imbalance in the design, although in the case of particular projects some dimensions are likely to be more important than others. These dimensions are

1. the social
2. the experiential
3. the functional
4. the ecological

Of course, since these dimensions interlock they have to be considered in an integrated way, rather than as separate, independent aspects. Thus, the interpretation and application of each dimension will be unique to the location, setting and social and cultural context.

6.4.1 The Social Dimension

Social functions of the urban forest are many and varied, generally including those aspects where the social life of people as individuals or in groups can be enhanced. To some people urban life, as a result of their living conditions, might be considered to be a negative experience, so that access to green areas is considered to be an escape. Others might see little distinction between the built and the green environment, considering them both to be equal parts of the urban area, using both components in an integrated way to obtain a high quality of life. This means that the aspects of the social dimension, escape, social activities, and safety and security, need to be considered in the context of the wider social and urban environment.

Escape

In all areas of Europe and especially in the larger cities, where the built environment is the dominant medium of most peoples' lives, a major social benefit is being able to escape from the urban scene from time to time and enjoy solitude or company in a more relaxed atmosphere conducive to reflection, conversation and stress reduction (Bell 1997a, 1999b). This is not to imply that urban life is wholly negative but that part of what contributes to positive urban life is the chance to experience the contrast with the built environment provided by nature. Street trees provide a valuable presence of nature and, *en masse*, can present a significant foil to buildings and other constructed features. Parks with a strong component of trees that screen out the sight of buildings provide valuable oases within the city. It is, however, woodland that provides the strongest sense of separation. This is because the mass of trees and the effect of their height can create an inward looking landscape, a separate world, where the visible and audible reminders of the external landscape can be blocked out and the constant, inescapable stimulation to the senses, which can be one of the negative aspects of an urban setting, replaced by the calming and harmonious exposure to nature (Bell 1999c, Fig. 6.8).

Thus, if the function of a park or woodland is to provide the opportunity to feel a 'psychic distance' from the urban scene, a style or approach to design that maintains, enhances or creates an impression of naturalness or wildness may be preferable to a more formal approach. However, it is important to allow for cultural references to be incorporated and to develop a sense of place that helps people to identify more strongly with their community. People living in cities in northern Europe, who feel closer to the forest, may need to be able to escape from the built environment more than those from southern Europe where the tradition of city living is more deeply rooted.

Fig. 6.8. When visiting the Amsterdamse Bos (city forest of Amsterdam) it is possible to shut out most of the visible signs of the surrounding urbanized landscape. Unfortunately, it is not possible to remove the sound of aircraft approaching or leaving the nearby Schiphol International Airport (*photo:* S. Bell)

Social Activities

Parks and woodlands provide the setting for many social activities, for example walking, sitting looking at the view, having a picnic, kicking a ball around, skiing, orienteering, for social intercourse with family or friends and so on. Some of these can take place in fairly gregarious conditions in a small space. Others require a bigger area and sufficient space to gain a sense of solitude. There is also the potential of streets, parks and woodlands to provide a neutral place (not owned or controlled by any one social group) where the integration of various ethnic, social or other groups can take place, thus reinforcing community integration. Squares shaded by trees are another example of a setting for social activities within cities, such as those in southern Europe, where more of life takes place out of doors than in the north.

The use of the urban forest by children is an especially important social use. Children who form associations with the natural world and who visit and play in woods and parks are much more likely to continue to do so as adults (Ward Thompson et al. 2002). The role of urban green places for play and the value that natural areas provide over more urban playgrounds is widely recognised and should be maximized (Bell 1997a).

Safety and Security

A practical aspect of the development of opportunities for social interaction in urban parks and woodlands, as well as on city streets, is the sense of safety and comfort experienced by visitors (Schuit and Hajonides 1991; Burgess 1995). In the northern and central European forest culture areas the population is generally more comfortable with visiting woods and forest parks. They are less worried about being attacked or getting lost. People of the north-western and southern forest culture may be less comfortable and need an atmosphere that reassures them. This may include greater visibility along paths and beneath trees and more obvious signs of a management presence and clear signposting. Conversely, it can be valuable to allow certain places to develop a wilder character, less easy to enter and perhaps more exciting, to cater for the people who prefer to find solitude, who wish to be self-reliant and who are not fearful of being in wild places (Bell 1994). Trees in streets and squares may attract people to use these spaces more and with this increased presence of people may come a greater sense of safety and security.

Safety issues also include physical safety and the worry, especially by elderly or disabled people, that they may hurt themselves. Accessibility to as wide a range of potential users as possible is also an important feature in the design and layout of paths, especially in hilly areas (Bell 1997a).

6.4.2
The Experiential Dimension

The urban forest provides opportunities for many experiences, like different aesthetic qualities presented through different design styles, and the role of the urban forest in urban life.

Aesthetics

Parks and especially woods provide opportunities for a rich aesthetic experience that is different from and contrasts with that of the built environment. In the fast changing urban scene, novelty and fashion are often the dominating aesthetic influence. In a forest park or deep in a woodland, the richer and more profound multi-sensory experience possesses a timeless as opposed to an ephemeral quality. In woodland, a harmonious blend of sights, sounds, smells, tastes and the full range of haptic or kinaesthetic stimuli are present. This can provide a rewarding contrast, where urban streets are counterpoised by the park or forest, enhancing both experiences. With the seasons these changes also present continuity (Berleant 1992; Bell 1999a). The full aesthetic engagement of all the senses works at a deeper level, for example the sense of time associated with large old trees that have been there for centuries or the connection of death and decay with new life and growth (Bosch and Slabbers 1993). These are features that enrich us and connect us with nature.

The aesthetic experience of urban centers is often enriched by the presence of trees in streets, squares and gardens. They can bring seasonal changes close to people and the sight of nature close to home can be very rewarding. Contrasts between built and natural forms also provide an aesthetic stimulus.

Design Style

The question of aesthetics is inevitably connected with style. Woods and parks take many years to plan and plant as well as to develop and mature and are at their best several decades or even centuries after they were first planned. Thus, if a particularly trendy style has been adopted it will be out of fashion well before the landscape has reached its prime. However, it is impossible and undesirable to eliminate all traces of contemporary design influences since these are, inevitably, applied unconsciously by the designer who was trained in a particular era. Furthermore, it is appropriate for there to be some references to the period in which the park or woodland was designed since these will reflect the current social and cultural norms. In this way they will contribute to the fabric of the city, which already reflects all eras of its development, and to the overall cultural heritage of the future.

Trees in streets and squares contribute much to the overall urban fabric and can be used as part of a contemporary design. Their use in such designs can involve the selection of tree form and also their management as individual and groups of trees. Many older examples reflect past architectural and design styles and the current and future trends are also likely to be represented.

The layout and design or style of places such as parks or woodlands, the paths, planting patterns and open spaces, can act as symbols for the degree of control or active presence of people that can have implications for the experiences available to people. For example, a woodland laid out and managed so as to present an impression of naturalness (the absence of geometry, formality, urban forms and materials etc.) can send a symbolic message to the visitor – that he or she is close to nature and away from too much control over the landscape. This can be contrasted with a woodland laid out in a formal way with avenues, *allées*, '*rond-points*' and other features and where paths are surfaced in tarmac, trees planted in straight lines and so forth (Forestry Commission 1992).

The Role of the Urban Forest in Urban Life

Trees in streets, squares and smaller spaces within the denser parts of cities enhance everyday life while larger parks and woods cater for the non-urban experience. As a sense of continuity and timelessness is needed in design to counteract the rapid changes in the urban scene, there is no better template for this than nature, in the sense of natural processes of vegetation growth and development. Furthermore, it can be argued that the urban forest acts as a kind of intermediate landscape, a stepping-stone between the built city and nature. The experience of a single tree in a garden or street, which is itself part of a larger urban forest, can provide that link, via the park, to the urban woodland, which, if well designed, can symbolize pure, idealized nature (Bell 1994, 1999b).

6.4.3 The Functional Dimension

Street trees, parks and woodlands carry out a range of functions, many of which are covered by other chapters. The functional aspects discussed here include accessibility, promotion of health and well-being, the need to provide for a wide range of types of physical exercise (carrying capacity) and the effect of different climatic conditions.

Accessibility

Urban woodlands and parks, as well as other open spaces, must be accessible to as much of the population as possible. This includes people with a wide range of physical or mental disabilities, elderly people, young children, people from different ethnic groups and poorer people. There are specific design requirements for many of these categories, but it is important not to spoil the desirable aesthetic qualities of the park, woodland or other space when increasing access provision, otherwise the experiences, which are as important to all these groups, will be diminished (Bell 1997a).

Different activities have different design requirements. For example, paths used by pedestrians, bicycles or horses are laid out differently with different widths, surfaces and headroom. The dimensions, gradients and other features needed for inclusive access must also be considered within the constraints imposed by the terrain and landscape character.

Carrying Capacity

Sites have to be designed to satisfy both physical and visual carrying capacity. For example, a heavily used park may suffer serious soil and vegetation erosion from too many feet. More robust surfacing and control of access would increase its physical carrying capacity. A straight path or avenue means that everyone using it is visible at once, so if it is busy it has a low visual carrying capacity (Forestry Commission 1991). A winding path among trees and shrubs means that it is only possible to see much shorter distances, so that most users of the path cannot be seen, even though there may be more of them. This increases the visual carrying capacity (Fig. 6.9).

Fig. 6.9. This former royal hunting forest, at Breda in the Netherlands, retains its formal layout of straight 'rides' or avenues. While reflecting the historical character and cultural history, this layout does not have as high a visual carrying capacity as more 'naturalistic' approaches to design (*photo:* S. Bell)

Experience has shown that physical and visual carrying capacity generally increases at a proportionally greater rate than an increase in area (Forestry Commission 1991). Thus the functional potential is more than double for an area twice the size. This has implications for both the pressures on small, isolated areas and the desirability of acquiring land areas that are as large as possible.

Climate

There are also climatic differences across Europe that need to be reflected in the design. For example a picnic or sitting area in a Mediterranean country probably requires a degree of shade, whilst in northern Europe the sunniest places will be chosen or, in windy areas, shelter might be the most important. Trees help to moderate extremes of climate and weather all year round in any country, for example by reducing windiness near buildings, decreasing the wind-chill factor, increasing cooling in summer and the reduction of glare or mitigating the impact of rain or freezing conditions. Thus, woodlands in particular with the greater tree cover, offer the possibilities of all-year-round use, ideal for those who enjoy the outdoors as part of their daily routine.

6.4.4
The Ecological Dimension

The four European regional forest cultural types described earlier are all generally based on climatic and ecological differences. The conservation and development of biodiversity is one important goal of urban forests despite the great social and economic pressures present. This is a major challenge for design. It is usually important to reflect the local ecological characteristics of the areas where the woodland, park or street trees are to be located. However, there are some challenges.

Urban Ecology

Many cities present a significantly altered ecosystem. In part this is due to the local microclimate change inherent in a built environment and also due to the large-scale introduction of exotic plant species in parks and gardens. In many instances there is abandoned land which becomes taken over by scrub woodland composed of an *ad hoc* range of plant species. Moreover, disturbed land from former industrial use such as coal mining or gravel extraction may lack soil or contain trace minerals or chemicals which inhibit plant growth, have impeded drainage or produce noxious gases such as methane (Moffat and McNeil 1994). All these influences may limit the ecological possibilities. On the other hand, urban forest planting can help to improve or revitalize the natural capital of an urban area through the increase of ground water infiltration, soil amelioration, or erosion control.

In cities where the urban development has expanded into or around woodland there is more scope to retain the natural processes and plant composition and structure, although climatic or drainage change and the impact of people using an area may inevitably alter it. Even quite small natural patches can be successfully retained. There is also scope to create new habitats or to promote natural processes that ultimately lead to the development of new habitats.

Landscape Ecological Principles

Landscape ecological principles should be employed as a key part of the design process, employing devices such as linking corridors to connect scattered habitat fragments and allow wildlife species to move from one to another (McHarg 1969; Forman and Godron 1986; Gustavsson and Ingelög 1994; Forman 1995; Komulainen 1995). It is important to design and manage the woodlands according to the natural conditions which give different potential and inherent habitat diversity to the site, although this may be difficult where the ground and soil have been disturbed. These approaches may have considerable impact on the design style when compared with more traditional urban parks, for example.

In urban areas there are possibilities to develop the ecological values at several different scales:

1. The regional scale: here the green area of a town or city can be linked into that of a wider region by maintaining or developing strong connections. Peri-urban woodland connected to the landscape structure of the rural hinterland can be very effective, while corridors extending into the urban areas from the peri-urban woodlands develop the connections further (Marsh 1991).
2. The city scale: there are opportunities to develop a green network within an urban area, connecting parks and woods via linear corridors, the use of street trees and also gardens (Tummers and Tummers-Zuurmond 1997). Trees can provide the connecting matrix with which patches of different habitats can fit and be linked to one another.

3. The habitat scale: a variety of habitats can be created and protected, many of which are not necessarily natural; in fact many habitats can be artificially created quite successfully in urban areas and be very valuable ecologically and educationally. Wooded areas can incorporate wetlands, ponds, grassy spaces and a variety of edge habitats. Parks can include ponds, which are important for birds as well as providing the chance for people to experience wildlife close at hand (Baines and Smart 1991).

The social value of nature to urban people should not be underestimated, and the ways of developing a strong ecological basis for the urban forest should include the possibilities for people to get close to nature as part of their everyday lives. This also needs to be considered in design (Coles and Bussey 2000).

6.5 Design Concepts

This section explores a number of key design concepts, which have been mainly developed through practical experience over many years, supported by a degree of research. There remains plenty of scope for designers to take these concepts and to develop them further.

6.5.1 Woodland

In order to satisfy the four dimensions described above, woodlands, whether existing or newly created, should generally embody the concepts of 'nature in the city' and 'composition and structure'.

Nature in the City

Woodland usually represents the archetypal 'natural' or 'permanent' landscape and should present opportunities for people to escape the pressures of the city by providing a natural or naturalistic ambience (Bell 1994, 1999b). Woods should enclose the visitor and screen the visual reminders of the city from view whilst at the same time avoiding creating an impression that frightens people (especially in the area of the north-western and southern forest culture). It may also be desirable to allow some views out of the woodland towards key city landmarks, in order to balance the idea of cutting people off from the city with a sense of place and orientation (Laurie 1979, Fig. 6.10).

Composition and Structure

Woods should contain the range of tree, shrub and other plant species and compositional patterns and layers found in natural woodland, as these produce more biodiversity values and are easier to manage and maintain. The matrix or structure of woodland should contain a range of open spaces but if these exceed around 30% of the area there is a risk that the sense of enclosure will be lost (Forestry Commission 1991). These open spaces may include different habitats and spaces for recreational and social activities. Linear spaces

Fig. 6.10. This sketch shows a path leading through an open space in a woodland. The path winds among the trees, creating a sense of mystery. While generally maintaining a sense of enclosure, screening out the sight of the city, glimpses of key landmarks, such as a church spire, have also been retained. This gives reassurance and orientation to visitors. The trees include multi-layered stands with graded edges, better for wildlife, and also open stands with no undergrowth, to allow views through the trees (*illustration:* S. Bell)

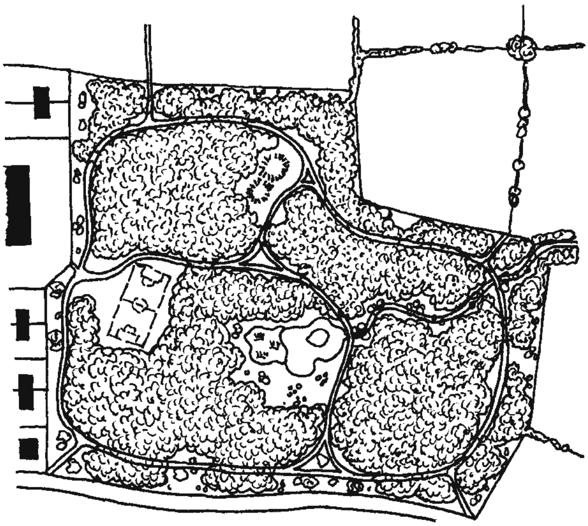

Fig. 6.11. This diagram shows a woodland within which are several open spaces. These include a children's play area near to houses, some archaeological remains and a pond, wetland and stream complex. These are connected by footpaths, along which there are some linear open spaces. Open space has also been designed around the perimeter of the woodland next to housing so as to avoid the effects of shading (*illustration:* S. Bell)

can be used to link nodes of larger scale open space. The main open spaces are usually located towards the edges of larger woodland areas nearer to the city, for ease of access and to emphasize the gradation of managed to wilder landscape (Fig. 6.11).

Within the range of possible structure and composition there are opportunities to manage woodland to create different atmospheres, or situations of greater safety. For example, simple structures that can easily be seen through might be used in some places while multi-layered, more complex ones might be used to create a wilder feel and a stand of more use to wildlife. Stands of single species can be contrasted with ones of mixed species. Stand conditions change with age, so while younger stands may be dense they may become less dense and more open as they mature and as various management activities take place. There is a lot of scope for design within the range of composition and structures found in natural or traditionally managed woodlands as well as the potential to develop new models to suit a particular purpose (Forestry Commission 1992; Gustavsson and Ingelög 1994; Gustavsson 2002).

Woodland design is accomplished through the manipulation of the spatial pattern of different stands of trees, their species composition and vertical structure. Edges are also very important. These elements are manipulated through woodland management and the adoption of different silvicultural systems (Komulainen 1995; Sarlov-Herlin and Fry 2000). Species selection can be based on the sole use of native species, or a mixture of native and introduced, depending on the design objective, site, climate or ecological value. There are often distinct regional variations, where, for example, woodlands in the northwestern zone may contain more introduced species for a variety of historical reasons, while the north European zone is almost wholly confined to the use of native species.

6.5.2 Trees in Parks

Parks, according to the definition given earlier, tend to consist of open spaces where trees provide mass and structure and define the character and scale of space. Trees may be dense and block views or more widely spaced and open so that the space/mass junction is blurred. It is the designer's job to control and manipulate the space/mass structure and relate it to the social, aesthetic, functional and ecological dimensions (Laurie 1979; St. Bodfan Gruffydd 1987; Bradshaw et al. 1995).

Much social activity in parks takes place along edges, where people can temporarily create personal space (Bell 1997a). The length of edges (often wooded areas, tree clumps, shrubs or hedges) and scale or variety of shape determines to some extent the capacity of use. Composing views, vistas and using coalescing groups or clumps of trees to make the size of the area appear larger is also a useful device. Imparting a sense of mystery rather than too much predictability into the design is always valuable (Kaplan et al. 1998).

Design Style

Historically, park design has evolved through a number of phases where different styles reflected the social, cultural and artistic movements of the times when they were created (Jellicoe 1995; Pregill and Volkmann 1999). These living works of art must be managed to retain their historic values whilst evolving in order to continue to fulfill contemporary functions. Thus, new park design can be inspired by historical precedents as well as by current artistic, architectural or cultural trends.

The use of trees in parks can range from deliberately architectural and formal, to informal and nature-like. Formal designs have been used for many centuries and are based on the arrangements of avenues, vistas and other elements laid out in strict geometrical patterns and using species of trees that also offer more formal possibilities. The arrangements may create symmetrical, balanced and formally harmonious aesthetic effects although it may be difficult always to accommodate the social, functional and ecological dimensions. Informal or deliberately naturalistic designs also have a very long pedigree (Von Buttlar 1989). They possibly lend themselves to a more eco-

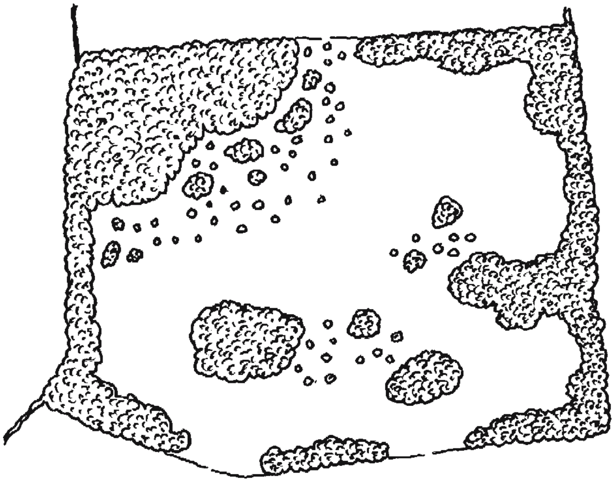

Fig. 6.12. This diagram represents the use of trees in a park (laid out in a very informal style) to create denser masses enclosing the main internal spaces. There are also larger or smaller clumps of trees and areas where the use of clumps and single trees blurs the mass/space distribution, providing different scales of space. The grass has been treated differently, being rougher and fuller of wild flowers in the area occupied by scattered trees, and more regularly mown in the main open areas. The large clumps block views, hide parts of the park and control vistas. They will coalesce in the view with other trees and the woodland to produce different degrees of enclosure or openness depending on the location of the viewer within the park (*illustration:* S. Bell)

logical approach where groups and clumps of trees together with shrubs and ground vegetation can be used to increase the biodiversity value. The spaces between trees may also offer more scope for a wider range of activities (Fig. 6.12).

Thus, there is a range of approaches, within which stylistic features can be selected as appropriate to suit the prevailing conditions. These considerations may also vary across the regions of Europe, since many of the traditions originate in different areas although they may have been copied elsewhere. Climatic variations may also influence the scope to use particular design elements, for example, in southern Europe the need for shade has led to park layouts where a high canopy of trees may provide a shade umbrella for activities taking place in the naturally colonnaded space beneath (Jellicoe and Jellicoe 1995; Pregill and Volkmann 1999). Conversely, some parks in northern Europe tend to favor dense clumps and belts to create sheltered places that also trap the sunshine. Such regional variations should not be overlooked.

Many of these park design principles may also be applied to the more intensively used sections of urban woodlands, since these can be quite park-like; in some places the park blends gradually into a wooded area.

6.5.3 Street Trees

Earlier chapters in the book have presented the rationale for street trees to perform a range of functions such as shelter, shade or pollution mitigation. Their aesthetic value can also be very high, helping to soften hard and unattractive buildings or to add a further architectural dimension to the urban design. To carry out this function they need to be of a form and function that complements the built setting (Lyall 1991, Fig. 6.13).

However, it is worth noting that there are circumstances where the addition of trees to a street or square does not enhance the urban design. This might be the case in cities when the facades of the buildings and the overall composition of the urban spaces is so fine that any interference of the space or of vistas would be deleterious.

In other cases, trees have been purposefully incorporated into the urban design, where the choice of species, the natural tree architecture and its management by careful pruning are key factors to ensuring success. Trees such as plane (*Platanus* spp.) and lime (*Tilia* spp.) have frequently been used, but the aesthetic effect has not always been maximized as a result of poor pruning (see Chap. 15).

Aesthetic functions of street trees include the creation or continuation of vistas; establishing a more human scale at street level in cities where the built scale is very large; providing a visual contrast in form, texture, color and seasonal changes to the buildings or in contributing to the element of mystery by hiding and revealing city elements (Clouston and Stansfield 1981; St. Bodfan Gruffydd 1987; Bell 1991).

Regional variations in the use of street trees may arise mainly due to climatic differences and the available species that will thrive in different places. Plane and lime are surprisingly ubiquitous whilst others are more localized. Similar variations also occur as in parks, such as the need for shade in southern Europe compared to the need for shelter in the north west.

Fig. 6.13.
These street trees, in Freiburg, Germany, through careful choice of species or cultivar and appropriate crown shaping as they have developed, produce an effective sense of space that complements the urban form (*photo:* S. Bell)

6.6 Design Considerations

This section takes each urban forest component, woods, parks and street trees, and considers a range of design aspects in greater detail. The emphasis lies in the presentation of a range of design considerations rather than a cookbook approach. Urban woodland design is achieved by the integration of a number of landscape elements in order to meet a set of design objectives and site constraints (Forestry Commission 1991). There is a well-established design process that should be followed, briefly described below.

6.6.1 Design Process

The first task is to develop a design concept for the area under consideration, whether street, park or woodland, that defines the structure and layout in relation to the functional requirements such as expected use patterns by people on foot, bicycle, horse etc., location of access points, topography, protection of valuable biotopes, landscape character or sites of cultural or archaeological value. These objectives need to be established and it is more and more common for them to be derived from a community participation process. It is advisable to prepare a set of maps that describe these factors, which must be ascertained from a number of site surveys. Topography and site variation (soil type, nutrient status, drainage characteristics etc.) are frequently key determinants of tree species selection as well as dictating some of the likely use patterns and woodland ecosystem processes. Analysis of these factors will help determine the development of the design concept, together with the objectives.

The different elements within the design concept should, where necessary, define functional zones and describe the desired characteristics of these zones. A large site may contain more zones than a smaller one. There may also be linkages between the site and neighboring areas to be considered at the concept stage.

Under some circumstances, such as where a woodland or park is to be created on a site formerly used for industry or mineral extraction or in other manmade landscapes, it is possible that there is scope to design the landform itself. In these circumstances the microclimate variations able to be developed can have a significant effect on the outcome of the design. It may also be possible to introduce water features (Bell 1997b).

The design concept is then developed into a sketch design. The degree of detail and the scale of resolution will depend on the size and complexity of the area. Usually, a street planting scheme will be more detailed than the layout of a woodland.

Fig. 6.14a–j. This sequence of sketches demonstrates the design process appropriate for urban woodlands. A basic survey to collect all the site and context information is followed by a thorough analysis. From this is developed a design concept which coordinates the areas for different uses, path circulation systems and the woodland/trees/open space structure. This is developed into the sketch design which demonstrates the character and quality of the design. Perspective sketches help to convey the character to members of the public (*illustration:* S. Bell) ▶

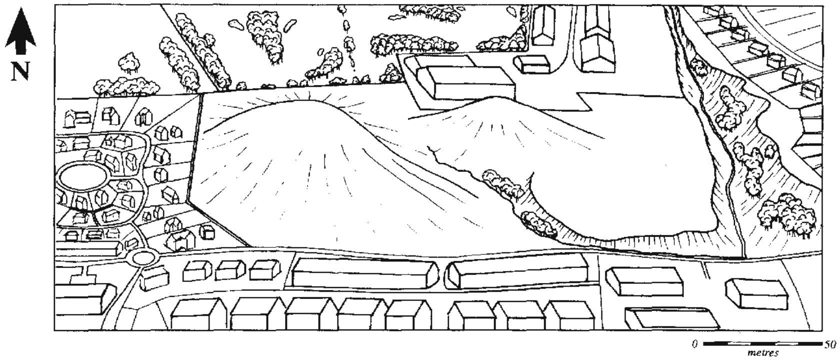

Fig. 6.14a. The existing landscape

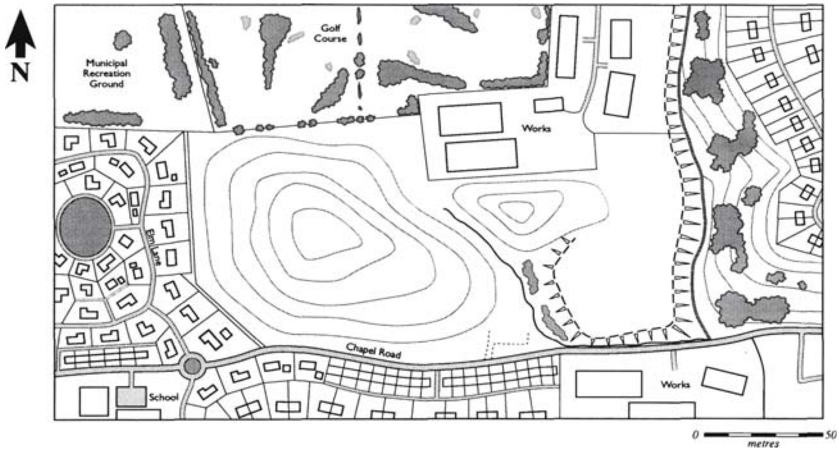

Fig. 6.14b. The existing landscape

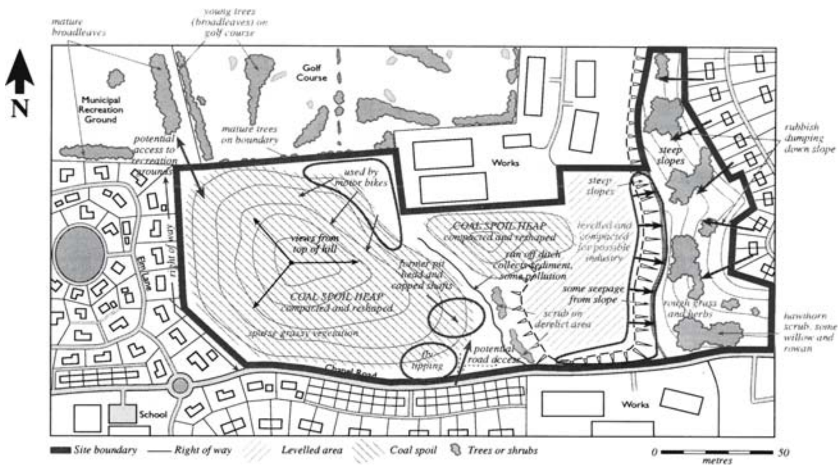

Fig. 6.14c. Survey

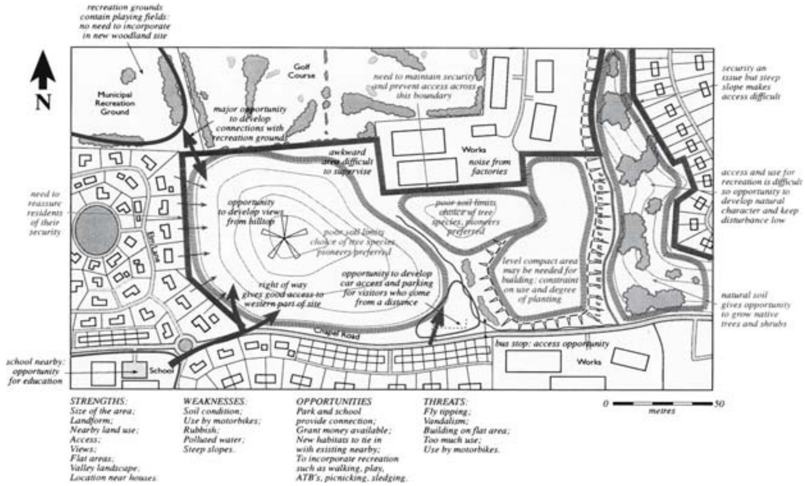

Fig. 6.14d. Site analysis

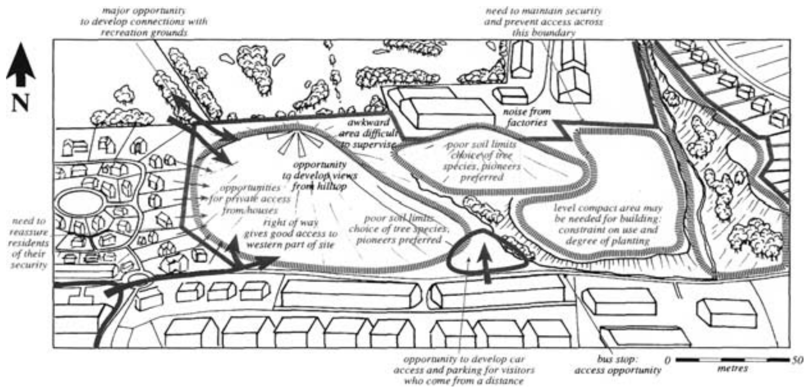

Fig. 6.14e. Site analysis

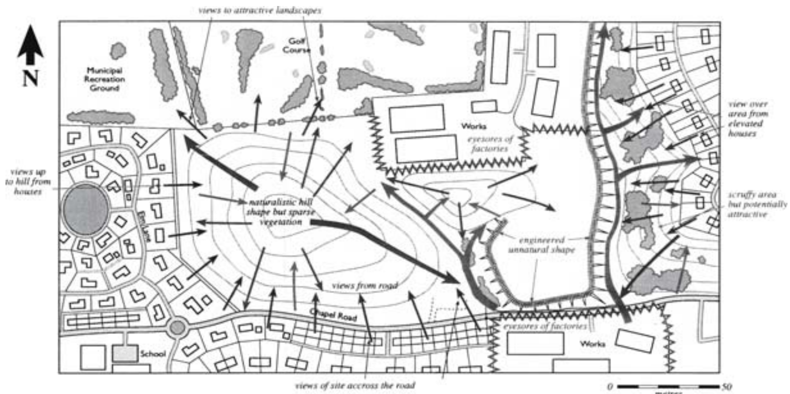

Fig. 6.14f. Visual appraisal

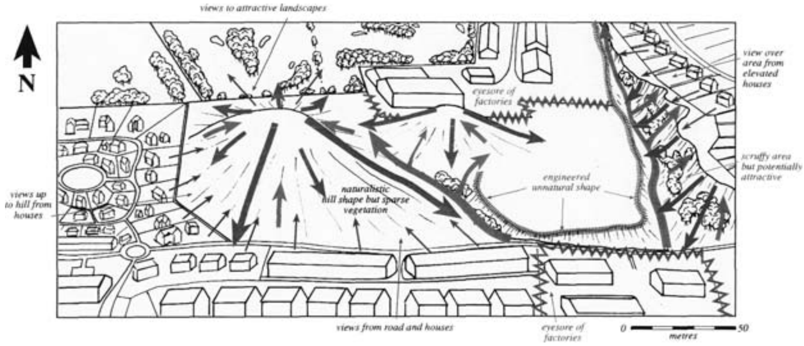

Fig. 6.14g. Visual appraisal

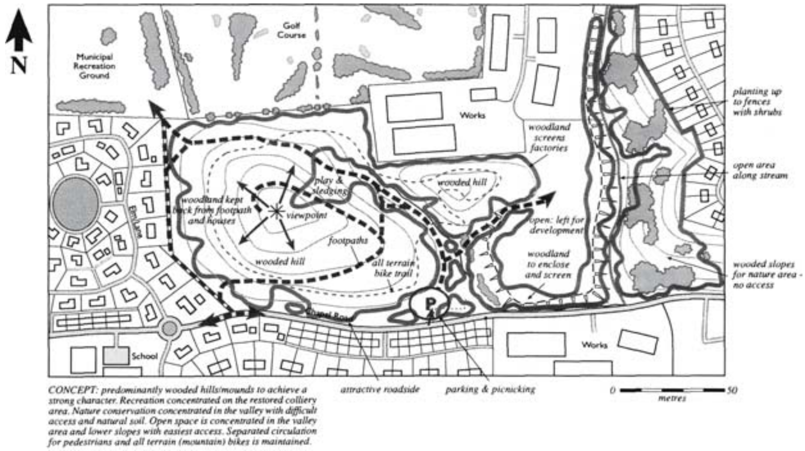

Fig. 6.14h. Concept

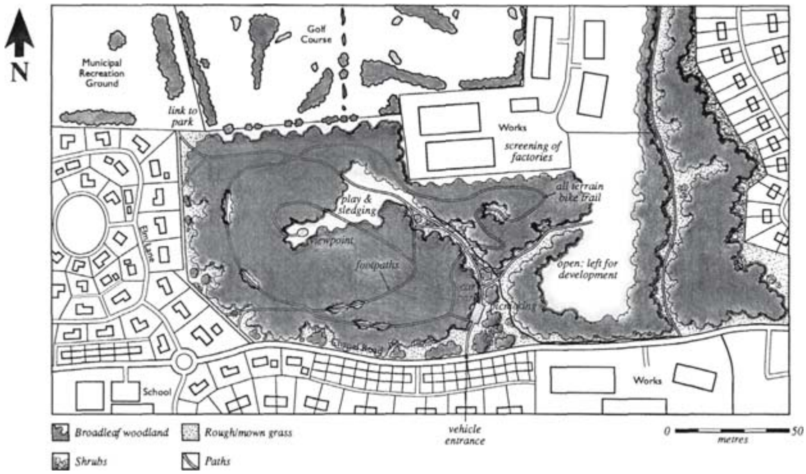

Fig. 6.14i. Sketch design

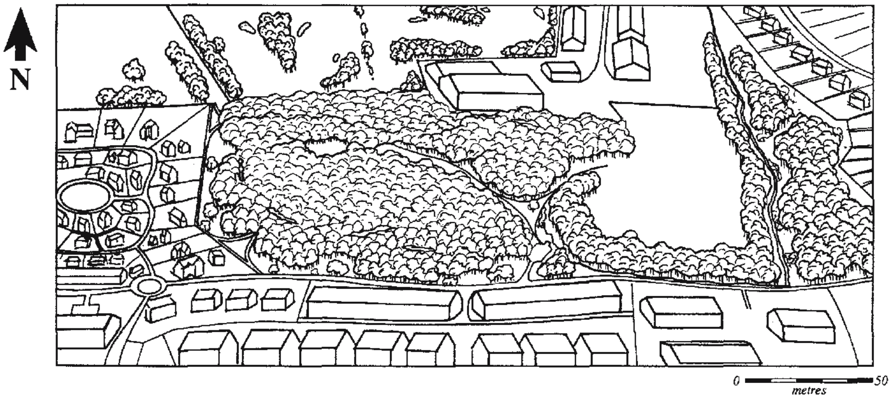

Fig. 6.14j. Sketch design

This generalized process may be applied as described or modified, depending on the circumstances (Fig. 6.14). Where communities are to be involved in design (see Chap. 8), this presents some interesting possibilities. Since most people are not designers, novel ways of generating ideas are needed. The use of art in various forms, model-making and processes such as 'Planning for Real' (Neighbourhood Initiatives Foundation 1999) can be used to help develop design ideas. If there is a deeper involvement by the community the design may never become detailed, remaining rather conceptual and only becoming finalized when actually implemented with the active participation of community members. The initial design in these circumstances may continue to evolve over time if the community is involved for a long period.

6.6.2 Woodland Design

Following the design concept the main task at sketch design is to determine the overall layout of the woodland in terms of spatial structure. This is the proportion and distribution of woodland versus open space and the degree of formality/naturalness in the design. Quite often, where there is topographic variation, this should reflect landform. For example, if woodland clothes the convexities whilst open areas are concentrated in hollows, this can not only develop a relationship between woodland and landform, but also tends to emphasize relief and increase the microclimatic benefits of sheltered hollows. Alternatively, woodland in valleys creates more shade and shelter whilst wide views can be obtained from open summits (Bell 1991; Forestry Commission 1991).

It is often a good idea to vary the overall proportion of woodland and open space across the site. Open areas can be concentrated around entrance points and in places where more intensive recreation takes place, whilst denser, wilder areas are located further away. This enables people to feel they are leaving the city further and further behind them as they move deeper into the woodland. Such a concept can be seen in the design of the Amsterdamse Bos (Oldenburger-Ebbers et al. 1998).

External Margins

The next step in the design is to consider the external definition of the woodland. This depends on the nature of the adjacent land use. If housing areas abut the woodland it may be necessary to develop a transition zone to avoid too much shade being cast and to allow for concentrated pedestrian use (Forestry Commission 1991; Hodge 1995; Komulainen 1995). If the woodland adjoins fields the margin should allow an ecotone to develop and link to existing features such as hedges. Where topography is significant the design of the margin can help to reflect its character.

Woodland Type and Species Choice

Once the areas to be planted with trees have been defined it is necessary to consider the woodland types to be used. Species choice alone is not enough. The future structure and management should also be considered. It may also be appropriate to plant pioneer species, especially on difficult sites, rather than those that tend to appear later in forest succession. Regional variation may have significant influence. For example, in Scandinavia, pine and birch may not only be the pioneer species but also the canopy species throughout the life of the forest, whereas in central Europe, birch and pine may be succeeded by oak, beech or fir. It might also be appropriate to seed an area or let it develop naturally rather than planting it. This will depend on how quickly woodland cover is needed and how successful seeding or natural colonization is likely to be.

Woodland type also means the difference between, for example, high forest, where the trees grow naturally and form a canopy, or coppice where the trees are cut and sprout once more from the stump. There are important differences between these systems which may be traditionally used and have different biodiversity values (Peterken 1981; Forestry Commission 1991; Gustavsson and Ingelög 1994; see also Chap. 13). Wood pasture is another traditional type that may be considered useful. Woodland type can also include the number of species planted together and the vertical structure that develops. Sometimes a simple structure with an open canopy is desirable, such as that provided by beech, or in a more layered structure with overstorey, understorey and shrub layer. The species may be planted in an intimate mixture or as a series of groups of each species. Some woodland types tend to be found in the interior of woodland, others at the edges, owing to differences in light availability and shelter. Others are more generally dense or more open in structure, cast more shade or admit more light onto the forest floor (Stoffel 1994).

Open Space

Open space is usually an important component of urban woodlands. This may include non-woodland habitats, such as grassland, wetland, open water or heath, where ecological values are important. Recreational open spaces, such as paths, picnic areas, play spaces or viewpoints may also be needed (Forestry Commission 1991, Fig. 6.15). Finally, there may be open areas because of constraints to tree planting, such as electricity lines, gas pipelines, roads or areas of disturbed ground where tree growth is impossible. All such spaces should be designed to reflect the overall concept (Forestry Commission 1991; Lucas 1991; Komulainen 1995).

Fig. 6.15. Open space in part of Losiniy Ostrov (Elk Island) forest park in Moscow which fulfills many functions. It is an attractive open space for recreation, and it provides habitat diversity (*photo:* S. Bell)

If a natural character is desired, spaces should generally have an irregular, organic shape, for example, perhaps reflecting any local topographical variations and the vegetation, such as grass, should be managed accordingly, through a varied mowing regime, for example. Linear spaces should wind through the woodland (except where functional constraints apply) to create a sense of mystery (Bell 1998). Larger scale spaces can be sub-divided by additional planting of clumps and groups of trees to create more interest and to provide a greater visual carrying capacity.

Paths and Circulation

A significant aspect of most urban woodland design will be the system of paths for walkers, cyclists and horse riders. The patterns will depend on the size and shape of the woodland, the degree to which it is bounded by houses or residential areas, the number of access points and the terrain. In larger woods a network of separated paths for cyclists, walkers and horses is ideal, each network creating a series of loops (Bell 1997a). Where houses lie next to the woodland a path running alongside, just inside the wood, helps to collect the walkers from each house who may be able to gain access (Forestry Commission 1991; Komulainen 1995). Where there is a degree of fear or discomfort about venturing far into deep, gloomy woodland, the paths should offer a range of experiences. Those most frequented and which lead to major facilities should be more open, straighter and possibly lit to create a greater degree of comfort (Burgess 1995; Hodge 1995; Komulainen 1995; Fig. 6.16). Paths of all types should make the most of the terrain to provide interest, views and variety of landscape without causing difficulties to disabled or elderly people by being too steep or rough. Surfacing that is smooth and dry without being too urban in the use of materials is desirable (Bell 1997a).

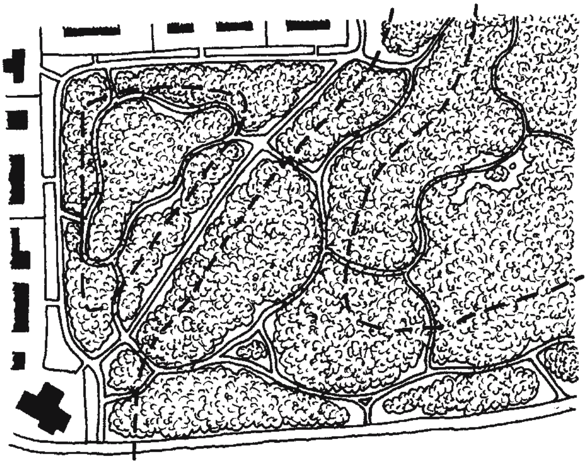

Fig. 6.16.
This diagram shows a woodland which has been zoned into 3 areas. Zone 1 has straight, wide, open, safe paths closest to the houses or where a direct route is needed. Zone 2 has winding paths, wide and easy to follow with many stretches running through open spaces. Zone 3 is a deeper woodland, with narrower, more twisting paths more usually running through closed canopy and less open. This provides those who enjoy solitude and wildness to get away from the busier parts of the woodland (*illustration:* S. Bell)

Edges

There are many edges along the outside of woodland or along internal open spaces. The structure of these edges can provide visual diversity and ecological value (Hodge 1995; Sarlov-Herlin and Fry 2000). Natural woodland edges usually grade from the tree canopy to the open area beyond through intermediate stages of clumps and groups of trees, patches of shrubs or younger trees, herbaceous plants and grass. These can provide added depth to views, help maintain a sense of mystery and provide variation throughout the seasons. They provide habitats for animals, birds and insects in conjunction with the denser woodland and open spaces, perhaps forming an ecotone. Conversely, it may be appropriate to develop a more open edge in order to provide views into the woodland canopy and to make it more accessible to people. Edge design follows two steps. Firstly there is the general shape of the line that defines the boundary between wooded and open areas, and secondly there is the structure and composition of the edge zone along that line (Lucas 1991, Fig. 6.17).

Use of Natural Colonization

Often, new woodland is established in areas that have been neglected in the recent past so that they may already possess a degree of scrubby woodland cover. This is usually the earliest colonization stage of abandoned land which will eventually become woodland, although at a slower pace than might be desirable. However, such natural colonization can be valuable since it presents a starting point for design, may save money and provide a degree of maturity to the area, wildlife habitat and a seed source for further expansion over time. In places where the site has been disturbed through industry and the soil is poor or non-existent, natural succession may be effective in helping soil forming processes and in creating conditions for the establishment of later successional tree species that would be unable to grow in the current condition of a site (Moffat and McNeil 1994; Hodge 1995).

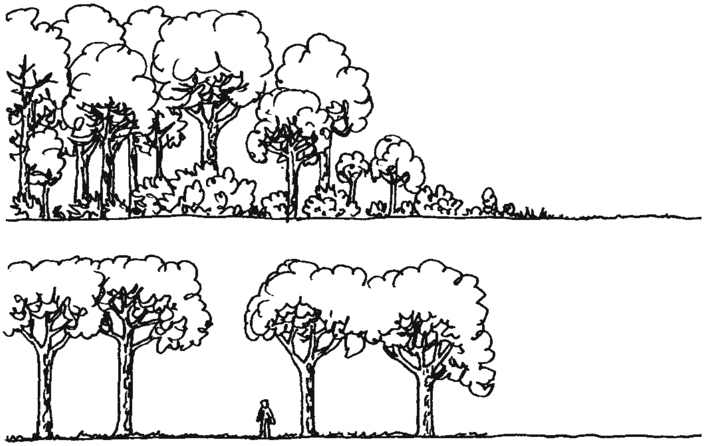

Fig. 6.17. In this pair of sketches example (**a**) shows a section through a natural woodland comprising many layers of trees, shrubs, ferns and herbaceous plants. At the outer edge the zone shows a tapering profile resembling that of a colonizing woodland. The ecotone structure as grassland gradually turns into woodland is ecologically valuable. Example (**b**) shows a simpler edge structure. The woodland has a single canopy and the ground layer is solely of grasses or herbaceous vegetation. The space flows into the woodland beneath the trees. While not as ecologically valuable, this creates a useful edge for recreational use and for enabling people to see beneath the trees, both into and out of the woodland (*illustration:* S. Bell)

6.6.3 Design Issues in Established Woodlands

There are many examples where urban woodlands were originally wooded areas set within rural countryside but which, due to urban expansion, find themselves surrounded by houses. The original layout and management may have been for objectives very different to what is now required, so that considerable redesign may be necessary.

Characteristics of Established Woodland

Managed woodlands, whether of natural or planted origin, are frequently laid out or subdivided into rectangular compartments separated by straight linear openings or 'rides'. Fellings may have taken place, also to these rectilinear shapes, and the canopy of the woodland may be so dense that there is little understorey. The road or path network may follow the compartments and be designed for timber haulage. Thus management may need to be redirected to remove the geometric patterns over time, to develop a richer stand structure, to create open spaces where non exist and to insert a completely different path system.

Future Vision

The design concept for such woodlands should set out the desired future vision, such as changes to the layout, structure and composition, which woodland management is then directed towards through the adoption of silvicultural techniques, including cutting to reshape edges, create open spaces and planting to change species. The future vision might involve significant restructuring of the woodland over time (Forestry Commission 1992, Fig. 6.18).

Open Space Creation

Open space creation may be complicated by the presence of stumps, which may need to be removed, depending on the function of the space being created. Existing, straight linear open spaces may need to be obliterated through re-shaping and partial or complete planting to fill them in. Open spaces carved from existing woodland retain shelter and trap the sun from the start, but their edges are likely to appear raw. Thinning into the edge and then planting other species of trees and shrubs to create structure is likely to be needed (Lucas 1991).

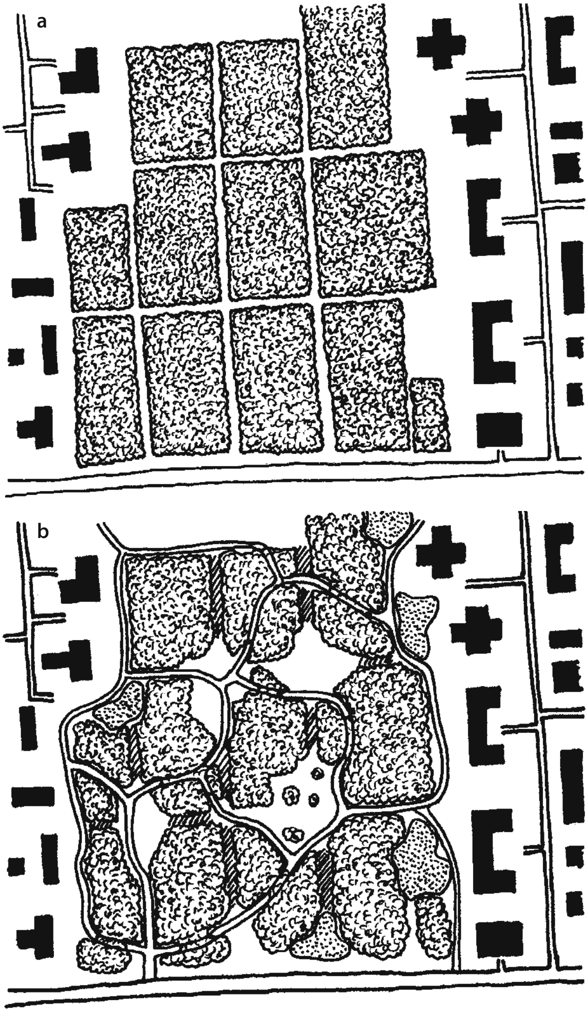

Fig. 6.18.
These two diagrams show a woodland that has become surrounded by housing and industry. (**a**) shows the layout resulting from when the woodland was originally managed for wood production. It now needs to be redesigned to function better as a recreational resource and to provide more habitat diversity. (**b**) shows how it could be diversified, expanded and remodeled to meet a new set of objectives. A new path network has been developed. Open spaces have been cleared, parts of the forest have been felled and replanted to break up the geometric layout and to diversify the structure. Some of the old 'rides' have been filled in by planting (*illustration:* S. Bell)

Paths and Circulation

While some of the existing roads and paths may be useable, it is likely to be necessary to develop a completely new path circulation system within woodland that has become part of the urban landscape. As soon as houses are built and people start to occupy them, they are likely to venture into the woodland. New path routes will start to appear which may be in undesirable locations. Once this pattern starts to develop it may be difficult to replace it, so it is advisable to consider the layout and development of the path system well before people start to use the woodland, if that is possible. Alternatively, adapting the initial pattern of desire lines, extending, linking and modifying it may be an equally if not more practical approach (Forestry Commission 1991; Bell 1997a).

Woodland Restoration

In urban fringe situations many woodlands may have been neglected by their owners and abused by people who realize that no one is particularly interested in them. If such woodlands are to be brought into positive use they must be restored. This not only includes cleaning them up, but regenerating the tree cover, installing or repairing paths and other facilities and possibly considerable redesign of layout, structure and composition, especially open spaces.

6.6.4 Parks and Urban Forest Design

The design principles for parks where trees, tree clumps or wooded areas are to form a significant element are little different from that of woodland. The spatial layout, functional planning and access provision all need to be considered. However, the spatial qualities of trees in parks may present a wider range of opportunities (Fig. 6.19).

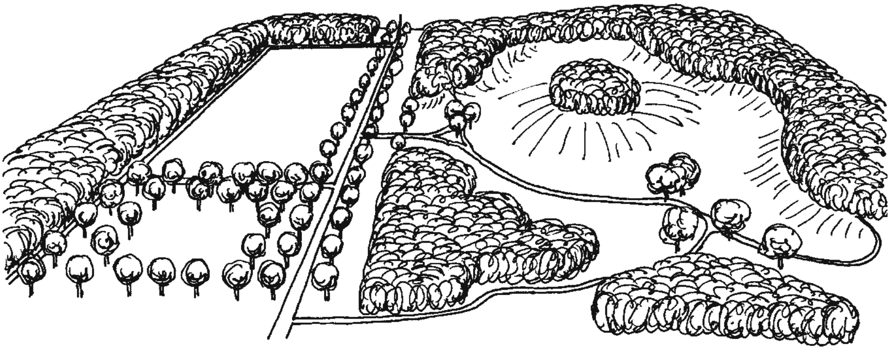

Fig. 6.19. This sketch shows the different design effects possible depending on how trees are deployed to create space, mass, enclosure and view control. To the left is a formal design, where a geometric grid has been used to create a very calm, static and controlled result, symmetrically balanced, axial and emphasizing the single point perspective. The design on the right is based on organic shapes with greater use of interlock, coalescence and asymmetric balance. By planting on the knolls, the enclosing effect has been intensified. The result produces a greater sense of mystery and is more relaxing (*illustration:* S. Bell)

Single trees in large open spaces act as focal points and an opportunity to display a specimen of beauty, perhaps a spreading form, large size or brilliant flowers, foliage or branch form. Open grown trees develop their crowns in different ways to woodland trees and can be used to great effect. They may also be pruned, trained or varieties may be chosen with particular crown forms (St. Bodfan Gruffydd 1987; Clouston 1990).

Clumps or groups of trees present masses in space, but also contain open volumes within them. The arrangement of the trees, whether there is an open, simple canopy or an understorey can make a compositional difference. Usually, the crowns of tree clumps grow together to present a solid mass. The space beneath, if the floor is clean, provides shelter and shade with views out all around. Trees arranged in straight rows at equal intervals create a formal atmosphere while those in more irregular spacing feel more relaxed and natural. Clumps can be used to emphasize topographical features by, for example, placing them on a knoll (Forestry Commission 1992).

Larger areas of woodland in a park should be considered much like woodland design described in the earlier section. However, the woodland, the clumps and the single trees should be considered as a compositional whole, screening or focusing views, balancing each other and enclosing or opening space.

Avenues and rows of trees may be used as other devices to compose space, focus views, emphasize spatial patterns or act as elements of continuation from street tree patterns (Clouston 1990). They generally formalize the composition and can also be used to relate to architectural elements in the landscape.

Larger clumps or patches of woodland can provide valuable habitat and can be developed with a more complex structure and composition. Edges and transitions from trees to the larger scale open spaces can range from abrupt and formal to gradual and informal (Forestry Commission 1991; Gustavsson and Ingelög 1994). The latter can also be a richer habitat.

Species choice for park trees can include a wide range. Parks are usually designed and laid out with amenity and recreation as a major objective and there are few natural park-like landscapes in Europe, except in some Mediterranean areas. Thus it is generally considered more acceptable to include a higher proportion of trees that are chosen for their aesthetic qualities of form, flowers, colors, branching habits and tolerance of urban environments (Clouston 1990).

6.6.5
Street Trees and Urban Forest Design

Street trees, those found in squares, streets and other public urban spaces, can be used in various ways. It is useful to consider what spatial qualities are desirable and to choose species with appropriate growth habits. For example, trees with large spreading crowns casting a wide zone of shade can be used in public spaces in hotter countries. These enable the outdoors to be used more than indoors, and life can take place on the street. Alternatively, trees with deeper, denser but narrower crowns, can provide shelter, especially where the city buildings accentuate the wind in colder northern climates. These functional characteristics also have an effect in creating space beneath a large canopy or enclosing it with rows of denser trees (St. Bodfan Gruffydd 1987; Clouston 1990; Lyall 1991).

Tree form: There is a huge range of different tree forms that present various textures or colors and provide different degrees of light and shade. Many also need careful pruning and management to gain the maximum effect. The scale of the street or urban open space should dictate the appropriate size of tree. Small spaces, narrow streets and low buildings can be dwarfed by trees that grow too big, while small trees look out of proportion in large scale spaces. It is possible, though, to use them to reduce spaces and buildings of a large, inhuman scale, down to more appropriate proportions as an integral part of urban design.

Trees can relate to built form in a variety of ways. The natural, graceful shapes of trees in contrast to severe, simple geometric forms of some modern buildings can make a fine composition. Trees can also extend the built form, such as rows of trees continuing a line of columns or an avenue where the tree crowns meet and form a natural vault continuing a natural colonnade or covered aisle. Trees of vertical, narrow form can be used to complement buildings of more horizontal emphasis. It is important in all these cases to choose trees that not only grow in the climate and soil conditions but also provide the correct architectural qualities (St. Bodfan Gruffydd 1987; Clouston 1990; Lyall 1991).

The architectural use of trees finds its greatest expression where they dominate the streetscape. Here, trees are used to create or to unify the urban landscape and are deliberately brought in to counteract problems of the built form around them. This may be because the buildings have little architectural merit and lack unity or because of the over-large scale combined with low variety, so that the trees provide an alternative, more powerful structure. The following list described some of the main ways that trees can be used.

Avenues should be used with care in urban areas, and are unlikely to be suitable within city centre core areas. Generally, streets are likely to be too narrow, and the need for an avenue to lead *from* something or somewhere *to* the equivalent can rarely be achieved. They can however be useful to define important routes into and out of the city core, add character to such areas and add to the establishment of a strategic hierarchy of route-ways. Normally, an avenue of trees should be of the same species, planted at the same time and to the same specification to ensure an overall conformity of appearance. Canopy height should be considered in terms of whether it is necessary to give vehicles or pedestrians clearance underneath.

A single line of trees is far more likely to be accommodated within a city centre core area than an avenue, as it takes up far less valuable space. Due consideration should be given to the aspect of the trees (i.e. either on the sunny side or the shady side of the street, depending on species or desired design effect). As with avenues, lines of trees should be of the same species, planted at the same time and to the same specification to achieve design uniformity. The use of a single line of trees of different species could be considered, but care should be taken to avoid compromising the strength and design simplicity of a mono-species approach. Often the only element of continuity that can be established in an area of mixed uses, architectural styles and variable scales is a line of mono-species trees.

The distance between the ground plane and the base of the canopy is crucial. Not only should this be designed to accommodate easy pedestrian movement, but also to allow unimpeded views of the fascia boards of adjacent commercial or retail premises. Streets suitable for single lines of trees could be considered as 'Key Streets', where a (long-term) program of public utility rationalization could be put in place so that trees occupy one side of the street, with the services and utilities located in a common service trench on the other.

Block: This would normally consist of four trees, or maybe four small groups of trees, sited to highlight or articulate an important point, an intersection for example, or perhaps where a light rail system traverses a trafficked road or a pedestrian route. Normally such trees would be planted as large specimens, to create an immediate 'presence' and also to accommodate movement (pedestrian or vehicular) underneath.

A grid of trees can be large or small, and be of variable spacing dependent upon the end-use of the area beneath. They can be used in pedestrian areas to add interest; can articulate car parks wonderfully; or can be used simply to define a flexible urban public space that could accommodate a wide range of uses on different days – a market, casual car park, seating and tables for adjacent cafés, etc.

Small groups: These can be used where a more informal planting layout is required, and can be associated with a wide range of different treatments, including detailed paving design, raised beds, at-grade beds, other planting schemes and seating. The informality of a small group allows more informal tree species to be chosen and, depending upon the location, may not require a canopy height which allows pedestrian movement to take place underneath.

Trained trees are greatly under-used in urban areas. They have great potential to help with articulating space in places where more traditional tree planting would not fit. There are a number of different types of trained tree, but pleached trees would seem to offer the most potential. Pollarding may, in certain locations also be a valuable tech-

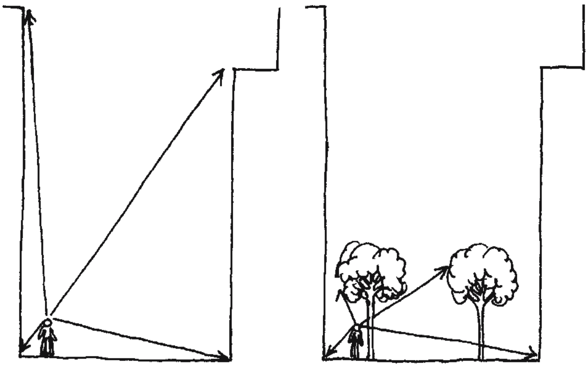

Fig. 6.20.
In this diagram the use of trees to break down the scale of a modern urban street is demonstrated. In (**a**) there is nothing to give a transition between the human size and that of the large scale, simple buildings. This dwarfs the person and can lead to discomfort. The use of trees, while themselves dwarfed by the buildings, creates an intermediate, more human scaled space at street level (*illustration:* S. Bell)

nique, but this should not be confused with annually pruning of all or most of a trees branches as a form of management.

Landmark: These trees should create a significant impact in their own right. They might compliment significant buildings or spaces, be key focal points, or articulate space. They would be 'characters' either in terms of size or appearance, but need not always be of large proportions, as landmark trees could be found in relatively small, intimate spaces.

Street trees can also be used, particularly in wider avenues or boulevards, to sub-divide the linear space and to separate pedestrians from traffic. In this way the trees define different use zones as well as helping to create visually and physically separate spaces. Wide pavements separated from cars by a strip down which trees are planted make a space that focuses attention on the pedestrian areas and building facades (Fig. 6.20).

In the context of the more important route corridors such as along the edges of urban motorways or railway lines, trees need to be planted in greater numbers and more densely, in order to create visual separation even if the noise abatement value is limited. These linear strips should be unified with the rest of the street tree structure while at the same time acting as wildlife corridors leading from urban edge to city centre.

Where there are streets that follow canal, river or lake edges, trees planted along them can provide a link between land and water, providing contrast and unity at the same time. Tree species associated with water, such as poplars and willows, might be favored in these circumstances. Examples of this type of planting can be found in Bruges or Amsterdam.

6.7 Conclusions

This chapter has explored a number of aspects relating to the design of the urban forest. Most opportunities to affect the urban landscape lie in the series of public spaces that form the glue holding the built environment together and provide the conduits for the movement of people and areas for outdoor city life and social intercourse. This is not to overlook the value of the contribution made by trees in gardens and other private or commercial areas. The urban forest, in occupying this network of public spaces, can form a matrix, unifying all those spaces with each other and with the built environment. Each constituent space should have its own character and reflect its context, whether peri-urban woodland, city park, small-scale park or garden, major or minor movement corridor, city centre street or public square.

The designer's job is to integrate each component into a unified whole, achieving a balance between each of the dimensions described earlier in the chapter – the social, the experiential, the functional and the ecological. In a peri-urban woodland the ecological dimension may take precedence, although the other three remain important. The design material is the 3-dimensional mass created by trees singly, in a group or *en masse* in larger volumes. Spaces inside, under, between and within these masses of trees provide an infinite variety of possibilities, set within the framework provided by the built environment.

Many cities are already richly endowed with components of the urban forest. The challenge is to take this rich legacy, protect and manage it but also extend and add to it to create a future legacy to pass on to the next generation of urban citizens. The existing examples, to be found all over Europe, may provide inspiration but it is also vital to develop new approaches and to apply novel solutions to meet the challenges of today.

What Are These Design Challenges?

The major challenge is to contribute to the development of sustainable cities by using trees in the best ways to enhance water and air quality, reduce energy costs and at the same time provide human and wildlife habitats.

Another challenge is to preserve and manage the existing resource while adapting it to present and future needs. This can mean some tough design decisions when trees are old, diseased or damaged yet highly valued by the public.

A third challenge is to make the urban forest accessible to everyone, no matter where they live, their age, ethnicity or economic situation. This means matching the urban tree resource to the places where people live and work so that the urban forest can become part of every citizens life, should they choose to take up the opportunity offered to them.

Good urban forests do not occur by accident; some form of planning and design is needed to ensure that woodlands, parks and street trees enhance the cityscape and provide settings that encourage people to use them as part of their everyday life. They must be welcoming, safe, attractive and conducive to a wide range of uses.

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Chapter 7

The Role of Partnerships in Urban Forestry

Nerys Jones · Kevin Collins · John Vaughan · Thorarinn Benedikz · John Brosnan

7.1 Introduction

It takes more than an understanding of trees and woodlands to sustain a successful urban forest. The high cost of land and diversity of ownership, the extent of social and environmental pressures and the wide variety of available funds and other resources make the planting and care of trees and woods in and around towns and cities extremely challenging. Success is increasingly reliant on different interest groups sharing a common ambition, working together in partnership and playing to their respective strengths.

Urban forestry needs to be delivered at a strategic scale if it is to provide a full range of environmental, social and economic benefits to the urban dweller. Therefore, there needs to be an effective and integrated working relationship across public, private, voluntary and community sectors – with contributions of land, skills and finance from the widest possible range of partners.

The development of partnerships in urban forestry is an increasing trend across much of Europe, but appears to be particularly well developed in the countries of the north-west. This may be due in part to their earlier deforestation and urbanization, with more recent social and political trends generating a focus on the creation of new *urban* woodlands. The urban context requires a more socially inclusive approach to planning and regeneration and this may have prompted an early recognition of the need to involve a much wider range of agencies in the urban forestry process (Forestry Commission 1998). The success of the partnership-led approach may also be attributed to the nature of the social institutions in these countries, although this approach is now becoming more prevalent in other countries.

This chapter discusses the value of a partnership-based approach in underpinning the sustainable development of the urban forest and maximizing its benefits (see Chap. 4). It also identifies the critical success factors for building and maintaining effective partnerships and highlights some of the difficulties that may need to be overcome in making them work. A number of successful partnerships from the field of urban forestry in Europe are described as illustrative examples and some have been developed as more detailed case studies, set out at the end of the chapter.

7.2 The Need to Work in Partnership

7.2.1 The Diverse Nature of the Urban Forest

In an increasingly urbanized world, there is a growing recognition of the complex interrelationships between environmental, economic and social processes. The growing focus on sustainable development is leading to a greater understanding of the multifunctional role that the natural environment can play in the health, well-being and quality of life of urban communities. The urban forest is a crucial component of this more integrated approach to city living. Planners, policy makers and politicians are starting to recognise the value of a bolder, more strategic approach to the provision of a functional green infrastructure that is able to deliver many different benefits and engage a broad cross-section of society (Jones 1994).

At the same time, there is increasing recognition across Europe of the important part that urban woodlands and other green spaces play in personal development, healthy living, social cohesion and the creation of sustainable communities (see Chap. 4). This prompts the need to engage a much wider range of expertise and experience in forest planning and management (Nilsson et al. 1999; Konijnendijk and Hoyer 2002; Hartig and Staats 2003).

Despite this emerging recognition of the value of the urban forest, if trees and woodlands are to survive within and around towns and cities, they need to coexist within a highly complex urban setting. This includes physical elements such as roads, buildings, utility service lines and other urban structures, as well as non-physical elements such as planning and development, finance, legislation, public expectation and many other factors that influence urban development and growth.

7.2.2 Potential Partners

More and more different professionals now have a major influence on the urban forest. They range from arboriculturalists, foresters, horticulturalists and landscape designers to planners, engineers, legislators, transport and utility managers, health practitioners and commercial developers. Where coordination is poor, conflict invariably follows, and this in turn can lead to misplaced resources, fragmented management and duplication of effort (Lewis 1991). All of these affect the urban forest, limit its effectiveness and deprive the public of many potential benefits. Therefore the case for partnerships is very persuasive.

Furthermore, there is a growing recognition that the urban forest can help to moderate many of the environmental and social problems associated with urbanization, such as air pollution, storm water flooding, decreasing biodiversity and social exclusion (Jones 2000). Clearly there is a need for the urban forester to interact with an increasingly diverse range of professionals – new colleagues who are beginning to appreciate the relevance that the urban forest has to their own field of interest.

Box 7.1. *The Green Gym*, UK: A cross-sectoral partnership linked to healthy living

In the UK, the British Trust for Conservation Volunteers (BCTV), a community-based land management non-governmental organization (NGO), has joined forces with health professionals to establish *The Green Gym*, a project offering gentle exercise in safe, leafy surroundings to improve both physical and mental health (Reynolds 1999, 2002; Fig. 7.1).

They organize programs of practical conservation, many of them in urban woodlands close to work or home, where those involved can have their performance monitored. Results show that most people enjoy sustained exercise for much longer in the *Green Gym* than in an orthodox sports centre. Natural surroundings and the company of other people involved in practical conservation bring added health benefits by relieving stress and increasing the sense of personal achievement.

Further information: http://www.btcv.org/uk/greengym

Fig. 7.1. The Green Gym has brought UK health professionals together with urban foresters and conservationists, to provide a green environment for carefully monitored healthy exercise (*photo:* British Trust for Conservation Volunteers, BTCV)

7.2.3 The Wider Relevance of Urban Forestry

Examples of complementary policy areas that are now beginning to be incorporated into urban forestry are increasingly easy to find:

- The road engineer using barriers of trees to deflect noise pollution away from adjoining residential areas.
- The community development worker using tree planting to encourage community activity and social interaction.
- The business corporation sponsoring tree planting as a way of strengthening its environmental image.
- The environmental NGO promoting trees as a way of recruiting supporters and volunteers.
- Government officials including the urban forest in strategies to promote public health and enhanced quality of life in urban areas.
- Developers adopting an ambitious scale of urban greening in advance of building work as a way of boosting land value and stimulating urban economic regeneration.

Fostering such linkages increases public recognition of the value of the urban forest, but development of the necessary partnerships in order to deliver these shared agendas does require new skills (Simmonds 2000). Each time a new role for the urban forest becomes established in the minds of the public, the prospect of long-term security for the trees and woodlands in towns is likely to be strengthened. Fostering such linkages is therefore extremely useful in securing long-term support for urban forestry.

Box 7.2. Middlesbrough Urban Forestry Strategy, UK: Improved inter-departmental cooperation within an urban local authority

The urban forestry strategy developed by Middlesbrough Borough Council, in north-east England, demonstrates an effective inter- and intra-departmental partnership within a local authority as a mechanism for managing a citywide urban forestry resource (Hannon 1996; Fig. 7.2).

The strategy is based on an assessment of the current state of the resource and sets out realistic targets relating to, for example, the removal of dead or declining trees, the creation of a specific amount of new urban woodland, the implementation of a cyclic aftercare program and the establishment of initiatives to promote community involvement. It evolved through extensive consultation throughout the local authority. The end result is a clear course of action to which all those involved, including tree professionals, planners, engineers, finance officers and city councilors, are committed, thereby avoiding many of the traditional pitfalls associated with local authority management of trees and woodlands.

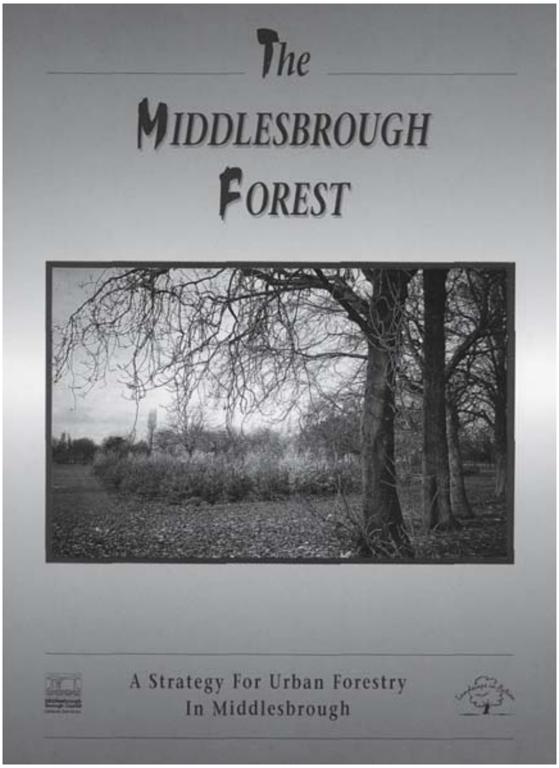

Fig. 7.2.
Publishing a joint strategy document for the urban forest helps to publicize the shared agenda and to build support among the partners (*source:* Middlesbrough Borough Council)

7.3 Benefits of Partnership

7.3.1 The Diversity of Potential Partners

As new partnerships in urban forestry extend beyond traditional tree agencies, they bring together new individuals and organizations from central, regional and local government, non-governmental agencies, funding bodies, special interest groups and local communities. These different players will all have individual strengths and weaknesses and they will almost always be able to bring complementary skills and expertise to a project, while at the same time increasing the range and availability of resources (Johnston 1996). Combining different strengths and aspirations through a partnership-based approach creates a more powerful force for change and also generates greater long-term sustainability. The following are just some of the key benefits likely to arise from innovative partnerships:

- *Greater coordination of effort.* This is particularly beneficial within local government, where even an informal partnership can greatly reduce conflict and lead to more efficient use of resources and expertise.
- *Shared understanding of important issues.* Those involved will increase their awareness of other partners' points of view.
- *Increased support and third party endorsement.* Individual partners will each engage their own particular circle of colleagues and contacts with the project.
- *Greater security.* The wider the ownership and the more intertwined the work becomes, the more secure the project will be in the face of threatening shifts in external policy.
- *Access to a wider range of resources.* Different partners may have access to otherwise unavailable funding, while the partnership itself may qualify for funding from budgets intended to foster cross-sectoral collaboration.
- *Greater and wider expertise.* In addition to obvious technical expertise, this may also include a fresh perspective on problem solving and forward planning.
- *Higher public profile.* The partnership's own distinct identity can present the benefits of the urban forest to new audiences and in new ways.
- *Renewed vitality.* Partners can inspire and energize one another.
- *Further collaboration.* Successful partnerships very often spawn ideas for additional joint projects.

7.3.2 Importance of the Process

The urban forest is a resource managed by people for people. The fact that it is made up of trees and woodlands may be considered secondary to the importance of planning and managing the resource in ways that bring people together.

There is an increasing trend towards subsidiarity – moving decision making to the most locally appropriate level. The benefits of increased public participation, the value of celebrating local distinctiveness and the economic benefits of utilizing local resources are now widely recognised (see also Chap. 8). They are all particularly appropriate to the urban forest and they help to secure its long-term sustainability.

Consensus building and cooperative working both involve compromise. To the modern urban forester, communication and networking skills may be as relevant as specialist silvicultural knowledge and social understanding may be as valuable as soil science.

7.4 Challenges to Successful Partnership Working

There are many issues which can challenge the strength, endurance and performance of urban forestry partnerships, including

- *Lack of leadership and coordination* – leading to wasted time, effort and resources
- *Insufficient shared long-term interest* to sustain cooperation
- *Lack of clarity* – of aims, objectives or responsibilities – leading to confusion or conflict
- *Competitiveness and rivalry* – for status, power or resources
- *Imbalances in power* – with consequent tensions, argument and feelings of disenfranchisement
- *Lack of openness and trust* – allowing suspicion and antagonism to develop
- *Lack of commitment or effort* – creating a two tier structure of partners
- *Lack of progress* – leading to disillusionment, disappointment and loss of interest
- *Gaps in skill or experience* – reducing effectiveness
- *Exclusion from the initial partnership* – generating political difficulties and potential external opposition
- *Unwillingness to surrender some autonomy* for the greater good
- *Partner fatigue* – where potential partners become over committed in working partnerships, to the detriment of their real aims and objectives
- *Clashes of personality*
- *External changes* in policy or funding

An open and transparent approach to recognizing and addressing these issues at an early stage is a fundamental characteristic of successful partnerships, requiring mutual trust and the ability to compromise and adjust individual and group behavior to match the wider collective interest in the expectation of greater long-term benefits.

In addition, it is in the nature of partnership-based processes that they are more difficult to formulate, slower to develop and more complex to administer and manage than a more direct, single-focus management approach. There must be due regard, from the very beginning of the project, for the extended timescale that will be required and for the additional human and financial resources that need to be budgeted for. All participants need to believe that these additional inputs are a worthwhile investment to secure a more sustainable and inclusive project with enhanced longer-term outputs.

It should be recognised that partnerships are not the only way of developing and managing urban forestry projects. There may be circumstances where direct action, possibly involving 'consultation' with stakeholders rather than their full involvement, may be more appropriate. Careful consideration needs to be given to the balance between these different approaches.

7.5 Types of Partnership

7.5.1 Variety

The diversity of urban forests may help to explain the persistent difficulty in reaching an agreed definition of *urban forestry* across different sectors and between different countries (see Chap. 1). However, its great strength is that it offers scope for a wide range of partnerships, reflecting the varied nature, location and ownership of the resource itself and the diversity of the many potential stakeholders and beneficiaries. The scale of partnerships can also vary greatly, from local neighborhood groups to complex federations operating at district or citywide level, national projects and even wider European initiatives such as the *COST Action E12 Urban Forests and Trees* research network and the European Forum on Urban Forestry (Nilsson et al. 1999; Konijnendijk 2003).

Box 7.3. The Forest of Belfast, UK: A local authority-led, cross-sectoral partnership

The Forest of Belfast, Northern Ireland, is an example of a city-wide urban forestry initiative led by Belfast City Council. The initiative was established in the early 1990s to promote a partnership approach to the planting and care of trees throughout Greater Belfast. The partnership is overseen by a formal steering group and various sub-groups which together include all the local authorities in and around Belfast, government agencies responsible for the environment, planning, forestry, roads and housing and environmental NGOs such as the Woodland Trust and Conservation Volunteers Northern Ireland (Johnston 1998; Simon 2001; Fig. 7.3).

The Forest of Belfast is involved in a wide range of activities designed to promote the city's urban forest, e.g., funding community planting, setting up tree warden networks, staging tree festivals and promoting landmark trees, as well as providing a professional forum to advance Belfast's urban forest and related issues. Thanks to its inclusive structure and cross-community nature, the Forest of Belfast is able to access the Northern Ireland *Peace and Reconciliation Fund* to finance its *Trees for the Community* project.

Further information: http://www.forestofbelfast.org.uk

Fig. 7.3. A press photograph showing some of Belfast's key opinion leaders supporting the urban forest. This encouraged many other individuals and organizations to join the partnership (*photo:* Forest of Belfast)

Some partnerships may be intentionally short-lived, while others will adapt and evolve over many years. They may take the form of charities, trusts or limited liability companies, or simply be based on much less formal agreements of intent. In every case, success will depend on charismatic leadership, genuine cooperation, mutual respect, recognition of the full range and diversity of the resource base and a strong shared commitment to a common set of aims and objectives.

A number of successful urban forestry partnerships drawn from the United Kingdom, Ireland, Iceland, Belgium and Italy are outlined as illustrative examples and case studies throughout this chapter and in the Appendix to show the way in which this approach can be applied to a range of different circumstances.

7.5.2 Stakeholders and Partners

Within this wider framework it may be helpful to draw a distinction between stakeholders and partners. Stakeholders are those individuals and organizations that have an interest in the urban forest either as potential beneficiaries or by virtue of their being affected in some way by its creation or management. Stakeholders need to be consulted on the urban forest but do not necessarily need to be directly involved.

Partners, on the other hand, are those agencies and individuals that are directly involved in the creation and management process. They may be involved in

- establishing the right policy context – at national, regional or local level,
- providing resources – financial, intellectual, human or technical,
- taking action – public, private or community.

7.6 Forming Effective Partnerships

The following are a number of *critical success factors* essential to forming effective partnerships.

Defining Aims

A clear definition of the aims and objectives of an urban forestry project, coupled with a flexible and responsive approach to delivery, will generate more broadly-based partnerships and encourage a wider variety of stakeholders to become full partners and play to their respective strengths. It is important that all partners share a common strategic vision and make a long-term commitment to success. Consultation is a time-consuming but vital part of the development process. When managed well, however, it enables potential partners to identify the contribution they are best able to make. It also helps them to recognise what they themselves are likely to enjoy. A jointly published urban forestry strategy or an agreed community forestry plan can be powerful early expressions of shared commitment.

Mutual Benefit

In identifying key partners, it is helpful to consider what each of them is able to contribute and what each expects to gain from their participation. Some may be best able to contribute to policy development, while others may bring in money, land or other resources, technical expertise, local knowledge or skilled personnel. Partnerships need to recognise the particular motivations and expectations of participants and accept that members may have differing priorities that need to be accommodated within an agreed common agenda (Simmonds 2000).

Complementarity

Partners need to believe that working together will be mutually beneficial and that by pooling skills and resources they will achieve more than would be possible through individual action. Government agencies may welcome the support of those with special interests such as wildlife organizations while non-governmental bodies can gain access to public funding through government backing for a local initiative.

Box 7.4. Eco Community Tree Nursery, Ireland: A shared resource, created through partnership

The ECO Community Tree Nursery, established in 1990 at Finglas, West Dublin, in the Republic of Ireland, is an example of an urban forestry partnership producing specific benefits for the different bodies involved, namely ECO UNESCO, FAS – the National Training and Employment Agency and Dublin Corporation (Mulread and Finnegan 1999).

The lead organization, ECO UNESCO (an Irish environmental conservation body specifically for young people) manages the nursery as an environmental education resource for its young members and volunteers and as a focus for community-led greening work in surrounding housing estates and schools. FAS funds the nursery to provide employment and training in horticulture and nursery skills for long-term unemployed people from the area. Meanwhile, Dublin Corporation supports the nursery as a project that strongly complements its own greening and landscape work within Dublin City.

Further information: http://www.ecounesco.ie

Box 7.5. The *NeighbourWood* scheme, Ireland: A national initiative, delivered through cross-sectoral partnerships at local level

The implementation of the *NeighbourWood* scheme in Ireland demonstrates a complementary partnership between a state agency and a non-governmental environmental organization. It provides a basis for the implementation of a grant package operated by the Irish State Forestry Service aimed at encouraging local authorities to work with community groups in the development of woodland amenities in and around towns and cities (Forest Service 2001).

The Forest Service funds the Tree Council of Ireland to provide on-the-ground support and assistance to local authorities and community groups as they develop projects, and to provide feedback on ways to streamline and enhance the workings of the scheme. This partnership is proving effective in initiating numerous projects in and around urban centers throughout the country, ranging from small-scale woodland improvements to larger strategic urban afforestation initiatives.

Further information: http://www.agriculture.gov.ie

Relevance

It is important at the outset to identify key partners, and to keep membership relevant to them. If the partnership becomes unfocused or unnecessarily large then there is a danger of the project becoming too complex or unwieldy. This increases the risk of outcomes being reduced or delayed and this in turn may cause valuable partners to lose interest and drift away.

Adaptability

A flexible and responsive approach will keep the partnership fresh and relevant. The partnership must include an inbuilt feedback and review mechanism to enable it to assess performance against its targets and to facilitate any necessary adaptation in the light of changing circumstances. This will also help to ensure that when a partnership is no longer relevant or effective, it can be comfortably dissolved. Sometimes, where the partnership has been set up to deliver a very specific goal, a finite life will be appropriate, even desirable. However, in many cases in the field of urban forestry, the partnership will need to be able to evolve and develop to remain effective and relevant to changing circumstances over a prolonged period.

Efficiency

Each of the partners should be clear about the time and other resources they can contribute. This is important for their own sake and also for that of other partners. In this respect it is important for the partnership to have an agreed structure. This is essential to ensure clearly defined lines of communication, to enable the partners to respond rapidly to problems and opportunities and to avoid unnecessary misunderstanding and confusion. As a rule, the structure should be kept as simple as practicable. The format may range from an informal grouping to a limited company with its own legal status and corporate identity.

Distinct Identity

It will usually help if the partnership establishes its own distinct, collective identity, with a special name, logo, notepaper, website etc. This will often help to unlock resources, simplify communication to wider audiences by reducing confusion with the profile of individual partners and help to ensure that any credit that the partnership attracts will benefit all its members equally.

Leadership

There is an important difference between leadership and control. Very often there will be a need for one organization in a partnership to lead the initiative, convene meetings and maybe to provide the majority of the funding, but it is vital that this relatively powerful position is not abused. It will help if the partners are clear about the unique individual strength which each of them contributes. Money is never the sole resource that holds the key to sustained success and many seemingly junior partners may well make critical contributions through their local knowledge, technical expertise, access to 'ring-fenced' funding or simply through their support from the local community. A true partnership will value all contributions equally and this must be reflected in the style of leadership.

7.7 Managing Partnerships

Partnership working is rarely straightforward. Complex initiatives can involve many different organizations and this can sometimes make progress frustratingly slow. New and unfamiliar relationships take time to evolve, while cultural and operational differences between partners can lead to disagreement and misunderstanding. All of these issues can add to costs and sufficient time needs to be built into the project process to allow them to be resolved. There may be merit in employing an independent facilitator, particularly in the early stages, to help with consensus building and with defining a shared agenda. It is important that individuals with appropriate social skills are involved throughout the period of partnership working, in order to deal with problems as they arise and to keep the partnership on track.

7.8 Conclusion

Partnerships in urban forestry place new demands on the traditional key players. With the recognition that the social and organizational processes that underlie urban living are as important as the physical fabric of our towns and cities, the urban forester's skills must now extend well beyond a knowledge of trees and woodlands. Negotiation and presentation skills are just as important for sustainable success. In order to steer projects through complex regulatory and auditing processes, it is essential to have an understanding of the political, policy and financial environment in which urban forestry has to operate. The ability to bring people and organizations together around a shared vision and to secure their long-term commitment to joint action is vital.

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Part II

Appendix

Case Study 1

**Community Forests, United Kingdom:
A national initiative delivered through local partnerships**

The Community Forests program is sponsored by the UK Government departments responsible for forestry (the Forestry Commission) and the UK Government's advisory body on countryside policy (the Countryside Agency).

The program comprises twelve Community Forests, each located in an area of low woodland cover adjacent to a major conurbation (Fig. 7.4). In each Community Forest, the two national sponsors have joined with local authorities and other agencies to establish Local Forest Partnerships. Together the twelve Community Forests involve over 60 local authorities, cover some 500 000 ha and are within very easy reach of over half of England's population (The Countryside Agency 1999).

The long-term aim of these Community Forests is to create new, well-wooded landscapes that enhance the health, the well-being and the quality of life of local people.

Community Forests operate in complex local working environments, involving land in both public and private ownership. They work across municipal boundaries, responding to local needs and opportunities, involving a wide range of local stakeholders and competing for resources with other regeneration initiatives.

Fig. 7.4.
England's Community Forests program (*source:* National Urban Forestry Unit)

This work is guided and catalyzed by specially established Forest Teams, employed and funded by Local Forest Partnerships, but structured to work independently as custodians of the long-term vision for their Community Forest. Forest Teams are charged with securing the ideas, opportunities and resources and managing the processes required to turn the Forest vision into reality over a 30–40 year timescale.

The Great North Forest is one of the twelve Community Forests. Here are examples of the way that partnership underpins its work (Vaughan in press):

- At a *strategic level*, through the North East Forestry Action Group:
  The North East Forestry Action Group brings together key regional players, including policy makers, forest managers, timber processors and social foresters. The Group acts as the focus for the preparation of a Regional Forestry Strategy, covering both productive and social woodland. It also provides a focus for the future targeting of national and regional funding for woodland creation and management.
- At an *operational level* as, for example, through St. Bede's Community Woodland:
  The Great North Forest was instrumental in bringing together a local farmer willing to sell a significant area of agricultural land, the Woodland Trust (a national charity devoted to woodland creation and management) and a major local funding agency (the County Durham Environmental Trust). The Forest successfully negotiated the transfer of 40 ha of land to the Woodland Trust for the establishment of a new community woodland in conjunction with a local community conservation group.
- At a developmental level through the *Views of Views* initiative:
  Using funding from a regional arts agency, the Great North Forest contracted a professional writer and animated film producer to work with a range of community groups to record and document their views and feelings about their local environment. The outcomes were published as a book of poems by both the writer and local people and as two short animated films that have since been circulated at international film festivals.

  Plant Dreams

  We are planting dreams.
  It is best to plant dreams.
  Some people think we are planting trees.
  We are.
  But mostly we are planting dreams.
  Because
  If you plant dreams
  Who knows what
  They will one day become.

Further information:

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- Internet: http://www.communityforest.org.uk

Case Study 2

Heiðmörk, Iceland: A local partnership to develop recreational woodland

Non-governmental organizations play a major role in urban forestry in Iceland. Most recreational woodlands were planted by local forestry societies (Benedikz and Sharphéðinsdóttir 1999; Fig. 7.5). They were created on open land and have become urban woodlands due to public encouragement in the face of encroachment of built-up areas.

The first area to be planted specifically as recreation woodland was the forest park of Heiðmörk in Reykjavik. Heiðmörk was established in 1950 on abandoned farmland on the outskirts of the city (Marteinsson 1975). The land, 1 350 ha in area, was heavily eroded and degraded (Svanbergsson 1986). Heiðmörk was then far from the built-up area and even today is not seriously threatened by urban encroachment, despite doubling of the population. The Reykjavik Forestry Society (RFS) enclosed the land, later enlarged to 2 800 ha, and made the initial plantings, financed by Reykjavik city. The RFS was commissioned to manage the area.

During the first decades the planting was carried out in a variety of ways (Sigurðsson 2001):

- by ***volunteers*** on small parcels of land, (1–5 ha), allotted to private societies or businesses. RFS provided the plants, fertilizers and supervision at the cost of the city authorities
- by ***RFS staff***, financed by the City, local businesses and private individuals
- by ***children*** in the 9th and 10th grades (14 and 15 years-old) of the primary schools, so-called *vinnuskóli*

The *vinnuskóli* give children the opportunity of earning pocket money, whilst working on environmental projects. This also keeps them occupied during the long summer vacation. The Reykjavik vinnuskóli was started in 1955 and has employed the majority of Reykjavik children born since 1941 for one or more summers. It has played a major part

Fig. 7.5.
There is a 50 year tradition of community tree planting in the landscape around Reykjavik. As the young trees grow they will provide a more sheltered recreational environment for local people (*photo:* Reykjavik Forestry Society)

in awakening Icelanders to the importance of the environment and to the vital role played by forests and it helps to explain the present day widespread interest in forestry.

The results of the first 50 years work in Heiðmörk were reviewed by Sigurðsson (2001). During this period some 500 ha, mainly conifers, were planted, 30 km of footpaths laid and some 45 picnic and rest areas established. The park is serviced by around 20 km of roads and has over 200 000 visitors annually.

Following the success of Heiðmörk, the city authorities have financed the planting of some 1 000 ha within the city boundaries by the RFS (Sigtryggsson 1986). Today all municipal plantations in Reykjavik are managed by the Parks and Gardens Department with the exception of Heiðmörk, which is still managed by RFS. Furthermore, the most recent forestry projects within Reykjavik have been made at the instigation of the RFS and show that non-governmental organizations continue to play the dominant role in Icelandic urban forestry.

Further information:

- Internet: http://www.skograekt.is (in Icelandic)

Case Study 3

***Trees of Time and Place*, United Kingdom:**
A national campaign to encourage personal involvement with trees

To mark the turn of the millennium, a partnership was formed in the UK, under the banner of the *Trees of Time and Place* campaign. The aim was to engage as many people as possible in planting personal trees, grown from locally-gathered seeds and particular efforts were made to reach individuals who might not normally be interested.

The basic strategy was very simple. People were encouraged to think of a particular tree that had been important to them, to visit 'their' tree and to gather some seeds. By planting their tree seed, and growing a personal seedling to plant for the future, they were able to mark the new millennium in a very individual way, whilst contributing to a national campaign which could have a significant collective impact.

All kinds of organizations, from across the public, private and voluntary sectors, were persuaded to join the partnership – over 100 in total (Fig. 7.6). Each was able to provide particular skills and resources. Some had technical skills whilst others could offer land for planting, or money to pay for publicity. Within the UK-wide campaign numerous smaller partnerships developed, each able to play to particular strengths, engage with particular members of the community or add extra value to the basic theme of *Trees of Time and Place*. The following initiatives and achievements are just some of the outcomes of the four year partnership.

Fig. 7.6. Generous corporate sponsorship from ExxonMobil over several years meant that the *Trees of Time and Place* campaign grew to a national partnership of more than 100 organizations, including environmental charities, government agencies, local authorities and other private companies (*source:* ExxonMobil)

Growing with Trees and the ***Children's Forest*** linked seed gathering and tree growing to the educational curriculum. More than 3 000 tree nurseries were established in school grounds.

Constituency oaks. More than 400 members of the UK parliament gathered acorns from an oak tree in their constituency and were later able to plant the resulting oak seedling.

Walk in the Woods and ***Seed Gathering Sunday***: Two new annual events were established through the campaign, with a large number of organizations sharing a program of guided walks to select favorite trees and to harvest seeds.

Technical conferences: The Forestry Commission (the state forestry service) worked with various NGOs to provide technical advice to the public, and to help secure success in tree-seed germination and seedling growing.

Time capsules: To provide a fitting conclusion to the millennium campaign, a large wooden sculpture was commissioned for each of the four UK countries – England, Wales, Scotland and Northern Ireland. Each one stood for three months, from late autumn 1999 until early spring 2000, and sculptures were then buried ceremonially, along with a time capsule containing the names of the tens of thousands of individuals who had grown a personal *Tree of Time and Place*.

Further information:

- Internet: http://www.totap.org.uk

Case Study 4

Ghent's Urban Forest, Belgium: A partnership between university research academics, non-governmental organizations, local authorities and private land owners

The Environmental Department of the East Flanders County Council took the initiative to establish an extensive new forest with easy access to the people of Ghent. In order to select the most suitable location, the County Council worked closely with the Ghent City Council and various other municipalities and local authorities in the region. They recruited the services of the University of Ghent's Survey and Spatial Planning Department and the NGO Flemish Forest Organisation (VBV), to provide specialist technical support.

The University and VBV used a system of Multi-Criteria Analysis (MCA) to analyze the options (Van Elegem et al. 2002). This system begins with the use of exclusion criteria which include physical characteristics (e.g., too densely built up, too wet) and land use restrictions (e.g., designated nature reserves, built development zones). The second stage selects for positive suitability and includes such criteria as recreational potential, scope for enhancing the landscape structure or for helping to restore the ecological integrity of the region. The third stage subjects the most suitable locations to a further screening for their acceptability to the agricultural and nature conservation constituencies, and for their compatibility with local urban planning strategies (Fig. 7.7).

The MCA identified the best site for a city forest of approximately 300 ha within 3 km of Ghent city centre. The Castle site was selected, and the Flemish Forest administration then acquired the land. The extra authority for site selection provided by the

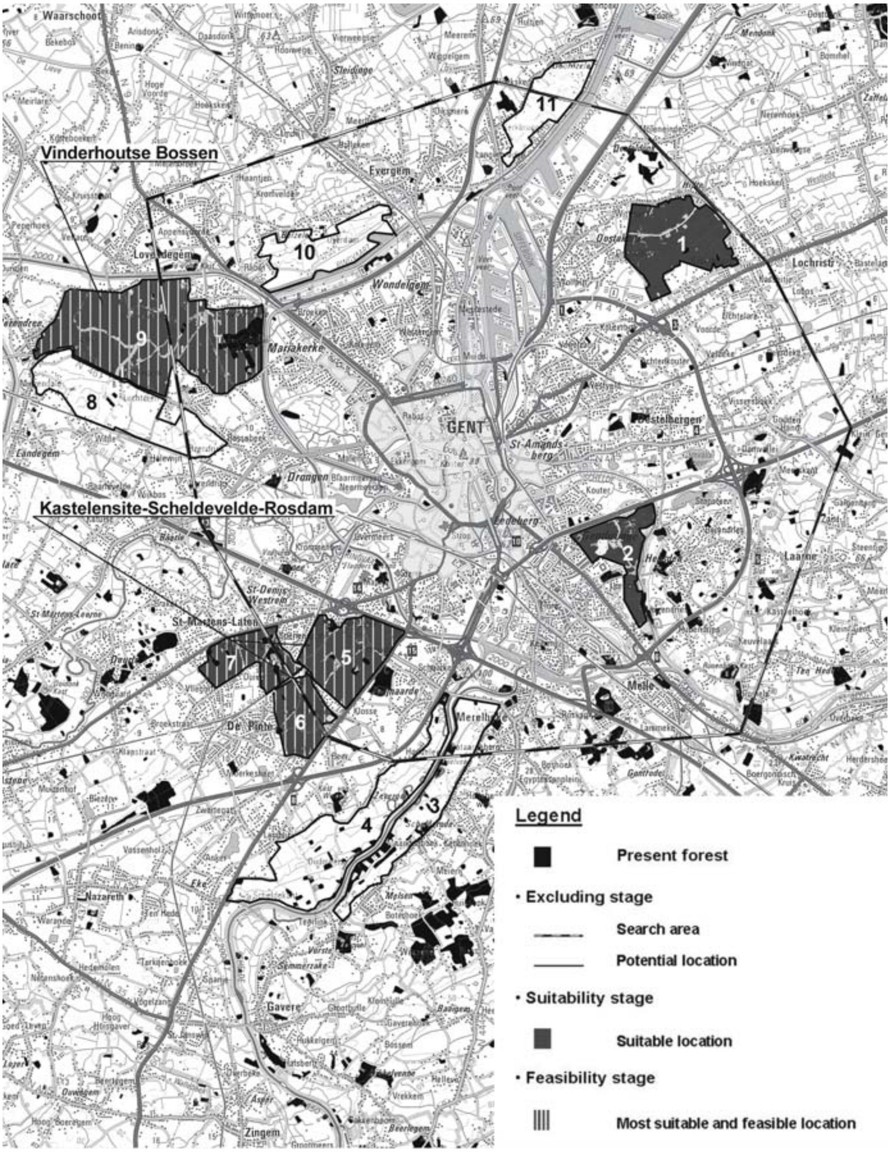

Fig. 7.7. A structured process of elimination was used in order to select the best sites for new urban forest establishment in and around the city of Ghent (*source:* Flemish Forest Organisation)

objective analytical work of the University of Ghent and the Flemish Forest Organisation helped to justify land acquisition, speed up negotiations and increase the likelihood of establishing an ambitious new city forest.

Further information:

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- Internet: http://www.parkbos.be and http://www.vbv.be (in Dutch)

Case Study 5

Campi Bisenzio, Italy:
A public green-space management policy which encourages widescale public participation

Campi Bisenzio is a small town on the south-western edge of Florence with a population of approximately 50 000. In the past twenty years it has seen one of the most spectacular industrial expansion rates in Italy, and this has led to rapid growth and a great influx of workers from such countries as China, the Philippines, Sri Lanka, Albania and Macedonia, as well as North Africa and other towns in Tuscany. In order to deal positively with this potentially stressful set of circumstances, Campi Bisenzio is the first municipal council in Tuscany to appoint a Deputy for Information and Public Participation.

Such rapid growth has subjected the land in the municipality to great pressure and in order to deal with this at least 70 protected areas have been created. These provide a green-space resource equivalent to 28 m^2 for every person in the town. This green-space network includes Chico Mendez Park: 15 ha of woodland, meadows and lakes on the site of old sand quarries and landfill tips.

The people of the town were keen to play an active role in the establishment and long term care of the green network and this has been encouraged through a contract with the ARCI (the Recreation Association of the Socialist Democratic Party) which provides an annual budget of €20 000.

The initiative is sponsored jointly by the Council's Department of Environment and Department of Information and Public Participation. Elderly people in particular have been consulted. Their wisdom and local knowledge is being highly respected and increasing numbers of them are engaged directly in the practical management of the green-spaces network.

At the end of each year the townspeople assess the performance of the green-space management. One result of this highly participative approach to green-space provision has been the involvement of growing numbers of young people, and they are now volunteering to work alongside the elderly in managing the parks.

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Chapter 8

Involving People in Urban Forestry – A Discussion of Participatory Practices throughout Europe

Ann Van Herzele · Kevin Collins · Liisa Tyrväinen

8.1 Introduction

Planning and acting on issues relating to people's living environment have increasingly become a socially embedded practice, shifting from serving an abstract public interest to actively engaging the public. Central to this approach is a greater emphasis on the exchange of knowledge and the development of ideas through communication with relevant stakeholders, including users, residents and community groups.

This trend towards greater communication in urban environmental or 'green' planning parallels the current success of various concepts such as collaborative planning, citizenship, social capital and participatory democracy. In addition, urban renewal strategies and environmental improvement schemes for creating livable cities, the establishment of Local Agenda 21, and the growing attention to the social dimensions of sustainable forest management, all provide a context to develop new interactions between society and forestry.

Cities, towns and suburbs are increasingly rich in different types of green spaces. In addition to traditional public areas such as urban woodland and parks, many different types of areas and new kinds of ownership or comanagement arrangements are now evident. As outlined by Agate (1998), these include community wildlife gardens, children's farms, school nature areas and community forests. This new diversity provides many opportunities for community involvement – including training and education, consultation and active participation – the realization of which will fully develop many of the 'real' benefits from the urban forest: health and well-being, community development, environmental education, sustainable urban design and planning (see Chap. 4). The urban population represents a huge potential, often largely untapped, to deliver creative ideas, skills and manpower to take care of these spaces and to maximize their contribution to the quality of urban life.

In various places throughout Europe, urban foresters, local authorities and community workers as well as individual activists are placing a higher priority on urban greening and a greater emphasis on ensuring that many different groups get as much benefit from it, using approaches that tap into the energy and commitment among local people. Very different projects all over Europe owe their success to the active participation of citizens. Examples of local initiatives are tree planting schemes and clean-up days. There are positive experiences with partnerships between city authorities and residents for the establishment and the maintenance of green spaces around high-rise housing blocks, for example in four city districts of Sofia, Bulgaria (Van Herzele and Denutte 2002) and in the suburb of Holma in Malmö, Sweden (Beer et al. 2003). At a larger scale, much of

Fig. 8.1. Local people were invited to a Planning event for the creation of a new city park in the former railway yard of Antwerp-North, Belgium. Planning-For-Real is a highly visible tool, which people of all abilities and back-grounds find easy and enjoyable to engage in (*photo:* A.Van Herzele)

the success of the UK's Community Forests initiative (The Countryside Agency 1999) and Ireland's NeighbourWood Scheme (Forest Service 2001) is attributed to the emphasis within each on community participation (see also Chap. 7).

A wide range of handbooks for practitioners describing participatory appraisals (e.g., Forestry Appraisal, Priority Search), consensus building techniques (e.g., Planning for Real (see Fig. 8.1), Strategic Choice) and monitoring tools (e.g., Cost-Benefit Analysis), is now available. Some examples of useful practical handbooks are given in the reference list (for example, McPhillimy 1998; Loikkanen et al. 1999; Van Herzele and Collins 2005). While prescribed procedures, methods and tools are increasingly becoming a routine demand in participatory practice, their use alone does not guarantee positive change. Instead of being primarily a process of social interaction, public involvement is too often approached as something technical and concerned with substantive ends. Moreover, results can be misleading without an appreciation of how the local situation and the process of social interactions may shape the outcomes of participatory activities.

This chapter is aimed at encouraging those seeking to choose or invent practices according to their own situation and with sensitivity to the social interactions within a particular process. The chapter starts with reflecting on the distinct reasons for involving people in urban forestry. With these objectives in mind, selected key questions relating to the involvement of the wider public are discussed, drawing in practical examples from throughout Europe. Rather than starting from 'how to…' guidelines or criteria for best practice, this chapter sets out to observe what actually happens in practice when people participate. An underlining theme throughout this chapter is the importance of developing successful interaction between lay people, officials and experts in the shaping of the local forest resource.

8.2 Why Involve People?

The underlying motivation or justification for involving people is likely to greatly influence how the process is organized, what's on the agenda and consequently, the type of social interactions that take place. However, the organization of participatory practices does not always start from explicit objectives. In many cases, the level of willingness and commitment to involve the wider public can vary greatly. For example, on one hand, public officials are reluctant to release control over the course of the events, and may feel insecure in their lack of experience in communicating with the public. Also, a certain degree of skepticism often exists concerning both the representativeness of participants who turn up in meetings, and the public's knowledge and understanding of the issues involved (Van Herzele and Collins 2005).

On the other hand, involving local people is increasingly promoted by national authorities. In Finland, the Forest Act (1996) requires public participation to be included in regional forestry planning, while the Land-use and Building Act (1999) stipulates that citizens have to be involved in planning in all planning stages. In other cases, public participation is made a prerequisite of funding, as is the case with the Millennium Greens Programme in England, which aims to assist at least 250 local communities to create their own new areas of green space. There are also examples where public participation was the main motivation to get the necessary public support for ambitious national forestry strategies. The Community Forest program in the UK – established in 1990 – has the primary objective of increasing the level of woodland cover in and around 12 major towns and cities. Although the community was seen as central to its vision, both as beneficiaries and as key stakeholders to be involved in the process, the early ideas of community involvement had much to do with the prevailing view that involving people reduces the level of vandalism to trees and the degree of animosity towards landscape change (King 1999). Strategic plans aiming to increase the urban woodland cover can be found in various Western European countries, e.g., the Central Scotland Forest Strategy (CSCT 1998a) and the action plans for the creation of urban forests in Flanders (Belgium) (Embo 1999) and The Netherlands (Van den Berg in press). However, these strategies often have no statutory basis and are constrained in their ability to access funding and to succeed in implementation. Consequently, they are often heavily dependent on linkages to existing plans and policies and must be based upon widespread citizen support and the presumption of voluntary participation by landowners.

There often exists a tendency to pursue participation primarily as a means to an end, with little or no commitment given to long-term engagement. In order to counter this, urban forestry programs such as England's Community Forest program are searching for approaches that place less focus on simply planting trees, and more on investing in the community. The underlying idea is that the involvement of users, residents and community groups is fundamental to the long-term success of urban forests and trees and to maximizing the range of benefits these provide a local community and its locality with, and hence, the quality of urban life. From this perspective, three major objectives of involving people in urban forestry can be highlighted.

Enhancing the Quality of Decision-Making

A first objective is instrumental in nature: using participation as a tool for enhancing the quality of the plan or decision. Planners and decision-makers increasingly tend to rely not only on traditional science for managing ecosystems, but also on civic science. Using local knowledge about the environment in which local people live, work and play, and the possible creative ideas and solutions they propose may considerably improve the quality and effectiveness of decisions. As a result, plans will be more sensitive and responsive to local conditions and needs, drawing upon a multiplicity of understandings and values (Healey 1997). Moreover, finding ways for the community's views to be heard and taken into account from an early stage helps to build consensus. It allows conflict to be anticipated, defined and resolved at early stage (Aygeman 1996). A large survey on the benefits of various participation methods used by the Green Area Division of Helsinki (Sipilä 2003) demonstrates that this quality objective is important to the different parties involved. For example, 80% of those residents who had been involved in planning stated that the quality of the plans is inadequate in the absence of residents' participation. However, more than half of the planning authorities at the department of public works felt that those plans drawn up solely by professionals were adequate enough for implementation.

Encouraging a Sense of Ownership

The second objective relates to the intangible benefits, in particular 'transformative' outcomes, which refer to social change. A main motive in this context is often called 'sense of ownership' or related terms (e.g., Crouch 1994; Greenhalgh and Worpole 1995; Aygeman 1996; Agate 1998). A study in England (Mostyn 1979) showed that almost everybody who had been involved in community schemes talked about the local natural area as 'my valley', 'my trees' and 'our place'. The people saw the fact that they had been involved in planting trees on the site as being symbolic of 'putting down roots'. When people feel that, due to their own input and efforts, they 'own' a line of street trees, a public park, a local woodland or a green neighborhood, then it will become an element of their daily life and surroundings for which it is worth struggling to retain and develop. This sense of ownership is very often apparent in a reduction in the degree of vandalism directed at urban trees and other elements of the environment. However, in this way, involving people is not only seen as a way to encourage people to take care of places, but also as a way to actively re-engage people with their local environment and with society (see Greenhalgh and Worpole 1995). Working together and achieving improvements to their living environment is empowering for those taking part, and helps to reduce the alienation that is very much a part of modern urban life. Moreover, participatory exercises can increase the community's collective confidence to undertake local initiatives, enhancing skills and ability to cooperate and work together, and generating a willingness for long-term commitment and accountability. These attributes can encourage the community to tackle other issues affecting it, such as the lack of proper recycling facilities, child care services, and so forth (Johnston 1985, 1986).

Raising Awareness of Urban Forestry Related Issues

Public involvement is also extremely effective in increasing the general awareness and appreciation of the multiple benefits and values of urban forests and trees which also includes developing a mutual understanding of the interests and values of others. Trees are something for which everyone has a deep and fond affinity (Dwyer et al. 1991). In the context of an increasingly urbanized society, connecting people with trees and forests on their doorstep can be a way to relate them to the wider environmental issues. In this way, environmental education is seen as an essential outcome of successful public involvement (Collins 2000; Konijnendijk 2000). The urban forest creates a convenient 'on-your-doorstep' resource for young people to learn about the environment and complex natural processes (Denton-Thompson 1989; Hayward 1993; Collins 2000), a role capitalized on in many European cities through the development of 'forest schools' for urban kids to learn more about nature (Konijnendijk 1999). One of the main benefits of the communicative planning approach used in Helsinki was considered to be people's increased awareness towards urban forest related issues (Sipilä 2003).

Ways and means in which the above considerations concerning the 'Why' behind people participation can be related to particular participatory approaches, together with their respective opportunities and limitations, are explored below, using the context or framework provided by seven key questions:

- When are people involved?
- What platform is used?
- Who is involved?
- Which interactive approach is adopted?
- Who controls the process?
- What resources are invested?
- Which issues are connected?

8.3 When Are People Involved?

Stakeholders often feel they are being consulted too late in the process, and that the real decisions have already been taken by agencies. However, the best opportunity to provide a creative contribution to the quality of the plan exists in the early stage of the planning process, before issues, goals and values are defined (Van Herzele in press). Moreover, the feeling of 'not invented here' is a major barrier to the likely future support for, and sense of ownership of, whatever emerges. There is therefore a challenge to bring people into the participatory process at the very early stages of policy or project development. Ideally, people should already be involved during the initial exploration of what can be done, where and when. For example, in the Roadshow projects in England (Architecture Foundation 2000), communities themselves identified spaces in need of attention and regeneration. In this way, the selected sites had an open agenda: none of the parties involved, including local people, interest groups and the local authority, had any fixed idea of how the environment should be generated. This meant that ideas could be explored and conflicting opinions resolved as part of positive discussions between community and professionals.

People typically expect to influence decisions and change. If this influence is only minimal, their involvement may lead to unfounded expectation and future disillusionment and thus probably is not a good option. For example, in the case of the Groene Vallei, a waste land in the city centre of Ghent (Belgium), the city authority delayed involving the local residents in the park design until the formal decision was made to turn 90% of the area into a park (Van Herzele and Collins 2005). Creating a constructive starting base is a precondition for effective participation, and part of this is about ensuring that important personal uncertainties and conflicts are resolved. For example in the case of Parkbos Gent (Belgium), the establishment of a sizeable 300 ha forest was negotiated with farmers and landowners who will be asked to sell or exchange their land. A situation like this needs a careful selection of issues and a great degree of sensitivity for successful communication with the wider public.

In Helsinki, both residents and authorities feel that the most important stage to involve residents is at the point at which planning goals are set, in particular, at the local level. This was considered distinctively more important than, for example, being involved in selecting the actual management methods for urban forests. The residents, however, emphasized the importance of early involvement of citizens in planning more than the city authorities. The authorities felt that giving the residents an opportunity to comment a draft plan would be adequate (Sipilä 2003).

Once involved, people want to have a view on what happens with their input and how decisions are taken. If this is not followed up, it can lead to disillusionment and anger. In practice, however, it is common to find local agencies keen to put people's participation on their agendas, while actually only using them as data gatherers and providers of ideas for solutions, without giving them any feedback about what actually happens with their input. For example, for the plan of a new 30 ha urban forest, the Everslaarbos in Lokeren (Belgium), the city asked the advice of the local neighborhood association. A drop-in evening for local residents was attended by over one hundred people, resulting in a treasure of ideas. Interviews with participants revealed a huge enthusiasm about this experience and the approach followed. However, they also felt very insecure about the actual impact of their efforts on the plan. Similarly, in Helsinki, the main concern of residents that had been involved in planning groups was that they had been given too optimistic an image of the possibilities to influence the plan (Sipilä 2003). Nevertheless, all of the interviewees in the case of the Everslaarbos in Lokeren wanted to take a further part in the planning process, and most of them were even willing to help to plant trees or to keep an eye on the area. Public involvement in this case however, has remained a once-off event, which means that a clear potential for an ongoing dialogue with the people and for creating social ownership and awareness was overlooked.

The example of the Rentukka project in Eastern Turku (Finland) shows, however, that participatory events can reveal a clear potential for long-term commitment. One of the project goals of a strategic, green-space planning project was to actively adopt traditional work parties, and to develop new forms of collaboration with local residents in the management of the urban forest. The city authorities organized 84 management and cleaning-up events during two years (2001–2002), in which more than 3000 residents participated (Rentukka 2002). The management work included the construction of a local nature trail, the management of meadows, thinning and understorey management within local forests. According to a survey study in the area, almost half of the residents (45%) were willing to participate in the management of the areas, most typically once a year. The most interested residents were unemployed, office workers with an academic degree or parents at home (i.e. housewives and -husbands), and the older age groups (56–65 years) (Rinne 2002). After the positive experiences, many neighborhoods have asked for annual management plans to enable them to work with professional managers, and the methods developed in the project have been applied to the whole city of Turku.

In other cases, people's involvement is often limited to the implementation stages of plans and projects. It is common to find people engaged in voluntary work and in raising money for a project, but having little or no say in the way a project is chosen, what the priorities are and how subsequent action may be taken. For example, one of the threats to the Wycombe Woodland project in England, as noticed by the Range Office, was that some youth and disabled groups, while enjoying the experience, actually viewed their involvement as labor (Van Herzele and Denutte 2002). Their volunteer work was perceived as a cheap way to elaborate the management work. On the other hand, in project stages where issues are proposed, discussed and negotiated, the involvement of those groups remains a common problem. Many social groups are not strong enough to enter the planning stages of projects without much needed support. As effective involvement during the whole process is critical to creating ownership and sustaining energy and action among local stakeholders, active strategies should be followed at that point.

8.4
What Platform Is Used?

The challenge is to design a social setting within which the full spectrum of all interests and values is represented, which facilitates an ongoing dialogue and out of which action may be mobilized. The platform design is closely related to the objectives of the interaction and the phase in the process. Where the emphasis is on information and consultation, wider forums can be used, focusing on the representation of interests. For example, the participative platform Forêt de Soignes/Zoniënwoud (Belgium) was set up by the Brussels' Environmental Agency as a consultation forum for user and other organized interest groups (horsemen, fishermen, cyclists, wildlife activists, guides, etc.).

Wider forums can be used to initially scope out the main issues, needs and desires within a community, which may facilitate the organization of the further process. For example, in the case of the management plan of the Vordenstein Park in Schoten (Belgium), an enquiry in the format of an attractive leaflet was used for the identification of individuals to be invited to the workshop meetings, and for the selection of the first topics for discussion (Van Herzele and Heyens 2004). When organized later in the process, wider forums may create opportunities for generating new ideas, feedback and collective action, and provide a safety net to catch any important considerations missed within more focused working groups. For example, in Helsinki, the use of an 'Intelligent Map' has been tested in the planning of urban forests. The program has been running on the Internet during the communicative planning process, and as a tool allows the planning group members to follow and to generate planning documents, maps and documented discussions (Tyrväinen et al. 2002). Other Internet users can also access the information pages and take part in the discussion by writing comments on specific sites on the maps. This platform seems to be suitable for residents who are familiar with the Internet technology. However, those people who had been involved in planning would still prefer using conventional tools such as meetings, field trips and surveys (Sipilä 2003).

Popular forums and activity events, that bring the community together, such as park events, tree planting and cleaning-up days, may also encourage people to take the first, vital step to involvement. In order to get as many people as possible involved, the Newham Community Project in London (UK) (Agate 1998) is innovative in its approach to tree planting, taking a holistic view of the environment. Arts projects such as murals, tree dressing, dance and drama all helped draw in people who might otherwise not have got involved.

Regardless of the many potentials, wider forums have their limits when it comes to fostering participation in shared planning and action for creating and maintaining places. Working with small groups and plenary feedback has proven to be appropriate for creative brainstorming in the initial phases of a project and for the in-depth exploration of ideas from a wider forum. Small groups comprising a variety of perspectives interacting over the issues at stake will learn from each other. This approach also provides opportunities for various values to be expressed in a relatively non-threatening setting, compared to a formal hearing in front of a large group (Van Woerkum 2000; McCool and Guthrie 2001). Occasional groups working independently on a particular task or agenda are most likely to challenge accepted views and reformulate problems in ways that produce creative new directions for action. For example, during discussions on the creation of a city park in a former railway yard in Antwerp (Belgium) a mixed-level group was created, involving participants who were operating at different city levels (neighborhood, city district, etc.). The existing relations were seen in a different context, leading to widened perspectives and enriched discourse (Van Herzele 2001). On the other hand, permanent and socially coherent groups are more likely to enrich social links among the group and hence, facilitate collaboration and trust (Rydin and Pennington 2000).

It is also in the forum setting that particular attention should be given to building up social contacts and networks around an issue agenda (Healey 1997). The challenge is to find ways of collaboration across the webs of relations with a stake in an urban forest or trees. Relation-building work cannot be the result of one-off participatory events alone. For example, in the case of Enamebos (Oudenaarde, Belgium) a working group of local volunteers has been managing the forest for more than ten years. Special attention is being given to building collaborative relationships with farmers and hunters (Van Herzele and Collins 2005).

Whereas small groups may be very productive in planning, organizing and working jointly with others and/or agency officials, in most of the cases drawing in the wider community is essential, as it promotes the initiative throughout the locality. For example, in the Terryland Forest Park in Galway City (Ireland) (Fig. 8.2), the planning section invited key resident group representatives, NGOs and local environmental activists for a management group to represent the wider community during initial discussions regarding the project's overall direction. Since then, the group has organized, in association with Galway Corporation (local authority), numerous community

Fig. 8.2.
The Terryland Forest Park project in Galway City, Ireland, is overseen by a steering group comprising local resident associations and interest groups, environmental NGOs, forestry companies, Galway Corporation and other statutory bodies. The steering group oversees a program of imaginative community events, which is proving highly successful in directly involving people of all ages in the development of the park (*photo:* S. van der Sleesen)

initiatives aimed at involving the wider public in the realization of the Terryland afforestation project. This example also shows that the long-term engagement so essential in urban forestry may involve shifts between different types of forums. As the 'How' and 'Where' of participatory forums may shift about, flexibility in organization and open-mindedness to the opportunities at hand are a prerequisite.

8.5
Who Is Involved?

As urban forestry is strongly linked with a multiplicity of social and physical aspects of urban liveability and their interrelationships (see Chap. 4), it is an issue in which so many different players have a shared interest. The identification of stakeholders, i.e. all those with a stake in an issue or area, is a central question in participatory literature and practice. In the UK, the term 'communities of interest' is also used (O'Brien and Claridge 2002), and Healey (1997) mentions the conception of 'stakeholder community' with both territorial and functional reasons for membership.

In order to make the plan sensitive and responsive to people's needs, a wide scope of interests should be considered and, where possible, met in the overall plan or decision. Involving different social groups is crucial for making plans more relevant to the life strategies of people for whom the local community and local green spaces are often more central to their needs: less mobile groups (children, elderly, etc.), ethnic groups, people in lower social classes, housewives, etc. (see also Chap. 5). In addition, the process must not be restricted to those with just an interest in the urban forest or trees. Many others may have important matters to contribute to the direction and success of the program, plan or project, for example by their access to expertise and facilities, their knowledge and skills, their possible role in putting decisions and plans into practice.

Even if a communicative approach is actively pursued, reaching the diversity of stakeholders remains a common problem. For example, Allison (2000) reports on the Woodland Trust's Woods on your Doorstep project (England) (1996–2001), which was aimed at helping people plant up to 200 new community woods close to where they live. Although the project was very successful and has created an appreciation of the diversity of communities, the outreach methods employed did not always reach minority social and ethnic groupings. This experience is reflected in research on public participation efforts in neighborhoods of various European cities (Chanan 1992) and in urban woodland areas in Finland (Tyrväinen et al. 2003), suggesting that the better educated and higher social classes are more likely to get involved, and that young people and ethnic minorities are likely to be under-represented.

In practice, the strategy followed too often relies on existing groups. Many who live in cities and towns, however, are not active citizens and may not associate with any particular interest group. Moreover, members of organized groups such as nature activists are often more assertive and familiar with speaking out in meetings, creating a real danger that the more silent voices may not be heard. From a study in Switzerland by Renn et al. (1995) it was concluded that lay people are obviously more willing to reconsider their preferences than representatives of interest groups, and to come out of the discussions with new views. They seemed to be less interested in just pushing through their own agenda and were more public-interest oriented than the representatives of socially organized interest groups.

Another strategy followed is simply to extend the boundaries of public participation, rather than seeking to remove the barriers. In the case of the planning of a local park, for example, this may cause little incentive for individuals with a clear stake – such as local residents overlooking the park or just seeking a peaceful environment – to mobilize if they expect the results of their negotiations to be simply overturned due to the influence of external interests such as an outside sports group.

These problems do raise concerns as to whether or not the interests of the people are really served, and consequently, the quality of decision-making might be questioned. Moreover, it is common for planning officials to have doubts about the legitimacy of participation processes as they do not truly reflect all citizen interests. Such a skepticism may be dangerous as it tends to ignore people's input. On the other hand, it should be acknowledged that participants in meetings inevitably represent many interests other than those to be focused on. For example, in the first meeting of the participative platform Forêt de Soignes/Zoniënenwoud of Brussels (Belgium), representatives of interest groups presented themselves as 'I am a member of the CQRWB and also have three children' or 'I am a horseman and I am also disabled'. By bringing to the table their personal roles, participants may contribute valuable knowledge and opinions which might otherwise not be included. However, appealing to people and interests who are not present can also be indicative of participants' awareness and anticipation of a possible 'delegitimisation' of their input, showing they do not speak for themselves or for any dominant group.

A study by Tyrväinen et al. (2003) dealing with forest management decisions has shown that unrepresentativeness is not always true. It concluded that the participatory planning groups in Helsinki (Finland) represented the views of residents and other stakeholders that were reached by large public meetings quite well. Anyhow, many experiences have shown that good ideas result from interactive processes and those do not need to be absolutely representative of the whole population. In making the urban forest, park or trees more widely 'owned', it could be a strategy not only to seek out the plurality of interests, but to involve the existing potential of catalyst actors who can play a crucial role in broadening and deepening the base of involvement which is so crucial for long term commitment and the future mobilization of action.

8.6
Who Controls the Process?

The nature and extent of participation are often measured in terms of the power and role that different stakeholders have in the decision-making process. Frequently used is the ladder of participation (Arnstein 1969), which defines the levels of community participation from consultation to total community control. Various authors (e.g., Innes and Booher 1999) argue that the planning process should be owned by local people and that stakeholders are more likely to feel comfortable with a process they themselves can organize and are more likely to be committed to its results.

The connection is inherently strong in cases where groups originate from spontaneous initiatives, even if those originally arise from defensive attitudes. For example, the Friends of Graves Park in Sheffield (England) evolved in 1998 from The Hands Off Graves Park Committee originally established to fight the proposals of the City Council to sell seven acres of parkland for development. The group applied later for and obtained charitable status and was given a broader mandate to protect the whole of Graves Park. Throughout Europe, initiatives originating from a fear of loss of green spaces and trees bring people together who are already environmentally conscious and active. The greatest challenge, however, is to activate the wider community, including those people who feel that they have no stake in their environment. In the case of Santa Viola in Bologna (Italy), cited by Greenhalgh and Worpole (1995), some people in an old persons' centre organized themselves on a voluntary basis and took over the management of a park that was in decline, transforming it into a centre of popular cultural activity. In conjunction with local residents, the organizers started a series of initiatives such as 'Green Saturdays' and 'Cleaning Up Days', which involved schools, residents and young drug addicts.

In arrangements like this, we often see public actors as participants, but not necessarily the initiators, coordinators or leaders of effort and activity. On the other hand, in many cases, relying on local initiatives is not enough. Official systems may be supportive in knowledge development and in facilitating social collaborative initiatives. Authorities can even play a vital enabling role for groups to move towards greater community control and over time, to take a lead in the running of a site. For example, in Surrey (England), public concerns over felling at Stoke Park Wood prompted the Forest Enterprise to arrange a meeting with the local people, which resulted in the setting up of The Guardians of Stoke Park. Initially, the Forest Enterprise chaired the group before handing over control to local people accepting greater responsibility. The development and work of the group have resulted in a greater understanding by local people of woodland management practices, and a modification of felling plans to minimize the impact on woodland users. The group's activities have expanded to include the organization of events, guided walks and conservation working parties. The Forestry Enterprise acquired the role of a facilitator, benefiting from its contacts, advice and office facilities (Forestry Commission 1996).

On the other hand, when opening up opportunities for local initiatives and community control, public actors may be confronted with important dilemmas concerning the quality of decision-making. Indeed, the outcomes of a citizen-led process may be very different from their own vision and/or incompatible with higher level interests. In The Netherlands, the National Forest Service employs limiting conditions of participation, such as 'the sustainable conservation of nature', in deciding which level of community control is acceptable. For example, it is considering to set up a users group for the Bieslandse Bos/Balij (near Delft), within which interested individuals will be encouraged to offer their ideas and advice. The group will not be able to influence the decisions made concerning the management, and will only take part in decisions such as that concerning the selection of art projects and will be allocated a main role in the realization of the design (e.g., the construction of small paths across the area) (De Graaf 2001).

In other cases, planning officials are reluctant to increase the level of influence given to people because they fear that the process will be dominated by local elites. In the Vordenstein project (Belgium) concerning the involvement of local people in the management plan of the park, for example, the main argument used by the officials in a discussion about the level of influence was the fear that nature conservation groups would capture and manipulate the process for their own ends at the expense of the interests of the ordinary park visitor and the multi-purpose function of the park. This has not been the case so far but there is indeed a general danger that collaborative initiatives might neglect some sections of the public interest. Therefore, official systems can play a role in taking control of social consequences of local initiatives (e.g., do they meet the needs of under-represented groups in the community?). Moreover, in urban contexts, populations are typically dynamic and characterized by frequent migration movements within and across the urban boundaries. As the interests of future residents cannot be included in participatory initiatives, public actors must also play an advocating role for future interests.

8.7 Which Interactive Approach Is Adopted?

Involving people is all about building relationships. Personal contacts (for example, between the urban forest manager and the visitors) are often as or even more efficient than organizing many meetings. However, it is not always a matter of course that such spontaneous communication exists and that it is automatically supportive for collaboration. Urban green spaces are typically multiple-use sites and there is potential for conflicts of opinion, which are likely to arise from the wide range of demands for attention. Stakeholders often start from stereotypes about other stakeholders and their underlining motives, and concentrate on their own interests first. A striking case in point is the often conflicting view between the public and environmental groups on the one hand, and urban foresters on the other. Disagreements exist on questions such as what aims should management strive for, by what means, and how much human interference is desirable. In particular, conflicts are readily noticeable between intensive management approaches and 'leave it untouched' attitudes of people towards nature (Konijnendijk 2000).

Many examples exist where such conflicts have led to strong public resistance against both the felling and the planting of trees. For example, in the case of Skelton Wood in Leeds (England) the City Council decided to fell and replace dead and dying trees and to make the woodland safer for users (Lomas and Gorner 2000). Despite widely disseminated information and the establishment of a contact point, community reaction was strong and venomous once the work commenced. The phenomenon of public resistance in urban forestry has been followed over time in Trondheim (Norway), where a systematic investigation was made of the impact of information and communication on criticism on urban forestry, as derived from newspaper articles during the last 125 years (Sætre 1999). In the 1970s, a system of disseminating information (information brochures, forestry information tracks through woods, forest days together with forest management, learning programs for schools, etc.) was established. For example, during site visits, the urban foresters explained the management to local people with the aim to secure acceptance that their plans are right. None of these strategies were able to stop the wave of criticism against forest operations. Only when forest master plans were issued jointly with the public at large (1992) did criticism considerably decrease.

The evidence is that top-down solutions and one-way communication forms are unlikely to work, especially where there is lack of trust. For creating public ownership of ideas and plans, the professionals' attitude should be directed at involving people on equal terms. Therefore, interactive approaches are needed, emphasizing joint discovery and learning between people and officials. In many cases, at least in Flanders (Belgium), the styles of discussion adopted in public meetings and workshops do not tend towards constructive two-way communication. Elements such as a fixed agenda driven from outside the community and the conventional forum set-up with platforms and rows of chairs, suggest that real power lies at the other side and are likely to reinforce 'them and us' attitudes.

Useful ways of interacting are via group discussions and practical work in the field. In on-site situations, the public as well as urban foresters may feel most comfortable. For example, in Vordenstein Park (Belgium) (Fig. 8.3), regular site walks are organized to discuss some practical choices and dilemmas of design and management with the park users. Careful attention is paid to ensure that most of the issues are relevant to the widest possible range of people. The participants and the park manager learn about each other and about different points of view. For example, the park manager expressed his enthusiasm about how the people themselves inspire him to see things in a new perspective. Moreover, manager and users try to move toward a common understanding of the issues at stake and to arrive at decisions for (joint) action. During such interactive approaches, vision and ideas may turn into a living reality, the contact with the public is kept lively and the urban forest can become a common concern for local

Fig. 8.3.
During field discussions with the Friends Group of Vordenstein Park, people from different ages and backgrounds bring in a diversity of knowledge and life experiences. In a very concrete way, from the experience of practice itself, both participants and park managers engage in a continuous process of mutual learning (*photo:* A. Van Herzele)

people as well as officials (Van Herzele and Heyens 2004). These processes can also demonstrate on a very practical level the role of environmental education and the need for different stakeholders to approach and address environmental issues as partners. In many ways, it incorporates the 'act locally, think globally' ethos, whereby people are encouraged to overcome supposedly insurmountable global environmental issues by realizing local solution to local environment issues. Such initiatives often require fresh perspectives and ideas which may only be realized in the creative 'hot-house' atmosphere of a participatory approach, whereby each party learns about the environment issues involved, and brings their own knowledge, skills and expertise, and a willingness to learn and listen to other views, to the table.

A particular learning approach involving a type of role-playing was followed in the Junior Foresters Education Programme (Clichy sous Bois, France) (Moignieu 1999). In order to tackle the problems of vandalism, littering and violence, an education program for schoolchildren was established with the aim of changing the forest users' behavior. Approximately 3 600 young children from the 51 ethnic groups in the area are involved in the 3–4 year program. They learn and carry out real and sometimes complex activities such as marking and cutting trees, plantation maintenance and establishing recreation facilities. At the end of the program, the children receive the diploma of Junior Forester and can remain actively engaged by providing guided visits to the forests and taking part in actual management. Bringing children in to the manager's role enables them to understand what the forester does and fosters a greater appreciation for the forest.

8.8 What Resources Are Invested?

Involving people in urban forestry needs more resources than traditional planning by professionals, primarily due to its time consuming nature. For example, in the case of the development plan of the Haagse Bos (The Netherlands), it was estimated by the Forest Service that the plan-making process lasted ten times longer than it would have, had the plans been developed without public involvement (De Graaf 2001). Moreover, building relationships and trust amongst the urban foresters and the public, and a bond with the urban forest, are inherently long-term processes taking many years.

The authorities often face difficulties in justifying the expanded planning costs, given that the benefits are not always easy to quantify for decision-makers. For example, since 1995, the Green Area Division of Helsinki, Finland has been working with planning groups involving approximately 600 residents in its management of urban forests. Based on this experience, the Division has been reconsidering the need for citizens to have an opportunity to influence the plans, and the stages at which this should take place. One of the main considerations is the need for cost-effective planning tools, given that communicative planning is such a time-consuming process (Sipilä 2003). Understanding the importance of multiple amenity benefits that appropriate planning of urban forest resource will realize also helps to justifying the costs of planning and managing the areas (see Chap. 4).

On the other hand, the costs of not involving people can be substantial, particularly in relation to the delay and efforts required to resolve otherwise avoidable conflicts.

This is demonstrated by the deadlocked planning process of the new town centre of San Donato, a suburb in Milan (Italy) (Balducci and Fareri 1998). A comprehensive public participation process only commenced after a ten-year period of conflicts regarding the use of a vacant land in the town centre, the outcome of an architectural competition which further entrenched option, and an unacceptable compromise by the authority on the development of a park in the area.

In addition to the time required, difficulties in promoting participation are often linked to the lack of other resources: information, knowledge and skills, money, etc. An aspect of many successful projects around Europe is the ability to 'think outside the box' in order to pull in the necessary resources. For example, a large part of the ongoing success of the Terryland Forest Park in Galway City, Ireland, is its ability to drawn in a wide range of skills and expertise from the many organizations and groups represented on the project's steering group. These includes skills in relation to the organization of community events, schools education work, ecological design and management, public relations and architectural design, all of which complement the administrative and organizational input of the leading body, Galway Corporation.

Local initiatives may also be attractive to potential sponsors. The benefits to the latter are generally in the form of publicity, 'green' image building and contact with a target audience. The resources that may be delivered by means of partnerships are described elsewhere in this book (see Chap. 7).

Being acutely aware of the role of professional support, management of the Red Rose Community Forest in Greater Manchester (England) came up with an approach entitled, 'The Participation Package'. It is a particular package of tools and incentives designed to overcome the blocks to participation: money, a framework for action with ideas and targets, direct links to the community through the Red Rose Forest Network, support from a dedicated worker, and anything from a tree kit to a 'how to' guide. For example, for their Urban Orchards Project, which aims to plant 12 community orchards in Manchester, Salford and Trafford, the toolkit includes training workshops, exchange visits and the creation of an orchards network providing ongoing information. A similar approach is followed by The Central Scotland Forest, an environmental regeneration initiative located between Glasgow and Edinburgh, which has developed the Community Woodland Support Pack as one of the key elements of their Community Involvement Plan (CSCT 1998b). It contains case study examples, information, an inspirational video and practical guidelines, and is aimed at being a point of reference for groups interested in developing their own community woodland.

Grants, supporting packages and sponsorships have proven to be very successful in helping projects off the ground. For example, the NeighbourWood Grant Scheme, available from the Irish Forest Service to encourage the development of urban woodland in and around towns and cities, has stimulated dozens of partnership projects through the country involving partnerships between local authorities, local communities and environmental NGOs. However, too strong a reliance on external resources may put limits on public involvement in the long-term. In a critical reflection on community forestry in England, King (1999) warned that 'If you stripped away the Government funding and commercial sponsorship and removed the various layers of infrastructure that support most, if not all, community schemes, what would be left – a few twigs in the ground with a rather doubtful future'.

Moreover, such external resources are no guarantee for wider involvement. For many excluded groups, information, communication and participation are not enough. In the example of Brunel University (UK), cited by Buckingham-Hatfield (2001), geography students work jointly with a community group on a particular issue identified by a community partner. For example, one student has been working with a community school in one of the poorest neighborhoods in the West London borough to establish a community garden. The school has identified the need for an organic garden, to act both as a source of food and as an educational resource for children. In addition, it serves as a focal point for a multi-ethnic impoverished community from which volunteers working on the garden are drawn. The student has been instrumental in raising money, equipment and seeds from local companies and organizations, and has organized the young children to help build the garden, alongside the volunteers.

Drawing from this example, Buckingham-Hatfield (2001) argues that such an approach not only offers children and adults insights into the multi-faceted aspect of environmental issues, but also creates the potential to develop their capacity for citizenship, which may eventually strengthen the social capital of neighborhoods in which they live and work. It is not enough to look to governments and other funding bodies to promote true and long-term sustained community involvement. Investments need to be made to empower residents and local groups, and a new focus is required on the ways in which social capital can be generated at a local level as a precondition for sharing the urban forest resources and its benefits with a wider range of people.

8.9 Which Issues Are Connected?

The challenge underlining participation is to develop ideas, plans and actions that make a difference, are owned by people, and add value to their lives. Therefore, plans and projects must be relevant to people's everyday lives and be rooted into local culture. The Forest of Belfast (Northern Ireland), for example, runs various projects which have a relevance to people through associations with local history and traditions, or which are linked to important events in people's lives. As described by Simon (2001) these include: a Family Tree Site where families can plan a tree to mark a special family event; a project which provides Irish yew – a tree closely associated with Irish church grounds – to churches of all denominations in and around the city; and an initiative which every year adopts a particular landmark tree and celebrates its history and associated folklore.

In order to gain and maintain the continuing interest and active involvement of communities, urban foresters are increasingly widening the issues beyond the horizon of technical considerations, as well as the ways in which they communicate with the wider public. While many information techniques become more specialist in nature, their underlining objective is to facilitate socially inclusive planning processes (Wallenius 2001). Various studies are experimenting with visual forms of information in participation, as it is perceived as a common language to which all kinds of participants, including those technically and non-technically educated, can relate. For example, visualization can be used to present and discuss different management alternatives in a readily understandable format (Karjalainen and Tyrväinen 2002).

Fig. 8.4.
Young people interview older visitors of the Ayazmo Park (Stara Zagora, Bulgaria). Involving the citizens in collecting their memories about the Ayazmo Park may raise the importance of community stories and connect the management of the urban forest to people's everyday lives (*photo:* A. Van Herzele)

Other studies suggest that heritage narratives and daily life stories form an important framework against which lay people interpret proposed plans. For example, a method of story telling was applied in the city of Stara Zagora (Bulgaria), where citizens have built up a strong connection with their urban forest, the Ayazmo Park, over the course of a century (Fig. 8.4). In the framework of a visioning process concerning the management, local people were involved in compiling a 'Story Calender' (Van Herzele et al. 2004).

In cases where the urban woodland, park or trees still need to be planned or established, connections are still to be developed. Arts can play a vital role in the creation of a new cultural and spiritual relationship between people and place. For example, Great North Forest, United Kingdom are partners in a community arts program that provides artists to work with local groups to produce seats, gates, waymarkers and other artifacts associated with rights-of-way and access paths across the new wooded landscape (Great North Forest 1998). Such projects have proven to be useful in capturing the imagination of residents and in encouraging greater levels of public involvement.

People's motivations to become involved are not just a matter of caring about forests and trees. For example, in the case of a drop-in event for the local residents concerning a new urban forest in Lokeren (Belgium), interviews with participants revealed that they are willing to take part in planting and maintaining the forest, regardless of their opinion about the desirability of this new forest. For example, there were strong opponents who proposed to help in the planting, and tree enthusiasts who had no interest in actual collaboration. Most of the interviewees associated their enthusiasm for a previous participatory event and their ideas concerning future volunteering with experiences of socializing, meeting people of their street, hearing their opinions, jointly working and celebrating. Similar findings were reported in the case of Slättäng Park in Lomma, a residential suburb in southern Sweden (Beer et al. 2003). The park has been developed and is currently maintained mainly through the efforts of seven elderly men, the so-called Friends of the Slättäng Park Society. Together they discovered various forms of satisfaction in their working together. Some of these are associated with working on one's own garden, a physical activity and a way of enjoying nature. However, there are also other factors involved, such as being together with friends and making a useful contribution.

Other examples link practical environment action involving the urban forest resource with issues relating to health and general well-being. For example, the 'Green Gym' initiative by BTCV (England) (see Chap. 7) relates to an improved quality of life for the whole community. In addition, products from the woodland can build connections. Local people across Greenwood Community Forest (England) are producing and selling charcoal and fences from local timber, and any profits made are ploughed back into the development of local facilities (King 1999).

Understanding the issues that connect people to urban forests are important when organizing participatory approaches. However, people also want to see the short and long-term benefits of their involvement and how their efforts will make a difference. In many cases, participatory methods continue to be used for the scoping of issues (i.e. seeking facts, defining values and problems) rather than to organize perspectives and ideas toward integration in decision-making and coordination of action on the ground. Various methods (e.g., Planning for Real) and visualization tools have proven to be helpful in visualizing what people mean, and have supported the structuring and implementation of ideas. On the other hand, there is a danger that the outcome becomes the focus of attention, taking it out of the social context from which it arose. As interactions and settings may shape the outcomes of participatory activities, professionals need to observe carefully how concepts and ideas are articulated, argued and mediated. In this perspective, an independent facilitator in charge of the process can play a crucial role. For example, in the case of the visioning process concerning the development of a railway yard into a city park in Antwerp (Belgium), the moderator of the discussions and the design of the minutes have played a bridging role between the lay discussions and the planning work of the professionals (Van Herzele in press).

8.10 Conclusions

Public participation in the area of urban forestry covers a wide range of situations, all of which represent various permutations arising from the physical diversity of the urban forest resource itself, the wide range of social groups and individuals representing the entire spectrum of motivations, needs and preferences, and the administrative and resource framework within which the process is being pursued. One aim of this chapter is to demonstrate that each situation will merit its own particular approach in terms of how best to realize the process of public participation. A real danger exists whereby pre-packaged approaches are applied which have little or no relevance to the situation in hand, and which effectively eliminate the vast range of relevant knowledge and information which can be gathered by simply observing the social dynamics driving the evolution of a local process. However, this does not mean re-inventing the wheel every time a new initiative is started. Instead, it means that previous experiences are learnt from and that basic fundamental principles, as represented in the seven key questions described in this chapter, are applied.

Public participation is driven by the common-sense realization that the urban forest can only be planned and managed effectively with the direct involvement of its eventual end-user – the urban dweller. The public represents a mine of local knowledge and expertise, and are now demanding a stronger voice in how their surroundings are shaped. Professionals should recognise this, and should regard the public as equal and capable partners with a wealth of creativity and enthusiasm to bring to the process. Perhaps professionals should now repackage themselves, not as technical experts seeking public endorsement for completed plans, but as facilitators intent on assisting communities to translate their needs and preferences regarding the urban forest into action on the ground.

In many situations, a greater emphasis is placed on the *forestry* side of the community forestry equation, with public participation pursued primarily to reach consensus with the community on how best to achieve a more successful urban forest, be it in the form of a plan for a new urban woodland or the management of a potentially controversial street tree replacement program. However, as the needs of societies in an increasingly urbanized Europe become more apparent, perhaps the emphasis should now be firmly placed on the *community* side of the equation, whereby the socially empowering nature of public participation in shaping the surroundings and improving the environment is the most important product of the process. Such an emphasis places a major responsibility on those professionals involved in the urban forest, expanding their role from simple resource management to the complex world of social inclusion and interaction. This necessitates the much-needed acquisition of new skills in communication and social science in order to communicate with diverse interest groups and to gather accurate and understandable information in a cost-effective way, and also a far greater allocation of resources to the planning process than is currently the case.

Such changes can only be brought about by convincing decision-makers and political masters to accept the vital importance of full and meaningful public participation. Perhaps it is the responsibility of all those professions involved in the urban forest to champion this cause, as it is essential not only in the shaping of a better urban forest, but also in assisting urban dwellers in the shaping of a better community.

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Part III Plant Selection and Establishment of Urban Forests and Trees

Chapter 9

Plant Quality and Establishment

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9.1 Introduction

In this chapter the importance of plant quality for establishing trees within the urban forest is highlighted. The chapter discusses current nursery production of trees and shrubs with the accent on plants grown for use in urban environments. Nursery practices, such as nutrition, growing plants in containers, early pruning and the use of mycorrhiza are briefly treated, as are the consequences of pests and diseases on nursery stock.

Plant production is the first link in establishing a healthy urban forest and its importance is obvious. All too often planting projects have failed through using poor quality plants. Failures can also be due to planting the wrong species or variety of plants on the site or failing to ameliorate the site to suit the trees; these problems are discussed in other chapters. The growing conditions, which the trees must face in the urban environment, are outlined, in order to emphasize the considerable differences compared to rural sites (Clark and Kjelgren 1989).

Climatic conditions across Europe are extremely diverse, varying from warm temperate to sub-arctic; hence the related priorities within the climatic regions of Europe must be kept in mind. As an example, the warmer microclimate of the built up areas within the cities can be advantageous in the far north of Europe (Iceland and northern Scandinavia), enabling the cultivation of less winter-hardy species and the choice of a wider range of exotic species and phenotypes than would normally be expected for those climates (Bengtsson 1998). Conversely the improved microclimate can also cause early flushing or prolong the growing season, rendering the trees susceptible to late spring or early autumn frosts. In Southern Europe the higher temperatures and the reduced water-availability in paved areas can lead to drought conditions and may even curtail the species choice. The fact that the urban environment is a series of heterogeneous microclimates must also be taken into consideration. Therefore, successful planting is dependent on many factors. It is not only necessary to use the right type of plant of the highest quality, but it is essential to ensure the site is suitable for the tree. Proper site assessment should precede plant selection if urban tree plantings are to be successful. The match up of site limitations with tree adaptability is commonly called the 'right tree in the right place' (e.g., Bassuk 1990). Hence not only must plant quality be considered, but also the choice of species, their origins, cultivars and site amelioration. These factors are discussed in other chapters.

9.2 The Urban Environment

Urban forestry is by no means a uniform practice and conditions differ even within the confines of the municipality. Therefore it is convenient to divide the expected site of the trees into three categories (Sæbo et al. 2002):

- trees planted in pavements, alongside streets and thoroughfares, or within paved squares (plazas);
- trees growing in parks or gardens within the built up areas;
- trees growing in woodland on the periphery of, or in between built up areas within the city boundaries.

Environmental conditions within these three categories of sites differ considerably and indeed major differences can occur within the categories themselves. It is not intended to pursue these differences further as they are discussed fully in other chapters. It suffices to say that within paved areas the trees face their most rigorous conditions, both above ground and especially below ground. Above ground they are subjected to vandalism, pollution, collisions with vehicles, buffeting winds funneled by surrounding buildings, shade and even excess heat radiated from their surroundings. Below ground they must often tolerate poor, infertile soils (often made up of rubble), compaction, limited soil volumes, drought and poisonous effluents due to de-icing salts, other chemicals and oils, and they are in constant danger of being damaged through installation of below-ground utilities or by maintenance work. In these situations the selected trees should have the genetic ability to fit the planting site and, at the same time the planting site should fit the trees or be modifiable to accommodate the tree favorably (Ware 1994).

In parks and especially in the peripheral urban woodland, these extreme edaphic conditions are usually absent or less prevalent, whereas vandalism can still be an important problem (Bradshaw et al. 1995). However, in old industrial cities woodland and parks are often established on industrial wasteland, and trees planted there will often face severe soil and air pollution.

It is important to remember that trees are long-lived beings, living from a few decades to many hundred years, depending on species. During their lifetime trees will experience great changes in their environment, both climatic and social, and these changes occur continuously.

9.3 Plant Quality and Nursery Production

Producing planting stock of the highest quality for the least cost is the main objective of plant nurseries. Plants must be grown at a price, which is attractive to the buyer, yet will yield the grower a profit. It is the aim of all commercial nursery-owners to make a profit and even state or municipal-owned nurseries strive to keep the costs to comparable levels with private concerns, even if they are not compelled to show profits. However, nurseries must sell their product, and they too often sacrifice plant quality for superficial looks. Stock is too often forced to reach a saleable size in the shortest possible time, and while it may be large, it is not necessarily hardy or physiologically ready for planting.

Again there is considerable variation in nursery practice throughout Europe, where practices have developed in response to the differing climatic and social conditions. However, urban trees are usually highly valued and greater costs of production and establishment are acceptable where the visual and other amenity values of the trees are great, such as within parks, plazas or along streets.

What Is Plant Quality?

'Tree establishment doesn't begin at the planting site. It begins at the nursery by picking appropriate nursery stock' (Gilman 1993). Production practices can cause problems years or even decades after the plant has been growing in the landscape. This is illustrated by the problems caused by root girdling of trees cultivated within a too small or wrongly designed container or for too long in the container (see Whitcomb 1987).

It is imperative that the planting stock used in any project, whether for commercial forestry or amenity planting, is of the best possible quality, especially in view of the financial investments (Fig. 9.1 and 9.2). But how do we define quality? Obviously quality is very variable and difficult to define precisely, since it is dependent on many factors and features of the plant, the site and on the objectives of the planting. Harris et al. (2003) state that there is no perfect tree. Selection is a compromise among the proposed function of the plants, its adaptation to the site and the amount of care it will require. The relative importance of a particular characteristic will vary as a function of the specific site and management situation. Langerud (1991) proposed the adoption of Willen and Sutton's (1980) definition, i.e. '… The degree to which that stock realizes the objectives of management (to the end of the rotation or achievement of specific sought benefits) at minimum costs. Quality is fitness of purpose.' The author also proposed adopting the respective attributes of vigor = 'Soundness: freedom from diseases or ailments', vitality = 'the capacity for survival or for the continuation of meaningful or purposeful existence' and viability = 'the degree to which an organization is capable of life, growth and development' (Langerud 1991). These definitions were attributed to forest planting stock (seedlings or young transplants), but are also applicable to the larger types used in urban situations. In 1979, during a workshop of the International Union of Forest Research Organisations plant quality was defined as 'the degree of answer to the objectives for which it is employed where the main targets are plant survival and growth'. Basically, therefore, it may be argued that quality means that the plant is vigorous and healthy, free of insect pests and fungal diseases when leaving the nursery and capable of making rapid root and shoot growth immediately when conditions for growth occur on the new site.

Perhaps the greatest problem in defining quality is due to the variable nature of the plants themselves and the environment in which they must grow. Lindquist (2000) describes plant quality as being the sum of four different aspects: genetics, morphology, physiological quality and the health of the plant. In other words the plants must be of suitable origins, be healthy, vital and have the right morphological attributes. The two

Fig. 9.1a. *Liriodendron tuli-pifera* – Good quality standard for street tree (*photo:* F. Ferrini)

Fig. 9.1b. *Ginkgo biloba* – Good quality standard for street tree (*photo:* F. Ferrini)

attributes of genetic origin and health are dealt with elsewhere and only a brief description of morphological and physiological (i.e. vitality) attributes are possible here.

Morphological attributes are the physical characteristics of the planting stock, which can usually be quantified and compared experimentally (Puttonen 1997). Regarding morphological attributes excellent sources of specifications are provided by the American Standards for Nursery Stock, published by the American Association of Nurserymen (Anon 1997) and the European Technical and Quality Standard for Hardy Nursery Stock (Anon 1996). They provide guidelines for several morphological characteristics for many plant types. Height, root-collar diameter, shoot or root biomass and their ratios, root characteristics, foliage amount and colour are some of the characteristics used to quantify plant quality. Most of the characters can be measured without destructive sampling. However, they are more commonly applied to small plants such as seedlings or young saplings and not easily used when comparing large planting stock. In this case other characteristics should be evaluated. Some of these have considerable influence on plant survival and growth, while others, although desirable, may not greatly affect performance. For example, Harris et al. (2003), state that branching pattern and size determine the landscape effect of the tree, but they have little or no effect on the long-term growth. Variation in vigor, lateral branches on the trunk and height-to-di-

Fig. 9.2a. *Quercus ilex* – Poor quality standard (*photo:* F. Ferrini)

Fig. 9.2b. *Tilia* × *europaea* – Poor quality standard for street tree (*photo:* F. Ferrini)

Fig. 9.2c. *Acer saccharinum* – Very poor quality plants for a parking lot (*photo:* F. Ferrini)

ameter ratio will not influence the survival, but they can negatively affect the efforts necessary to obtain a satisfactory growth. On the other hand root and shoot quality can determine not only tree performance and aesthetics, but also survival.

Experiments have shown that there are often strong correlations between various morphological characteristics and survival and subsequent growth in the field (Ritchie 1984). As an example Scots pine seedlings selected on the basis of minimal size and root collar diameter had significantly higher survival (92% compared to 80%) and growth after planting (243 cm height after 8 years compared to 150 cm) than the culls, and they were more tolerant of root desiccation prior to planting (74% survival when roots were desiccated for larger seedlings as compared to 39% for culls) (Rikala 1989). Hence morphological attributes can be used as a criterion for quality. However, caution is advised since inconsistencies have been observed which can only be attributed to the internal status (i.e. vitality or physiological status) of the plants (Chavasse 1977).

Vitality (i.e. the physiological status) is more difficult to assess, but numerous methods have been evolved to evaluate the potential performance of the plants (e.g., Grossnickle et al. 1997; Mohammed 1997; McKay 1998). Many of the tests are destructive to the stock and must be used on a sampling basis. They often require sophisticated equipment, are time consuming to apply and cannot be performed by the nurseries themselves. Furthermore they are designed for small planting stock, bare-rooted seedlings and transplants, or even containerized seedlings. The most commonly used physiological assessment is root growth capacity (RGC) or root growth potential (RGP), which is the capacity of the roots to grow after the plant is moved into a warmer environment prior to out-planting. RGC has frequently been correlated with field performance as an indicator of establishment success (see Mattsson 1991 for references). As a matter of fact the ability to develop new roots is considered the key attribute of plant quality (Ritchie 1984). However, the correlation between RGC and field growth has not always been consistent. RGC has been shown to be affected by many factors, such as species, genotype within species, many cultural practises, state of dormancy and the test environment (Ritchie and Dunlap 1980; Simpson and Ritchie 1997).

Various other physiological assessment methods have been tried, which have been reviewed by Mattsson (1997). Foliar chlorophyll, fine-root electrolyte leakage (REL), root moisture content (RMC) and needle water potential (McKay and White 1997; McKay 1998) are some examples that have been shown to correlate with survival and growth of planting stock. However, they suffer the same drawbacks mentioned above in that the results have not always been consistent, and that the methods are often complicated and require sophisticated equipment.

9.4 Nurseries

Nurseries can be divided into several groups depending on their production technique. Frequently the nurseries follow a mixture of practices, although the large production types are generally very specialized for economic purposes. It is not intended to describe nursery production in detail, but only to mention the major types of production.

9.4.1 Open Nurseries

The simplest example is where sowing and transplanting is done on raised beds on open land (see Duryea and Landis 1984 for a review). This type requires more land than those nurseries, which practice more intensive cultivation, and the plants raised require more resources in terms of time and labor. However, the capital costs are lower than in more sophisticated nurseries. In colder climates seedlings will require far more time to reach sufficient size for transplanting for further cultivation in the nursery. In addition the plants are likely to suffer damage from winter cold and frost-lift, and they will be susceptible to animal depredation.

In some nurseries seeds are sown in cold frames under glass and then the seedlings are transplanted into open beds. The seedlings are regularly root-pruned and wrenched, and are left unmoved for two years or more. The frames enhance the microclimate and provide protection from animals and wind, but are labor intensive and do not provide controlled environmental conditions. In such nurseries plants produced from cuttings are also inserted directly into open soil, or through plastic sheeting, which is spread over the soil beforehand and used to conserve moisture, moderate soil temperature and suppress weeds. The plants are regularly root-pruned and wrenched to encourage a compact fibrous root system (Watson 1988).

This type of nursery is commonly used to produce forest-planting stock, where the plants are grown relatively young and small, and are taken directly out of the sowing beds, undercut or not, or grown as transplants for one or more seasons. They produce larger planting stock for gardens or urban sites, either as large transplants or in containers.

9.4.2 Covered Nurseries

The alternative to simple nurseries, as mentioned above, is provided by nurseries where at least the sowing of seed and striking of cuttings are performed in greenhouses (Fig. 9.3). These can vary in sophistication from a simple greenhouse with no heating, light control or automatic irrigation, to highly sophisticated greenhouses where all procedures are precisely controlled: lighting, temperature, irrigation, humidity, fertilization and the application of pesticides and fungicides. Greenhouses shelter the plants from adverse climate and animals (excluding insects) and provide higher and more congenial temperatures. In these nurseries stock grown to large sizes is usually cultivated outside in beds, as bare-rooted transplants or root-balled stock, or in containers. Irrigation facilities are provided to apply water, nutrients, fungicides and insecticides.

The houses are heated, or can be heated, especially during early spring and mid-autumn, when frost-risk is high or when the outside temperature is not sufficient to heat the houses to the desired degree. In this way planting stock can be obtained in a single season, although the ultimate size must be controlled so the root system does not become deformed in the pot. Root deformation has been the biggest problem for container stock, and considerable research has been put into designing containers, which do not deform the root system (Whitcomb 1987; Gilman 1993).

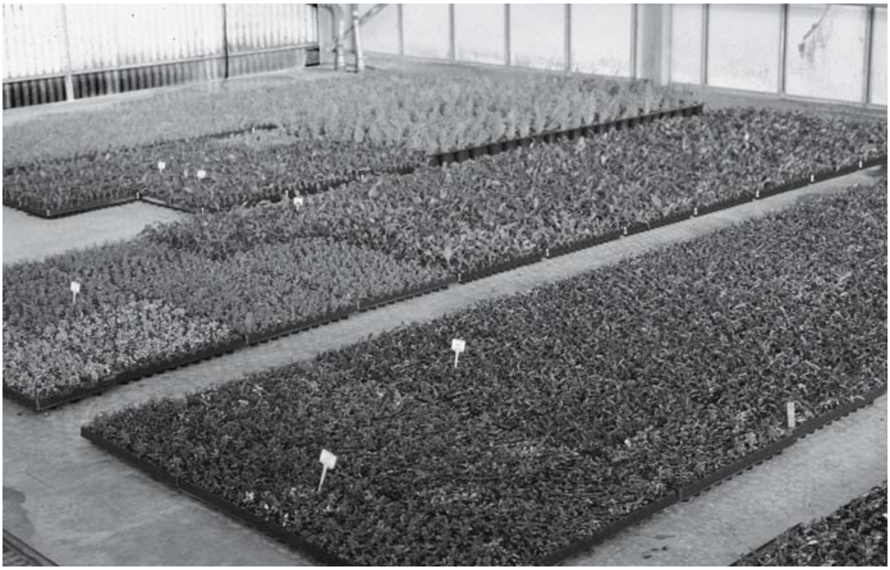

Fig. 9.3. Greenhouse for cutting propagation of different species (*photo:* F. Ferrini)

In cold-winter areas, where there is a danger of soil freezing for long periods, planting stock is often kept over winter in refrigerated storehouses so that its availability for spring planting can be synchronized with soil conditions. Frequently the stock is subjugated to a short-daylight regime during late summer (late July to early August) in order to encourage the plants to stop shoot growth and to induce greater frost hardiness (Sandvik 1980; Tremblay and Lalonde 1987; Bigras and D'Aoust 1993).

9.5 Plant Types

The choice of plant size is large and the decision, of which size and type to use, needs to be addressed. Furthermore, whether the plants should be bare-rooted, root-balled or container-grown is an important decision and has considerable effect on the cost of planting. The type of plant used is therefore just as dependent on finance as on site and species.

Basically planting stock is classified into various categories according to size and maturity. Some of the more commonly planted categories are described below.

9.5.1 Seedlings

These are trees taken directly from seedbeds, or from containers into which the seed was sown directly. They are bare-rooted, or if from containers, with a plug of soil. They are commonly used to establish forest plantations where the vegetation is not too vigorous or dense, such as on heaths and on cultivated land, where large numbers are planted simultaneously. In the northern part of the Nordic countries the seedlings are usually grown in containers and are commonly planted as one-year old plants, sometimes after two growing seasons' growth, where the containers have a larger root capacity. Special planting tools have been designed (planting staff) on which the head removes a plug of soil identical in shape and size to the root-plug. Commonly, the site is cultivated prior to planting by spaced ploughing, harrowing or rotor-cultivation or by screefing. This system enables the planting of large numbers quickly and lends itself to considerable mechanization. Over 2 000 plants per day per planter are commonly attained, where planting is done manually, and up to 12 000 plants per day when machine-planted. This large number results in economies of scale. The plug-plants share the advantages and disadvantages of larger container-grown plants.

Bare-rooted seedlings are probably only planted in warmer areas of Europe today, where soils do not generally freeze during the winter, or where there is a long dormant season for planting. The seedling itself is a source of variation with long-term consequences. Small seedlings are not used on street or park sites, where the visual impact of the planting is great.

9.5.2 Transplants

These are seedlings which have been cultivated in beds for one or more years and are usually in the size range of 0.2–0.6 m, with a root-collar diameter varying from 1.5–2.5 cm for the smaller plants to 5–10 cm for larger transplants. The actual dimensions depend on the specifications given by the relevant authority on plant standards (Aldous 1972).

Transplanting slows down height growth in the first season and results in sturdier plants with relatively thicker stems and more compact root systems. They are the preferred plant-types for afforestation in Northern Europe (e.g., in Britain, Denmark and Germany) and are of various ages and types depending on cultural methods (Fig. 9.4). It is usual to describe them in shorthand, e.g., as 1 + 1; 1 u 1; 1 + 2; etc. The first number indicates the time (in years) spent in the seedbed (or container tray) and the second number is the time spent in the transplant bed or, if u, the time the plants stand in the bed after undercutting and or wrenching (Rushforth 1987). If the trees are transplanted a second time, which is unusual but known to have occurred in Iceland when cultivating slow-growing species, such as Engelmann spruce (*Picea engelmannii* Engelm.) for afforestation, then the extra time spent in the transplant bed is added onto the first two figures and so on. For example 2 + 2 + 2 would indicate that the said transplant was 6 years old from sowing and transplanted twice.

Again small transplants are usually not planted in street locations, and are seldom used to establish trees in parks.

9.5.3 Whips

These are larger and older transplants, with a single whip-like shoot, about 1 m in height, whose side branches have been pruned to reduce the danger of drying-out and to hold down transport costs. They are preferred on heavily vegetated sites, being larger and more visible and therefore easier to keep weed free. Being larger, they give a maturer look than small transplants.

Fig. 9.4.
Traditional forest nursery in Central Italy (*photo:* F. Ferrini)

9.5.4
Feathered

These are trees varying from 1.5 to 2 m in height and whose side branches are still attached, hence the name. They look more natural than pruned trees and by having side branches are considered more likely to recover if damaged during planting or by vandalism.

9.5.5
Standard Trees

On these trees the lower branches are removed to leave a shorter length of clean stem. Their size is designated by the length of clear stem and its girth at 1 m above ground level. Hence a 'semi-standard' (or light standard) has a clean stem of 1.2–1.5 m and a girth of 6–8 cm (2–2.5 cm diameter) and is about 2.4 m tall. Ordinary 'standards' have a clean stem of up to 1.8 m and a girth of 8–10 cm (Fig. 9.5). Above this there are two other types of standards, categorized by their girth at 1 m, e.g., 'select' (10–12 cm) and 'extra-heavy' (girth up to 25 cm) (Rushforth 1987).

Fig. 9.5a,b. Field grown nursery, standard trees (*photos:* F. Ferrini)

Standards are used where an immediate height is wanted, such as along streets or on plazas. Hence, they are appropriate in urban situations where the higher cost of site preparation and of planting stock can be justified by their greater amenity and ornamental value.

9.5.6 Semi-Mature

These are larger trees, up to 12–20 m in height, which are planted for their immediate landscape effect (Fig. 9.6). Obviously they are very expensive to prepare and very costly to move and plant and are only justified where their immediate visual impact is considered essential. Experience has shown that such large trees can survive and thrive, but their success is dependent on many factors and the chance of failure is much higher than with smaller stock. When a tree reaches such large dimensions in the wild or in a plantation, more than 60% of the root system has grown beyond the crown diameter (Harris and Bassuk 1993). Hence most of the feeding roots will be left behind. It might be feasible to prepare the trees for moving by root pruning over a period of time beforehand, to concentrate the feeder roots in the proposed root-ball (Watson 1988). Large-scale mechanical equipment is needed to move a sufficiently large root-ball with the tree and various types of heavy machinery has been developed to move mature trees (Watson and Himelick 1997).

Fig. 9.6.
Semi-mature *Quercus robur* prepared for transplanting, using a method developed and trademarked by a nursery in Pistoia (Italy) (*photo:* F. Ferrini)

9.6
Bare-Rooted, Root-Balled or Container Plants?

9.6.1
Bare-Root Stock

The bare-root nursery has long been the backbone of the ornamental green industry (Hegwood 1995). A wide variety of trees, shrubs and herbaceous perennials are still harvested bare-rooted, especially in the United States, because of the high costs of shipping plants with soil and to obviate the loss of valuable topsoil from production fields (Englert et al. 1993). As the name implies this describes trees, which are taken up out of their beds and gently shaken free of soil from around their roots. Usually these are small plants, either seedlings or transplants, taken up during the dormant season or after shoot elongation has ceased. It is possible to plant fairly large bare-rooted trees, e.g., as whips, feathered or even small standards, but once this size is reached the trees are much more susceptible to drying out and are usually not moved during the growing season. As underlined by Buckstrup and Bassuk (1998 and 2000) few studies have reported the impact of bare-root production methods on transplanting success in the urban environment, and it is difficult to make general recommendations due to contrasting results obtained by different authors (Cool 1976). There is a great deal of variation between species in their tolerance of being planted as bare-root stock. Some, such as poplars and willows *(Populus* and *Salix* spp.), are capable of renewing their root system rapidly from dormant adventitious root initials. These types can be planted as large specimens if transplanting is performed during the dormant season and the trees are staked until well established. Others are extremely susceptible to root loss and are unable to recover, e.g., *Eucalyptus* spp.

Another source of variation can be the time of planting (fall or spring). The planting of bare-root stock is restricted to the dormant season – from bud formation in the fall through the winter until just before flushing in the spring, excluding freezing periods (which excludes winter planting in regions where the soil is frozen for long periods). Larger trees usually require staking until established.

9.6.2
Root-Ball Stock

This method, often referred to as balled-and-burlapped (B & B), is generally applied to 'standard trees', but can also be used on whips and semi-mature trees. Here the trees are taken up from the beds with a clump of soil attached to the roots (Fig. 9.7). The root-ball usually has some type of packing material, which includes bags, baskets, burlap

Fig. 9.7.
Ball and Burlapped (B & B) plants ready for shipping in the nursery center (*photo:* F. Ferrini)

Fig. 9.8. Typical packing system used in the Italian nurseries for shipping plants (*photo:* F. Ferrini)

or other fabrics, wrapped directly around the root-ball (Kuhns 1997). Several other new packing materials and systems are also available or are being developed (Appleton 1995). Often the burlapped root-balls are reinforced with rope or cord, nails, wire baskets, or other materials (Kuhns 1997; Fig. 9.8). When a B & B plant is moved, the majority of its root system may remain in the field, especially if trees are not adequately prepared for transplanting (Watson and Himelick 1982; Watson and Sydnor 1987; Gilman 1988; Watson 1988). The preparation of trees to be dug up with a soil ball includes pruning of the root system. If done correctly this result in more branched and denser root systems (Harris et al. 1971; Watson and Himelick 1997). Although decreased top growth may be a result, mainly due to a reduced water and nutrient content with subsequent lower photosynthetic activity, root pruning can have a negative effect since the plant will take longer to reach a marketable size (Watson 1988; Watson and Himelick 1997).

Even so it is usual to avoid moving root-balled trees whilst they are putting out new shoots, as these can easily break or suffer drought. However, if the technique is carried out with proper care and good preparation of the plant beforehand, it allows trees to be moved even in leaf (Bradshaw et al. 1995). Due to its heavier root system, this type of plant is more costly to produce and handle, but is more likely to succeed and prolongs the planting season somewhat.

9.6.3 Containerized Stock

The growing of plants in containers is an ancient practice, but has been less used in forestry or urban tree planting than bare-rooted or root-balled stock (Fig. 9.9). In history, containers were expensive and heavy compared to their size, as they had to be

Fig. 9.9. Container grown nursery (*photo:* F. Ferrini)

made from rigid material, usually clay, or wood, which had the disadvantage of a shorter life, or metal. With the advent of manufactured plastics, much cheaper, lighter and equally long-lasting containers could be made. The wide spread of containerized plants was pioneered in California after World War II, when an enormous demand for ornamental trees arose in the post-war building boom. The building boom spread to other parts of the USA, and to Europe by the 1960s, where the use of containerized plants developed later because of a long tradition for using bare-rooted and root-balled stock.

Although large containerized plants are even more prone to the many problems, which also plague small container plants, there has been a trend among nurserymen in Europe and USA in recent years to produce large plants in containers (Fig. 9.10). This is the most rapid growing segment within the nursery industry. The most important reason for this trend is the growing customer demand for 'instant landscape', which requires large plants that must sometimes be planted during the growing season (Tilt et al. 1995).

Consequently nurserymen have become increasingly aware of the advantages offered by container-grown stock, especially when planting during the growing season or on adverse sites. Nursery production techniques can influence plant performance and initial maintenance practices (Gilman 1993), but while many production methods have been recently developed (Appleton 1995; Ferrini et al. 2000; Landicho 2002), only a few comparisons have been made on post-transplant growth (Arnold 1993; Gilman and Beeson 1996; Ferrini and Nicese 2001). Moreover, the results are often contradictory because of varied protocols and their interactions with the physiological condition of the tree at the time of transplanting and the varied climatic, microclimatic and soil characteristics, and post-transplant care, which are seldom consistent among experiments.

Fig. 9.10. Large plant production in container (*photo:* F. Ferrini)

Some authors report that container-grown plants frequently establish poorly when moved to the landscape (Costello and Paul 1975; Gilman 1993), while others found no differences in establishment among different production methods, including balled and burlapped and plastic containers. Gilman (1993) states that trees from a variety of production systems perform almost equally well if regularly irrigated. Watson and Himelick (1998) consider that water stress after planting is the most limiting factor for plant growth and is probably the major cause of planting failure.

Today containerized stock is commonly used in Europe, especially in the southern regions where rainfall is less and irrigation must be practised, and where the root system is under greater stress at planting. Containerized plants have various advantages over other types:

1. The trees can be planted with all their root system, a great deal of which is left in the soil when bare-rooted or root-balled stock is moved.
2. Containerized stock is better suited to temperamental species such as *Liriodendron tulipifera* (Rushforth 1987) and *Eucalyptus* spp., which are notoriously difficult to transplant.
3. The planting season is considerably extended as the trees can be planted any time during the growing season, although it is not recommended to plant containerized stock whilst the shoots are actively elongating and easily damaged mechanically and by drought. Also it is imperative to water the trees after planting, especially during drought.

Apart from the above points container plants have several marketing advantages as they can be displayed ready for sale when in full bloom and therefore are more attractive to the buyer, and furthermore, they can provide instant greenness when planted on new, bare sites. However, they do have several disadvantages:

1. It is essential that they are watered and fertilized whilst in their containers as the soil volume is limited to the containers themselves. Hence much care is needed during cultivation to ensure they do not dry up or suffer from nutrient deficiency.
2. If the trees are grown too long in the same container their root system will become deformed. Once the roots reach the bottom of the container they will begin to grow in a circle and grow through the drainage holes into the soil below. In the latter case roots will be lost when moved. Root deformity will often result in instability and poor anchorage, resulting in socketing, basal bow and eventually the tree topples over (Håkansson and Lindström 1994). Some species, such as lodgepole pine, *Pinus contorta* Dougl., are extremely susceptible to root deformation during cultivation, especially in containers and even from transplant beds if they are left too long. Through the use of properly designed containers (Appleton 2002) and by using physical means such as air-root pruning and chemical coatings (copper and copper based products) the root system can be modified so it becomes more fibrous and avoid circular root growth (Burdett 1981).
3. Roots have been shown to be less tolerant of cold or heat than the aboveground parts. They have been damaged by exposure to low temperatures during the dormant season, temperatures, which do not damage fully hardened tops (Tinus 1982). Hence in cold climates the containers must be protected from extreme cold during winter.

Container plants can be more expensive and bulkier than other types. Furthermore the size of the container must be sufficient to hold a large enough root system to support the plant. Considerable advances have been made in the production of containerized stock. Various designs of containers that have been made to alleviate the problem of root deformation, i.e. root circling, and to promote branching of the roots (e.g., Whitcomb 1987; Appleton 1993).

9.7 Control of Pests and Diseases in Urban Tree Nurseries

9.7.1 Pests and Diseases in Urban Tree Nurseries

Pests and diseases are important factors affecting the production of woody plants in nurseries. The specific environmental conditions created in the nursery can enhance the development of pests and diseases. Their effects reduce plant quality by altering aesthetic value and health, loss of vigor, impaired growth, shoot or bud mortality, bark lesions, etc. The costs of production also increase due to the need to control pests and diseases or to remove dead or infected plants.

However, there is also another reason for preventing or controlling pests and diseases in the nursery, namely the possibility that infected, asymptomatic plants, seeds or plantlets, in which the pest or disease is in incubation or latent phase, can act as vectors of the pest or pathogen and disseminate them.

The most frequent symptoms observed in young, diseased plants growing in nurseries could be summarized as:

1. 'Damping-off' in seedbeds, where the seedlings wilt, topple over and die.
2. Dwarfing, girdling, galls, stunting, wilting, root rotting, yellowing defoliation, and loss of vigor and death.

Some common diseases in nurseries are: (*a*) fungal diseases, such as *Botrytis* blight or gray mould caused by *Botrytis cinerea*; powdery mildews; rusts; damping-off and cutting rot caused by soil-borne pathogens such as *Phythium* spp., *Phytophthora* spp., *Fusarium* spp., *Sclerotina* spp., *Sclerotium* spp., *Verticillium* wilt; *Fusarium* wilt; *Phytophthora* root rot and dieback; (*b*) bacterial diseases; e.g., crown gall caused by *Agrobacterium tumefaciens* and bacterial blight due to *Pseudomonas syringae*; (*c*) nematode diseases, mainly affecting roots; and (*d*) diseases caused by viruses and phytoplasmas.

Among the pests, aphids, mites, thrips, scale insects, suckers, white flies, caterpillars, larvae of numerous insects (weevils, leatherjackets, chafer grubs, cutworms, swift moths, wireworms), slugs and snails are important and frequent.

9.7.2
Control Management of Pests and Diseases in Urban Tree Nurseries

The management of pests and diseases in the nursery is most effective when all suitable and available control methods are integrated in a balanced way (Perrin and Sutherland 1994; Powell 2001). This is the aim of the Integrated Pest Management (IPM) or, preferably, Integrated Health Management. It is important to remember that every situation requires a detailed study of its specific characteristics (environmental conditions, pathogen, host species, physiological state of the host, social and economic aspects, etc.), which will determine the best, and probably different, solution in each case. As Powell (2001) rightly expressed,

> for different diseases of different crops in different situations, various practices take on primary or secondary importance.
>
> Attention to the entire group of applicable management practises, however, will always be needed for success (…) The most important step in controlling plant diseases is choosing the best method for a given situation. Control strategies for a particular disease of a certain host may not be the best strategies for another disease of the same or a different plant.

The IPM method is based on prevention, since it implies that it is crucial to avoid stress factors, because a stressed plant is more susceptible to pests and diseases (Powell 2001). According to this theory a correct pest/disease management strategy should allow these phases:

- Before the pest or disease appears: recognizing stress factors (scouting for diseases, trapping, etc.) and monitoring for pests and diseases, and environmental management: counterbalancing the effect of disturbance.
- When the pest or disease appears: pest/pathogen management, using methods of dealing with the pests/pathogens: (especially accurate diagnosis (it is necessary to be armed with a good knowledge of the pest/pathogen and its life cycle), knowledge of the host-parasite interaction, possible control methods and their efficacy, and evaluation of costs and practicality of these methods, and finally, the phase of implementation of the selected control methods.

According to Powell (2001), the basic methods of control in nurseries can be summarized with the following four categories:

- *Exclusion* is a term used when spreading of pests and pathogens is prevented. Several methods can be applied, e.g., using pathogen-free plants, cuttings and seed; using tolerant clones; sanitation (cleaning and disinfecting pots, benches, bins, tools, equipment, etc.); using a soil and potting medium that is free of pathogens or pests; checking the quality of irrigation water, controlling weeds by regulatory control (inspection, quarantine, passport/certificate for export/import requirements, etc.).
- *Protection* may be applied by application of pesticides (insecticides, fungicides, bactericides, nematicides), with an appropriate timing of application and combining chemical products or broad-spectrum chemicals. However, most pesticides are protectives (preventives) and have limited curative or eradicative activity. Also, cultural practices as soil drainage and dehumification may be advantageous.
- *Prevention* may be applied by the use of cultural practices (soil drainage, dehumification, proper irrigation, soil and crop aeration, avoiding root damage and mechanical injuries) and through management of the environment to prevent stress. Prevention may also be applied by biological control, which is much more successful with insect pests. Biological control programs are only successful with low levels of inocula and therefore must be implemented in conjunction with other disease management strategies in an integrated management program.
- *Eradication:* Usage of pesticides is rarely completely effective (it works mainly against ectoparasites and insects). In the case of well-established pathogens, special care must be taken, since the disease may be masked and can reappear at a later stage, when planted out (Gibbs 2001). Other methods of eradication can be the removal and destruction of infected plants or plant parts or crop rotation.

A healthy plant will have a greater chance of becoming a healthy mature tree and being able to offer all the benefits expected from an urban tree.

9.8 The Use of Mycorrhiza in Plant Nurseries

The main characteristic of mycorrhizae is that the fungi establish symbiotic colonization of the root cortex, becoming part of that structure. The benefits of such a symbiosis have been shown to be that the fungus develops a net of hyphae, which is extremely efficient in exploiting the soil around the tree roots, greatly enhancing the absorption of nutrients by the tree root system (Azcón-Aguilar and Bago 1994). Furthermore, mycorrhiza increase host resistance to drought, salinity and root pathogens, as well as improving water-uptake (Azcón-Aguilar and Barea 1996). Mycorrhizae display their capability for improving plant quality in several ways. Setva et al. (2000) describe one such way, showing that the quality of mulberry leaves (*Morus* spp.) as food for silkworms, was improved when the tree roots were infected with mycorrhiza.

One of the most interesting features of mycorrhizae is that they improve the adaptability of the trees to poor and degraded soils. This has been extensively studied in the case of agricultural soils (Brundrett et al. 1996). This feature is of especial importance for establishing trees along streets or in small urban gardens. In fact one of the main problems in urban tree planting is the need to plant in heavily degraded soils or for re-vegetating land without any natural soil cover. Frequently urban planters must work with a substrate that is completely lacking any mycorrhizal element or organic fraction. The obvious solution is to plant trees that have previously been inoculated with mycorrhiza. The benefits of such practises have been well documented in the field (e.g., Fahey 1992), taking into account the many problems that can arise (Grove and Malajczuk 1994).

Inoculation in the nursery provides many advantages, such as better growth and transplanting ability, and a significant increase in plant quality. Inoculation prior to planting is advantageous because spontaneous infection by mycorrhizae in the nursery seems to be difficult or sporadic, and if it does occur there is no guarantee that the mycorrhizal species or variety occurring is suitable for the tree in the field.

The most effective method of inoculating the plants in the nursery is with pure cultures of the mycorrhizal mycelium. The best method is also the most costly, as is often the case, and could involve considerable increase in establishment costs when inoculating large numbers of forest stock. However, there would be a relatively a negligible increase in the cost of individual plants, when raising large ornamental trees, which can be over a hundred times as expensive as forest planting stock.

For inoculation to be successful there are various criteria in the nursery that must be satisfied and controlled if necessary:

- *Temperature:* mycorrhizae live within a temperature range from 0 °C up to 38 °C. Hence temperature is not normally a limiting factor under European conditions.
- *Chemical composition of the soil:* only extreme soil acidity and salinity appear to be harmful to symbiotic fungi. These conditions would be avoided in the nursery, which is normally sited under the most amenable conditions possible.
- *Pesticides and fungicides:* There are many complex compounds used for such purposes and it is impossible to give any general recommendations. Each case must be examined individually.
- *Fertilizers:* in general a high level of nutrients, especially nitrogen and phosphorous, will hinder inoculation or even arrest it. Hence one must avoid over-fertilizing in the nursery and maintain a careful balance of nutrients so as not to hinder mycorrhizal infection.

As a general conclusion it can be stated that inoculation with mycorrhizae in the nursery is a powerful tool for establishing urban trees and shrubs, considering that urban soils are often hostile, and that it is essential to provide the trees with every possible benefit to ensure good survival.

9.9 Nutrition

Fertilization has been used as a tool for improving growth and yield of forest plantations since the early twentieth century. However, ornamental trees are not grown for timber production, but for their attractive features such as their shape, foliage, flowers, fruits, and, importantly so in southern climates, for shade during the summer, and for shelter in windy regions. Hence a problem such as chlorosis, which is often due to nitrogen deficiency and would not necessarily be a serious problem in normal forestry practise (Messenger 1984), would be problematic in an ornamental plantation.

There is still some debate among arborists concerning fertilization of ornamentals, revolving around if, what, when and how much fertilizer is appropriate (Miller 1998). At present, because of many contrasting results, there is no consensus on whether or not fertilizers should be applied to landscape trees. As a matter of fact some authors state that, for example, early spring and late fall are not the best time to fertilize trees through nitrogen application (Struve 2002); others recommend fertilizing then, despite low nitrogen uptake potential during those seasons (Rose 1999). Whitcomb (1979) found that application of fertilizers did not enhance post-transplant growth of several landscape trees. On the other hand several literature studies indicate that the application of inorganic manures aids plant establishment. In general the time of maximum nutrient uptake is from bud break until leaf color change in the fall (Smiley et al. 2002) and the variable results can be due to the different environmental conditions.

Results by Ferrini et al. (2003) show that, providing adequate water is supplied, the most important factor for the trees is fertilization, which, especially in the second and third years, was the determinant for greater photosynthesis, total chlorophyll and leaf area values when compared with the other treatments.

When considering urban forestry focus must be on those aspects wherein fertilization can affect the urban plantings positively:

- *Survival.* It is well known that well-nourished trees will have a greater chance of survival than those suffering nutritional deficiencies. This is of the greatest importance for ornamental plantings, which are normally very costly. For example a 10% loss at planting may be tolerated in traditional forestry, but would be totally unacceptable in street plantings.
- *Growth rate.* It is important that the plantings quickly present a mature aspect and realize large trees as soon as possible, bearing the characteristics of maturity, such as large crowns, casting heavy shade where appropriate, impressive branching, etc.
- *Beauty.* The beauty of any tree, as manifested by flowering, foliage, branching, etc. is enhanced when the tree is nutritionally well balanced.
- *Resistance to external factors.* A well-balanced nutrition improves resistance to external attacks, such as frosts (Rikala and Repo 1997).

9.10 Where and How to Fertilize

It must be taken into account that urban trees grow in a different environment than trees in nature, wherein the usual techniques of nutrition have been studied. The differences are greatest for street trees, but less so for trees in parks and even less in the peripheral woodland areas. In the built-up areas the original soil has usually been completely removed, prior to the construction work.

The soil structure in urban areas is strongly modified by compaction, which is discussed more fully in Chap. 11. One of the consequences of compaction is that bulk density increases to a high level, and that will determine soil aeration and the depth of rooting. Moreover the volume of soil available for rooting is greatly reduced by the underground installations, such as sewers, water and gas pipes, electrical cables, tunnels, and so forth. In the paved areas the free surface around the tree is small, usually less than 1 m^2, reducing drastically the amount of water reaching the roots. Tolerance of some of the physical characteristics of the urban soil can be an essential factor to the survival of the tree (Clark and Kjelgren 1989).

As mentioned above natural soils are usually lacking on urban sites, and the organic component is frequently absent. Leaves and branches are removed as soon as they fall to the ground on the streets and in the parks. This practice breaks the normal nutrient cycle. Microflora and microfauna are almost non-existent, rendering the full breakdown of the existing, meagre supply of organic material impossible.

In winter-cold regions, sodium ions, arising from de-icing salts, accumulate to high levels around the roots. Furthermore, urban soils may be affected strongly by various pollutants originating from the environment, such as chemicals, leakage from sewers, traffic spills, and the like.

Fertilizers are applied in various ways:

- *By direct application to the soil surface.* This is a rapid and inexpensive method, but it is not recommended for paved surfaces.
- *Trunk injection.* The fertilizer is injected directly into the sap flow in liquid form. This requires skilled labor as the dosage needs to be carefully calculated and the conductive tissues must be located precisely. The method has been criticized by some authors as opening the way to pathogens and pests.
- *Foliar sprays.* These are considered to be less effective than other methods and only applicable in parks, where the resultant spillage from the foliage falls onto vegetation and not onto people or their property. They do, usually, result in a fast response.
- *Soil drill-holes.* This method is recommended for street trees. The holes are drilled at 50 cm intervals around the tree trunk and should be at least 50 cm from the trunk.
- *Trickle-irrigation.* This is considered the most efficient, reliable and effective way of watering and fertilizing urban trees, especially in southern regions, and enables precise and continuous dosages to be applied to the root zone.

It is impossible to recommend a single best method. Usually it is better to combine two or more methods depending on the site conditions and the species involved.

As a general rule, the period from late fall through winter is the ideal time to fertilize, so that the nutrients will be available at the right moment in late winter or early spring. However, in heavy rainfall areas or in winter-cold regions it is better to apply fertilizer during early spring or late summer, when root activity is greatest, so that it is not washed away before the tree roots can absorb it. This applies only for normal situations, where fertilizing is aimed at maintaining the trees in good condition. In some cases, however, a special and immediate fertilization may be required to rectify a glaring nutrient deficiency, for instance where symptoms indicating chlorosis or other stresses appear.

Before choosing the fertilizer one must know what is necessary and how much is required. There are three main methods for evaluating nutrient requirements, namely soil analysis, foliage analysis and visual observation. Although there is an extensive literature on the visual symptoms of deficiencies (e.g., Stone 1968; Kuhns 1987), the symptoms can cause confusion with other symptoms due to damages from air or soil pollution, acid rain and other causes. Therefore other authors (e.g., Kopinga and van den Berg 1995) recommend making both soil and foliage analyses.

There is little general agreement on the optimum amount of fertilizer to be applied to trees (e.g., Van de Werken 1984; Doughty 1988; Smith et al. 1992). In general annual applications of about 175 kg per hectare of elemental nitrogen, 150 kg ha^{-1} of phosphorous and 300 kg ha^{-1} of potassium, are recommended. Nevertheless much more research on the very specific requirements of the environment is needed.

A cheap, ecological and simple method of fertilizing trees is to add organic manures such as peat or humus around the trunk. One of its advantages is that it improves the soil structure (Harris et al. 2003) and releases its nutrients over a long period.

For urban trees, slow release compounds are of great interest (Harris et al. 2003). It would be very advantageous to use a system that provides nutrients over a long period of time. The greatest disadvantage of these fertilizers is their high cost (Lilly 1993).

In spite of some authors reporting on the detrimental effects of excessive nutrient dosage, the benefits of urban tree nutrition far outweigh the possible damages. In every instance it is essential to provide adequate watering. Even trees in the cold climates of Central and North Europe can suffer from drought, when grown in paved areas, and without adequate water fertilizing is useless.

As mentioned above the restrictive soil volume available to street trees is one of the main constraints to successful establishment. Therefore the provision of sufficient nutrition fertilizers can be of great help. Sword (1998) has shown that fertilization enhances root development, allowing trees to absorb greater amounts of water and nutrients. Finally it must be emphasized that the complex reactions between the atmosphere, the plant and the soil must be studied carefully before a decision is taken.

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Chapter 10

The Selection of Plant Materials for Street Trees, Park Trees and Urban Woodland

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10.1
Introduction

This chapter focuses on the plant materials being used in urban forestry. It intends to be an introduction to the choice of species and a guide to the identification of better plant materials for different urban situations. However, the chapter is not aiming at giving advanced guidelines for plant breeders, although some of the different methods of tree improvement are mentioned briefly. The methodology of tree improvement programs needs to reflect national and regional aims. The chapter also includes an overview of genotypic resistance to stresses, which trees need to withstand in urban situations. Those stresses are mainly dealt with elsewhere (Chap. 11). The status of tree selection is also illustrated by some European examples.

In Europe the recent focus has been on the relationship between the location in which trees are planted and the relative resulting stresses, which they experience. *Street trees* are exposed to a relatively high stress level and the average lifespan of the trees is short. The stresses include different polluting agents, mechanical damage, high and low ambient temperatures, de-icing salt, restricted space for crown development, small root volumes, low quality growing substrates and insufficient access to water and oxygen to roots (see also Chap. 11). Street trees may also be negatively affected by shading, local wind gusts and the impact from recreational users of green areas. *Park trees* are exposed to moderate stress and the average lifespan of trees increases. However, the trees are often exposed to pollutants and to stresses from people and animals. Finally, trees in *urban woodland* are subjected to relatively low stress levels and may reach a considerable lifespan. In urban woodland, the level of stress depends more on climatic growing conditions, long distance air pollution, soil conditions, recreational patterns with increased fire risk and biotic damages (Sæbø et al. 2003).

Today, urban forestry relies mainly on the selection and breeding efforts done in species of interest in conventional forestry. Plant materials, which have been selected for commercial forestry, can probably be used with some success in urban areas. However, for many of those species of interest to urban forestry, selection of improved trees, and related research, such as the mapping of the genetic structure of the species, has mostly not been carried out. Thus, there is a strong need to increase systematic work on selection and even breeding of trees and shrubs adapted to urban conditions, with the aim of finding genotypes that can easily be propagated, produced and established in urban green areas. This is especially the case if planners and practitioners are to succeed in increasing the range of species used in cities.

The choice of species and genotypes should be based on three main considerations:

- Adaptability to the environmental site conditions
- Functions of the tree
- Low cost of propagation, production, establishment and management

10.2 Need for Broadening the Range of Species and Genotypes

A pilot study in COST Action E12 (e.g., Pauleit et al. 2002) showed that, especially in northern European cities, a small range of tree genera and species, and even clones, are to be found (Table 10.1). Although planners in central and north-western European countries use a relatively broad range of species (see Table 10.2), only three to four genera predominate. These are in particular *Platanus*, *Aesculus*, *Acer* and *Tilia*. In southern Europe a broader range of trees is used, often with genera and species that can only be grown there. Even there, only a few genera and species dominate. One example is *Platanus* × *acerifolia*, despite the fact that this species is increasingly threatened by diseases and pests (Tello et al. 2000), and that extensive literature exists on trees for different uses (e.g., Krüssmann 1976–1978, 1983; Dirr 1990; Borzan 2001).

The list of plants in Table 10.1 shows that the range of species used increases towards the south of Europe. This is unsurprising, given the climatic conditions. However, a relatively restricted number of genera and species predominate in cities. This is particularly the case with street trees. In Spain, only five genera represent 56% of all the trees planted in paved areas (García-Martín and García-Valdecantos 2001), whilst many more species are planted in parks and gardens (López-Lillo and Sánchez de Lorenzo 1999). In Montpellier, the five most used trees account for 73% of the trees used. In conclusion, 70–80% of the trees planted in European cities represent a relatively small number of species. Planners of urban green areas should aim to expand the range. Planning, based on knowledge about the importance of genetic diversity and the species properties, will lead to both greater variation and better health of trees in urban areas. Given the range and diversity of trees which are capable of growing in cities, especially in south-east Europe (Duhme and Pauleit 2000), the potential for increasing the diversity of city trees is tremendous. Duhme and Pauleit (2000) pointed out that many of the species may have a potential for growing in a much wider geographical range than at present, since their geographic distribution is determined more by former glaciations than by present day climates. Table 10.2 shows that the number of trees that are used and thrive in and near the urban areas are large.

This list of plants (Table 10.2) does naturally not include all actual trees for urban green areas, and the listed species should also not be regarded as recommendation for trees for the urban areas. For example *Acacia dealbata* and *Ailanthus altissima* are considered to be invasive species some places, and the branches of *Eucalyptus viminalis* are not strong and may cause a danger to the public. These examples illustrate the need for careful evaluation of how and where to use the different species, also based on other criteria than the adaptation to the geographic region in question.

The use of clones may secure homogeneity in form, growth and stress resistance. They are therefore often used, especially for street and park trees. However, for example in Sweden, the amount of trees delivered with wrong identity of cultivars was estimated to be as much as 20–30% of the plantings (Bengtsson 1998). Such errors make it difficult to evaluate the trees under urban conditions. One reason for confusion is that the nurseries may not be able to separate cultivars from another. It is not easy to detect a mixture of cultivars, especially when the trees are young. However, the final result in urban plantations may be trees with different growth habits and of variable hardiness.

Table 10.1. The most common tree species used as street trees in northern, central and southern Europe. The list is based on a survey made in COST Action E12 *Urban forests and trees* (Survey coordinated by S. Pauleit)

Location	Much used trees	Used to some extent
Northern Europe	*Acer platanoides* *Acer pseudoplatanus* *Aesculus hippocastanum* *Betula pendula* *Betula pubescens* *Populus trichocarpa* *Sorbus* spp. *Tilia × vulgaris* 'Pallida'	*Acer* spp. *Crataegus* spp. *Malus* spp. *Platanus × acerifolia* *Prunus avium* *Prunus padus* *Quercus robur* *Quercus petraea* *Robinia pseudoacacia* *Tilia* spp. *Ulmus* spp.
Central Europe	*Acer campestre* *Acer pseudoplatanus* *Acer platanoides* *Aesculus × carnea* *Aesculus hippocastanum* *Platanus × acerifolia* *Quercus* spp. *Robinia pseudoacacia* *Tilia platyphyllos* *Tilia × vulgaris* *Tilia cordata* *Ulmus* spp.	*Alnus × spaethii* *Celtis australis* *Corylus colurna* *Crataegus* spp. *Gleditsia triacanthos* *Malus* spp. and cvs. *Prunus* spp. *Sophora japonica* *Sorbus* spp.
Southern Europe	*Acer* spp. *Brachychiton diversifolium* *Brachychiton acerifolium* *Ceratonia siliqua* *Celtis australis* *Gleditsia triacanthos* *Koelreuteria paniculata* *Melia azedarach* *Morus alba* var. *pendula* *Olea europaea* ***Phoenix canariensis***[a] ***Phoenix dactylifera*** *Pinus halepensis* *Platanus × acerifolia* *Populus alba* var. *nivea* *Populus nigra* 'Italica' *Populus canadensis* *Prunus cerasifera* var. *atropurpurea* *Robinia pseudoacacia* *Sophora japonica* *Tilia* spp. *Ulmus* spp. ***Washingtonia robusta*** ***Washingtonia filifera***	*Acacia cyanophylla* *Acacia decurrens* var. *dealbata* *Acer negundo* *Albizzia julibrissin* *Cedrus atlantica* *Cercis siliquastrum* *Citrus aurantium* *Cupressus arizonica* (*glauca*) *Cupressus sempervirens* *Laurus nobilis* *Pinus pinea* *Platanus orientalis* *Populus nigra* *Quercus ilex*

[a] Names in bold are palms.

Part III

Table 10.2. Trees for streets, parks and urban woodland in southern[3], central[2] and northern[1] Europe. The numbers are referring to which part of Europe the trees are growing successfully

Much used trees		Used to some extent	
2	*Abies alba*	1	*Abies alba*
3	*Abies cephalonica*	2	*Abies concolor*
2	*Abies nordmanniana*	1	*Abies nordmanniana*
1,2	*Acer campestre*	1	*Abies sibirica*
2	*Acer negundo*	1	*Abies veitchii*
1,2	*Acer platanoides*	3	*Acacia dealbata*
2	*Acer platanoides* 'Crimson King'	2,3	*Acer monspessulanum*
1,2	*Acer pseudoplatanus*	1	*Acer platanoides* 'Crimson King'
1,2	*Acer saccharinum*	1	*Aesculus × carnea*
2	*Aesculus × carnea*	2,3	*Ailanthus altissima*
1,2	*Aesculus hippocastanum*	3	*Albizia julibrissin*
1,2	*Alnus glutinosa*	2,3	*Alnus cordata*
3	*Arbutus unedo*	1	*Alnus incana*
1,2	*Betula pendula*	1	*Betula pubescens*
2	*Betula pubescens*	2	*Buxus balearica*
3	*Buxus balearica*	1	*Carpinus betulus*
2	*Carpinus betulus*	2	*Cedrus atlantica*
2	*Catalpa bignonioides*	2	*Cedrus deodara*
3	*Cedrus atlantica*	2	*Cedrus libani*
3	*Cedrus deodara*	2	*Celtis australis*
3	*Cedrus libani*	3	*Celtis occidentalis*
3	*Celtis australis*	1	*Cercidiphyllum japonicum*
2	*Celtis occidentalis*	2	*Cercis siliquastrum*
3	*Cercis siliquastrum*	1	*Chamaecyparis lawsoniana*
2	*Chamaecyparis lawsoniana*	2	*Cornus mas*
3	*Chamaerops humilis*	1,3	*Corylus colurna*
2	*Corylus colurna*	2,3	*Crataegus laevigata*
1,2	*Crataegus laevigata*	2,3	*Crataegus monogyna*
1,2	*Crataegus monogyna*	1	*Crataegus × media 'Paul's Scarlet'*
3	*Cupressus arizonica*	2,3	*× Cupressocyparis leylandii*
3	*Cupressus sempervirens*	2	*Diospyros virginiana*
1,2	*Fagus sylvatica*	3	*Eriobotrya japonica*
2	*Fagus sylvatica* 'Purpurea'	3	*Eucalyptus viminalis*
3	*Ficus carica*	2	*Gleditsia triacanthos* 'Inermis'
1,2	*Fraxinus excelsior*	1	*Ilex aquifolium*
2,3	*Fraxinus ornus*	3	*Jacaranda mimosifolia*
2,3	*Ginkgo biloba*	1	*Juglans manchurica*
2	*Ilex aquifolium*	2	*Juniperus virginiana*
3	*Juniperus oxycedrus*	2	*Koelreuteria paniculata*
3	*Laurus nobilis*	2	*Laburnum anagyroides*
3	*Ligustrum japonicum*	1	*Laburnum × watereri* 'Vossii'
3	*Magnolia grandiflora*	1	*Larix decidua*
2	*Magnolia × soulangiana*	1	*Larix sibirica*
1,2	*Malus* sp. cvs.	2	*Liquidambar styraciflua*
3	*Olea europaea*	2	*Liriodendron tulipifera*
2,3	*Ostrya carpinifolia*	3	*Melia azedarach*
1,2	*Picea abies*	2	*Mespilus germanica*
1	*Picea pungens* f. *glauca*	2,3	*Paulownia tomentosa*
1,2	*Picea omorika*	3	*Phoenix canariensis*
1	*Picea sitchensis*	2	*Picea sitchensis*

Table 10.2. *Continued*

Much used trees		**Used to some extent**	
3	*Pinus halepensis*	3	*Pinus brutia*
2,3	*Pinus nigra*	1	*Pinus cembra*
3	*Pinus pinaster*	2	*Pinus heldreichii*
3	*Pinus pinea*	1	*Pinus peuce*
1,2	*Pinus sylvestris*	2	*Pinus strobus*
3	*Pittosporum tobira*	3	*Poncirus trifoliata*
2,3	*Platanus × hispanica*	1	*Populus simonii*
1,2,3	*Populus nigra* 'Italica'	3	*Prunus dulcis*
1	*Populus simonii* 'Fastigiata'	3	*Prunus mahaleb*
1,2	*Populus trichocarpa*	1	*Prunus sargentii*
1,2	*Prunus avium*	2	*Prunus serotina*
1,2	*Prunus padus*	2	*Prunus serrulata*
1	*Prunus maackii*	2	*Pseudotsuga menziesii*
2,3	*Quercus cerris*	1	*Pterocarya fraxinifolia*
3	*Quercus ilex*	1	*Quercus palustris*
2	*Quercus petraea*	1	*Quercus rubra*
2	*Quercus pubescens*	1	*Robinia pseudoacacia*
1,2	*Quercus robur*	1,2	*Salix alba* cvs.
1,2	*Quercus robur* 'Fastigiata'	1,2	*Sambucus nigra*
2	*Quercus rubra*	2,3	*Sophora japonica*
2	*Robinia pseudoacacia*	2,3	*Sorbus aria*
1	*Salix alba* cvs.	1	*Sorbus decora*
2,3	*Sophora japonica*	2,3	*Sorbus domestica*
2,3	*Sorbus aria*	2	*Sorbus torminalis*
1,2	*Sorbus aucuparia*	2	*Taxodium distichum*
1	*Sorbus intermedia*	1	*Taxus baccata*
1	*Sorbus × thuringiaca* 'Fastigiata'	2	*Thuja plicata*
2,3	*Tamarix* sp.	1	*Tilia platyphyllos*
2	*Taxus baccata*	2	*Tilia tomentosa*
1,2,3	*Tilia cordata*	3	*Trachycarpus fortunei*
1,2	*Tilia × euchlora*	2	*Tsuga canadensis*
2	*Tilia platyphyllos*	2,3	*Ulmus × hollandica*
1,2	*Tilia × vulgaris* 'Pallida'		
3	*Trachycarpus fortunei*		

10.3 The Choice of Species and Selection of Genotypes

The successful use of plants in urban green areas depends on the selection of those that can function according to the design requirements, even under stressful environments. Thus, the selection and use of suitable tree species and better genotypes are important factors in a strategy to improve quality, decrease costs in establishment and management and to fulfill the expected functions of green areas. The effect of the choice of species in relation to design of plantings may contribute considerable to a city's distinct appearance.

A tree improvement program is a long-term project, with 30 years or more elapsing, before the results of investment are apparent. However, in urban areas, only limited efforts have been made to find improved genotypes, except for those species of interest to commercial forestry. Some of the selection criteria of 'traditional' and urban forestry are common, but urban circumstances place additional demands on trees and these also need to be taken into account. The main goal for breeding in commercial forestry is timber production. However, urban forestry breeding needs to balance many aims.

Results should not be expected too soon after the start of a tree improvement program. The benefit of the work should be measured in terms of improved establishment and functionality, lower costs of management and generally higher quality in urban green space.

10.4
Physiology and Genetic Variation in Stress Resistance and Tolerance

Over the last 30–40 years, the vitality of street trees has fallen drastically (Bradshaw et al. 1995). In 1989, the average life span of a newly planted street tree was estimated to be as little as 10–15 years (Moll 1989), and the high mortality rate after planting (Gilbertson and Bradshaw 1985) emphasizes the problems of urban trees. Knowledge of environmental physiology of trees in urban situations is therefore important in order to understand the responses of trees to different stresses and to find trees that can cope. Ecotypes represent the phenotypic response of plants to the habitat (Turesson 1922). Thus, the stress responses are keys to the selection criteria and to markers that can be used in tree improvement programs. Although much information can be found on environmental tree physiology (Kozlowski et al. 1991), the stress physiology of urban trees has until now been rather overlooked. Stressful natural environments may be a good starting point for finding plants adapted to a stressful urban environment (Ware 1994).

10.4.1
Abiotic Stresses

Climate

The hardiness of a tree is, largely, defined by the minimum winter temperature, but the summer and autumn temperatures are also important factors in determining the degree of hardiness during the following winter (Kozlowski et al. 1991). However, especially in the north, the (potential) absolute frost hardiness of a tree seems to be less important than the timing of growth cessation and hardening before the winter. Whereas in the warmer regions of Europe, the gradual decrease in temperature in the autumn is the main signal for growth cessation and hardening before the winter frost, the growth cessation of many trees in cold temperate regions is under photoperiod control (Heide 1974; Håbjørg 1978). This response is an indirect adaptation to the temperature conditions on the site of origin of the plants (see also Kozlowski et al. 1991). However, in street trees, bud break may be 10–15 days earlier, and senescence in the autumn 10–25 days earlier than in trees of parks of the same city (Supuka 1988). These responses are caused by a higher temperature in the city (on bud break) and probably by the combined effect by high temperature and water stress (on leaf senescence). The effects of global climate change are difficult to evaluate, but phenological responses in tree collections in Europe indicate that the growing season has been extended by almost two weeks during the last 30 years (Menzel and Fabian 1999). Such changes should be a signal for tree breeders to maintain a large genetic diversity within their breeding populations, so that breeding aims can easily be adapted.

In *Pinus ponderosa* there was a significant correlation between growth increment and the duration of active growth (Rehfeldt 1992). Thus, the selection for increase in growth also led to the selection of plants that had a later growth cessation. In this way, selection for one trait may influence other desired properties in a negative way (Rehfeldt 1992).

Water Stress

Resistance or tolerance of water stress is mainly mediated through the functioning of the stomatal aperture of the trees (water use efficiency). However, efficient root systems may also be important. Li (1998) showed that there is a genetic variation to be found in drought adaptation in *Eucalyptus microthera*. Since trees in general show a large level of heterozygosity, the selection of drought tolerant clones may be the best strategy for urban forestry. In any case, the selection for tolerance of drought should be focused on, rather than avoidance, since the shedding of leaves is aesthetically highly undesirably in urban forestry. The ability of the trees to adjust the osmotic potential (Patakas and Noitsakis 1999) may be a useful method to find drought tolerant trees. Also, the responses in survival and phenology of trees in dry years may show which trees that are useful as mother trees. However, this needs to be tested.

Light

In cities, trees planted between tall buildings may suffer from low light levels for part of the day or the year. Lack of light is a severe stress factor, especially at relatively high temperatures and high transpiration rates. Choice of species with a low photosynthetic compensation point (shade plants) may be important, especially under extreme shade conditions. In urban situations, artificial light can disturb the hardening and frost resistance of trees, due to the prolonged light regimes. In shaded areas, an eastern exposure of the trees may be an advantage, since much of the net photosynthesis occurs before noon. Breeding for tolerance of low light levels should, however, not have high priority.

Soil Conditions

Although tree species are more or less adapted to different soil conditions, the variation in soil properties of urban areas is probably much larger than what can be accounted for through a tree improvement program. The soil should therefore be amended and treated to supply roots with oxygen, to avoid water stress, nutrient deficiency and soil compaction. Selection of clones, which exhibit tolerance of even high levels of toxicity, could be important when dealing with contaminated soil substrates.

Street Architecture

Within all species, the variation in growth rates and growth habit varies tremendously. This gives the tree breeder opportunities to select trees for almost all situations. For narrow pavements, small trees or trees with narrow crowns should be chosen. Selection of genotypes with narrow crowns may also allow the use of tall growing species in relatively narrow streets. Clones of diverse growth forms are already available for most of the species of city trees, but the continuously seeking for specific growth habits in trees should always have a high priority. Different clones, with close to identical habit, may strengthen the diversity in hardiness and tolerance of stresses.

De-Icing Salt

Plants survive salt, as they do many other stresses, either through tolerance or avoidance. The avoidance of uptake of Na^+ and Cl^- from the roots and the prevention of the ions from reaching the leaves (Allen et al. 1994) is an important mechanism in woody species. However, much of the damage in trees from de-icing salt could probably be avoided by measures taken at the time of the plants' establishment and the time of salt spraying. Differences between genotypes in salt tolerance have been found in several species (see Allen et al. 1994; Fostad and Pedersen 2000). Planted and naturally occurring trees in coastal regions, which are continuously exposed to salt spray and high wind speed, may offer unexplored genetic resources of use to urban forestry. However, although there is potential for successful development of salt tolerant forest trees, little progress has been made (Allen et al. 1994). The most salt and drought tolerant plants may be found in dry and alkaline soils, as a specific ecological adaptation in the trees (Supuka 1992; Supuka 1994). In The USA (Chicago), observations of damages from salt have produced some useful generalizations. Fine-twigged species such as willows and birches seem to suffer twig die-back owing to salt spray (George Ware, personal communication). Coarse-branching species suffer much less. Qualities that seem to lessen salt damages are buried buds, resinous buds and many layers of terminal bud scales. However, densely packed buds of oak do not inhibit the damage from road salt, if the trees are too close to the traffic.

Air Pollution

Differences in susceptibility to polluting gasses have been found, but breeding for a greater tolerance of air polluting agents is not the best way of dealing with this problem. Emissions from industry and vehicles are already being reduced. It may be preferable to focus on choosing tolerant species for the relatively few problematic sites. However, plants may adapt relatively quickly to soil and air pollution (Barnes et al. 1999), even if resistance seems to depend on multi-gene action. The mechanisms of resistance are often unknown, but for air pollution the anti-oxidants seems to be important.

Security Problems

As trees grow larger they can become a cause of concern with regard to public safety in streets and parks. The response is frequently to carry out heavy pruning, trigger-ing a fast and irreversible decline. The need to deal with mature trees in this way may be an indication that an inappropriate species was selected for the circumstances, although the rate of decline may also be attributed to poor quality of management and environmental disturbances, especially soil compaction. Although it is not easy to predict conditions 50 or 100 years into the future, great care needs to be taken by the planner, and trees with favorable crown characters must be used and selected for. The description of the development of trees is therefore important, and the selections must be tested for a long time, until the habit of the mature tree is established.

Wild Fires

The choice of tree species for Mediterranean urban woodland has to take into consideration the flammability of the ecosystem, based on the dominant tree species. In this context, deciduous broad-leaved species are preferable in pure or mixed stands, because they decrease the development of flammable shrubs in the under story. Also, trees with thick bark and tall crowns are more likely to survive after surface fires. Nevertheless, modern Mediterranean forestry is more concerned with the concept of 'type of vegetation', rather than species alone. This means that silviculture (management) is considered to be of major importance (Dimitrakopoulos in press).

10.4.2 Biotic Stresses

The worst example of a serious tree-killing pest is probably Dutch elm disease (DED) (*Ceratocystis ulmi*, see also Chap. 12). As a result of the disease, the urban elm trees of many parts of Europe are now replaced by other species. Another very actual example is canker on *Platanus* × *acerifolia*. The lesson should be to use a broad range of species and genotypes, so that damages can be limited, even if one species should disappear from the cities. There may be interactions between biotic and abiotic factors affecting plants. Those plants, which are not well adapted to the climate, are often susceptible to disease. Also, certain combinations of species or genera are not recommended because diseases or pests may alternate between them. However, if plants of local provenance are selected and the trees are given optimal growing conditions, there is a greater likelihood of sustained success.

Resistance against Pests and Diseases

Traditional plant breeding relies on crossing to combine resistance genes. This method is most often focused on single gene resistance, usually easily overcome by adaptations in the pest or pathogen genomes. Breeding for multi-gene resistance or tolerance, which usually is only a partial resistance or tolerance, is a rather slow process, especially in species with a long juvenile phase. However, introduction of multi-gene resistance provides a long-lasting resistance in plants, compared to single gene resistance. Multi-gene resistance implies at least two independently acting resistance processes in the plants. For example, in insect resistance, this may be based on genes encoding two or more toxins with different modes of action (Jouanin et al. 1997). In many species, resistant clones can be found after hybridization (e.g., in *Ulmus* for DED and in *Platanus* for anthracnose). On the other side, the predominant use of a restricted number of clones can increase the pest and disease problems.

The use of genetic modification of trees may present new opportunities, although the methodology is still at an early stage. There is also public suspicion of genetic modification, which may affect its use in urban trees. Careful evaluation of its consequences is required. National legislation restricts the use of genetically altered genotypes in most countries. This is unlikely to change unless published data shows objectively that the technology and its products are harmless to the environment.

For the time being, we suggest that problems with pests and diseases should be dealt with by using the (low tech) methodologies already at hand. Firstly, plants that are hosts for serious diseases or pests should not be used in urban areas. Secondly, many selections of trees are sufficiently tolerant of or resistant to pests and diseases if they are used within a region where they are properly adapted to the environment. Thirdly, plants should be given optimal growing conditions through good establishment practices and management programs. If those precautions are taken, the trees are likely to be healthy most of the time. It should be stressed that problems with pests and diseases are increased if clones are over-used. More variation in clones, species and even genera should be recommended.

10.5 The Genetic Resources in Trees – Selection of Trees for the Urban Environment

Trees have a genetic potential for adaptations to many stresses, also to those found in a harsh city environment. However, some times are the stresses beyond what is realistic to breed or select for (for example soil compaction), or the problem should ideally be dealt with through other measures than selection (for example pollution). The message is that priorities must be made, in order to make the best use of funding. In the following section, some of the genetic background for selection and breeding is mentioned.

10.5.1 Phenotypic Plasticity

Phenotypic plasticity of a tree describes the phenotypic amplitude of an individual plant studied in two or more environments (Eriksson 1996), and is considered to be under genetic control (Eriksson 1998). Barnes et al. (1999) define plasticity as the degree to which a given genotype can be modified by environmental conditions. A large phenotypic plasticity has substantial adaptive value, particularly for trees, because they are rooted in their environment and have long life spans. A good example of adaptive plasticity is the root system of individual trees of many species in different soil conditions. Species such as pines and oaks, adapted to sites characterized by summer droughts, may possess deep-penetrating taproots. Long-lived and wind pollinated plant species are generally presumed to have a large phenotypic plasticity. This makes genotypes of many trees useful over quite large areas, in spite of differences in growing conditions.

The potential distribution area of a species cannot be deduced from the present distribution area. Human activities have greatly restricted the available range of plant material. This, combined with selected harvesting of the best genotypes for timber use, etc. may result in only low quality plant materials to be left behind and thus decrease their value as seed source. In such cases, there may be great need for a systematic tree improvement program, to select what is left of favorable phenotypes. Small numbers of trees may also be relicts of a larger population. Such small relicts may have a genetic constitution quite different from that of the original, larger population. However, populations on the fringe of their distribution may have a high adaptability to harsh conditions, but this must be tested for each population.

10.5.2 Genetic Variation in and among Populations

The prerequisite for all selection is genetic variation. The genetic structure of a population describes the variation in properties in the collection of plants studied. Both the genetic structures and the mating systems of the trees are important for the design of the selection programs (Zobel and Talbert 1991). Pioneer species (e.g., in *Alnus*, *Betula*, *Salix*) are genetically rather uniform within the populations. To capture the genetic variation in such species, only a small number of individual plants need be collected from each population but a large number of populations should be explored (Eriksson 1996). In a climax species like *Fagus sylvatica* however, the differentiation among populations may be smaller, and therefore a larger number of genetic entries from each population should be included in the basic population from which selection is made. In small insect-pollinated populations, the risk of losing additive variation may be large, and random genetic drift may coincidentally influence what genes are present or lacking in the population. Large, wind pollinated populations will ensure the preservation of large variation, without the differentiation of sub-populations. To capture alleles of different types, the sampling should cover several populations over a range of environments. At least 20 sub-populations and 50 individuals from each population are needed to capture genes that occur with a frequency above 0.01 (Namkoong et al. 1988). Genetic variation is often particularly large in species with a large distribution area. The development of differentiation within populations depends on a heterogeneous environment, with a limited or no exchange of genetic material between the differentiating populations (Eriksson 1998). Large variation within stands, combined with little variation among populations, has been observed in several tree species. However, in other studies, differences between populations have been found in many of the same species. In some species great care needs to be taken in the collection of mother plants for a breeding or selection program. For example in *Populus tremula* and *Prunus avium*, whole stands may consist of the same genotype (clone) after propagation through root suckers.

10.6 Selection Criteria and Selection Strategies

The desirable characteristics of trees must be clearly identified before effective selection can take place. The previous sections have shown that the physiological responses of trees to stresses may be the key to selection criteria related to stresses in the urban environment. The selection criteria must also be based on beneficial properties, taking into account possible negative aspects for people (e.g. fruit, litter and allergy).

10.6.1 The Choice of Species

Functions of trees in the urban environment depend on the trees being healthy and vigorous. Thus, the choice of species and selection of genotypes are important for a good result. Some species tend to be over-used (Chacalo et al. 1994; Miller 1997; Nilsson et al. 2000; Table 10.1). Problems will sooner or later develop with the use of too few species. Given the number of species that may grow and thrive in a region (e.g., Table 10.2), it is surprising how few species are actually used in urban areas. Therefore, the potential for the use of a broader range of tree species for urban use is considerable.

Santamour (1990) describes the use of a model for urban planting, to secure species diversity and to guard against large-scale insect attacks or diseases. For maximum protection against such pests, he suggests that the urban forest should contain no more than 10% of any single tree species, no more than 20% of species in any tree genus and no more than 30% of species in any tree family. For street trees, we suggest that within a species, several clones should be used in the city, if at all possible. In streets and ornamental parks there is a tradition of planting clonal selections of tree species, chosen for their distinct form, habit and leaf color. By contrast, in urban woodland, maximum genetic diversity is preferable and the use of seedlings is to be preferred to the use of clones. For example in Greece, species are recommended after the analysis of naturally occurring species of the region, the site conditions and the climate. The main considerations for the choice of trees for urban areas, stated at the beginning of this chapter should be achieved at a relatively low cost. However, costs and benefits should be considered over a long time span. The aesthetic appearance of a tree often varies with the inherent growth form, management and environmental factors like climate, available space, light, water, soil and nutrients. Climate is the most limiting factor in the choice of species for urban areas in northern Europe, as water availability determines this for southern Europe.

According to Miller (1997) the process for selecting species for urban uses may be facilitated through the use of a Species Selection Model (Fig. 10.1). Site factors consist of cultural and environmental constraints, where cultural constraints refer to physical limitations of the site caused by human structures and activity, and environmental constraints refer to insects, diseases, climate and microclimate, and soils. Social factors include neighborhood and community values, functional utility, species aesthetics, public safety, and negative social externalities. Economic factors include establishment, management, and removal costs. However, in such a model, the soils are probably only a limited constraint, since they are usually accepted as they are. In the future, it would be desirable to optimize the growing conditions by investing in site preparation beforehand, rather than by rectifying problems later.

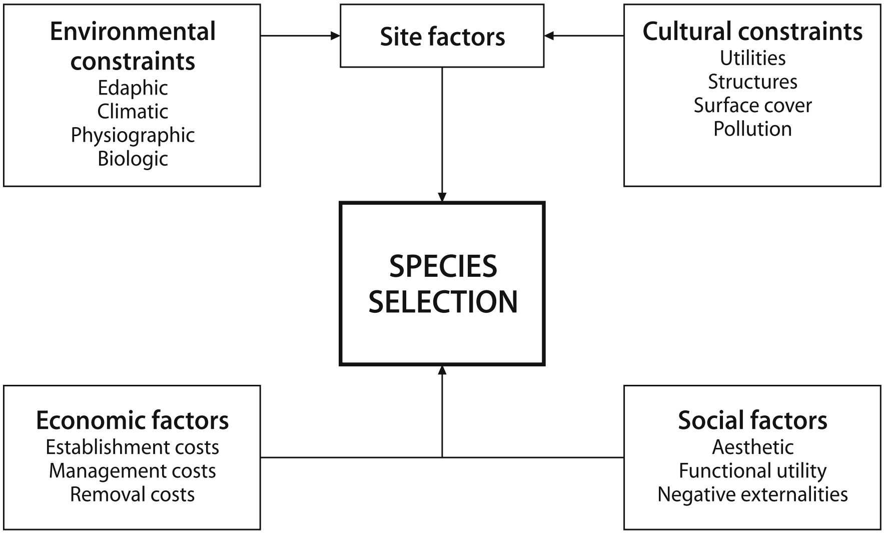

Fig. 10.1. Factors important in a model for selection of species for urban areas (Miller 1997)

Preferences vary according to region. For example, in northern Europe trees like *Betula* spp. are highly appreciated because of their light shading. By contrast, in southern Europe, denser shade is preferred.

The composition of species in urban situations also relies on the ecological and epidemiological knowledge of designers and planners. The mixture of *Sorbus aucuparia* and *Juniperus communis* for example, may yield serious problems with rust (*Gymnosporangium cornutum*) because the fungus alternates between the two species (Wennström and Eriksson 1997). Some species may have invasive characters, and thus are not desirable in all situations. Examples of such plants are found in *Acacia*, *Acer*, *Ailanthus*, *Ilex*, *Prunus*, *Laburnum*, *Sambucus* and *Rhododendron*. Special selection criteria are needed in particular environments, such as for example seashores.

10.6.2 The Introduction of Uncommon Species

It is difficult to introduce non-traditional species for urban uses, because there is a lack of knowledge of the species, its properties and how it performs in urban situations and usually, it is not possible to buy the trees since they are not available in nurseries. We suggest two measures to be taken. Firstly, the species of interest should be evaluated in the nursery under realistic situations. The trees should be made available for observations and be demonstrated to planners and other professionals in urban forestry. The information about the importance of biodiversity must be distributed. Secondly, protocols of propagation of the 'new' species must be given to the nurseries. Both tasks probably need new initiatives in research and information. When collecting seeds from the native vegetation, it is also important to consider the negative selection that has been done in many natural populations, by harvesting the best specimens for timber production etc.

10.7 Survey on Selection Criteria for Trees in Europe

As part of COST Action E12, a questionnaire to which 14 countries responded (led by J. Van Slycken), showed that a large part of tree selection is related to conventional productive forestry. For example, adaptation to local site conditions (climate, soil); resistance to or tolerance of diseases; growth performance; straight stems and wood properties; were all deemed important selection criteria. Although some of these selection criteria are important for use in urban conditions, the results of the selection work seemed mainly to be applicable to urban woodland. Also, a large part of the selection work referred to the evaluation of plant materials introduced to botanical gardens and arboreta, rather than to more realistic urban situations.

Selection for climate adaptation focused mainly on frost resistance in northern Europe and drought resistance in the south. Special attention was also given to urban climate factors, such as heat, drought and wind. Resistance to salt, general stress, soil compaction and air pollution was important in only a few places. Also, a lot of selection work is focused on improving the ornamental value of trees and shrubs.

10.7.1 Methodology of Assessments

Resistance to, or tolerance of the main threats to urban trees, were mostly assessed through field trials, observation plots and surveys. These methods are less costly, but still require adequate resources and a long timescale to ensure useful results. However, methods for early assessment have been developed and some of these are reported below.

Disease Resistance/Tolerance

Resistance to diseases is tested using artificial infection techniques. Austria, Belgium, Italy and France are testing the resistance of elms against Dutch elm disease (*Ceratocystis ulmi*). Austria reported artificial infection methods for screening the susceptibility of *Sophora japonica* L. towards canker. Spain and France are using them for the assessment of resistance to anthracnose on *Platanus* L. Italy and France reported artificial infection to test susceptibility of *Cupressus sempervirens* L. for cortical canker. An artificial infection technique to test resistance of willows to Watermark Disease is under development in Belgium.

Pest Resistance/Tolerance

Nearly no early assessment methods were reported to test resistance to, or tolerance of pests. However, pot experiments are used in the UK, Sweden and Austria to test the susceptibility of horse chestnut toward leaf miner (*Cameraria ohridella)*.

Climatic Adaptation

In general, field trials are used, involving many species. In Italy, isozyme studies in combination with field trials are used for *Quercus* L., *Juglans* L. and *Prunus avium* L. Frost tolerance of *Acer platanoides* L. and *Pinus halepensis* Mill. is tested by studying electrolyte leakage after freeze testing plant material. Hydroponics was used to test drought resistance of this species. Iceland reported freeze testing of *Picea sitchensis* (Bong.) Carr. and *Abies lasiocarpa* (Hook.) Nutt.

Adaptation to the Urban Environment

Surveys, monitoring and *in situ* trials are common methods of testing the general performance of trees in the urban environment (UK, Germany, The Netherlands, Greece), salt resistance (UK, Iceland), resistance to photochemicals (Greece), stress resistance (Finland, Greece) rooting ability (Spain) and shape of the crown (Sweden). The UK and Belgium are using hydroponics to test the tolerance of salt and heavy metals in *Salix* clones. In Austria, pot experiments are used to screen the tolerance of de-icing salts of *Acer* L., *Tilia* L., *Picea* spp. and *Pinus nigra* Arnold. The growth reaction of *Tilia cordata* Mill., *Acer platanoides* L. and *Pinus nigra* Arnold is also being studied in this way.

Ornamental Value of Trees

The ornamental value, including habit, fruit color, flowering, autumn color, covering capacity and competing capacity of a whole range of species and varieties is mainly assessed visually. Breeding programs were also reported.

Conservation of Genetic Resources

Most of the participating countries are running programs on the conservation of genetic resources in trees. Inventories, within and outside conservation projects exist, as well as studies on genetic diversity. In Sweden, selection is done in *Tilia* L. in historical plantations in combination with the establishment of trial plots and DNA-studies.

10.7.2
Recommendations from the COST Action E12 Pilot Study

During the existence of COST Action E12, F. Duhme and S. Pauleit from Germany suggested a pan-European information network on the urban dendroflora of major European cities, in order to compile the information, which already exists. New knowledge should be collected in systematic surveys based on a common methodology adapted to the eco-regions of Europe. Such an information network may offer new opportunities for testing the potential plant resources, present in many botanical gardens and arboreta, especially in south-eastern central Europe.

10.8 Examples of Selection Programs in Europe

10.8.1 France

In Montpellier in France, *Platanus × acerifolia* made up 47% of the trees in the city (in 1995) and the most used species accounted for 73% of the trees. In Antibes (Ducatillion and Dubois 1997) a project was started, aiming at increasing the number of genera and species used, by identifying wild species with potential for urban areas. The factors evaluated for the decision of what species to use are:

- The environmental and functional properties of the urban site (biotic and abiotic factors)
- The natural biodiversity in trees of the area
- Human and social factors (functions, litter, allergens, etc.)

For planners, a tool based on multi-criteria analysis has been developed. The database is organized hierarchically, taking account of site and plant traits:

- The site: natural or urban environment and functions
- Amenity and ornamental values
- Ecological limits for the plants (climatic adaptation, edaphic factors etc.)
- Interaction with humans at the site (toxicity, allergy, etc.)
- Environmental risks (e.g., invasive plants)

Information on species included in the study is collected from bibliographies, archives and observation of living plants in different locations in southern France, in botanical or private gardens. Data of interest include growth characteristics, morphology, phenology and susceptibility to pests, pathogens and climatic stresses. Each selected species is verified in a decision-making system as a tool for green-space planners. The results are synthesized and distributed to city management services and nurseries. The organization of an experimental and demonstration network is also an important aim of this project. This network starts with regional cities and nurseries, and the first 22 new species will now be planted in order to observe their properties and development in the realistic urban situation.

10.8.2 Portugal

In situ testing of species may be possible when large areas are afforested in or around cities, because of special circumstances. A good example is the *Expo98* in Lisbon, Portugal (Rego and Castel-Branco 1998). More than 1 000 trees, belonging to 182 species, were planted and evaluated for survival in demanding soil conditions. Valuable knowledge was acquired and the best performing trees can be found if the testing can be continued for a number of years.

10.8.3 Sweden

Systematic data collection in botanical gardens, arboreta and private gardens may yield valuable information. In Sweden, a model for tree improvement includes the following steps, based on progeny evaluation of seed stands (Lagerström and Eriksson 1996). Trees in tree nurseries are evaluated visually (growth characteristics, phenology and health). Variation in the growth habit of the approved seed stands is then decreased, through selection, before the establishment of new seed stands. Delineation of the climatic breeding zones, based on phenological studies follows. Phenotypic selection of individuals with good external characteristics is then carried out, and seed orchards are established. Finally, simple recurrent selections are carried out, without keeping track of the pedigree.

10.8.4 The Netherlands

In The Netherlands, a large proportion of oak seeds (*Quercus robur*) has been harvested from roadside stands (De Vries and Van Dam 1998). Such trees are relatively unaffected by their neighbors and their growth form should reflect their phenotypic potential for such characteristics as trunk straightness, forking, branching, epicorms etc. From these seed sources, Dutch tree nurseries have selected 2–5% of the trees for the new generation of roadside trees with the intention of achieving a gradual improvement in tree quality. In addition to this, systematic selection and comparative trials in progeny tests continues to evaluate stands as potential seed sources.

10.8.5 Slovakia

In Slovakia, several of projects are aiming at selecting better plant materials, focusing on biotic factors (pests and diseases) and abiotic factors (emissions, climate adaptation and soil conditions), as well as growth characteristics (growth rate, shape of root and crown and tree habit). Ornamental factors (leaf characteristics, color of plant parts and blooming) and functional criteria (timber production, fruit production, secondary metabolites etc.) are also important. The focus on plant selection and breeding has contributed to the use of 2500 cultivars of native and exotic woody plants.

10.9 Recommendations for Selection Programs for Phenotypes within the Species

It is important to be clear about the aims of any tree improvement program. These programs should include climatic adaptation, phenotypes that are relevant to the desired function of urban trees and pest and disease resistance.

10.9.1 Selection Criteria

Selection criteria for plants vary in different parts of the world, according to site variation and the differing priorities given to actual selection criteria. Information can also be found in general books (e.g., Phillips 1993; Stoecklein 2001). The COST E12 survey of research institutions in Europe (led by J. Van Slycken) showed that climatic adaptation was the selection criterion of the highest priority in the Scandinavian countries and disease resistance and tolerance of drought were, in general, regarded as the most important selection criteria in southern Europe. The selection of species for street trees should have especially high priority. Shrubs should also be a part of the comprehensive selection program of plants for the urban green areas.

Selection Criteria for Street Trees

There is a demand for street trees of high uniformity, with specific shapes and growth potential. Response to pruning and the need for other management measures may also be important characteristics for street trees (Harris et al. 2004). Tree quality may often be best served through the selection of clones or by reducing the variation in a seed orchard to produce homogeneous offspring (Lagerström and Eriksson 1996). But, diversity can be encouraged through the use of a number of clones in each city or region. At present, clones with similar properties rarely exist, and the development of parallel clones may be difficult because it adds to the costs of the trees. Thus commercial and ecological interests are in conflict. However, clones should not be introduced until the plant material has been thoroughly tested. In many cases better seed sources can be as good as clones and the selection work may be both quicker and cheaper. In the future, selection of untraditional species should be encouraged, in order to enhance the biodiversity of cities.

Street trees should possess strong apical growth, strong branching angles, predictable growth rates, high overall aesthetic value and potential for a long lifespan. Trees with large fruits and allergy-inducing pollen should be avoided. Inherent potential for strong compartmentalization responses will be advantageous where trees are subjected to pruning or damages from human activities. There is a need for both large and small trees, as well as for a range of crown sizes and shapes to meet the needs of different streetscapes. Both nurseries and users of plant materials should be involved in the selection program. A number of tree species probably have great potential for improvement in selection programs aiming at use in urban areas.

Selection Criteria for Park Trees

The requirements of park trees are often the same as for street trees, but a larger variation is desirable. It is still necessary for planners to know the potential growth rates, shape and lifespan of trees recommended for parks. These may be planted as solitary trees or in small or large stands. Different styles as well as different functions create a demand for increased diversity of age, size and structure.

Selection of Trees for Urban Woodland

The approach of selection of trees for urban woodland is probably often the same as in commercial forestry. However, the range of species ought to be much larger than what is found for forests managed for timber production. The use of 'landscape laboratories', introduced in Sweden, may be a good way to introduce new species, designs and methods for management of urban woodland (Gustavsson 2000).

10.9.2
Selection Strategies

A wide perspective is a prerequisite of the selection program for urban trees. It is important to capture the variation in the gene pool. Mapping of available traits in the plant population will benefit a dynamic breeding program, in which aims and strategies may change with time, due to changing demands. Global climate change should also be considered. Since it is impossible to anticipate all possible changes, emphasis should be on the preservation of large phenotypic plasticity and genetic diversity in the gene pool of plant materials (Eriksson 1996, 1998; Koski 1996). Multi-population breeding (Namkoong et al. 1988) seems to be a good option for the future. In this system a number of populations are preserved, either with the aim of breeding for genotypes of the desired properties within each population, or breeding for different adaptations among different populations. Both approaches seem feasible for urban tree improvement programs. However, breeding is expensive and time consuming, especially when the number of species is so large and the objectives for breeding are so diverse. There is some merit in cooperation between regions, which are climatically comparable. Exchanging knowledge and genetic materials between south, central and north of Europe will probably be of great value.

Ware (1994) suggests selection of trees for the urban environment from stands in difficult, demanding sites, such as floodplains, swamps, savannahs and dry habitats. This approach should, however, not be an excuse for not making the growing conditions in cities appropriate for trees. The soil must not be compacted, drainage must be addressed and trees must be supplied with sufficient water and nutrients. Under harsh conditions, pioneer species may have higher tolerance of stress than climax species.

Selection of Provenances

Provenance selection has been a prominent theme in forestry since the beginning of the 19th century, and the results have been most successful in commercial forestry. Provenance selection in tree species with a high value for use in urban and roadside planting, yet, remains relatively unexplored. Much knowledge exists about where to find the variation that is necessary in programs for both selection and gene conservation in tree species (Namkoong et al. 1988; Eriksson et al. 1993). However, urban trees are used in much smaller scales than provenances in forestry. With high costs for establishment and management and the high demand of success in establishment and management of urban trees, provenance selections alone are probably too 'rough'. The method implies a too large phenotypic variation in the trees. However, climatic adaptation in trees will mainly be achieved by selecting trees with a growth pattern adapted to the climate of the site. The idea of selecting good seed sources is thus still the best strategy for the production of good plant materials.

Selection of Plus-Trees

One way of finding better parent trees is to test the best mother trees (plus-trees) through observations of their offspring. Plus-trees may be used in seed orchards.

Early Testing

The aim of early testing is to incorporate traits of importance to tree performance as soon as possible and at as low a cost as possible. Early testing may have large potentials to speed up the gain in a breeding or selection program (Lambeth 1983). But how early in a tree's life can we make the selection and still be sure that it is relevant for the adult tree? The work done on correlation between properties selected for in the juvenile plants and in the adult plants justifies optimism, even for traits selected for in rather young (juvenile) trees. The age-age genetic correlation was large even after one year, indicating that early selection is an efficient strategy to improve rotation-age growth in *Pinus banksiana* (Riemenschneider 1988). However, some characteristics important in urban trees do show up in seedlings. Examples are pubescence for interception of aerial particulate matter and high root-crown ratio, indicating adaptation to dry growing sites (Ware personal communication). Although some of the trees used in urban areas have a relatively short juvenile period, many tree species set flowers and viable seeds first after several decades. It is necessary to test how well early selection can function in urban trees, where tree form and habitus, traits of a mature tree, are often the most important traits selected for.

New Tools and Methods in Tree Breeding

In tree breeding the use of markers of different kinds has been usual for some time. However, the phenotypic markers and isozyme markers are relatively few in numbers in a given genotype as compared to DNA markers with nearly unlimited numbers (Winter and Kahl 1995). The use of molecular markers can accelerate the breeding programs considerably and allow linkage of phenotypic characters with the genomic loci responsible for them. The techniques of different kinds of molecular markers are gaining even more speed and at lower costs through automation technology. Tissue culture makes it possible to start the selection already at an early stage, both in seedlings and clones *in vitro*. Several tree species are being worked with in order to develop a protocol of clonal propagation through somatic embryogenesis. The medium of the cultures may be added selecting factors, like salt, toxins from pathogens or high or low pH values. Thus the manipulated growing medium can be used in the early selection of tolerant genotypes. However, field tests are necessary to examine whether the properties selected for, such as tolerances or resistances selected for *in vitro,* extends into the *in vivo* conditions.

Traditional selection programs are usually performed in rural landscapes by experimental stations, and the like. This is seldom the most realistic situation for trees in urban areas. However, in urban areas, large enough plots with homogenous growing conditions to support a comprehensively designed selection program lack. In urban areas, the variation in the environment may camouflage the genetic variation completely (causing the heritability to be close to zero). Under such conditions, genetic gain due to selection cannot be expected. In the actual selection process, all other factors than those selected for should be optimally standardized, and the actual stress factor, preferably in gradients, should systematically be imposed on the plants in which selection is to be made. This makes it possible to draw sound conclusions, as opposed to in urban environments, where conditions may change spatially over small distances. However, the final testing of selected seed sources or clones may be performed in comparison with other and well known genotypes in realistic situations, for example along roads. However, the Dutch system for selecting road side trees is a good example, where selection can be made from functional urban vegetation (De Vries and Van Dam 1997).

10.9.3
The Production and Distribution of Improved Plant Materials

Seed orchards and clone archives are used to secure the availability of true to type and hardy plant materials. The establishment and design of seed orchards need to be carried out with care, in order to reach the aims of the orchard and tree improvement programs (Namkoong 1990). Seed orchards should be placed close to where the seeds are to be used, or else unexpected phenotypes may occur in seedlings from the tested seed sources (Skrøppa and Johnsen 2000).

10.10
Conclusions and Progress in Choice of Species and the Selection of Plant Materials

Within regions in Europe with similar climates, cooperation between countries should be initiated, so that genotypes can be tested over larger areas. This may be the basis for common selection programs, also justified through a larger market to pay for the investment in tree improvement programs. Botanical collections in arboreta, botanical and private gardens represent an unexplored resource. These collections may be a good starting point for selection work. However, botanical gardens and arboreta should emphasize, more than today, the ecological aspect in the testing of the plants, so that the trees can be tested under conditions to which they are adapted. The focus should be on the genetic diversity when testing new tree species. Better knowledge of physiological processes related to stress is needed, and research is required to fill the gaps in knowledge. This may be an important input for the design of large tree improvement programs. The example from Slovakia indicates that the work with selection and breeding may spur the increase of the biodiversity in woody species.

In addition to some new selection criteria, tree selection for urban areas disperses from that of commercial forestry by the focus on many species and, in the future, more on the untraditional (for commercial forestry) tree species.

In spite of the growing importance of urban forestry and the great need of a broad range of species, phenotypes and genotypes, there is little selection work on urban trees going on in Europe. The present documentation of COST Action E12 ought to spur the demonstration of new species in urban plantations and the start of selection programs in new and traditional species. If selection programs are started now, the quality in urban forestry of the future may be dramatically increased and the costs of establishment and management will decrease.

In the selection and breeding of street and park trees, we suggest that the following strategies should guide the upcoming work:

1. Selection criteria referred to in this paper should be adopted in selection programs, to suit the different uses of trees in urban conditions. The main selection criteria are climatic adaptation (growth rhythm, adaptation to high and low temperatures, winter survival and tolerance of water stress), growth and exterior characters, incorporation of functional properties (plants for shade, wind shelter, playground elements, aesthetic elements, etc.) and resistance against pests and diseases.
2. Cooperation with nurseries, architects and city planners is both desirable and necessary.
3. Untraditional species should be tested, selected and demonstrated for planners and practitioners.
4. Pragmatic selection programs are the cheapest alternative and can make use of plant materials in production. Exploration of existing collections in parks, arboreta, botanical gardens, private gardens, road plantings and landscape may be used to broaden the use of species and genotypes.
5. In a tree improvement program, several populations, preferably comprising a broad gene pool should be maintained and explored. The aim should be the dynamic selection and breeding of genotypes.
6. Pan European networking and database building of existing information should be fostered.

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Chapter 11

The Abiotic Urban Environment: Impact of Urban Growing Conditions on Urban Vegetation

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11.1 Introduction

'Planting of trees in towns should not be given in senseless and untrained hands, because one has to fight against unfavorable soil-, air- and other conditions. From noticing them the safe and prospering development of expensive establishments highly depends' (*translated from Fintelmann 1877*). Depending on the geographic situation and the urban structure, the environmental conditions in urbanized areas are more or less harsh and they differ from natural growing conditions. The impact of the urban environment on urban vegetation is neither constant in intensity nor periodical. There are numerous constraints that are crucial for the survival and vitality of urban vegetation.

This chapter focuses on basic abiotic growing conditions in urbanized areas, on artificial deviations from the natural undisturbed habitat quality in forests that contribute to stresses and threats for urban vegetation. This includes both the qualitative and quantitative impact of different site factors and the time-scale as well: specifics of urban climate, air pollution, constraints and peculiarities of urban hydrological cycles, urban soil conditions in general and in particular unfavorable physical soil properties, unbalanced nutrient supply, soil pollution and fire problems. Possible remedies and precautions to improve growing conditions for urban trees are implicated. In short, the interactions between human activities and the urban environment are discussed to help minimize abiotic stresses that reduce the vigor and vitality especially of trees, and that increase their susceptibility to biotic stresses. Vice versa the impact of urban vegetation on urban ecology is summarized.

11.2 Urban Climate in Europe

Cities create their own climate. The most important factors are the change of the natural surface characteristics into artificial structures with artificial materials. This results in changes of the biosphere with less green covered surfaces with a pronounced effect on the physical environmental conditions of radiation, wind, temperature and humidity. Urban trees and urban forests play a key role in controlling the local and regional aspects of these changes. On the micro-scale, each tree has a potential to influence the microclimate conditions as well as energy consumption for housing and living (Cofaigh et al. 1996). The green space in the urban environment not only influences the urban climate but also has a pronounced effect of the whole city interacting with the surrounding landscape. Therefore, urban greenery faces changed climate conditions in urban areas but also influences the complete urban environment.

11.2.1 The European Perspective

From a climatologically point of view, Europe can be divided into two sharply contrasting parts (Hare 1961). South of the Alpine Divide – a line formed by the Cantabrias, Pyrenees, Alps, Dinarics and Balkan Mountains – the climates are of the Mediterranean type, while the rest of the continent, except of mountainous regions and the far north, temperate climate with more or less continental influence prevails (Fig. 11.1). This is important from the perspective of urban climate and trees since the interaction of trees and forest with the physical environment are different under different climatic situations. Also the goals for managing trees and forests in urban areas are different in cold or hot conditions as well as in humid or dry conditions. In the Mediterranean, cooling is a major focus where in the cold northern conditions wind shelter and minimizing shading is a major goal.

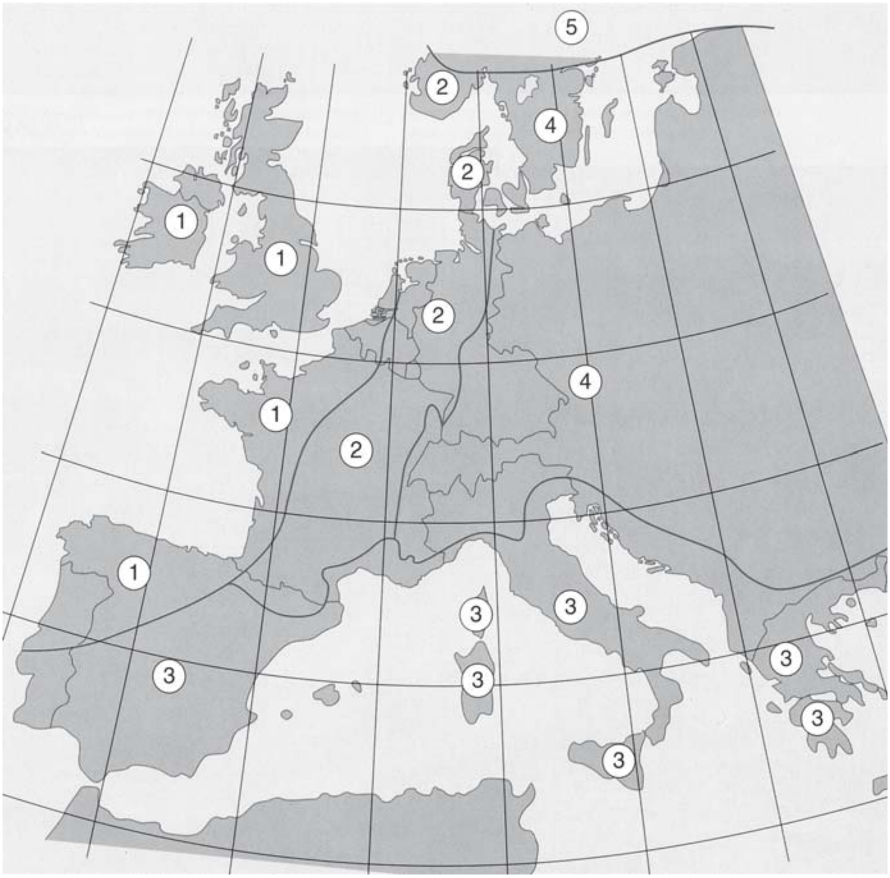


Fig. 11.1. Modified Köppen climates for Europe (Schuurmans et al. 1995). *1:* Oceanic climate; *2:* altered Oceanic climate; *3:* Mediterranean climate; *4:* continetal climate; *5:* sub-arctic climate

11.2.2 Radiation – The Urban Structure

The artificial urban structure has a pronounced influence on the interaction with the radiation environment. Most of the natural vegetated surface is replaced by concrete structures, which have different albedos, and as a consequence of the regular structures of buildings the solar radiation will face multiple reflections and therefore multiple absorptions. The density and size of the built-up area affect the degree by which the local climate will be modified. Thus, the city creates its own specific urban climate. The changes introduced by urbanization may have negative effects on human health and well being. It also may have negative influence on structures and materials but also may put stress on the left vegetation.

The geometry of city streets makes short wave radiation more likely to be absorbed and long wave radiation is exchanged between buildings rather than lost to the sky. The concrete structures and especially paved roads as well as the high density of industrial processes in the urban environment are favorable for pollution and dust release. Long wave radiation is trapped in the polluted urban atmosphere which leads to the urban greenhouse effect. Therefore it is plausible to modify the urban climate through urban design. In this process the urban morphology and the use of green space are the most important factors. Urban trees play a special role since they are able to change the radiation field by putting shade.

11.2.3 Temperature – The Urban Energy Balance and the Urban Heat Island (UHI)

Air temperature in densely built areas is higher than in the rural surrounding country. The prime factors are the increased absorption of heat caused by the changed land cover and the ability of these structures to store heat very effectively. Heating and other increased energy use contribute to increased outdoor temperature during winter at high latitudes. At lower latitudes, air conditioning increases outdoor temperatures. The forced drainage of rainwater is changing the water balance and less vegetation gives less evaporative cooling which also contributes to the urban heat island effect.

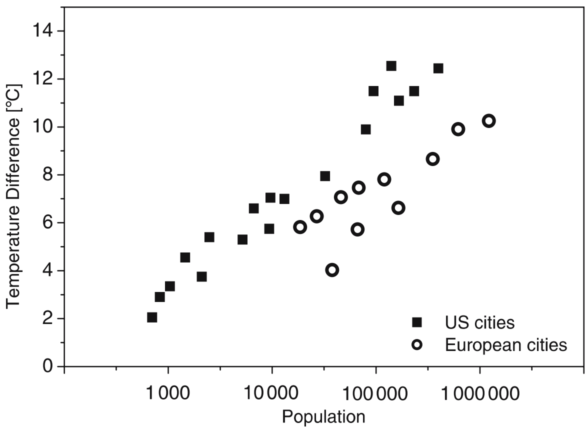


Fig. 11.2. Maximum difference in urban and rural temperatures for US and European cities (Data from Oke 1994)

In cold climates the urban heat island can be beneficial in reducing the heat demand, but in warm climates the urban heat island effect can significantly worsen the outdoor comfort and the energy demand for buildings. The intensity of the urban heat island can be up to 12 °C depending on the size of the city. The bigger the city the more intense is the effect (Fig. 11.2.). In comparison to the rest of the world, higher temperatures are often seen in the US due to taller buildings and higher density in the city centers.

As a consequence of the urban sprawl and as well as of the trend in global warming the tendency of the heat island intensity is growing. At the moment more than 50% of the whole human population is living in cities and this trend is rapidly increasing. The major differences for the climatic factors between urban and rural areas can be seen in Table 11.1. The most important differences are loss of evapo-transpiration and increase of sensible heat flux. In addition, important differences are for wind reduction and increased turbulence. These last two factors are very important in the aspect of air pollution and ventilation, which is a major problem especially with the respect of particular matter and human health.

Vegetation and especially trees can play a major role in improving the atmospheric condition and therefore the quality of life in urban areas. They influence factors by a few important functions:

- Climatic factors: shading and cooling
- Air quality factors: filtering of particular mater and sound
- Climate change factor: carbon fixing

Table 11.1. Overview of the differences between urban and non-urban areas for certain climatic aspects for mid-latitude cities with approximately one million inhabitants (modified after Oke 1994)

Variable	Change	Magnitude
UV radiation	Much less	25 – 90%
Soar radiation	Less	1 – 25%
IR input	More	5 – 40%
Visibility	Reduces	
Evapotranspiration	Less	50%
Heat flux	More	50%
Turbulence	Greater	10 – 50%
Wind speed	Decrease	5 – 30% at 10m
Wind direction	Altered	1 – 10°
Temperature	Increase	1 – 3° annual mean, up to 12° on individual occasions
Humidity	Decrease	Various extent
Cloud	More moist urban haze, more clouds in the lee of the city	
Fog	Either more or less, depends on city	
Precipitation	Less snow (converted to rain)	

All these functions should be optimized in the urban design process. From the urban climate perspective, the potential of vegetation for shading and cooling is the most important. The effect as a heat sink is a function of the size and location of the green area.

- *Large scale* = surrounding land or large areas within the city such as forests or urban parks
- *Medium scale* = distribution of green on the urban level
- *Small scale* = local features like trees and green areas at street level and in adjacent or enclosed areas of buildings.

Plants and trees regulate their foliage temperature by evapo-transpiration. This leads to a reduction of the air temperature. Low air temperature and shading result in decrease of heat gain of building materials and in an increase of the efficiency of air-conditioning systems. Measurements and numerical simulation show the cooling effects of trees by reducing the maximum daily temperature up to 4 °C (Shashua-Bar 2000). The cooling effect from a forested park can also be felt up to 100 m distant in the surrounding.

Apart from evaporative cooling effects by trees, other major factors that change urban climate are:

- shading effects due to trees
- reduction of surface temperatures; decrease of convective and conductive heat loads
- reduction of short-wave and long-wave radiation from soil to environment or to building
- wind break effects or insulation effects

11.2.4
Precipitation – The Urban Water Balance

Water in various forms deeply affects the life of a city. One major aspect is the controlled drainage of rainwater during meteorological conditions with heavy precipitation. This should work without flooding, erosion or landslides. Urban sensible heat flux can trigger convective storms, which lead to higher precipitation downwind of the urban area. Radical changes in surface characteristics lead to:

- rapid precipitation runoff
- flooding
- erosion
- earth sinkage

Vegetated areas play a key role for handling this type of rainwater problems. In cold climates the major problem will be snow and blowing snow.

11.2.5
Wind – Ventilation for Health

In urban areas, wind is reduced depending on the urban structure. In cold climates this is a positive effect since the cooling by wind flow is reduced. In hot and humid-hot climates the reduction of wind speed leads to worse conditions for human living since wind is under these conditions sometimes the only ‘air conditioner’. From the view of air pollution and human health reduced ventilation of urban structures is always very negative.

Worldwide most cities suffer from serious air-pollution problems. One major reason for the air-quality problem is again the growth of urban population and the dramatic land-use change in the urbanized areas. The most important pollutants are nitrogen oxides (NO_x), ozone (O_3) and particles (dust). A major source for NO_x is car traffic coinciding with high values of solar radiation and O_3; NO_2 is formed, which is harmful for humans. Excepting point sources, high concentrations are normally present during low wind speed synoptic weather condition. Under these conditions with weak vertical exchange, the urban structure makes the problem even worse. In that case, local wind systems are the only source of fresh, unpolluted air. In these situations the presence of temperature inversions, which suppress vertical exchange are very important. In cities these inversions are always located as elevated inversion above the ‘urban canopy’ (urban structures). This is a consequence of the high level of turbulence inside the urban canopy, which leads to approximately well mixed conditions inside the building structures. Trees are also structures and therefore they will reduce flow and lower the potential for exchange of air masses.

To enhance the natural ability of the urban structure to be ventilated it is necessary to support areas with contrasting temperature. This will introduce pressure differences inside the urban canopy layer, which will lead to small-scale flow systems, which help to exchange the air. As trees have a high efficiency in cooling the air by transpiration they will help to increase contrasts and so will be beneficially to reduce emission concentration levels. Especially for particulate matter the big surface of leaves will act as filters and therefore reduce particle concentration.

11.3
Air Pollution and Trees in Urbanized Areas

Various observations have shown that Ozone (O_3), sulfur and nitrogen oxides (SO_2, NO_x), particulates, and carbon dioxide (CO_2) are regarded as the most important air pollutants affecting trees in the cities. Urban trees offer many benefits, including the ability to neutralize unstable pollutants, as O_3, SO_2, NO_x, and eliminate particulates from the air. As trees remove pollutants from the environment, visible or invisible changes in functionality arise. Thus, tree health status represents an indirect indicator of air quality. Against direct benefits on air quality like pollutant removal and CO_2-sequestration and indirect benefits of trees like energy use reduction, biogenic volatile organic compounds (VOC) emission is a potential air quality liability associated with urban trees.

11.3.1
Effects of Air Pollutants on Urban Trees

No species are absolutely resistant to pollution. Resistance is always relative and depends on the pollutant characteristics, the plant development stage and the physiological leaf age, the growth conditions, and the location. Lists are available ranking trees resistances to pollutants (e.g., Flagler 1998), even if most investigations have been carried out on young plants, by chamber exposures, at high pollutant concentrations, for short time periods, and under nearly optimum environmental conditions. Moreover, different provenances and even single individuals may respond differently to pollutants.

Lists of urban trees ranked based on their detoxification ability are still lacking, while a little has been made for ranking them based on their ability to sequestrate CO_2. An arrangement of shrub and tree species because of their ozone-forming potential is instead available (Benjamin and Winer 1998). Even if these values reflect environmental conditions representative of a summer day in Southern California, the methodology can be used to select low-emitting species for urban planting programs.

Ozone

Ozone is the most widespread and harmful pollutant in Europe and North America, and is projected to further increase, especially in developing countries (Fowler et al. 1999). Ozone is a normal component of the upper layers of the atmosphere, the stratosphere, where it absorbs UV rays. Even in the lower atmosphere, the troposphere, O_3 is normally formed in the presence of oxygen and light, but it rapidly degrades back to oxygen. The presence of other air pollutants, especially NO_x and VOCs, shifts the balance of the reaction and favors the formation of O_3. The new agreed Ozone Daughter Directive for Europe running from 2002 sets a target value of 120 μg m^{-3} as an 8-hour average to protect human health, not to be exceeded more than 25 days per year (EEA 2002). Exposure of urban population to O_3 higher than 110 μg m^{-3}, in the 1990s in the EC, was constantly increasing (Fig. 11.3).

Exceeding of EC O_3-threshold during the summer season 2001 were widespread throughout Europe and especially in the Mediterranean area (de Leeuw and Bogman 2001). Measurements performed in Pisa, a city in central Italy, show that the critical level of ozone for forests, that is 10 ppm multiplied by hours of AOT40 in the entire growing season, is reached in only eight weeks between June and July (Lorenzini 2002). AOT40 is the **A**ccumulated hourly concentration **O**ver a **T**hreshold of **40** ppb O_3, a

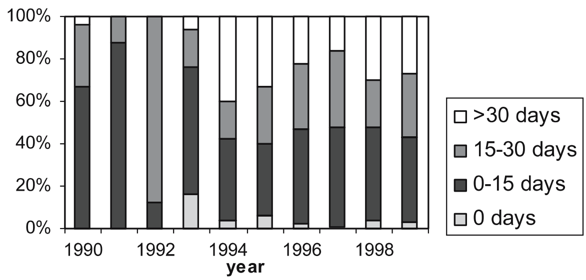


Fig. 11.3.
Days of urban exposure to ozone higher than 110 μg m^{-3}, 8-hr average concentration, in the European Community (EEA 2002)

concentration below which no significant biological effect can be reasonably expected. Critical level is the concentration of O_3 above which direct negative effects can occur on plants, according to current knowledge. The most significant negative effect is the reduction by at least 10% of biomass accumulation. Ozone concentrations in rural areas are often higher than in cities, and this is due to three main reasons:

- Ozone is a secondary pollutant; its synthesis takes time, so that it is likely to be formed at distance from the precursor source.
- The generally high pollution level in urban areas favors return reactions with NO_x, which lead to O_3 depletion.
- In vegetated areas, biogenic VOC may contribute to the formation of O_3, since they are more reactive than anthropogenic VOC.

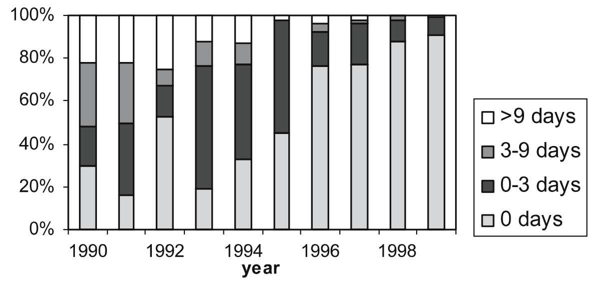
The most common effects of plant exposure to O_3 are alterations of stomata behavior. This includes a reduced photosynthesis and an increased respiration, which is shown by an increased ratio between above and below ground biomass. Further, overall reduction in biomass production and in reproductive ability occurs. The quantity of epicuticular waxes is reduced, and their degradation increases – last, the alteration of pathways related to secondary metabolism, such as ethylene or phenylpropanoids occurs. Visible O_3 injury of foliage is detected more and more frequently, even in open field conditions. A number of manuals and handbooks exists that make diagnosis easier (e.g., Innes et al. 2001; Flagler 1998). Typical symptoms are described in Sect. 11.3.2.

Sulfur- and Nitrogen-Oxides

Sulfur and nitrogen oxides are both directly emitted during combustion of fossil fuels. SO_2-problems on trees are usually localized around point sources such as power plants but can to some extent also be correlated to long distance transport of polluted air. Technological progress and economic recession have contributed to a general decrease in the number of SO_2-problems on trees within the past 10 years. In fact, exposure of urban population to SO_2 in the 1990s in the EC was constantly decreasing (Fig. 11.4). Concentrations are expected to further decline. A limit value of 125 µg m^{-3} as daily average not to be exceeded more than three times in a year has been set for the protection of European human health (EEA 2002).

Among the seven NO_x, only monoxide and dioxide are important pollutants. NO_2 is the more phytotoxic due to its higher water-solubility. The limit value in Europe is

Fig. 11.4.
Days of urban exposure to sulfur dioxide higher than 125 µg m^{-3}, 8-hr average concentration, in the European Community (EEA 2002)



40 µg m^{-3} in one year (EEA 2002). No clear trend in the exposure of urban population has been recorded in the last decade. Peak concentrations occur in busy streets where road traffic is the main source. The introduction of catalysts in cars has contributed to the reduction of NO_2 urban emissions.

SO_2 and NO_x are toxic in the form of gas or of particles when they are converted to sulfate and nitrate. Deposition onto the ground is an important cause of soil acidification. The main role of NO_x at present is in ecosystem eutrophication and photochemical smog. As a gas, they damage cuticles and stomata and, most importantly, they penetrate through stomata and alter mesophyll tissues. SO_2 can cause both acute (cell plasmolysis) and chronic injury (reduced gas exchange, chlorophyll degradation, chloroplast swelling, alteration of cellular permeability). Yellowing and necrosis are interveinal in leaves and apical in needles. Levels of NO_x detectable in the environment are generally responsible for chronic type effects. Visible symptoms, like mild chlorosis and reduced development, are so aspecific as to make diagnosis practically impossible.

Particles

Atmospheric pollutants that damage trees are mainly gases, although particles are also involved. Negative impact on human health is mainly associated with PM_{10}, defined as particulates with a diameter less than 10 µm. PM_{10} in the air can result from direct emission or emissions of particulate precursors, mainly NO_x, SO_2, ammonia and organic compounds. The European limit is 50 µg m^{-3} as daily average. Particles are expected to remain well above such a limit in the future (EEA 2002). At present, a significant proportion of the European urban population is exposed to concentrations of particles in excess. Dust that sediments on leaves can shield sunrays or block stomata movement, so affecting the energy balance of leaves and the gas exchange, and allow the penetration of phytotoxic gases. Further, chemical substances contained in the dust can dissolve in the presence of moisture and damage the leaves. Besides nitrogen- and sulfur-compounds, other substances in the dust include heavy metals (HM) such as lead, copper, zinc, etc. Except at very high concentrations combined with low pH HM are never toxic for plants, but they can be toxic for people and other animals, although Europe still lacks emission indicators for them.

Carbon Dioxide

Global change is a topical issue of our time. In the Kyoto Protocol, the EC agreed to reduce its greenhouse gas emissions by 8% by 2008–2012, with respect to 1990 levels. CO_2 is by far the most important greenhouse gas, accounting for 82% of total EC emissions in 2000 (Gugele and Ritter 2002). The same processes that produce pollutants release CO_2 and so it can actually be considered a pollutant, despite that its effects on vegetation are never negative. But, if among the various definitions of pollutants we choose the one that considers them 'substances found in the troposphere in quantities in excess of normal values', then CO_2 is to all intents a pollutant, since its atmospheric concentration has increased by some 25% over the last 150 years, and is projected to double within the next 80 years (Brown et al. 1988). Trees are believed to be able to contribute to mitigate global climate changes because of their key role in the energy and mass exchanges between the atmosphere and the geosphere.

11.3.2 Bio-Monitoring

Bio-monitoring can be defined as using an organism to obtain information on the quality of the environment; it is active, by introducing into the study area selected and standardized plant material, or passive, by using plants that are naturally present in the environment. Urban trees are excellent passive monitors. Due to their long lifespan, they are exposed to pollutants over a much longer term; as such, they are usually well adapted to their environment, and they are often well distributed throughout the urban area. But care must be taken in the interpretation of macroscopic, physiological and biochemical effects, since many pollutants elicit similar responses and it is very rare that only one kind of pollutant is present in an environment. Further, the injury is rarely acute, i.e. caused by a short exposure to high pollutant concentrations, and often chronic – caused by prolonged exposures to relatively low levels of pollutants. Occasionally trees can also display reduced productivity and vitality in the absence of visible symptoms.

The effects of pollutants on trees are then very subtle, since they are often invisible and aspecific.

Diagnosing air pollution injury to trees is not easy because the injury can occur in many different forms depending on the respective pollutant, tree species, and environmental conditions. Visual injuries, like growth reduction, crown thinning, phenological alteration, and leaf injuries, like chlorosis and necrosis may be caused by several factors. However, there are types of visible symptoms that are associated with specific air pollutants. The use of indicator plants for active monitoring can help to address diagnosis.

Among visual injuries, today's attention focuses on O_3. The most important characteristics that can be applied to distinguish O_3-induced symptoms in broadleaves are summarized in Innes et al. (2001): O_3-induced injury is usually expressed as a dark-colored, upper leaf surface with stipples smaller than 1 mm, or as an upper surface general pigmentation with bronzing or reddening discoloration, with the lower leaf surface clear of symptoms. Only towards the late season, O_3-induced injury may also be visible on the lower surface. Symptoms are never present on the veinlets. Leaves towards the base of the twigs exhibit an increasing presence of stippling due to longer seasonal O_3-exposure, thus showing an ageing effect. Additional typical features are the shading effect by an overlapping leaf, the shaded leaf area is clear of symptoms, and premature leaf senescence followed by early leaf abscission.

Among microscopic injuries, most of the attention has been paid to cuticles. Waxy cuticles are the interface between higher plants and their aerial environment. The erosion of the surface structure – with reduction of wax amount and structural damage – is considered one of the most reliable indicators of pollution, even if ageing and artifacts may complicate data understanding (Percy et al. 1994).

Leaf washing is the simplest method to allow quantification of dust. Scanning electron microscope coupled with electron probe microanalysis has been widely used as a tool to identify dust deposition onto leaves and to identify particles. The total amount of diluted waxes is often inversely proportional to the amount of accumulated surface substances, like dust, and decreases from rural to urban areas. Particles usually accumulate over time; anyway, the pattern of accumulation is species-specific, depends on leaf morphology, especially on size, position, type and distribution of hairs.

11.3.3 Effects of Urban Trees on Air Pollutants

Urban Trees As Sink for Pollutants

Urban trees act as pollutant sinks both directly and indirectly. Directly they remove gas and dust from the air, and indirectly they minimize air temperature extremes and thus energy use, that is the main contributor to air pollution. Energy savings thanks to urban forests depend on the different sources of energy, on tree morphology, and on climatic conditions.

Data for the rate of carbon sequestration by urban trees are still scarce; most data are given in tons per year of carbon per hectare of forested land, even in the cities, where trees are often in lines (Nowak and Crane 2002). However, a few authors have analyzed the carbon sequestration by individual tree species (e.g., Akbari 2002). The calculations yielded an average of about 4.6 kg yr^{-1} calculated over the life of a tree. With ongoing trees growth, the rate of sequestration increases. The average sequestration rate at maturity was estimated at about 11 kg yr^{-1}. If planted in Los Angeles, the same trees avoid the combustion of 18 kg of carbon per tree per year, thanks to the indirect reduction in the cooling/heating energy use of buildings. Vehicles are by far the largest contributors of CO_2 in urbanized area (Koerner and Klopatek 2002). A tree planted in close proximity to the pollutant source may be more effective in mitigating pollution. Planting efforts must focus on putting the right tree in the right location, for example in parking lots. A consistent pool of carbon can be stored in urban forest soils. However, very little data exist to assess how urbanization affects soil carbon (Pouyat et al. 2002).

Vegetation directly captures particulates on its leaf surface. The particulates are either trapped on the surface, or directed onto the ground with precipitation. However, 'uptake rates' have not been measured for many European amenity trees. Therefore, only limited advice can be given on how to best design urban plantings in order to optimize vegetation uptake of particulates. Clear understanding of the principle factors, which determine capture efficiency, like the species-specific velocity of particle deposition, is also required (Beckett et al. 2000).

Gaseous pollutants may be directly absorbed into the leaf through stomata, and indirectly adsorbed by physical surface reactions. It is clear that the deposition of gases and of particulates is greater in woodlands than in shorter vegetation. In addition to having greater leaf areas than other types of vegetation, trees create more turbulent mixing of the air passing over land.

Research integrating the cumulative effects of urban vegetation on air quality, particularly on O_3, is very limited (e.g., Nowak et al. 2000). Usually, the higher the losses of forested area are, the higher the increase in O_3 concentrations. Although there are fewer trees to emit hydrocarbons, an increase in air temperature, concomitant with tree loss, increases biogenic VOC emissions from the remaining trees and from the anthropogenic sources.

Urban Trees As Source of Pollutants

Trees emit volatile organic compounds (VOC) that may contribute to air-quality problems. The term VOC includes organic atmospheric trace gases others than CO_2 and CO. They are isoprenoids, isoprene and monoterpene, as well as alkanes, alkenes, carbonyls, alcohols, esters, ethers, and acids. Isoprenoids are the most prominent compounds. Their role is to protect plant membranes against oxidative stress by O_3, drought and elevated temperatures. Atmospheric concentrations of biogenic VOCs range between a few parts per billion (ppb) and several parts per trillion (ppt), as they are very reactive, with a chemical lifetime ranging from some minutes to hours. Concentrations reflect several factors, such as anthropogenic and biological sources or sinks, meteorological factors, chemical reactivity and deposition. Isoprenoids are involved in troposphere-chemistry, by directly or indirectly fueling the production of air pollutants and greenhouse gases, such as O_3, and increasing acidity as well as the production of aerosols.

11.4 Urban Soils in Europe

Soils are one of the most important natural resources and act as the interface between atmosphere, lithosphere and plants. The rapid sprawl of urban areas leads to soil degradation or total soil loss. Thus, the public awareness for soil science activities especially in urban areas increases, and the attitude of city planners, landscape architects, and contractors towards urban soils has changed. Just in his 1992 book *Urban Soils in Landscape Design*, Craul defined urban soils as being 'a soil material having a non-agricultural, manufactured surface layer more than 50 cm thick, which has been produced by mixing, filling, or by contamination of land surfaces in urban and suburban areas'. Only in 1999 the same author had to revise this generalizing definition, because it can be applied neither for the US nor for the European situation. The key roles of soils in any terrestrial ecosystem are to

- support the growth of organisms, mainly by providing a physical rooting medium and supplying air, water and essential nutrients,
- control the fate of water in the hydrologic system, including water loss, utilization, contamination and purification,
- recycle nature's waste products by making the basic elements available for reuse and storing released carbon, nutrients and pollutants,
- function as engineering medium in human built ecosystems.

Human activity modifies the natural 'soilscape' and makes the functions of urban soils, as an environmental interface restricted, altered, severely changed or totally lost. Depending on the intensity of urbanization, European urban soils represent a wide variety between naturally developed soils with intact soil functions, towards disturbed and altered soils, that might have lost their environmental key role and totally artificial, mixed, technological prepared or designed substrates with any variation in between. Urban soils can just carry urban infrastructure or be developed out of building rubble. They can even become time bombs containing organic and inorganic hazardous compounds. This conflicts not only with their function as vegetation sites, but makes them a human medical or phyto-sanitary threat.

11.4.1
Is Soil Taxonomy a Useful Tool in Urban Forestry?

The study of the soil profile yields much evidence as to the capabilities and limitations of the soil for plant growth and other uses and even under highly disturbed urban conditions the examination of the soils profile is profitable and necessary. The knowledge of the ecological properties of soil units and their spatial distribution delivers basic information not only to understand the landscape but also to understand specific soil factors for urban planning and for information exchange with policy makers. Even if urban soil profiles have an appearance totally unlikely natural soil profiles, an agreed vocabulary in terms of nomenclature for soil horizons and classification into specific soil units using an agreed taxonomy may be important tools, provided it uses specific properties for urban use and relate to parent material, topography, climate and vegetation.

Soils in urban regions are extremely heterogeneous: settlements were founded on various parent materials or on existing soils. In urban areas several natural lithogenic and pedogenic processes as well as anthropogenic influences contribute to a different extent to the morphology and ecological properties of top- and subsoil profiles; this magnifies the problems for soil taxonomists. Contrary to the common idea that urban soils are static soil systems, several dynamic processes that form and develop soil morphology take place due to big gradients in physical and chemical properties. Compared to more or less natural soils the vertical and spatial variability of urban soils is generally higher, their development is faster due to maintenance practices and 'anthropogenic heritages', peculiarities of urban climate and non-indigenous urban vegetation. Urban soils can be seen as a part of cultural ecotypes, so the type of land use is highly affecting their development.

Genetic Versus Effective Classification Systems for Urban Soils

The mosaic patterned distribution and high variability of urban soils makes it difficult to integrate them into existing genetic soil classification systems for 'natural' soils. Several ecological forms of soils can be observed in urban environment and can be attributed as a product of urban utilization with some generalization to urban vegetation types thus creating an effective taxonomy according to their usability:

- Natural soils: They are comprehensively described in several scientific books on nature and properties of agricultural or forest soils. Natural soils may be found in urban settings, like urban forests.
- Originally natural, but disturbed soils: They are in various stages of degradation or melioration. They are the rooting substrate for various urban vegetation types like urban woodlands, parks, gardens, playgrounds, cemeteries, roadside trees etc.
- Remediated soils: They derive, for example, from reclaimed mining sites or waste deposits and various vegetation types cover these soils.

- Artificial soils: They are created unintentionally or on purpose. In the first case, they may be mixtures from various 'parent (recycling) material' like building rubble, horticultural soil, deposits, ash, slag, waste material and sludge. For the latter a layer of specific growth substrate on existing subsoil with variations mostly in organic content is applied. Designed soils serving as substrates for planting pits underneath pavements or for unpaved areas or rooftop garden soils are in this group.

Genetic Taxonomies for Urban Soils

A worldwide used international classification system, the World Reference Base for Soil Resources (WRB: FAO 1998), offers a general nomenclature combined with a genetic categorization of soils in urban areas and gives a large scale, general information. WRB focuses on subsoil and lacks systematic categorization of humus and topsoil characteristics, and offers the general reference soil group 'Anthrosol', describing soils, which are highly impacted by human society. Further anthropedogenic diagnostic horizons with diagnostic properties and anthropedogenic processes can be attributed that form these horizons and define lower level units. WRB provides taxonomic possibilities due to anthropogeomorphic material, which is unconsolidated, produced by human activities and not subjected to a sufficiently long period to find significant expression of pedogenic processes. For different urban soils the WRB taxonomy ends up at 'urbic Anthrosol' which is not precise enough to deliver the necessary information for non-scientific users like landscape architects or contractors.

There are attempts to include topsoil taxonomy in the future, because of the high ecological importance of the topsoil horizons. A draft version of an expert group was already delivered, however the WRB, as many national soil classification systems, is poorly adapted for the urban situation.

National soil classification systems are applied for urban purposes using lithogenic and pedogenic properties combined with ecological conditions they provide for vegetation on a more regional scale (e.g.: UK: Avery 1980, D: AK Bodensystematik DBG 1998; F: Baize and Girard 1998). The advantage of most national classification systems is that humus characteristic and topsoil properties are main features for categorization. This helps to add ecological properties in narrow spatial and temporal scales.

In a few European countries, national soil classification and taxonomy with separate key-groups or classes or types of soils from urban regions are established and can partly be linked to WRB. The common intention is to distinguish between totally artificial technogenic soils and soils influenced by urban land use and management and to implement positive (ameliorative) or negative (toxic) properties: e.g. CS: Nemecek et al. 2001; F: Baize and Girard 1998; D: AK Bodensystematik DBG 1998; SF: Yli-Halla and Mokma 1999. For Slovakia Hraško (1990) published a scheme representing the full catena of soils in the urban environment and attributing ecologically positive and negative features.

Any attempt to find an agreed European classification system for urban soils that uses observable chemical, physical and biological properties as criteria should be encouraged. This may help to find a vocabulary to communicate between soil scientist and users.

11.4.2
Analytic Tools for Urban Soils and Urban Vegetation

To examine soils for their suitability for urban greening, soil physical and chemical analytic methodology is an important tool. This includes determination of texture, structure, pore size distribution, bulk density as well as chemical parameter like total element contents in soils as well as different degrees of element solubility and availability or adsorption of nutrients and toxic elements or organic compounds. Chemical analytic results are an important tool to distinguish not only the nutritional state of urban vegetation but also pollution. There are no European standard procedures concerning sampling techniques for soils and foliage, neither for season nor for crown part nor for soil horizon or soil depth.

Analysis of Soil Physical Properties

Soil texture refers to the mineral matter in a soil and includes only particles smaller than 2 mm. It is defined as the proportions of different particle sizes and it is important to understand soil behavior and management. The main particle sizes are sand, silt, and clay. Their proportions are arranged in the textural triangle. Several specific soil textural classes' names convey the idea of particle size distribution; unfortunately, their classification differs between countries.

In the field particle size distribution can be determined by the 'feel method': samples are pre-wetted, kneaded, smeared and rolled between the palms and fingers. Texture class is determined to these observations (Brady and Weil 2002). The accuracy of the obtained results is highly dependent on experience, but is sufficient for practical application.

More detailed information on particle size distribution delivers laboratory particle size analysis: after humus-oxidation, the fine soil is dispersed. The sandy fraction is determined using various sieve meshes. For separation of the silt and clay fraction sedimentation methods are used. According to Stoke's Law the settling velocity of a particle is proportional the square of particle's diameter. This principle is used for any sedigraphic method to distinguish the percentage of particle classes smaller than the sand fraction.

For practical use, textural classes of fine soil have to be linked with the abundance, size and form of coarse mineral fragments with a diameter >2 mm, e.g., stones, gravel, cobbles, which are considered to be more or less inert, but contribute only by their physical presence thus severely affecting water balance and aeration.

Soil structure is a descriptive feature for the arrangement of mineral soil particles and organic matter forming aggregates or soil peds. The pore spaces between structural peds influence any parameter related to rooting-ability, like bulk density and soil hydrology. An accurate description and interpretation of soil structure can help to distinguish these specific soil properties.

Soil particle density is defined as mass per unit volume of soil solids, so it is essentially the same as specific gravity and not affected by pore space. It varies in narrow limits for the most mineral soils (2.6 and 2.75 g cm^{-3}). If it is not exactly determined, a value of 2.6 can be assumed for soils with organic matter content up to 5%, for soils high in organic matter it ranges between 0.9 and 1.3 g cm^{-3}. Pycnometric methods are used for exact determination.

Bulk density is defined as the ratio of the mass of dry solids to the bulk volume of the soil including both solid particles and pores. Soils with a high proportion of pore space have a low bulk density, compact or artificially compacted soils with low pore space obtain a high bulk density. An agreed method for determination is the core method: the dry mass of a soil sample with a known volume is determined. Bulk density is affected by soil texture and management practices, like soil compaction, and affects soil strength and root growth, which can be summarized as penetration resistance.

Penetration resistance can be measured by various penetrometer techniques. Metal cones are usually used as transducing elements to measure vertical penetration resistance, not taking into account that penetrometer are not comparable to roots, which are flexible organs and grow into pores between aggregates. Penetrometer techniques are frequently unreliable in stony or very dry soils. Nuclear gauges are suitable for soils with less than 5% organic matter and give easy, reliable values just for the surface horizon (Randrup and Lichter 2001). Various mathematical models for soil processes that are valid for e.g. water flow in highly compacted soil are concepts that can be applied especially in anthropogenic soils and are based on parameter like swelling and shrinkage, volume changes, hydraulic conductivity and water retention.

Soil colour has little effect on the behaviour of soil, but it is a valuable clue for specific soil properties. It helps to distinguish organic matter content, soil development stages, hydrologic features like drainage classes and aesthetics. Munsell color charts are used for determination.

Determination of Chemical Properties

All over Europe, there is a high variability in laboratory methods especially for chemical soil analyses and to a minor extent for analysis of vegetation sample. Sample preparation, sample pre-treatment and measuring techniques are not internationally standardized. On national level in most European countries, standards for analytic procedures exist. In most cases these national standard procedures differ for agricultural and forest soils and sometimes for the respective vegetation. In some European countries (e.g. A, F, D, NL) rather strict respective analytic frameworks are used. The impact of analytical work during the extensive period of forest dieback research in the ’80s and early ’90s is obvious.

It is common for all directives that they are not specially adapted for urban forestry use. It depends on both the experience and the commonly used methods of the concerned laboratory, which methods are applied for urban soils and urban vegetation. This may be a restriction for the applicability, especially of soil chemical data for practitioner in the field of urban forestry. Therefore, it is generally unlikely that analytic data from different countries are comparable. Published analytic data without knowing the entire methodology are useless as references for interpretation and practical application. It is an urgent need to find European methodological harmonization to strengthen the analytic tool for problem-oriented application also within urban forestry. Examples of helpful publications, which may be fundamental for further harmonization of chemical analytic methods in urban forestry are Kopinga and van den Burg (1995) and Stefan et al. (2000, on-line site http://fbva.forvie.ac.at).

Apart from these basic problems, analytic results for urban vegetation can be evaluated on existing references for threshold values for nutrients as well as for pollutants and toxic elements and compounds. However, these threshold values cover a broad range (Bergmann 1993; Kopinga and van den Burg 1995), and are not specific for urban application. In national laws and regulations threshold values for air pollutants using contents in leaves or needles as indicators are reliable references as well as figures for appropriate nutrient supply. Because of the incomparability of analytic procedures and the numerous interactions between various soil properties and vegetation, the evaluation of soil analytic data is even more complicated. For instance, heavy metal contents in soils are mostly published as 'total' contents, but their plant availability is highly dependent on soil pH, humus content and speciation of the concerned element, induced Fe- and Mn-deficiency in plants on calcareous sites is well known. For some elements, e.g. phosphorous, soil contents may be low, because they are effectively translocated in the plant and via litter decomposition recycled, so low soil contents are no general indicator for deficiency.

A ranking of the importance of chemical soil analysis that give basic information about the suitability of soil for urban forestry could be: pH; organic matter; CEC; contents of P, K and N; Mg; Al; electric conductivity (soluble salts); adsorbed Na for soils with salt impact; Fe and Mn for soils with an pH above 7.5. The determination of micro- or trace-elements such as heavy metals is normally not taken into consideration unless a suspect of element deficiencies, impurities or toxic levels arises. This is also true for specific organic compounds, organic chemicals and contaminants, that can be quite abundant in urban soils.

11.4.3 Urban Soil Properties

Water Balance in Urban Soils

Variations of the amount of available water explain 70 to 80% of the variation in tree (diameter) growth in forests. Unfortunately, there is little scientific evidence for actual water utilization by individual street trees. In temperate climates, solitary trees need about 800 l water per m^2 crown projection per year for unlimited growth. This value reduces to 600 l water for trees in a row. Generally, 40% of this amount is considered to be the absolute minimum for vital growth. When roots reach the groundwater table or sufficient capillary rise is provided, there is generally no water shortage, apart from the first years after planting, when the root system is confined. In case of no groundwater availability, the soil water storage capacity and soil water availability are the critical values. Reference data on water storage capacity, macro-pore space and plant-available capacity for different texture classes are available (e.g., Craul 1999). Related to data on potential evapo-transpiration of a tree species and precipitation a simple water budget calculation can be done. Calculated soil moisture deficits can be used to design the appropriate irrigation management.

Urbanization adds new structures and impervious, paved or roofed areas to the watershed that intercept rain and precipitation. City trees planted in pits surrounded by asphalt or concrete are supplied with very little water during summer and frequently too much water during the dormant season. Surface runoff occurs more rapidly: depending on the percentage of paved and built up areas water storage and infiltration are reduced to nearly zero, so less precipitation is feeding urban vegetation. The sealed percentage ranks between 0% for urban forest, up to 15% for parks, cemeteries and playgrounds, up to 50% for family houses and 90% for dense built up areas and industrial zones and it can reach 100% in the city centers. Building density also influences the temperature balance and the evapo-transpiration thus intensifying the water shortage. Additionally sealing and soil compaction change the hydrological features of the remaining soils as well as maintenance, like changes of the amount of coarse material, addition of technogene substrates and of material high in humus. Altogether, influence the main features of the soil water cycle like water storing capability, hydraulic conductance as well as capillarity. Lateral water movement is somehow limited at urban sites.

Because precipitation is often treated like wastewater, groundwater formation is reduced and leads to groundwater drop, which increases drought problems for urban trees. In regions where urban vegetation is rooting near the groundwater table the problems are different: Urban soils play a key role in bio retention of storm water, but as evaporation of the paved surfaces is less, the storm water runoff increases and leads to severe fluctuation of groundwater level. This contributes to low vitality of urban trees at these sites. In some European cities costly irrigation measures are the only remedy to rescue city trees from drought in others the groundwater fluctuation leads to severe aeration problems and technical measures have to be set to improve stagnant conditions.

Measures to mitigate the deterioration of the urban water cycle are to open paved areas or to use permeable pavements and allow higher infiltration. Integration of natural rainwater in urban water management and urban planning processes are important tools to reduce drought. Species depending crown architecture may contribute in different percentages to reduce interception.

Physical Soil Properties

The urban situation tends to destroy soil structure, and thus soil compaction and surface sealing are severe problems for urban vegetated areas. Soil compaction occurs as surface or subsoil compaction due to pedestrians, riding, biking, vehicle traffic, parking, traffic vibrations, construction activities, wrong soil preparation techniques and maintenance. Urban climate with a low frequency of wet-dry or freeze-thaw cycles, that naturally enhance aggregation and structural formation, is also a prerequisite for compaction.

There is a direct relationship between soil compaction and inhibited plant growth. At compacted sites root development is restricted and root morphology is deteriorated (Brady and Weil 2002). The physical resistance of highly compacted soils impedes root penetration, because tree roots tend to follow paths of low resistance. In compacted soils, root systems become shallow and sparsely branched. Further, in compacted soils, direction of water and nutrient movement is changed and movement rates are slower. In rain fed sites, thus the susceptibility to drought increases and the efficiency of nutrient Utilisation is reduced. Water availability is reduced, pronounced in the range close to saturation.

The degree of soil compaction highly depends on soil texture and organic matter content. Soils with high clay contents (30% and more) are easier to compact than lighter (sandy) textures. Soil compaction increases bulk density, soil particles are packed closer, and porosity decreases. Compaction affects not only total porosity but also pore-size distribution. Coarse, structural pores (10–50 µm in diameter), that are responsible for soil aeration, water infiltration and hydraulic conductivity, decline as well as medium sized capillary pores (0.2–10 µm in diameter), that mostly store plant available water. In the large pores saturated flow and gaseous diffusion occur. Compaction does not affect the fine textural pores <0.2 µm, but it alters pore geometry: pores become interrupted or thorn; artificial shearing processes aggravate pore disruptions, pores become relict (Richard et al. 2001). Under wet conditions, soils high in organic matter are more resistant against compaction than soils low in organic matter.

Roots tend to follow the path of least resistance, favoring former root channels and coarse pores from soil fauna. Macro-structure should be granular, crumbly or fine subangular blocky. In well-textured and structured soils pores can make up to 60% of soil volume, and function as channels for air, water and root growth. Good microstructure has at least 40% pores, preferably 50%. In pure sand the bulk density should not be higher than 60% of maximum soil particle density (specific gravity), calculated with the mean value for rocks of 2.65 g cm^{-3} this makes 1.59 g cm^{-3}. For soils with organic matter, the bulk density should be much lower (1.1 g cm^{-3}). Bulk densities ranging from 1.45 g cm^{-3} in clays to 1.85 g cm^{-3} in loamy sands generally limit the growth of roots into moist soil (Harris et al. 2004).

A high penetration resistance can be a barrier for root growth, water and nutrient uptake. A penetration resistance of 1.0 MPa is often regarded as ideal, while it should never exceed 3.0 MPa. The maximum tolerable penetration resistance is highly dependent from soil texture: in clay soils it is lower compared with coarse textured soils (Glinski and Lipiec 1990).

Soil compaction leads to low soil aeration. Gas diffusivity and exchange with the atmosphere are reduced. Plants vary widely in their response to oxygen deficiency in soils. To provide roots with enough oxygen, at least 10% of the pores should be air-filled, preferably 20–25%. Soil air with less than 10% oxygen will cause root damage, while oxygen contents of 16% or more in the soil guarantee good root growth. These percentages should be present when the soil is at field capacity (Glienski and Lipiec 1990).

Good drainage of soil maintains adequate soil aeration; the groundwater table should be at least 50 cm below ground level in the dormant season. Site morphology and soil texture and structure highly influence the hydraulic conductivity of soils and should be optimized. If amelioration of stagnic conditions is impossible, selection of tolerant species is the only remedy.

Generally oxygen diffusion rates of less than 35 µg m^{-2} s^{-1} limit root growth. Poor soil aeration and changes in thermal balance influence many soil reactions and soil properties that are mostly associated with rate and nature of microbial activity. Poorly aerated soils contain partially oxidized products, which can be toxic to plant roots and many decomposing and structure forming soil organisms (Glinski and Lipiec 1990). Losses of soil structure together with changes of thermal balance reduce the microbial activity and the decomposition and mineralisation of organic substances. In compacted soils nitrification and carbon-mineralisation are significantly lower, availability and cycling of nutrients in the soil/plant continuum is retarded (De Neve and Hofman 2000). Low soil oxygen contents have a high impact on the availability of mineral elements: e.g. N- and S-availability is reduced as well as for Fe and Mn. The redox potential determines the speciation and thus the toxicity of elements like Cr or As in contaminated urban soils and affects the availability of heavy metals.

The least permeable horizon controls water flow and gas diffusion: the nearer this compacted horizon to the surface is, the greater the influence on plant vigor. A compacted subsoil horizon may affect water movement and aeration of the entire soil profile and create stagnic conditions like in anaerobic water logged soils. Even then, water supply of trees may not sufficiently be covered, because water potential of the high percentage of fine pores is too high. A compacted surface soil horizon is highly detrimental. Depending on soil water content and compaction level, the soils exhibit changes of infiltration rates that are generally ten times lower compared to uncompacted soils. Surface soil compaction enhances erosion of soil material and plant debris because of increased velocity and power of runoff. As a consequence, precipitation and nutrients are lost for plant growth. Falling water drops on bare surfaces can beat apart the aggregates exposed to the soil surface. Dispersed particles tend to be washed into clogs and pores as soon as the surface is covered with so-called surface seal. A horizontal orientation of fine particles occurs, creating micro-layers. This inhibits water infiltration and increases loss through erosion. When drying, hard crusts are formed that can hardly be rehydrated. Like soil compaction surface sealing increases surface runoff and restricts water infiltration into the rooting zone; unproductive evaporation increases, water storage and ground water regeneration decrease, capillarity is minimized. As in compacted soils extreme topsoil temperatures are more frequent and pronounced under sealing crusts.

'An ounce of prevention is worth a pound of cure' is a saying, which is true for any kind of negative ecological impact. It is obvious that careful planning, designing and maintenance of urban tree sites can prevent or minimize soil compaction. Separate the compactor from the soil surface or use soil coverage, that protects the tree disk and the root system are general demands. Careful planning and integration of design and maintenance features that prevent or minimize the effects of compaction and sealing obviously improve the growth and survival of trees and shrubs under stressful urban conditions. Humus plays the major role in conservation of well-aggregated soils by attracting soil-fauna that produces stable aggregates. Vegetation cover prevents bare soil surfaces, and keeps the soil structure sufficiently stable, allows rapid water infiltration and prevents crusting. Mulching the soil surface with plant residues not only mechanically prevents surface compaction, but it encourages earthworm activities and protects the soil aggregates from beating rain and from solar radiation.

For already compacted soils mechanical loosening and refilling the artificial holes with sand improves aeration. Air injection or mulching with wood chips and gratings for topsoil protection are accepted remedies, whereas the positive effect of organic polymer addition is not yet scientifically proved. By choosing species with high rooting intensity and root deformation resistance rooting itself has a positive effect on soil structure. Roots create macro-pores and release organic debris for structural stabilization into the mineral soil.

11.4.4
Chemical Features of Urban Soils

Urban soils show chemical human impacts; compared with natural soils their pH, element cycling and nutrient availability are altered. Their node function as nutrient source and buffering system or as detoxification medium is restricted or imbalanced. Fertilizer or compost application, atmospheric pollution and outwash via stem-flow, heavy metal contamination from various sources, de-icer from winter maintenance, contaminated irrigation-water, debris from exotic species, litter removal etc. contribute to chemical deviations from the natural element budgets and have additive or antagonistic effects.

Fertility of Urban Soils

Usually the foliage of most urban trees is acceptably green even though nutrient deficiencies and nutrient imbalances or even toxicities may significantly limit their growth. Generalizing: the more natural the urban site and vegetation type, the less nutrient deficiencies and imbalances occur. For urban soils, it is difficult to ascertain the origin of parent material and vertical and spatial variability is high. Soil testing and fertilization to ensure good vegetation growth is also important. However, for arboriculture applications there is still an information lack concerning nutrient requirements of the respective species.

Organic matter is a major energy source of soil biota, which brings nutrients back into the cycle. Urban soils generally lack organic matter and its nutrient contribution, because nutrient-containing litter is removed during maintenance. This deteriorates not only carbon pools and fluxes but also influences nutrient cycling and has via changes of soil inhibiting organisms a severe impact on nutrient availability. Off-site litter disposal removes high amounts of valuable plant nutrients and accumulates them elsewhere. On the other hand, the positive side effect is the removal of toxic elements and biotic stressors. Because of frequent compost application and intensive tillage combined with a relatively closed nutrient cycle soils of urban gardens and parks show higher nutrient contents compared with street tree sites, which have a severely deteriorated nutrient cycle. The nutrient cycle of urban woodlands are nearer to the natural, but still show the impact of urbanization e.g. air pollution.

Without permanent remediation, the nutrient supply for urban street trees becomes insufficient or unbalanced. Soils of urban street tree sites have a restricted nutrient availability and potential for several elements; N, P, K, and Mg are frequently lacking elements; the humus contents are low. The majority of tree species prefer soil-pH between 4.5 and 7.0. There are exceptions: One should check for the respective tree species (see e.g., Warda 2002). Soil-pH influences many processes, such as the release, availability and uptake of nutrients and pollutants from the soil. A pH below 4.0 that is present in soils, increases availability and uptake of heavy metals and can cause manganese and aluminum toxicity. Soil-pH above 7.5 can cause shortage of Fe and Mn.

Calcium depletion is also typical in acidic soil. Depending on parent material all over Europe pH of urban soils is highly variable. In humid regions of the north acidic soils with low base saturation predominate, in middle and south Europe soil-pH is mostly too high for several tree species. High soil pH increases antagonistic phenomena and malnutrition of urban trees: in alkaline substrates, the plant availability of micronutrients like B, Fe, Zn, Mn and Cu is reduced because they remain insoluble. The positive effect of soil-alkalinity is that toxic elements like Al or Pb remain unavailable for root uptake. High soil pH influences quality and quantity of mycorrhiza, alters fungi species composition, diversity and vitality; urban trees have less mycorrhiza, which enhances the nutrient deficiency. Fertilization or organic amendment fails as long as the pH has not been adjusted. The pH may be lowered by application of one of several sulfur compounds or by addition of acidic organic matter. Raising of pH by liming is the common practice, which also has a long-time effect. Both lime and sulfur-compound application is more effective when mechanically worked into the soil.

For improving nutrient levels of alkaline soils acidic, slow-release fertilizers are proposed, but changes in availability of mineral nutrients or toxic elements by simultaneous adaptation of soil pH have to be taken into account. Antagonistic and synergistic effects of the fertilizer constituents have to be kept in mind and basic knowledge of the respective soil nutrient concentrations are helpful. Technique and timing of amendment application are controversial topics. Both surface fertilization in the forms of application or injection into deep horizons have advantages depending on soil textural distribution and the respective element. Two examples: because of their high mobility soluble nitrogen- or potassium-fertilizer applied on top of a soil with high hydraulic conductivity will quickly reach the main rooting horizon, immobile phosphorous will remain on top. Slow release fertilizer injections into the soil or packed under tree balls at planting might guarantee sustainable nutrient supply and deep rooting. Because of maintenance methods, soils of urban tree sites are generally poor in nitrogen. As nitrogen is the most important element for tree growth, excessive nitrogen input to soils may cause nutrient imbalances. The uncontrolled application of agro-mineral fertilizers (e.g., NPK) may lead to high soluble nitrogen contents in urban soils.

Sustainable remedies to improve the nutritional situation for urban trees are in situ recycling of urban vegetation litter. This has to be handled very carefully because of possible chemical and biological contamination of vegetation debris. Recycling of urban tree litter in situ contributes to biological urban soil improvement, delivers adequate organic material for soil fauna and helps to save money. Under-planting with shrubs can provide litter protection, humus layers are formed by development of 'more natural' structured vegetation, which has the positive side effect of decreasing temperature gradients. It improves soil gas balance and living conditions for soil biota. E.g. trees with grass-covered disks are better nitrogen-supplied despite of root concurrence, because of lower denitrification-rates due to less soil compaction (Nossag 1971).

Nutrient losses are partly compensated by other sources like fertilization, compost application, mulching, particular deposition or construction debris. Provided quality control they are appreciable soil amendments. Organic soil conditioners function as slow release fertilizers and improve deteriorated soil physical properties. Because of maintenance methods, soils of urban tree sites are generally poor in nitrogen. As nitrogen is the growth-determining element, excessive nitrogen input to soils may cause nutrient imbalances. The uncontrolled application of nitrogen-containing fertilizers may lead to high contents of soluble nitrogen in the soils, which may be washed out to the groundwater table.

Nitrogen emission to urban soils coming from intensified agricultural production and animal husbandry in the agricultural-urban interface represent the type of a point source. E.g. in recreation forests near poultry farms N-inputs of 80–120 kg N ha^{-1} yr^{-1} were measured (Sieghardt and Hager 1992). This induced rapid growth and depletion of other nutrients and had a severe impact on nutrient balance of trees; tree vigor and frost-resistance were reduced. Some fertilizers like urea or ammonium-sulfate are used as additives for de-icing products for paved pathways or pedestrian areas. N-containing de-icers induce over-fertilization of soils and eutrophication of water and enhance nutrition imbalances for vegetation. They increase transpiration and deteriorate the soil nitrogen cycle. In alkaline soils they contribute to gaseous nitrogen losses. For Vienna (A) these additives are already prohibited. Tree sites where people frequently walk their dogs are severely affected. Dog urine contains high amounts of P and NH_3, and has a low C/N-ratio. It is alkaline and highly corrosive for above ground plant parts. Via stem flow the trunks and root systems are osmotically affected, bark-colonizing algae die as well as the tissue under the bark. Wood decaying fungi penetrate into the trunk. Later nitrification of NH_4 causes soil acidification and an increase of water-soluble mineral compounds (heavy metals release), and unbalances plant nutrition (Balder 1998; Balder et al. 1997). Even if these sources are just selective and affect trees locally, they can be severe stressors for urban greenery in high-populated urban areas.

Chemical Pollution of Urban Soils

In urbanized areas a large number of inorganic and organic elements and compounds deriving from different point or non-point sources end up in the soil. Depending on the respective pollutant, concentrations and exposure time, soil contents may go beyond toxicity levels, contaminate, and degrade the soil. They contribute to unfavorable soil conditions for urban vegetation. The special features of urban climate and urban water cycle influence the distribution of pollutants, emitted as gases, particulates or liquids. Direct contamination by discharging from sewer systems is another possible source. Sometimes chemically polluted soils require remediation not only to provide an appropriate growing medium but because they have become medical threats for urban people at least for young children with their 'hand-to-mouth-activity'. The sources and pathways of hazardous substances in urban soils are generally as described in Table 11.2.

Table 11.2. Sources and pathways of hazardous substances in urban soils

Pathway via	Form	Source
Atmosphere	Solid particles (dust), liquids (acidic rain), gaseous (N_{ox}, SO_2 etc.)	Industry, manufacture, traffic, combustion, domestic heating
Hydrosphere	Contaminated suspended matter, adsorption of dissolved compounds	Sedimentation, percolation- and groundwater
Natural wind and water erosion- and accumulation processes	Contaminated particles, dissolved compounds	Litter and particles from various sources
Anthropogenous applications	Diverse contaminated solid substances and liquids	Oil, rubble, debris, ash, slag, sewage sludge, compost, reclamation of dumps, etc.

Salt Stress, De-icers

Salinisation is a serious but often underestimated ecological problem. De-icing agents contribute to a high extent to salt-damages of urban trees and roadside forests. In several European countries, natural marine aerosol deposition plays a role in soil salinisation. Less frequent causes for saline growing conditions are salty groundwater or naturally halomorphic soils. The impact of marine aerosol on vegetation intensifies the problems caused by de-icing salt application. For marine-aerosol impacted sites, deposition rates of up to 80 kg Cl ha^{-1} yr^{-1} are reported. The increase of storm frequency during the last 30 years and the inland transport and deposition on rough surfaces like urban woodlands and street trees are, intensify salt stress in coastal areas (Gustafsson and Franzén 2000).

Sodium chloride (NaCl), the most common and cheapest de-icer, is very efficient in terms of improving traffic flow during winter. However, even when applied in low doses as wet salt or brine it contributes to less vital urban trees. Salt is highly soluble and reaches the tree soil directly by splash, surface run-off, as ploughed snow, as spray or aerosol. It migrates through the soil, is taken up by roots, and finally may reach the groundwater table and the underlying aquifer. The salt can persist in the subsoil and hydrologic environment after the end of the de-icing period for a long time.

Salt-sensitivity of species and even strains within a species differs. Both salt ions are taken up by trees in various ratios, Cl being considerably preferred, because of active anion uptake channels and preferential Cl-influx. Salt tolerance of trees seems to be directly related to the extent of Na- and Cl-intake and to the degree of salt retention in roots and stems. The extent of ion accumulation differs markedly among species: Maple, Lime, Chestnut, Cherry and Ash accumulate Cl, whereas in Plane, Locust and Walnut leaves Cl-contents are lower; Birch, Hackberry and Oak prevent both salt ions from being translocated into the leaves. Taxa originating from warm and dry climate (Plane, Locust, Hackberry, Oak) are more salt and drought tolerant. Therefore, the search for salt tolerant species focuses on species that exclude Cl. Several authors give species-lists according to salt sensitivity. A comprehensive study can be found in Dobson (1991), where it is also shown that sensitivity rankings differ between scientists.

Gibbs and Palmer (1994) report that after a severe winter more than 35% of the London road trees showed salt damages depending on road class and tree species. This extrapolates to 20 000 damaged trees in the city of London. Salt reaches the site partly via salt spray: 20–60% of the de-icing salt applied on the road is transported by air and deposited 2–40 m distant from the road; depending on wind speed, transport distances of up to 100 m are reported. 90% of the aerosol is deposited in a distance in between 20 m. (Blomqvist and Johannson 1999).

Concentrations of Na^+ and Cl^- in the soil that exceed by far the demand for both ions – chloride is an essential micronutrient and sodium a mineral nutrient for some C_4-species – have primarily two impacts on plants: osmotic effects and specific ionic effects (see Fig. 11.5). Salt lowers the osmotic potential of soil water, soil becomes physiologically dry; this requires that plants spent more energy for making osmotic adjustments. As counteraction, plants accumulate organic and inorganic solutes to lower the osmotic potential inside the root cells. This lost energy investment induces growth-reduction. Young roots may loose water to soil solutions high in salt content; the root cells collapse and the lifespan of root hairs becomes short.

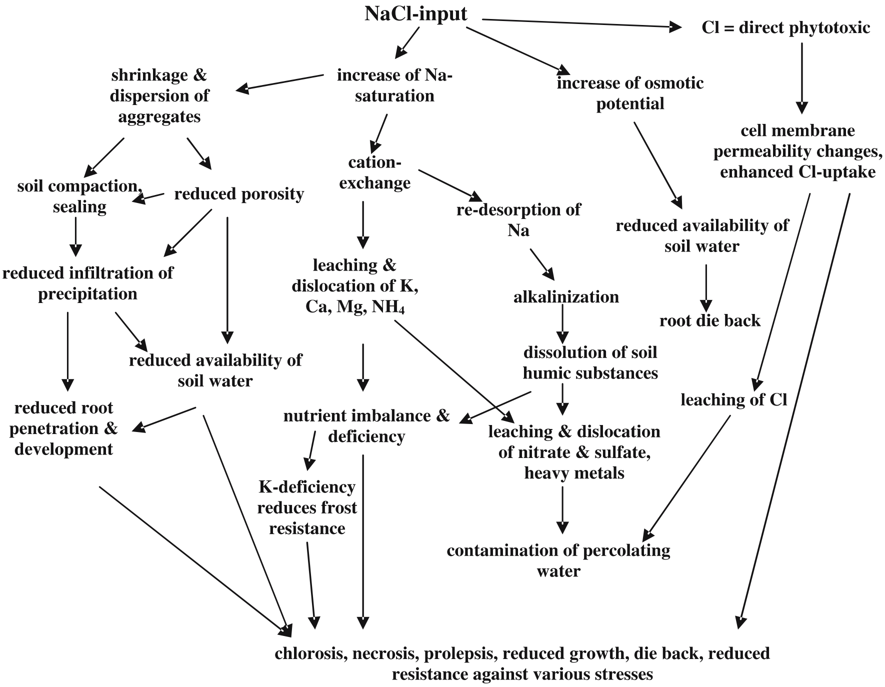


Fig. 11.5. Impact of de-icer NaCl on vegetation and soil properties (modified after Sieghardt et al. 2001)

Salt accumulation in the apoplasm of leaf-cells is an important component of salt toxicity, leading to dehydration, turgor loss and death of cells and tissues. At high soil salinity, growth depression may also originate from inhibited nutrient availability in the soil, inhibited nutrient uptake, transport and utilization. Sodium is only transferred to leaves at very high concentrations in the soil solution. High levels of Na^+ in plant tissues can cause imbalances of other cations, for example Na^+ competes with K^+. Sodium contents in leaves are significantly correlated with the degree of visible salt damage. In trees with Cl-accumulation an enhanced uptake of K, sometimes also of Mg, Ca and Na is obvious to encounter for the high anion-concentrations. This increases the total electrolyte content. Simultaneously the quality of organic acids changes, their quantity decreases. Ion pattern of salt sensitive species is dominantly changed due to salt stress and leads to uncontrolled transpiration (Trockner and Albert 1986).

Salt impact deteriorates physical and chemical soil properties: Cl is highly mobile, percolates quickly through the soil and contaminates groundwater or aquifers. High Na-saturation in the soil solution leads to competitive cation exchange: nutrients like K, Ca, Mg or NH_4 are desorbed (removed from), leached and lost for tree nutrition. There is some scientific evidence that via mobilization of humus substances salt application has an impact on heavy metal mobilization. Provided severe salt contamination soils become alkaline, organic matter is extensively mobilized. Bio-available concentrations of heavy metals are elevated, because of ligand complexation and competitive exchange affected mobilization. Soil aggregates collapse due to Ca-deficiency, which enhances the susceptibility for soil compaction and incrustations, so capillarity and soil aeration are severely reduced. Species composition of soil biota changes (Mekdaschi et al. 1988).

The symptoms as response to excessive salinity differ somewhat for broadleaved-deciduous and evergreen species and depend on whether damage is caused by soil salinity or by salt spray: Direct contact damages by aerosol are less important for broadleaved trees, because of dormancy during winter season. If de-icer application is necessary in late winter or early spring the problems are intensified. For fir and spruce, tip burn of needles and progressive necroses are typical symptoms for salt spray; buds are very well protected and flushing is normal. However, aerosols crust on plant surfaces, and are washed to the topsoil. This intensifies salt stress in the soil.

In deciduous trees chloride tends to accumulate in dormant twigs and buds during late winter; buds may fail to open or the so-called 'post-flushing dieback' occurs. Typical salt injury of normal developed leaves occurs as scorching or chlorosis, marginal and tip browning and necrosis, leaves begin to wrinkle and curl. Necrosis spreads to inter-veinal tissues. Salt stressed plants lose their leaves prematurely, full defoliation can occur before the end of September. Crown dieback is a common consequence of severe salt damage. For evergreen needle trees typical soil induced salt damage symptoms are that buds fail to flush and browning of needles in the summer they emerge from the bud. Needles in the upper crown part show greater damage than those needles in the lower part. In both tree groups bark injuries seems not to be significant for mature trees. Salt stress situation generally increases susceptibility to drought and frost, pests and diseases.

Ameliorative measures for already salt affected sites are seizing salt application, additional irrigation to flush the soil and remove salt from the rooting zone, addition of gypsum, ammonium nitrate or potassium- and magnesium sulfate to re-exchange adsorbed Na-ions and flush them out, fertilization to improve nutrient balance, and bio-turbation to improve soil physical properties. Heavily damaged tree sites need five to ten years treatment for recovery. In worse cases, excavation and replacement of rooted soil are the only remedies to rescue mature trees. Several authors, e.g., Mekdaschi et al. 1988; Petersen and Eckstein 1988, published ameliorative programs.

To reduce ongoing salt damages doses for road maintenance have to be minimized. Applying de-icing salt as wet salt or brine reduces the necessary amounts by up to ten, but needs new expensive equipment. To avoid progressive damages by NaCl many municipalities switch to other de-icing agents. $CaCl_2$ is high in price but has the beneficial effect of containing Ca as cation, which helps minimize deterioration of soil chemical and physical properties. Ca protects soil structure and does not have the same exchange strength as Na. $CaCl_2$ is frequently used as an additive to NaCl. Potassium carbonate has the advantage of containing K, an element frequently deficient in urban and roadside soils and low in already NaCl-affected soils. Nevertheless, it is highly alkaline and increases soil pH in the topsoil. In Vienna (A) it is used where sensitive and valuable urban green is neighboring de-iced pavements. Alternatives like organic compound, e.g. Ca-Mg-Acetate (CMA) are currently regarded as too expensive for a widespread use and their ecological impacts are yet not well studied. CMA is highly corrosive, so addition of anti-corrosives is needed.

Physical protection measures have been developed and should be located along the street, in a way that will allow the de-icing agents to flow back onto the road surface

Fig. 11.6. Physical protection measures against de-icing agents in Copenhagen (*photo:* T. B. Randrup)

(see Fig. 11.6). Protection devises should only be used on locations with relatively low traffic speeds in order to avoid salt dust to accumulate behind the device.

Heavy Metals

A big share of other inorganic contaminants released into the environment ends up in the soil. The greatest problems involve "heavy metals" like Al, As, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb and Zn, although not all of them are strictly heavy metals. They are natural elements found at various background-levels, depending on their concentration they are to a greater or minor degree toxic for humans, animals or plants. Heavy metals are persistent; they cannot be deleted from the environment, they have to be in an available form for plant uptake, and plants have mechanisms to make metals available. The most pronounced factors influencing their bioavailability are the soil pH, the cation-exchange capacity (CEC), and the clay- and organic matter content. Because of the higher affinity of H^+ for negative charges on the soil colloids, metals are exchanged and released into the soil solution, so a low pH increases the metal availability. Soils high in organic matter adsorb and bind heavy metals by forming complexes with organic acids. High CEC means lower bioavailability of heavy metals. The higher the clay- or organic matter contents and the soil-pH are the lower heavy metal bioavailability.

Various metals can be grouped according to their effect on plants in essential micronutrients, and non-essential toxic elements. For essential metals, e.g. Mn, Zn, the dose-response curves have three phases: deficiency, tolerance and toxicity. For non-essential metals, e.g. Pb and As, only a tolerance plateau, which extends to zero-concentration and the toxicity level can be drawn. As a rule, plants exposed to heavy metal concentrations clearly above their critical toxicity level show decreased transpiration and increased stomata resistance combined with a negative impact on photosynthesis and growth. Inhibition of root elongation is in many instances the most sensitive parameter. Heavy metals also influence mycorrhiza quality and quantity. There is an implication from the viewpoint of decreasing resistance to pests and diseases. Sensitivity or tolerance of trees against heavy metal stress exhibits high variability and depends on species, strain, clones or even the genetic structure of the individual tree. The differences can be quite remarkable and are used for phyto-remediation of polluted sites (see below).

Most urban soils contain some levels of heavy metals. Contrary to agricultural areas the heavy metal contents of soils in urban habitats, particularly those in parks, gardens or playgrounds may influence public health via direct contact with contaminated dust or soil. Even in absence of industries, the contents of several heavy metals in urban soils are generally higher compared with agricultural areas or natural forests. The latter show natural acidification with heavy metal release to the soil solution but compensated by leaching and translocation by soil biota. These differences are mostly apparent for roadside soils, but also park soils show a considerable enhancement over values recorded from similar rural soils (Paterson et al. 1996).

In most cases, an increasing gradient from forest soils towards agricultural and suburban soils to urban soils is monitored. Highest values occur in the proximity of roadsides and decrease with distance and soil depth. Topsoil horizons contain the highest total amounts of heavy metals. Beside industry, traffic is the main pollution source. Vehicles stipulate up to 90% of lead emission and high lead contents correlate directly with traffic density. Other sources like corrosion, weathering of parent soil-substrates and redistribution of polluted topsoil compensate the increasing use of unleaded petrol. E.g. German garden soils showed higher heavy metal contents than soils from rural areas, with generally higher values in top soils and highest values in the centre of the cities (Kahle 2000). Sevilla (E) is an example for a significant degree of heavy metal pollution in urban soils, particularly for Cu, Pb and Zn: close to the historic centre contents exceed maximum national limits for residential and recreational use (Madrid et al. 2002). For Scotland (GB) a comparison of rural, roadside and parkland soil reveals the same trend for Cu, Ni and Pb (Paterson et al. 1996). For roadside soils in green areas in Göteborg (S) due to local infiltration of storm-water as a method for storm-water treatment, heavy metal concentrations are on average 200% higher than in reference areas (Lind and Karro 1995). In roadside soils and infiltration ponds in Sweden, national threshold value were exceeded 3 times for Cd, doubled for Pb and reached the 43 fold of the overall mean concentration of Swedish soils. Large amounts of heavy metal are vulnerable to leaching when exposed to high NaCl-concentrations intensifying problems for roadside vegetation where de-icing is used or marine aerosol occur (Norrström and Jacks 1998).

Threshold values as well as toxicity values for the urban vegetation are hard to distinguish: they are established for agricultural use or human health and analytical methods are not adapted. As roots produce to some extent their own ambience concerning pH and ion exchange, the interactions of complex rhizospheral processes change bioavailability and can hardly be forecasted. Total heavy metal contents are not representative for plant availability. Better estimates come from EDTA-, NH_4NO_3-, Ammonium acetate-, $CaCl_2$- or $BaCl_2$-extraction, because of heavy metal adsorption by soil colloids and organic matter. Correlation coefficients for soil contents represented by the respective extraction methods, and the element content in the tree, differs for any particular element (Hornburg et al. 1995).

At reclaimed mining sites or post-mining landscapes, which are reforested and used as public recreation areas, at early reforestation stages threshold values or better soil quality criteria for heavy metals are exceeded by far. Compost application or generalized any application of organic material has to be controlled carefully: For urban soils in Madrid (E) a study of De Miguel et al. (1998) demonstrates an obvious contribution of the widespread use of compost as park and garden fertilizer to enhanced trace metal contents in soils. Bio solids applied as organic matter supplements can be beneficial but may as well enhance the heavy metal problem. Composted sewage sludge often contains high amounts of heavy metals, so a restrictive use in urban forestry is suggested (De Miguel et al. 1998).

In Table 11.3 'total' heavy metal contents of urban soils in some European cities and for a few cases data for organic heavy metal complexes (EDTA-extractable) are presented. The latter serve as a coefficient to estimate the plant availability of the concerned element. Metals like Cr and Ni are taken up in low concentrations, Cd, Cu, and Zn are relatively accumulated. Even when we assume a reduction of emission down to 1% of the values of twenty years ago due to more effective filtering systems, changes in environmental behavior or changes in technology, urban soils are still a pronounced sink and source for pollutants. They accumulate considerable amounts of stored heavy metals, which can be released into other environmental compartments.

It is impossible to ameliorate soils contaminated with heavy metals in a strict sense, except for phyto-remediation (Brady and Weil 2002). Anyway, they are expensive methods. Remediative methods for soils can be phyto-stabilization, phyto-mobilization, phyto-extraction or phyto-volatilization. They are used for sites with a high impact of heavy metals like reclaimed mining or dumping sites or former industrial areas under forest re-cultivation. Commercial driven research on heavy metal extraction by hyper-accumulating plants (e.g. poplar clones) is encouraged but may contain a high risk of minimizing the genetic diversity of trees in a city. Rhizosphere-management methods that use micro organisms or chelates to enhance the heavy metal uptake by hyper-accumulating plants, followed by harvest and off-site deposition are just new developed methods. In severe cases of heavy metal contamination, soil exchange or addition of uncontaminated material is the only remedy.

Table 11.3. Heavy metal contents of urban soils in some European cities and for a few cases data for organic complexed heavy metals (EDTA-extractable)

City/Country	Site	Author	Cd	Co	Cr	Cu	Pb	Ni	Zn
Vienna (A)	Recreation forests	MA 22, Report 2003	0.5	10.8	36	28	42	30	100
	Parks	MA 22, Report 2003	0.6	8.0	35	56	79	28	164
	Roadsides	MA 22, Report 2003	1.0	8.6	48	71	151	34	217
Sevilla (E)	Parks	Madrid et al. 2002			39 (0.46)	68 (26.5)	137 (24.1)	22 (2.6)	145 (19.3)
Madrid (E)	Green areas	De Miguel et al. 1998		6.4	75	72	161	14	210
Rostock (D)	Gardens	Kahle 2000			48	35	83	30	100
Berlin (D)	Urban Forest	Sukopp 1990	0.2 (25)			5–50 (20)	20–200 (25)		30 (20)
	Parks/ Cemetery	Sukopp 1990	0.2–2 (60)						
	Roadsides	Sukopp 1990	2 (20)				200–1 000 (30)		300–2 000 (27)
Kiel (D)	Green areas	Beyer et al. 1996	0.4–238			7–264	15–156		45–916
Hamburg (D)	Green areas	Lux 1986	2.0		95	147	218	63	516
	Gardens	Heymann 1996	0.7–5.0		33–69	69–564	103–417	13–48	141–526
N-Rhine-Westphalia (D)	Urban forests	Held 1998	0.1–0.2 (17–67)			14–20 (36–43)	98–127 (68–78)		56–78 (14–31)
	Gardens	Brüne 1988	0.2–0.7		45–48	37–81	85–206	27–35	179–273
Rome (I)	Green areas	Angelone et al. 1995	0.31				331		
Palermo (I)	Green areas	Manta et al. 2002				63	202		138
Birmingham (UK)	Green areas	Davies et al. 1987					56–1 650		
London (UK)	Roadsides	Thornthon 1991	1.0			73	294		183
Great Britain	Gardens	Culbard et al. 1988					185		
Aberdeen (UK)	Parks	Paterson et al. 1996		6.4	24	27	94	15	59
	Roadsides	Paterson et al. 1996		6.2	23	45	173	16	113
Warsaw (PL)	Green areas	Czarnowska 1980	0.73	5.1	32	31	57	12	166

Organic Contaminants

Numerous of toxic organic chemicals are produced in enormous quantities every year. Pesticides and hazardous industrial organics often end up contaminating soils. Pesticides are commonly classified according to the group of pest organisms targeted (insecticides, fungicides, herbicides, rodenticides and nematocides). Industrial organics contaminate sites usually located near chemical manufacturing plants or oil storage facilities, but contamination can occur along accident hot spots of railways or highways.

Once organic chemicals reach the soil they start to move: they may vaporize into the atmosphere without change, they may be absorbed by soils, they might get lost by leaching through the soil or by surface run off, they may undergo chemical reactions with the soil or they may be taken up by organisms, and move into the food chain. When absorbed they may remain intact or may be degraded. The persistence time of pesticide in soils ranges between only a few days and a couple of years or even longer.

The most important impact of pesticides is on soil organisms. Some of them are toxic to specific microorganism populations but most pesticides do not kill a broad spectrum. However, nitrificants and nitrogen fixing microorganisms are in some cases highly affected. The effects on soil fauna vary within the pesticide groups. Earthworms are not as much affected except by carbamates. For other soil-inhabiting animals, the impact depends on the applied pesticide group. Decomposition and degradation of organic contaminants can produce toxic metabolites that have a more severe impact on plant growth and soil biota. Pesticides accumulate in urban soils: for Poland organic compounds (organochlorine pesticides, DDT, HCH, CHL, HCB, PCB) are reported to be in urban soils 10 times higher than in agricultural and forest soils (Kawano et al. 2000).

Because of broad range fires during the last war and deposition of contaminated rubble, especially Polycyclic Aromatic Hydrocarbons (PAHs) are widespread in urban soils. At roadside sites increased PAH-values can be found. Plant leaves are a pronounced sink for PAH in urbanized regions due to their large surface with lipophile properties and a low vapor pressure of most PAH (Kuhn et al. 1998). There is some evidence, that PAHs are highest concentrated in leaf litter. They are hazardous via food chain and influence the site quality for urban trees when altering mycorrhiza or other soil biota. Contamination of soils via input from paved areas depends on used materials. Tar pavements and old asphalt showed high pollution with PAH in nearby soils.

A wide range of methods for remediation and clean up of soils polluted with organic chemicals is available. Very expensive and disruptive techniques, which are usually quite rapid, are excavations and washing of soil or in situ heating and decomposing. Phyto-remediation by enhanced rhizosphere breakdown or natural attenuation takes more time to accomplish the breakdown (Brady and Weil 2002).

Due to leaking of domestic gas supplying systems depending on duration severe changes of soil air quality take place: oxygen contents are decreasing, CO_2-concentrations are increasing, and methane is enriched and later degraded. Affected soils become blue and have a putrid smell. Long-term impact of methane in urban soils needs a long decontamination times and is detrimental to roots (Balder et al. 1997).

Substrate Application – Substrate Erosion – Soil Fragmentation

Substrate applications may be temporarily during construction work or persistent. They alter the ambience for the tree roots not only because of the weight of the applied soil layer but they also change the pathway for gas exchange and for water infiltration due to changes in particle size distribution and interrupted capillarity. Erosion processes consist of detachment of soil particles, transport and deposition by wind or by water. Bare soils are impacted by micro-erosive forces of raindrops, which splash soil particles and lead to soil crusting and less water infiltration, or by storm-flow erosion. Erosion from urban areas can be rather strong because of thin vegetation cover, decrease of absorbing soil surface, changes in infiltration and drainage configuration due to soil compaction and surface sealing, alterations in precipitation volume per soil volume causing peak flows. Soil loss by human excavations confines the rooting volume and the nutrient and water supply and decreases the mechanical stability. Soils have to be seen as entities, where several exchange processes take place. Fragmentation of soils, which is frequent in urbanized areas, makes the entities smaller. Exchange of water, air, nutrients and soil-organisms become restricted.

11.5 Mechanical Injuries

Mechanical injuries to urban trees occur not only because heavy machinery is used for excavations, construction pits, road establishment and maintenance, but also due to traffic (accidents, parking, biking) or landscape management practices. Furthermore, maintenance methods (e.g. improper tree or root cutting) and landscape gardening activities that are casually hazardous for urban vegetation; e.g. transplanting of trees is always connected with root injuries. Vandalism is also frequently observed as a problem for urban trees (see Chap. 3).

Public services generate conflicts between urban green areas and utilities, e.g. water, sewer, electricity, phone or television cables. Establishment and maintenance of these often damage tree roots considerably, particularly during trenching operations for installations. In densely urbanized areas injuries to trees are almost unavoidable. Mostly roots are affected. Even when trenching carefully, like digging by hand, using pneumatic methods or installing root bridges at the construction site, root damages still occur, and may lead to unintentional tree mortality – in some cases several years after the impact. Careful handling of the roots is a remedy that reduces these impacts. Broad dimensional root damages and losses are not just a problem for water and nutrient supply of trees, but they cause static problems and are security or hazardous threats. Reduced and invital root systems cause reduced tree vigour and the susceptibility for pests and wood decaying fungi increases (Balder et al. 1997; Harris et al. 2004).

Flat root systems are more susceptible to mechanical injuries than deep ones. Traffic usually causes bark injuries, roots are contused or thorn. A strategy to improve water and nutrient balance of urban street trees is to enlarge the open soil surface by the removal of surface sealing and pavements. Opening of soil surfaces is just a remedy at sites where trees need no protection against contaminations by various chemicals, deicers, excessive amounts of nutrients from dogs, etc.

11.6 Fire and Urban Forestry

Fires are one of the most far reaching ecosystem disturbances. Forest fires convert nitrogen, sulfur and phosphorous to gaseous forms in which they are lost from the site. The dramatic changes in soil temperature may have other lasting effects. Unless fires are artificially stroked with additional fuel the soil temperature rise is limited to the upper few centimeters. It contributes to a quick breakdown of minerals as well as to a breakdown and movement of organic compounds. Temperatures higher than 125 °C distill various fractions of the organic matter with some of the volatilised hydrocarbons moving quickly through the soil to deeper and cooler areas where they condense and fill pore spaces. Some of the newly formed organic compounds are hydrophobic and reduce water infiltration.

Fires also affect the seed germination: it may kill seeds or enhance germination of seeds with hard coatings that need to be heated to sprout, thus changing the succession. Heat and ash also hastens nutrient cycling, depletes soil organic matter and kills soil organisms, forest regrowth is inhibited.

Since the 1980s in areas where urban development and wildland intermix, the so called wildland-urban-interface (WUI), fires have become worldwide an increasing environmental problem and public safety issue (Hirsch et al. 1996). Human activities encroaching into natural ecosystems have caused land fragmentation into a mosaic of residential, rural, forest and agricultural areas of severe fuel hazard, high fire risk and complex fire management problems. The increasing frequency of wildland-urban fires provides compelling reasons to mitigate the problem. Particularly in the Mediterranean countries the WUI fires have become a political and social issue, because compared to wildfires they are associated with considerably high losses of human lives and property.

11.6.1 Characteristics of Wildland-Urban-Interface (WUI) Fires in Europe

The WUI is associated with extreme fuel hazard conditions: natural combustibles, like living and dead vegetation and artificial fuel, like housing structural components combine various fuel loads, fuel sizes, fuel bulk densities, and horizontal and vertical continuity. These features create extreme and erratic fire behavior in both wildland and structural fires. In the WUI vegetation fuels are usually a combination of indigenous natural flammable vegetation and exotic species. High population density, irregular topography and an increasing mobile society with the 'close to nature' syndrome contribute to the fire hazard. In the Mediterranean WUI fires occur as:

- Peri-urban fires: Expanding residential development encroaches into the wildland around urban centers. Isolated, luxurious estates engulfed by natural vegetation at the suburbs or housing settlements that were constructed on wildlands without previous urban or regional planning and provisions for fire safety are typical. High population density and accessibility result in increased fire frequency. Various combustible materials, both natural and artificial fuels, increase the fire potential. Fire protection is problematic.

- Forest-urban: Private summer resorts and hotels are constructed in remote forested areas; WUI is enlarged. Good accessibility to urban forests, high dispersion and water availability problems for fire suppression forces are created. Increased outdoor activities combined with human negligence have multiplied the number of fires in these areas. Tourism development in certain Mediterranean areas without proper regional planning has led to uncontrolled construction of facilities in remote wildland without any fire safety infrastructure.
- Rural-urban: Over large areas in the Mediterranean countryside the extensive intermix of agricultural areas with forest lands and rural settlements creates a mosaic of different land uses and fire hazards. Agriculture has expanded on wildland, causing fragmentation of the natural landscape. The traditional model of small rural villages is now changing to farm houses constructed near cultivated fields, while wildland become more isolated. This results in high fire risk and complex fire management planning.

11.6.2 Fire Control and Safety in the WUI

The mixture of wild, urban, agricultural, public and private land prevents the choice of either urban or wildland fire suppression strategies. Ethical instincts and legal structures impose the preferential protection of houses and their residents, even if this allows the overall fire to propagate freely (Pyne et al. 1996). Compared to wildland fires, in WUI fuel loads are heavier, fuel moisture lower, residence time longer, and fire build-up more rapid (Cohen and Butler 1996). Although advances in fire fighting technology and management have resulted in very effective capabilities, WUI-fires damage most structures when they are not separated from the surrounding flammable vegetation, when built in steep slopes (over 50%), when fire-fighting forces have poor access and arrive late, and when water supply is limited. Fires at the WUI can simultaneously expose numerous structures to flames and to numerous firebrands and burning embers that fall on houses and adjacent vegetation over a wide area. No clearly agreed fire control strategy exists: perimeter control is problematic, counter firing almost impossible and prescription control unthinkable. Fire fighting resources, especially engines, are massed and dispatched to protect structures. It is likely that fire management will focus on just such issues in the upcoming decade (Miller and Wade 2003).

A combination of legislation, land-use planning, landscape design, and structural design is necessary to alleviate the fire safety problem at the WUI: Land-use plans should create zones of fire hazard severity. Legislative regulations should provide for maximum housing density per unit of wildland area, for adequate road network density for easy accessibility of all structures, for evacuation routes and sites in case of emergency and for restricted zones where construction is prohibited due to high fire risk. This includes strict regulations for waste disposal sites, open mines, amusement parks, picnic areas, nature trails, etc. Fire Safety regulations for houses, like clearing of vegetation, extra sources of water, appropriate building material etc., have to be applied at the residents own expenses, and penalized for violators. Jurisdiction by legislature should be granted to the fire-fighting forces regarding the selection of the appropriate fire strategy, e.g. choice of fire protection priorities, forced evacuation of people from residences, destruction of fences and gardens, use of private water sources, curfew of vehicle circulation.

Some general rules can be proposed to protect residences from wildfires:

- avoid structural ignition from direct exposure to flames and radiated heat
- avoid ignition by firebrands carried by winds or convection columns by appropriate roofing materials (fire retardants) and cleanliness, design and maintenance of windows, doors or vents to prevent the entrance of firebrands
- minimize the opportunity for interior ignition from external sources, and avoid large windows and sliding glass doors
- install electric power circuits underground in wildland areas
- make extra sources of water (e.g. swimming pools) available to the fire suppression forces
- avoid creating obstacles, e.g. fences, dead-end roads, to the movement of the fire suppression forces

11.6.3 Landscaping, Silviculture and Forest Management in the WUI

Landscaping for fire protection starts with clearing of all flammable vegetation at least 30 m around the house. The cleared native vegetation can be replaced by drought tolerant species with low ignitability, and low fuel volume. FIRESMART (2003) provides a list of the desirable attributes of fire-resistive vegetation. Trees should be spaced far enough apart that their crowns will still be separated when full-grown and they will not overhang the house.

Silviculture and management practices should focus on the protection of the urban structures that they engulf to protect human lives. Forest in WUI should not be managed on a traditional sustained yield basis or as protective forests, but fire-preventive silviculture measures, like pruning, thinning, fuel removal and isolation, breaking of horizontal continuity, etc. should be applied.

Extra water supply and special underground installations for ample water should be established in the wildland areas prior to urban development. Perimeter protection from wildfires should be incorporated into the design of residential areas developed in wildland. Territory planning and strategic environmental assessment are necessary in order to establish a network of fire escape routes and fire safe concentration points in the WUI regions. WUI areas should be delineated according to the degree of potential fire risk, the value of properties protected and the potential difficulty of fire suppression. For cultural monuments that are surrounded by natural vegetation of high aesthetic value all fire suppression measures should aim at adequately protecting the monument without disturbing the natural beauty of the site.

11.7 Establishment of Trees in Urban Areas

Many interests exist in urban areas, and urban soil is often not mend as a growing medium, but as a building/construction base material. Thus, urban soil conditions often limit planting success. The reasons for this are often caused by compacted soil, and restricted potential rooting volumes. Therefore, site preparation is needed on most urban sites. However, on many sites little site preparation is needed, e.g. in situations similar to natural settings digging a hole large enough for the root ball/roots will be sufficient. In all cases sufficient drainage should always be secured prior to planting.

The amount of soil available for root growth determines how long the tree will live, and how healthy the tree will appear. Since the majority of the tree-feeding roots appear in the upper layers of the soil, planting pits should in general be as wide as possible, but also deep enough to guarantee the statics of a developed tree.

In some urban locations the soil is favorable for root growth. This is basically the case if the soil structure is good, and loose. This 'natural' situation may be found in older parks, and in other urban situations established prior to the introduction of heavy mechanical equipment in construction. In these situations planting is in principle unproblematic. However, in many urban locations, the soil has been submitted to human (anthropogenic) modifications. This means that especially sub-soil in parks, around houses and along roadsides will be compacted to a degree that is detrimental to root growth. In these situations it must be secured that the planting pit is large enough to support future root growth. Breakage of the soil, soil-loosening etc. is necessary to secure efficient drainage, and to limit mechanical impedance to root growth.

In streets and under similar paved areas the natural sub-base is either removed and replaced by a new compacted soil mix, or is build in and compacted in order to secure stability of the surface for traffic etc. The compacted sub-base is in most cases detrimental to root growth.

It must be secured that the planting pit is large enough to support future root growth. It is in general better to install a large planting pit and to establish several trees in this, rather than to plant the same amount of trees in individual small planting pits. If a large planting pit can not be achieved, alternative sub-bases such as root friendly base materials (structural soils) may be applied (see below). Decks are fully manipulated planting systems, in which preparation for planting should be secured at installation of the deck. If this has not happened, further investigations of the conditions should be made, including potential maximum load (future size of trees), depth of soil, drainage etc.

To achieve the desired size, longevity and structural stability of a tree, it must be allowed to spread its roots into sufficient soil volumes (rooting volume) to obtain the necessary water, nutrients and minerals and to provide the necessary anchorage. Numerous publications have been published focusing on the establishment of trees for urban areas (e.g., Bradshaw et al. 1995; Watson and Himelick 1997; Balder et al. 1997; Harris et al. 2004). In these publications, optimum situations for plant growth is usually outlined, and basically there are no set specifications for urban growth compared to rural or 'traditional' forest growth – except for the long list of abiotic factors to be taking into consideration. In recent years focus has been on securing adequate room for root growth, as well as optimum drainage.

In Chap. 9 about Plant Quality and Establishment (especially 9.5 and 9.6), different establishment needs and methods are outlined for different plant sizes and qualities. Also, the effects of different production methods, and post plant treatments on establishment success are discussed. In Sect. 9.8 and 9.9 the issues of mycorrhiza and nutrients are discussed. Specially formulated soils that can be compacted enough to satisfy highway engineers, yet still allow root penetration, have been developed for this purpose in the USA and mainland Europe over the last decades. Below are some of the newest methods within establishment of urban trees presented.

11.7.1 Designed Soils for Street Trees

Designed soils for street trees cover a special niche of urban soils. These soils are designed, or engineered, for use in situations where a combination of traffic and plant growth is equal. Rocks form the load-bearing element of the soil and can be compacted so that they do not subside, whilst the soil, which will provide the tree with water, minerals and nutrients, is located in the voids between the rocks. The proportion of the two elements is important. Too much soil and the rock matrix will not interlock and when externally compacted the soil in between will also be compacted. Rather too little soil (air spaces in the voids), than too much. The strategy is to create a rigid matrix for bearing loads from the road, with rooting space in between the matrix elements. Basically these designed soils are made of a mix of stones or maybe rocks, in combination with soil. The main challenge seems to be related to the installation process in order to minimize or preferable totally avoid soil compaction.

In the US, a method described as Structural Soil (Grabosky and Bassuk 1995; Grabosky et al. 1996) uses organic hydrogel as a glue between the exact amounts of stones and soil (ratio 5:1). In Europe, several variations have been introduced and described in the literature.

In Denmark, a stone/soil structure almost similar to the Cornell Structural Soil is recommended used under pavements, bicycle paths etc. where no trucks and related heavy traffic occurs. The pavement sub-base is constructed using the structural soil/rock matrix, extending from one tree pit to the next thus giving greater opportunities for root spread. Using approximately brick to ½ brick sized rocks the recommended ratio of rocks to soil seems to be around 4:1 giving a 25% soil filled void. Especially stones (63–125 mm) have been commonly used to form the load-bearing matrix. It is most important that the rocks are as even in size as possible. The tree pit itself is filled with uncompacted topsoil, of the same type as what is used in the soil/rock mix. This is important in order to minimize barrier zones between different soil textures. At each planting site ideally an area as large as possible is excavated to a depth of e.g. 0.6 m, avoiding services and other obstructions. Drainage is secured by installing drainage pipes or by other means. Three methods of placing and compacting the structural soils have been developed; each has advantages and disadvantages.

- Premixing of soils and stones (see Fig. 11.7). This must be installed and compacted in layers of no more than 150–200 mm, to achieve good compaction. Separation during transportation may be a problem. Also, there is a risk of de-mixing when the rocks and soil is filled into the pit. In this case, the soil in the voids may be compacted, when the soil/rock mix is compacted. The mix may be created by a front-end loader. Sometimes it may be beneficial to add a little water to the mix, in order to have the soil and the rock better 'glued' together. Smaller rocks tend to be better premixed with soil than larger rocks.
- Water mixing during installation (see Fig. 11.8). 150–250 mm layers of stones are installed and compacted. Screened soil (e.g. a sandy loam) is spread on top of the stones and watered into the voids. The advantages with this method are that you are sure that the soils are uncompacted in the voids between the rocks. The main disadvantages are

Fig. 11.7. Primixing of the soil and stone mixture before installation (*photo:* P. Kristoffersen)

that the soil may separate and occur in layers within the mix. However, this problem has never been significant in the Danish cases. In practise, problems may occur when the soil is watered into the voids. Small rocks and/or sharp edged rocks should be avoided, since the amount of voids in the upper layer of the rocks tends to be minimal when compacted. This will make the process of watering soil into the rocks very difficult. Large rocks are in general favorable for this type of installation technique.

- Dry mixing during installation. Stones are installed in layers to a depth of 150–250 mm and the voids filled with dry soil by sweeping and vibration. The advantages with this method are similar to the water mixing installation technique. Drawbacks are that soil and stones need to be completely dry and this method is not suitable for stones less than 80 mm in diameter (Kristoffersen 1998, 1999).

11.7.2 Soil Mixes

Another approach was developed in The Netherlands back in the late 1970s. The Amsterdam Tree Soil (ATS) has been in use since 1980 in several varieties, some better than others. It consists of a mixture of poorly graded medium coarse sand (91% w/w) with a D60/D10 not exceeding 2.5, well decomposed organic matter (5% w/w) and some clay (4% w/w). The mix is fertilized with P and K to fertilizing standards. The dryness of the Amsterdam Tree Soil mixture at filling in is critical. It is applied by filling it in and compacting it in layers of 40 cm maximum, until a penetration resistance is reached of 1.5–2.0 MPa, measured during the compaction action. It is covered with bedding sand before being paved over (Couenberg 1994).

Fig. 11.8. Watermixing of the soil and stone during installation (*photo:* P. Kristoffersen)

In France, the Melange Terre Pierre was developed in 1990 by the city of Angers in association with the laboratory of Ponts et Chaussées and INRA (Research Centre of Angers). The soil mixture is constituted of agricultural soil (35% v/v), chosen, amended and enriched according to the requirements of plantations to be made, and pebbles (65% v/v) resulting from crushing, and made of different materials (limestone or siliceous material puzzolane, a volcanic ash) depending on the tree species to be planted. The mixture is made on a platform, the soil being worked on a fixed rate of humidity (Lemaire and Sorin 1997).

None of the designed soils are recommend for use under 'heavy' traffic. All of the soils above have been engineered to use as stand-alone solutions. However, they can only be used properly in a locally designed planting pit. This technical below ground design is needed to deal with drainage, irrigation and aeration, and is necessary because of differences in local soil properties, and dependent on the actual design of the landscape.

11.8 Conclusions

Urban trees live a hard life: Their mean life span is by far shorter than for a tree in his natural forest habitat; e.g. the mean life expectation of a lime tree in a city road may be sixty years, in an undisturbed natural habitat up to a thousand years.

Even if urban foresters, arborists and other landscape professionals try to ameliorate the situation or optimize the sites for new urban tree plantings, urban growing conditions will remain unfavorable for trees. Besides ecological, esthetical, architectural and social concerns, the die-back of urban trees causes economic losses. Provided it is possible at all, the remediation of growing conditions for existing urban trees is highly time-consuming and expensive. In order to keep urbanized areas green, the detailed knowledge of growing conditions, possible stresses and threats and their interrelationship is an important prerequisite to develop strategies and tools for urban green-space planning. Due to the respective scientific research the impacts of single ecological factors in the urban environment is well known and documented, but interrelationships and combination of various impacts need more research. This is especially true for the belowground ambience, which highly influences root development and which is often one of the outstanding constraints for tree growth and vitality. The practical applicability of scientific results, the generation of creative solutions and management tools for new plantations of sustainable urban green spaces and for melioration of problematic sites is an important issue, which ecological urban forestry research has to face more intensively in the future.

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Biotic Urban Growing Conditions – Threats, Pests and Diseases

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12.1 Introduction

Woody plants in the urbanized landscape are highly influenced by the presence of pests and diseases. The objective of this chapter is to provide an insight into the current main problems affecting urban trees due to biotic agents at the European level. The goal is to offer basic knowledge of the most important pathogens focusing on what is specific to the European situation. The reader can also find examples of some of the latest European problems and recent findings. Importance is given to the control methods currently adopted in Europe, including discussion of their feasibility. The chapter concludes with some remarks on how the situation is in Europe at present and in which direction we should work in the near future.

12.2 Tree Protection in Urban Conditions

The ecological conditions imposed by the urban lifestyle and urban activities, and their specific unfavorable effects strongly influence tree development and the presence and behavior of pathogens affecting them. It is known that some fungi, such as *Ganoderma australe* or *Abortiporus biennis*, occur almost exclusively in areas of human habitation or areas influenced by human activity – the so-called synantropic species. Serious damage is done to trees by traffic, incorrect tree maintenance, construction work near trees and deliberate man-made injuries. This includes damage to trunks, tree crowns, branches and roots. As a result, the wood-destroying fungi are very active, since they penetrate into woody plants through those wounds caused by abiotic or biotic agents. For example, *Ganoderma resinaceum* and *Meripilus giganteus* are usually found to produce fruit bodies at the base of trunks, which are often damaged when lawns are cut. All mechanical injuries reduce the vitality of woody plants and so diminish plant resistance to parasites.

Furthermore, the fact that people live in urbanized areas restricts the use of certain control methods. It is quite difficult to prune or spray tall trees in narrow streets or busy avenues when big cranes are necessary, nor is it possible to spray with chemicals that exceed a certain level of toxicity for humans. The intrinsic layout of the town or the ornamental function of the trees frequently determines the shape of the trees, and subsequently the type of pruning, drastic and harmful much of the time, weakening the trees and favoring the entrance and attack of the pathogens. Frequently, in order to offer a high aesthetic value, a mixture of a great number of plant species of diverse colors, shapes, foliage, height, etc. can be found growing together in close contact in parks and gardens, mostly exotic species showing different levels of adaptation to the urban environment. This mixture, although very attractive and desirable in terms of species diversity, has two sides. On one hand, species diversity successfully reduces the risks of serious widespread outbreaks of pests and diseases, whilst on the other hand their different sensitivities to pesticides and different environmental requirements can make the difficult task of keeping pests and diseases under control even more complicated.

Another notable difference between plant protection in urban areas as opposed to in forests or agricultural crops is that sometimes it is necessary to control a pest or disease that does not cause direct damage or is not particularly harmful to the tree, but it causes a great deal of inconvenience to, or it is aesthetically undesirable for, the citizens. The ornamental value of urban trees implies the acceptance of a level of damage or visible symptoms of zero, or very close to zero, which requires the application of more drastic control measures. That is the case with many aphid species or with their associated non-parasitic fungi Capnodiaceae (sooty mould). Trees blacken due to the accumulation of sooty mould on tree surfaces and the honeydew the insects produce falls on vehicles parked underneath, street benches, pavement cafés, sidewalks, etc., which get dirty and sticky.

Commonly, the main concern for a plant/forest pathologist or entomologist when working on a certain disease or pest is not its effect on a single host plant but on the majority of the population (the crop or the forest). Within the urban pathosystem, both approaches can be necessary; either the pest/disease affecting a group of trees (in a park, garden or urban forest) and also the problems affecting a single tree of special importance – with a high historical, social, cultural or aesthetical value.

12.3
Influence of the Environment

The environment is a key factor for the development of pests and diseases in all kinds of plants. In this way, it is well known that pathogens show limited attacks when environmental conditions are not favorable for them, i.e. when they are outside the thresholds that mark the viability of the pathogen. This phenomenon determines the appearance of diseases typical of different climates (warm and humid, warm and dry, temperate areas, etc.). On the other hand, if the trees are not adapted to the climate of the planting site or to the soil, the environmental stresses may cause the trees to be more prone to attacks from pests and diseases (see also Chap. 11).

The activities in the urban environment introduce several factors that can greatly modify the general characteristics of the geographic area in which the town is located and, subsequently, the life cycles of the pathogens. For example, (*i*) the heating systems needed for big groups of buildings in winter create a much warmer environment than the surrounding areas. In summer, concrete and asphalt structures act as giant accumulators conserving the heat, which delays the cooling that naturally occurs during the night, (*ii*) the amount of light decreases in narrow streets with tall buildings, (*iii*) air humidity varies depending not only on the irrigation systems used, but also on the evaporation altered by the normal activities in the town, (*iv*) air pollution caused by the gases expelled by vehicles, industries and other urban activities increases in the urban and peri-urban areas.

All these factors, and others, can make possible the presence of pathogens non-indigenous in a geographical area and can also limit others that should be endemic. In this respect, it is possible, and even frequent, to find severe diseases affecting urban trees that are not important or cannot be found on the forest trees growing outside the influence of the town.

12.4 Current Status of Main Pests and Diseases in Europe

12.4.1 Study of Main Pests and Diseases in Europe

Between 1999 and 2001 a pilot study was carried out within COST Action E-12 on the main pests and diseases in urban trees and forests in Europe. In it, information from nineteen countries was collected and compared with data available in literature and with authors' own experience, trying to create a list of the most important pests and diseases in Europe. Unfortunately, some aspects never became complete, as important information concerning severity, incidence and control of particular pests in some countries was not available. Therefore, the pests and diseases presented in this chapter are only those mentioned as important by the countries themselves: it does not mean that a disease or a pest neither exists in Europe if it is not at all mentioned, nor that it is absent from a country that did not include it in the list.

According to the mentioned pilot study, the following tree genera, largely used in parks and streets, frequently face problems with pests and diseases: *Acer*, *Alnus*, *Betula*, *Fagus*, *Fraxinus*, *Picea*, *Pinus*, *Platanus*, *Populus*, *Prunus*, *Quercus*, *Robinia*, *Salix*, *Tilia* and *Ulmus*.

Data on damaging organisms, hosts and countries in which they were recorded are presented in Tables 12.1–12.9. Some general comments can be applied to them.

Firstly, damaging organisms are often quoted in several countries, but, in some cases, the determined geographic area in which the host is present restricts the number of records. Consequently, we can recognise some pests and diseases whose importance is similar all over Europe, and note that eight, ten or more countries face the same problems. In other cases, only a few countries quote it; it is clear, for instance, that cypress canker or *mal secco* of *Citrus* spp. has no importance in Finland. In conclusion, when we agree that a disease or pest is a 'main' one, we state it is important, for its intensity and prevalence, even if present in few countries.

Secondly, in preparing each national list, particular attention was paid to leaf diseases and to decay fungi. The former alter the crown, decreasing the aesthetical value of the tree; the latter cause a serious alteration of stems or branches and increase risks of collapse; i.e. they are very evident and generally tree managers look for them very carefully.

However, while we give a general presentation of the main pests and diseases in Europe, it is necessary to discuss the role they play in altering urban trees. When a disturbance is observed in trees and the presence of a damaging organism detected, we should ask: can it be regarded as a primary problem for our tree or is it only an accompanying, secondary problem, in a complex disease? We have to be aware that urban trees live in an unnatural environment, and undergo many more types of stress than in a natural forest. As a consequence, in an urban forest we often observe a decline in health. According to the forest decline model established by Manion (1981), many predisposing long term factors can act in the urban context: unsuitable genetic potential, soil compaction, poor fertility, climate change, air pollution, etc. When a tree is weakened, inciting (defoliating insects, pruning, adverse climatic conditions or machinery damages) and contributing factors (canker fungi, decay fungi, wood and bark boring insects) can produce their final effect, causing the death of trees. In conclusion, not all the infectious or damaging organisms we meet on/in a tree are really the only causal element of the alteration observed. Nevertheless, in some cases a true causative agent of the disease can be recognised, like *Ceratocystis fimbriata* f. spp. *platani*, or *Seiridium cardinale*, even if they sometimes need help to penetrate into the tree (pruning wounds or root anastomoses, frost cracks in the bark). In the case of pest insects, primary infestations only occasionally lead to tree death. Mass attacks of leaf feeding species such as *Tortrix viridana*, *Operophtera brumata*, *Lymantria dispar* or *Euproctis chrysorrhoea*, repeated regularly for several consecutive years can significantly weaken the trees and, with the aid of secondary pests, such as bark beetles and cerambycid beetles or fungal pathogens, cause death of the most affected individuals.

The most frequently cited damaging organisms in our survey were fungi (55%) and insects (41%), followed a long way behind by mites (2%) and bacteria (1%).

12.4.2
Pests

Urban trees and forests are colonized by a large number of insects also normally present in plant nurseries, commercial forests, orchards or various agricultural plantations, but only some species can cause extensive damage. Damage ranges from discoloration and malformation of leaves and shoots through partial or complete defoliation to serious weakening or killing of the infested trees. A number of insect species can also serve as vectors of dangerous viral (aphids, suckers), fungal (bark beetles, weevils) or nematode (long-horned beetles) diseases, thus contributing to even greater damage than actual feeding itself.

The most important pest insects of urban trees belong to Lepidoptera (moths), Hymenoptera (sawflies), Coleoptera (beetles) and Homoptera (aphids, leaf hoppers, psyllids) orders.

Insects infesting urban trees have been grouped into four main categories:

a Leaf feeders – species with larval and/or adult individuals directly consuming the leaf tissue and causing perforation, fragmentation or complete removal of the foliage (Table 12.1).
b Wood borers – species tunneling the tree stem and branches and living inside the hardwood (Table 12.2).
c Bark borers – insects living in the tree bark or phloem. They can occasionally extend their galleries to superficial parts of the hardwood (Table 12.3).
d Sapsuckers – insects living on leaves, shoots or steams and feeding on the tree tissue sap. Their mouthparts are modified into a rostrum, which is capable of deep penetration through the leaf cuticle or stem bark (Table 12.4).

Mites have been cited separately (Table 12.5).

Table 12.1. Leaf-feeding insects and mites mentioned as important pests (+) by countries participating in the COST E12 pilot study

Agent	Host(s)	Country																			
		A	B	CH	D	DK	E	F	FIN	GR	H	HR	I	N	NL	P	PL	Sk	SLO	UK	Total
Altica quercetorum	*Quercus*													+		+	+				3
Caliroa annulipes	*Tilia*		+	+	+												+	+			5
Cameraria ohridella	*Aesculus*	+	+	+	+			+			+	+	+		+		+	+	+		12
Euproctis chrysorrhoea	*Quercus*												+		+		+	+		+	5
Euproctis chrysorrhoea	*Prunus*												+							+	2
Euproctis chrysorrhoea	*Tilia*							+					+								2
Euproctis chrysorrhoea	*Acer*							+										+			2
Hyphantria cunea	*Acer*							+			+	+	+								4
Leucoma salicis	*Populus*						+						+				+				3
Lymantria dispar	*Quercus*				+		+						+		+						4
Lymantria dispar	*Acer*						+	+										+			3
Operophtera spp.	*Quercus*				+		+										+				3
Operophtera spp.	*Acer*							+									+				2
Operophtera spp.	*Betula*								+								+				2
Neodiprion sertifer	*Pinus*								+	+				+			+				4
Phyllonorycter spp.	*Platanus*				+					+	+	+							+		5
Phyllonorycter spp.	*Robinia*			+	+			+			+							+	+		6
Rhyacionia buoliana	*Pinus*						+			+		+						+	+		5
Stereonychus fraxini	*Fraxinus*							+				+					+				3
Thaumetopoea processionea	*Quercus*	+	+												+						3
Thaumetopoea pinivora	*Pinus*			+			+			+		+	+		+						6
Tortrix viridana	*Quercus*	+			+	+			+					+	+		+		+		8

Table 12.2. Wood-boring insects mentioned as important pests (+) by countries participating in the pilot study

Agent	Host(s)	Country																			
		A	B	CH	D	DK	E	F	FIN	GR	H	HR	I	N	NL	P	PL	Sk	SLO	UK	Total
Aromia moschata	*Salix*								+										+		2
Cossus cossus	*Salix*														+				+		2
Cossus cossus	*Betula*								+					+							2
Cossus cossus	*Tilia*		+										+								2
Cossus cossus	*Populus*				+		+						+	+							4
Cossus cossus	*Aesculus*							+					+								2
Cossus cossus	*Acer*							+				+	+								3
Cossus cossus	*Fraxinus*							+						+							2
Saperda carcharaias	*Populus*			+	+				+				+								4
Xyleborus spp.	*Acer*			+				+													2
Zeuzera pyrina	*Aesculus*															+					1
Zeuzera pyrina	*Acer*							+					+								2

Table 12.3. Bark-boring insects mentioned as important pests (+) by countries participating in the pilot study

Agent	Host(s)	Country																			
		A	B	CH	D	DK	E	F	FIN	GR	H	HR	I	N	NL	P	PL	Sk	SLO	UK	Total
Hylesinus spp.	*Fraxinus*	+						+													2
Pissodes spp.	*Pinus*												+					+			2
Ips typographus	*Picea*			+					+					+							3
Leperesonus spp.	*Fraxinus*					+		+						+							3
Phloeosinus spp.	*Chamaecyparis*							+		+											2
Phloeosinus spp.	*Cupressus*									+			+								2
Pityogenes chalcogrphus	*Picea*			+					+												2
Scolytus spp.	*Ulmus*					+	+			+						+	+				5
Scolytus spp.	*Betula*								+					+							2
Scolytus spp.	*Quercus*				+								+								2
Tomicus spp.	*Pinus*						+		+	+			+	+							5

Table 12.4. Sap-sucking insects and mites mentioned as important pests (+) by countries participating in the pilot study

Agent	Host(s)	Country																			
		A	B	CH	D	DK	E	F	FIN	GR	H	HR	I	N	NL	P	PL	Sk	SLO	UK	Total
Corytucha ciliata	*Platanus*	+		+	+			+		+	+	+	+					+	+		10
Eucallipterus tiliae	*Tilia*		+	+?		+					+?		+		+		+	+?			8
Eupulvinaria hydrangea	*Acer*		+					+							+						3
Eupulvinaria hydrangea	*Tilia*		+					+					+		+						4
Liosomaphis abietinum	*Picea*	+		+	+						+	+		+			+			+	8
Pemphidus spp.	*Populus*	+					+				+						+	+	+		6
Periphyllus spp.	*Acer*			+				+									+				3
Phyllaphis fagi	*Fagus*				+							+					+				3
Pulvinaria regalis	*Acer*			+	+			+							+						4
Pulvinaria regalis	*Aesculus*			+	+			+													3
Pulvinaria regalis	*Tilia*			+	+										+						3
Sacchiphantes spp.	*Picea*	+									+							+	+		4

Table 12.5. Mites mentioned as important pests (+) by countries participating in the pilot study

Agent	Host(s)	Country																			
		A	B	CH	D	DK	E	F	FIN	GR	H	HR	I	N	NL	P	PL	Sk	SLO	UK	Total
Eotetranychus spp.	*Tilia*	+	+		+			+					+								5
Eriophyes fraxinivorus	*Fraxinus*											+					+	+			3
Eriophyes triradiatus	*Salix*											+						+			2
Eriophyes spp.	*Tilia*			+															+		2
Oligonychus ununguis	*Picea*	+									+		+								3
Tetranychus urticae	*Aesculus*							+			+										2

12.4.3
Diseases

Pathogens have been grouped with regards of the part of the tree they mainly infect:

a Leaves and shoots – these pathogens cause diseases such as leaf or needle spot or blight, anthracnose, mildew, rust or dieback; their role can be important in inciting a decline, as they act as defoliating agents, resulting in almost complete shedding of leaves with subsequent production of new shoots and foliage (Table 12.6).
b Stem and branches – they can provoke a permanent alteration of the woody structure of the tree or even the death of the whole tree. For instance, a canker may kill a branch or may become a perennial, 'target' canker. Besides, a tracheomycosis, that is a vascular wilt disease will rapidly kill the tree as the infection obstructs the vessels (Table 12.7).
c Roots and collar – infections generally alter the uptake of water and nutrients causing a general thinning of the crown and finally tree death. As some agents are also able to decay wood, they very often cause tree failure (Table 12.8).
d Finally, an important group of fungi has to be considered, as wood destroying fungi play a fundamental role in creating risk of failure in street trees. The decay fungi use different components of the woody structure of the tree as energy sources: if they break down the cellulose, a brown rot will be produced; when lignin is utilized, a white rot will be observed. Obviously, both kinds of rot and all their possible variations due to the enzymes the organisms possess, dangerously compromise tree steadiness (Table 12.9).

12.5
Aetiology, Symptomatology and Epidemiology of the Most Important Pests in Europe

For each country or region there is a fairly specific set of major pests present in the urban environment. Many of these insects are also distributed across entire Europe and pose similar problems to geographically distant countries. Therefore, some of the most representative species, which occur over a large area causing extensive damage to the tree foliage and that can frequently be observed for several consecutive seasons shall be discussed here.

12.5.1
Leaf Feeders

This group includes numerous representatives of the Lepidoptera, Coleoptera, Hymenoptera and Diptera orders. They are usually the most important defoliators of urban trees. Mass infestations and significant foliage damage frequently require implementation of control measures.

Horse Chestnut Leaf Miner – *Cameraria ohridella* Deschka et Dimic

Since its first discovery in Macedonia in 1985 *Cameraria ohridella* has rapidly spread in Europe and become the most important pest of the horse chestnut in many coun-

Table 12.6. Fungi and bacteria causing leaf and shoot diseases mentioned as important (+) by the countries participating in the pilot study

Agent	Host(s)	Name of the disease	Country																		
			A	B	CH	D	E	F	FIN	GR	H	HR	I	N	NL	P	PL	Sk	SLO	UK	Total
Apiognomonia veneta	*Platanus*	Anthracnose of plane	+	+	+	+	+	+		+	+	+	+		+	+	+	+	+	+	16
Apiognomonia errabunda	*Fagus*	Beech leaf anthracnose						+	+										+		3
Guignardia aesculi	*Aesculum*	Leaf blotch of horse chestnut		+	+	+		+			+	+	+		+		+	+	+	+	12
Lophodermium piceae	*Picea*	Needle blight of spruce			+	+			+								+				4
Lophodermium seditiosum	*Pinus*	Needle-cast of pine			+	+	+		+	+	+		+				+	+			9
Marssonina brunnea	*Populus*	Leaf-spot of poplar	+		+		+		+	+			+		+				+		9
Marssonina salicicola	*Salix*	Leaf and shoot blight of willow					+											+			2
Melampsora spp.	*Populus*	Poplar leaf rust	+		+				+	+					+				+		6
Microsphaera alphitoides	*Quercus*	Oak mildew		+		+			+			+	+			+	+	+	+		9
Microsphaera platani	*Platanus*	Plane mildew		+		+	+			+			+				+				6
Pseudomonas syringae	*Fraxinus*	Ash tumour				+		+							+		+				4
Rhytisma acerinum	*Acer*	Tar spot of maple		+	+	+	+	+	+		+		+				+		+		10
Sphaeropsis sapinea	*Pinus*	Shoot dieback	+		+					+		+	+					+	+		7
Venturia macularis	*Populus*	Shoot blight of poplar			+	+			+				+				+		+		6

Table 12.7. Fungi causing stem and branch diseases mentioned as important (+) by the countries participating in the pilot study

Agent	Host(s)	Name of the disease	Country																		
			A	B	CH	D	E	F	FIN	GR	H	HR	I	N	NL	P	PL	Sk	SLO	UK	Total
Ceratocystis fimbriata	*Platanus*	Canker stain of plane			+			+					+								3
Nectria spp.	Broadleaves	Cankers	+	+	+	+		+	+						+		+		+		9
Ophiostoma ulmi	*Ulmus*	Dutch elm disease	+			+	+		+	+			+		+	+	+				9
Phoma tracheiphila	*Citrus*	Mal secco								+									+		2
Seiridium cardinale	*Cupressaceae*	Canker					+	+		+			+								4
Verticillium spp.	Broadleaves	Wilt	+	+	+	+	+								+		+	+			8

Table 12.8. Fungi causing root and collar diseases (* = decay extending also into the stem) mentioned as important (+) by the countries participating in the pilot study

Agent	Host	Name of the disease	Kind of rot	Country																		
				A	B	CH	D	E	F	FIN	GR	H	HR	I	N	NL	P	PL	Sk	SLO	UK	Total
Armillaria spp.*	Broadleaves	Root and butt rot	White		+		+		+	+			+	+			+	+	+		+	10
Armillaria spp.*	Conifers	Root and butt rot	White			+	+	+	+	+				+	+		+	+				9
*Heterobasidion annosum**	Conifers	Root rot	White				+			+				+	+			+				5
Phytophthora spp.	Broadleaves	Root and collar death	–	+	+		+							+			+				+	6
Meripilus giganteus	Broadleaves	Root and stem decay	White			+										+		+	+		+	5
*Phaeolus schweinitzii**	Conifers	Root and stem decay	Brown				+			+				+				+				4
*Ustulina deusta**	Broadleaves	Root and stem decay	White				+									+		+				3

Table 12.9. Fungi causing decay mentioned as important (+) by the countries participating in the pilot study

Agent	Host	Kind of rot	Country																		
			A	B	CH	D	E	F	FIN	GR	H	HR	I	N	NL	P	PL	Sk	SLO	UK	Total
Fistulina epatica	*Quercus*	Brown				+											+	+			3
Fomes fomentarius	Broadleaves	White				+		+	+	+			+	+			+	+			8
Fomitopsis pinicola	Conifers and broadleaves	Brown				+								+			+	+			4
Ganoderma spp.	Broadleaves	White		+		+		+	+	+			+		+		+	+			9
Inonotus spp.	Broadleaves	White				+		+	+	+			+	+	+		+	+			9
Laetiporus sulphureus	Broadleaves	Brown		+		+		+	+				+	+			+	+	+		9
Perenniporia fraxinea	Broadleaves	White				+											+	+			3
Phellinus	Broadleaves	White				+			+	+			+	+		+	+	+			8
Phellinus	Conifers	White pocket			+	+			+	+			+				+				6
Pholiota spp.	Broadleaves	White				+										+			+		3
Piptoporus betulinus	Birch	Brown				+			+			+		+			+	+			6
Pleurotus ostreatus	Broadleaves	White				+											+				2
Polyporus squamosus	Broadleaves	White				+			+				+				+	+			5

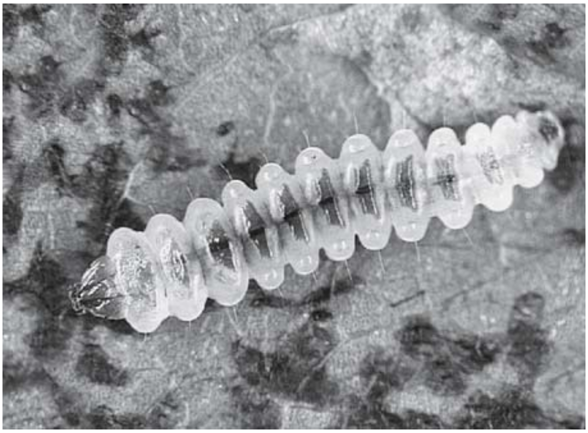

Fig. 12.1.
Larva of *Cameraria ohridella* (*photo:* M. Tomalak)

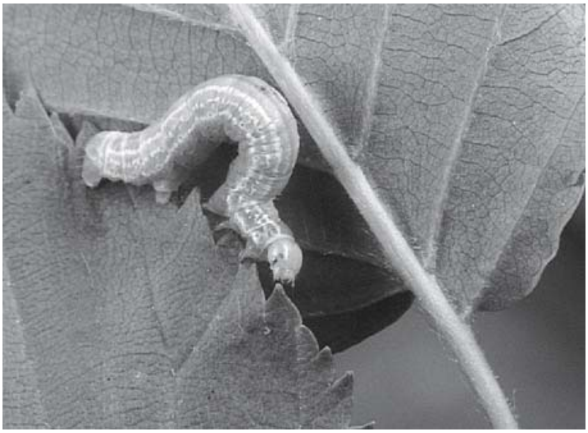

Fig. 12.2.
Larva of *Operophtera brumata* (*photo:* M. Tomalak)

tries. The insects overwinter as pupae in silken cocoons inside fallen leaves. First adults fly in the spring shortly after development of the foliage. Females deposit eggs on leaves, close to main veins. Development of larvae (Fig. 12.1) and pupation takes place inside the leaves. As a result of larval feeding large whitish or brownish mines are produced. Occasionally, more than 100 mines are present on a compound leaf. The insect can develop 3–5 generations during a single season. Heavy infestation leads to browning and premature death of leaves even as early as in July or August.

Winter Moth – *Operophtera brumata* L. and Northern Winter Moth, *O. fagata* Scharf.

Both winter moths are generally common and often destructive to foliage of many tree genera, such as *Carpinus*, *Ulmus*, *Quercus*, *Acer*, *Betula* etc., grown in urban parks and forests. Larvae with abdominal legs reduced to only two pairs at the very end of the body feed on leaves from April until early June (Fig. 12.2). The insect pupates in the soil and adults emerge from late October until December. Males fly on cold nights while females with reduced wings can only walk up the tree. After copulation eggs are deposited on twigs close to leaf buds. Mass feeding of winter moths larvae leads to partial destruction of the foliage. The infested trees usually do not regenerate the damaged foliage, which remains on the tree until autumn.

There are also a number of other geometrids, such as *Erannis defoliaria*, *Apocheima pilosaria*, *Campaea margaritata*, *Biston betularia*, etc. often feeding on urban trees. However, they rarely produce large enough populations to cause damage comparable to the previous species.

Brown-Tail Moth – *Euproctis chrysorrhoea* L.

The insect, usually associated with blackthorn and hawthorn, can occasionally produce large populations on oak and many other tree species. It is widely distributed in central and southern Europe.

Adult moths fly in summer. Females deposit eggs in batches and cover them with hairs from the abdomen. Young larvae appear from mid-August on and start feeding together in large groups. They construct silken tents in which they shelter during unfavorable weather and overwinter. Feeding is resumed the following spring when new foliage develops on the host plant. Older larvae become solitary. In late June they spin individual silken cocoons between leaves and pupate there.

Gregarious feeding of the caterpillars can cause substantial defoliation of infested trees. Moreover, the hairs covering their body frequently become a source of allergy for humans. Therefore, careful monitoring and control of this pest is often necessary.

Green Oak Tortrix Moth – *Tortrix viridana* L.

This common and destructive moth is associated with oak (Fig. 12.3). Adults are numerous in early summer. Eggs are deposited on the bark of twigs, close to leaf buds. Larvae hatch the following spring (Fig. 12.4). At first they feed on bursting buds and later inside rolled and partially spun leaves. Pupation takes place in the same habitat in June. Mass feeding of the insect larvae significantly reduces the tree foliage and can occasionally lead to complete defoliation. Such trees usually develop a second set of

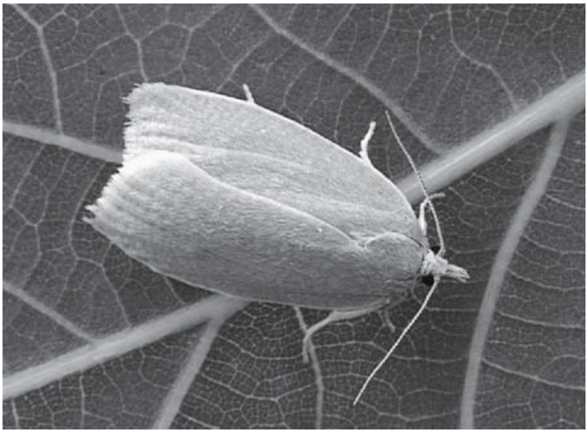

Fig. 12.3.
Adult of *Tortrix viridana* (*photo:* M. Tomalak)

Fig. 12.4.
Larva of *Tortrix viridana* feeding inside a leaf (*photo:* M. Tomalak)

leaves later in the season. Mass infestations repeated for several consecutive years may, however, seriously weaken or even kill the trees.

The family Tortricidae includes a large number of small moths, many of which are known to damage leaves of most trees and shrubs. Although they are not as destructive as *T. viridana*, characteristically spun or rolled leaves damaged by the insect larvae can be frequently seen in spring and early summer.

Gypsy Moth – *Lymantria dispar* L.

Due to its ability of mass feeding on a wide range of deciduous species, the insect is considered an important and often destructive pest of urban trees. It is present throughout Europe and has been introduced to North America.

The insect overwinters in the form of eggs deposited in mass on tree bark and covered with female body hairs. The eggs hatch in late April or May and young larvae start feeding on newly developing buds and leaves. During 2–3 month feeding the larvae reach maturity and pupate on the host tree. Adult moths start to fly from late July on. Mass feeding of this species can cause considerable defoliation of the host trees.

Pine Procession Moth – *Thaumetopoea pityocampa* Denis et Schiffermuller

The insect is widely distributed in southern Europe, especially along the Mediterranean coast. Adult moths fly in summer and lay large clusters of eggs on needles of various pine species. The larvae hatch at the end of summer, from late August on. They live in community nests at the top of tree branches and disperse only during feeding at night. They continue feeding until the spring and early summer when fully-grown caterpillars move to the soil for pupation. There is a single generation annually, although the pupae can remain in the soil for several seasons.

Direct damage caused to the pine needles can affect growth of the infested tree and significantly reduce its aesthetic value. When present in the urban environment caterpillars of procession moths can also pose health problems due to shedding of easily broken hairs, which cause severe skin allergy in humans.

Leaf Beetles – Chrysomelidae

Many species of this beetle family are frequently present on urban trees. Several of them, such as *Altica quercetorum* on *Quercus* (Fig. 12.5 and 12.6), *Agelastica alni* on *Alnus*, *Pyrrhalta luteola* on *Ulmus*, and *Phyllodecta laticollis* on *Populus* can occasionally become important pests. Adult beetles overwinter in the soil or litter and appear on trees in the spring and early summer. They intensively feed on leaves before reproduction. Eggs are deposited on the lower side of leaves where young larvae subsequently develop in large groups. Mature larvae fall to the soil for pupation. Young adults emerge 2–3 weeks later and resume feeding in the canopy. Usually one, or two generations are produced per year. Feeding of both the adult beetles and larvae causes extensive damage to the leaf tissue and often leads to premature browning of the foliage. Most of the leaf beetle species have a tendency to appear in large numbers for several consecutive seasons.

Fig. 12.5.
Adult of *Altica quercetorum* feeding on a leaf (*photo:* M. Tomalak)

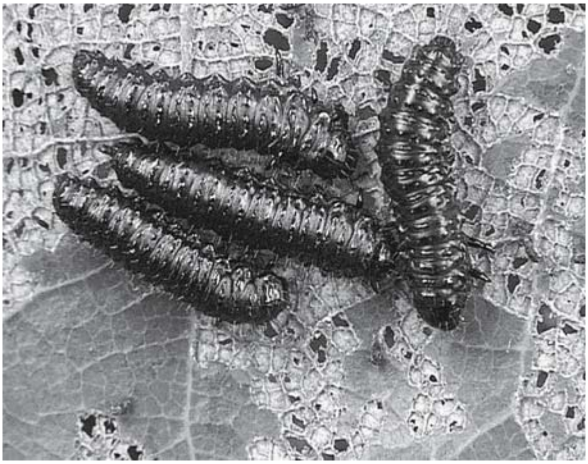

Fig. 12.6.
Larvae of *Altica quercetorum* producing the characteristic damage on leaves (*photo:* M. Tomalak)

12.5.2 Wood Borers

This group is represented by numerous species from several families of the Coleoptera (Cerambycidae, Scolytidae, Buprestidae, Curculionidae), Lepidoptera (Cossidae, Sesiidae) and Hymenoptera (Siricidae) orders. They are common throughout Europe and in some areas can cause significant damage to individual urban trees.

Goat Moth – *Cossus cossus* L.

This widespread moth can attack many different deciduous trees in Europe, including *Populus*, *Acer*, *Betula* and *Tilia*. Although not very common, it was reported as important urban tree pest in several countries. Adult moths are present in June and July. Females deposit groups of eggs in bark crevices. Young larvae burrow into the trunk to continue their development in the sapwood and hardwood for 3–4 years. Fully-grown, characteristically red individuals reach 8–10 cm in length and over 1 cm in width. Gradually expanding larval galleries can fill most of the trunk, thus causing substantial damage and frequently killing the tree.

Long Horned Beetles – Cerambycidae

Beetles of this family live on various coniferous or deciduous tree species. There are some 500 species of cerambycids living in Europe, most of them associated with tree hosts. They usually build their larval galleries in the hardwood of living, dying or dead trees and can occasionally damage valuable old individuals. In the COST E12 survey some species, such as *Saperda carcharias* and *Aromia moschata* were reported as important pests. Characteristic galleries of many other long horned beetles can be frequently observed in urban forests and parks. However, most of them are typical secondary pests infesting already weakened or dying trees.

12.5.3 Bark Borers

This group comprises most species of the bark beetles (Scolytidae) family and some representatives of weevils (Curculionidae) and buprestid (Buprestidae) families.

Bark Beetles – Scolytidae

This is a large group of 2–10 mm long beetles, usually living under the bark and occasionally in the hardwood of various tree species. They are common forest components throughout Europe and can be found in any woody habitat. Several species are known to infest street trees and become urban pests contributing to dissemination of tree diseases (e.g., *Scolytus multistriatus* and other elm *Scolytus* species are vectors of *Ophiostoma ulmi*) or killing temporarily weakened trees. In the COST E12 survey several species of bark beetles, including *Scolytus* spp. on *Ulmus*, *Tomicus* spp. on *Pinus*, *Ips typographus* and *Pityogenes chalcographus* on *Picea* and *Leperesinus* spp. and *Hylesinus* spp. on *Fraxinus* were reported as important pests of urban trees in several European countries. The insects' life cycle is closely related with the host. Adult beetles conduct their maturation feeding on twigs or under the bark. After reaching the new host they construct parent galleries under the bark in the phloem. Young larvae hatching from eggs deposited along the parent gallery produce their own feeding galleries and after reaching maturity pupate in the bark or in shallow pupal chambers located in the hardwood. Feeding of the insect larvae leads to gradual killing of the phloem and subsequently to tree death. Bark beetles prefer weakened or injured trees as potentially best breeding sites. Therefore, adequate attention should be paid to protection or removal of such individuals.

12.5.4 Sap Suckers

This group of pests is represented by insects from the Homoptera and Heteroptera orders. Although very common and numerous on urban trees, only a few species are considered important and require regular monitoring and control.

Green Spruce Aphid – *Elatobium abietinum* Walker

This aphid is considered as one of the most important pests of ornamental and forest spruces (*Picea*). It usually overwinters in the egg stage. The wingless generation appears in spring and rapidly builds up the colony. Frequently, the colony covers a whole tree. The feeding in large numbers causes gradual discoloration and die-off of needles in late spring and early summer (Fig. 12.7). Interestingly, the young, freshly developed needles are not affected. Thus, infested trees can survive, although their aesthetic value is severely reduced. Winged individuals appear in the colony from May onwards and fly to new trees to initiate new colonies.

Many other species of aphids are frequently associated with urban trees and shrubs and some of them, including *Eucallipterus tiliae* on *Tilia*, *Periphyllus* spp. on *Acer* and

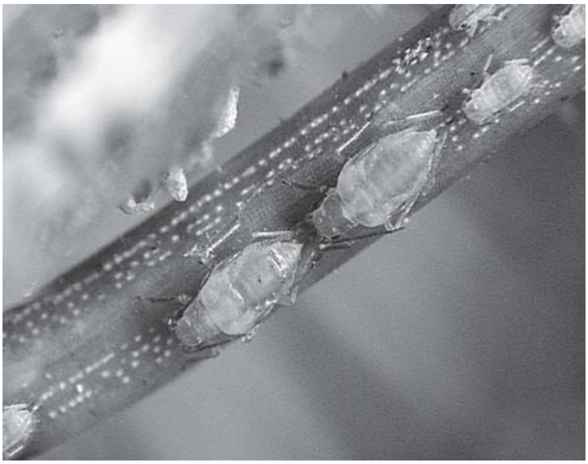

Fig. 12.7.
Elatobium abietinum individuals feeding on spruce needles (*photo:* M. Tomalak)

Pemphigus spp. on *Populus* were reported as important pests in various European countries. They cause distortion and discoloration of leaves, shoots or flowers. Their mass colonies are frequently observed in spring and early summer. The sticky honeydew produced in large quantities by most aphids covers leaves and facilitates permanent deposition of dust and development of saprotrophs. All these factors can severely reduce the aesthetic value of infested trees.

Sycamore Lace Bug – *Corythucha ciliata* Say

This native North American pest species of plane trees (*Platanus*) has been introduced to Europe and since 1964 has spread throughout most of the southern regions.

Adult insects overwinter under the bark of trees and emerge in the following spring after the trees resume development of the new foliage. Eggs are laid on the underside of the leaves. Nymphs of the first generation mature in late June and July. The second generation develops during summer. In most southern regions up to three generations can develop annually.

The infested foliage gradually turns whitish and frequently falls prematurely. In heavy infestations tree vigour can be substantially reduced. In the urban environment, the damage produced by this pest is due not only to its effect on tree physiology (photosynthesis) and ornamental value, but also to the disturbance of certain urban activities that take place under infested trees.

Mites – Acarina

From the large group of mites present on urban trees only a few species are known to cause significant injuries. Many of them can, however, cause visible malformations or discoloration of leaves.

Gall or rust mites, Eriophyidae. Many species of these small (0.2 mm long) mites (*Eriophyes* spp., *Aculus* spp.) are associated with urban trees, particularly those of *Acer*, *Aesculus*, *Alnus*, *Betula*, *Carpinus*, *Fagus*, *Fraxinus*, *Salix*, *Tilia* and *Ulmus* genera. They induce development of pimple-like bead galls, blisters or brownish, yellowish or whitish erinea on the upper or lower side of leaves. Although the viability of attacked trees is usually not affected, galls or blisters on heavily infested leaves can cause considerable distortion and reduce aesthetic value of specimen trees.

Spider mites, Tetranychidae. A number of species in this family (*Oligonychus* spp., *Tetranychus* spp., *Panonychus* spp. *Eotetranychus* spp.) have been reported to cause damage to urban trees in Europe. The mites (0.4 mm long) feed directly on needles or leaves and cause silvering, browning and eventual death of the attacked branches. They overwinter as adults or eggs in bark crevices and quickly build up their populations in the spring. In temperate regions of Europe they can develop 5 or more generations per year and reach large population size on suitable hosts. Some species such as *Oligonychus unungius* can be particularly dangerous to young trees of susceptible species (*Pinus*, *Abies*, *Chamaecyparis*) and they occasionally require control.

12.6 Aetiology, Symptomatology and Epidemology of the Most Important Diseases in Europe

Despite the regional environmental differences that can be found in Europe it is possible to highlight some important diseases that affect a more or less extensive part of the continent, with only some differences in disease incidence, prevalence and/or intensity. The described organisms are grouped following the categories considered in the tables. Fungal taxonomy follows Ainsworth and Bisby's Dictionary of Fungi (Kirk et al. 2001).

12.6.1 Leaf and Shoot Diseases

Anthracnose of Plane Trees – *Apiognomonia veneta* (Sacc. et Speg.) Höhnel

Since its first detection in Europe, some 30 years ago, this ascomycete (Diaporthales), has spread widely throughout the continent; it has been reported in Italy, France, United Kingdom, Croatia, Switzerland, Russia, Germany, Spain, etc. At present, anthracnose constitutes the most important disease of plane trees in the central part of the Iberian Peninsula, with less than 3% of the trees showing no visible symptoms (Tello et al. 2000).

In leaves, the pathogen produces vein and petiole necrosis, premature desiccation and leaf-fall. In shoots and twigs, it can produce bud death and prevent shooting.

Fig. 12.8. Characteristic symptoms of anthracnose on plane trees: growth in whorls, branches in angles and cankers (*photo:* E. Mateo-Sagasta)

Fig. 12.9.
Plane tree showing a severe attack of anthracnose in summer (*photo:* E. Mateo-Sagasta)

This provokes the sprouting of new leaves and shoots with shorter internodes from adventitious buds that very frequently tend to grow in whorls at the base of the shoot. The leaves wither and the crown looses its ornamental appearance. In branches the fungus produces cankers and necrotic lesions that make branches fragile and easily breakable (Fig. 12.8). The succession of breaks and new growth in the same branch produces a characteristic growth in angles. In the final stage of the disease progress, most of the branches are dead and the tree shoots only from the trunk and older branches.

Optimum temperature for sporulation and dissemination of the fungus seems to be around 15–25 °C with high humidity (saturation). Its mycelium, when inside the host, can resist temperatures ranging from –12 °C to +42 °C (Tello et al. 2000). Diseased trees can survive for several years, but their ornamental value starts to decrease in the third or fourth year after infection, when the characteristic symptoms become visible. The severity of the disease can even cause an early defoliation that makes the trees unable to offer enough shade, an extraordinarily important role in the towns of southern Europe (Fig. 12.9).

Powdery Mildews – Erysiphales

The Erysiphal fungi constitute a very important group of pathogens, widespread all over Europe and attacking many broadleaves. They are obligate parasites that can cause serious outbreaks provoking intense defoliation and compromising the ornamental value and shade effect of the trees. The most characteristic symptom is the appearance of a whitish powdery coating, consisting of mycelium and masses of conidiophores and conidia, on the surface of leaves, buds and young shoots (even young flowers and fruits; Fig. 12.10 and 12.11). During intense attacks, the leaves become deformed, wilted, brown and fall prematurely. However, these pathogens, although frequent, usually cause moderate damage, mainly aesthetical, only being really dangerous when affecting young trees.

Some of the most common species in Europe are *Microsphaera alphitoides* Griff. et Maubl. on *Quercus* (mainly *Q. robur*, very susceptible), *Fagus* and *Castanea*; *Microsphaera penicillata* (Wallr.) Lév. on *Alnus*, *Tilia* and *Betula*, *Microsphaera platani* Howe on *Platanus*, *Phyllactinia guttata* (Wallr.) Lév. on a wide range of broadleaves but more frequent on *Corylus*, *Acer*, *Alnus*, *Betula*, *Castanea*, *Fagus*, *Morus*, *Populus*, *Prunus*, *Salix* and *Ulmus,* and several species of *Uncinula* on many hosts (*Uncinula adunca* (Wallr.) Lév. on *Salix* and *Populus*, *U. bicornis* (Wallr.) Lév. and *U. tulasnei* Fuckel on *Acer*). Powdery mildew on plane trees is at present a very common disease in most parts of southern and central Europe, being endemic in large areas of Greece, Italy, France, Portugal and Spain, where it causes intense defoliation.

Fig. 12.10. Symptoms of powdery mildew on leaves of *Platanus* sp. (*photo:* M. L. Tello)

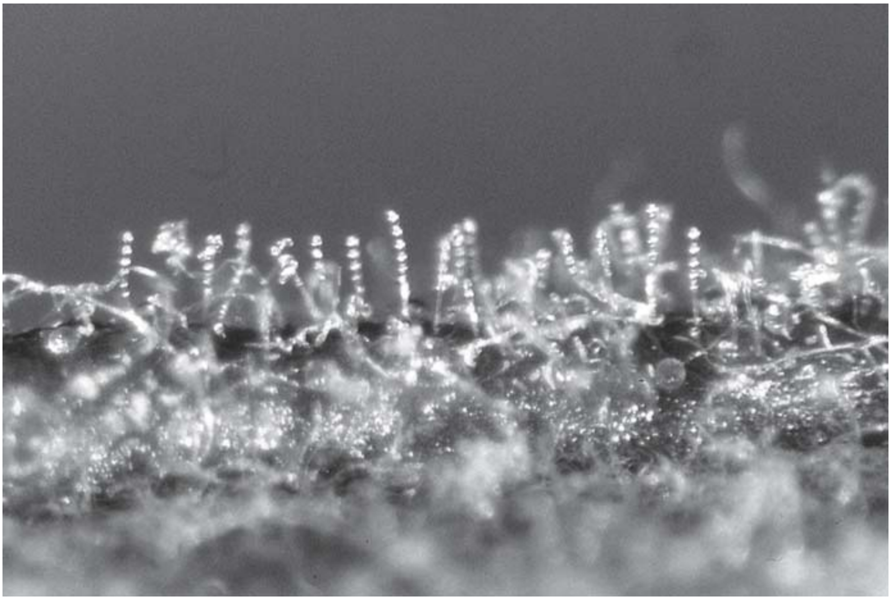

Fig. 12.11. Conidiophores and spores of powdery mildew on leaves (*photo:* M. L. Tello)

Lophodermium Needle-Cast of Pine – *Lophodermium seditiosum* Minter, Staley and Millar

The fungus (Rhytismatales) penetrates into pine needles at the beginning of autumn, causing little yellow spots that become larger and brown later on. When each needle shows several infection points, it dies and falls during the following spring. After the spring defoliation, others are possible, depending on weather conditions and disease intensity. The fruit bodies of the fungus ripen on needles lying on the ground during the summer and emit spores only after abundant rains. The severity of damage is higher in young trees (less than 10 years old).

L. seditiosum can be accompanied or followed by *Lophodermium pinastri* (Schrad.) Chev., a saprotroph very similar to it; in this case, several black lines are visible across the attacked needles.

Leaf Blotch of Horse Chestnut – *Guignardia aesculi* (Peck) Stew.

This widespread fungus (Dothideales), attacks all species of *Aesculus* and causes the leaves to become blotched brown, with marginal scorch, to wither and finally fall prematurely. The pathogen overwinters in leaves on the ground where the spores are produced in the following spring for starting the infections. The small black pustules of the conidial stage appear in the centers of the spots while leaves are still on the tree, being responsible for further spread of the disease.

An abiotic leaf blotch is also detectable, caused by salt, high temperatures and drought; in this case, no fruit body appears.

Fig. 12.12. Necrotic spots on leaves caused by *Pseudomonas syringae* on *Prunus* sp. (photo M. L. Tello)

Bacterial Blight – *Pseudomonas syringae* pv. *syringae* Van Hall

The concurrence of this bacterium with low temperatures has been pointed at as a main reason for disease appearance, mostly on leaves and shoots of *Populus*, *Salix* and *Alnus cordata*, and seldom on other trees, like *Ulmus americana* (De Kam 1982a,b; Ramstedt et al. 1994).

Pseudomonas syringae pv. *syringae* seems to occur as an epiphyte on many plant species (O'Brien and Lindow 1989). The change of an epiphytic form into a pathogenic one can occur under favorable conditions. Its pathogenicity was determined by Haworth and Spiers (1988), who detected its presence on leaves with small, irregular necrotic spots (Fig. 12.12) as well as on dying shoots, showing canker-like lesions and covered with white sediment and proved that *P. syringae* pv. *syringae* is the causal agent of those symptoms. Similar results were obtained by Spiers (1990) and Scortichini (1997) on *Alnus glutinosa* and *A. cordata*.

Bacterial canker of ash, caused by *P. savastanoi* pv. *fraxini* (Janse), is a new and very damaging disease affecting single ashes growing in cities and along communication roads.

Fire Blight of Pomoideae – *Erwinia amylovora* (Burrill) Winslow et al.

A quarantine disease and one of the most important and harmful diseases of fruit trees. In cities it can attack trees and shrubs of the following genera: *Cotoneaster*, *Crataegus*, *Cidonia*, *Malus*, *Pyracantha*, *Pyrus* and *Sorbus*. The bacterium infects leaves and young shoots. Symptoms of fire blight, if characteristic bacterial slime does not accompany them, may be mistaken with symptoms of other diseases, or damage caused by pests and frost. Similar symptoms can be caused by other pathogens such as *Pseudomonas syringae* pv. *syringae* and *Nectria galligena* Bres.

Phytoplasmas – Mollicutes

The main symptoms of diseases caused by the formerly called 'mycoplasma-like organisms' (MLOs) observed on trees are leaf yellowing, reddening of the foliage with smaller leaves, stunted growth, shoot proliferation and witches' brooms formation, damage in flowers and sometimes rapid shoot death.

Phytoplasmas may have different shapes in the host's cells (round or elliptic, irregular or thread-like), have no cell wall and their membrane is made of three layers. They colonize the phloem sieve-tube elements and are sensitive to tetracycline antibiotics (which may control the disease but cannot be used in most of the European countries as a control treatment, according to regulation due to human health protection). Phytoplasmas spread mainly through insect vectors and vegetative propagation (Maramorosch and Raychaudhuri 1981; Raychaudhuri and Maramorosch 1996).

Some diseases caused by these organisms are: elm yellows – symptoms on *Ulmus* being yellowing of leaves followed by necrosis, and ash yellows – witches' brooms on *Fraxinus* (Ash witches' brooms) and other tree genera such as *Juglans*, *Syringa*, *Salix* and *Populus* (Sinclair et al. 1987).

Viruses

In the last twenty years several monographs have been published on both general and more detailed problems of etiology, symptomatology and epidemiology of viruses that infect many trees and shrubs (Cooper 1993).

In a recent review Cooper and Edwards (1996) presented a table in which 25 taxonomic orders of trees, single species, varieties and clones were listed against the corresponding viruses that infect them. The most susceptible trees are broadleaves such as: *Acer*, *Aesculus*, *Betula*, *Corylus*, *Fagus*, *Fraxinus*, *Juglans*, *Populus*, *Prunus*, *Quercus*, *Robinia* and *Ulmus*. There are only a few references on coniferous species being infected by viruses (e.g., *Chamaecyparis*, *Cupressus*, *Larix*, *Picea* and *Pinus*).

The viruses' infection results in changes of leaf color: from green through yellow, pale green to red/brown. It subsequently affects the process of photosynthesis and thus decreases growth and tree development. Viruses can be transported through insect vectors or pollen and seeds.

12.6.2
Stem and Branch Diseases

Cankers on Broadleaves – *Nectria* spp.

A group of fungi in the genus *Nectria* (Hypocreales) are responsible for perennial cankers in different broadleaves. In this kind of canker, typically target-shaped, a series of callus ridges are formed by the host for stopping the fungus, but, during each dormant season, the last ridge is newly invaded. The canker can also serve as an entry point for wood decay fungi.

In Europe the main hosts are *Acer*, *Fagus*, *Fraxinus*, *Platanus*, *Robinia* and *Tilia*. The fungal species involved are *N. ditissima* Tul., *N. coccinea* (Pers.) Fr., *N. galligena* Bres., *N. cinnabarina* Tode (Fr.). When the main stem is attacked, trees are subject to wind breakage. Infection occurs through wounds or alterations that reach the cambium (branch stubs, frost cracks, pruning wounds, etc.). Infection is also possible through leaf scars.

Dutch Elm Disease (DED) – *Ophiostoma ulmi* (Buism.) Nannf. and *O. novo-ulmi* Brasier

This infamous disease has caused great losses of adult *Ulmus* in Europe. The Ophiostomatal fungus, formerly named *Ceratocystis ulmi* (Buism.) Moreau, was first detected in Europe (France and Belgium), at the beginning of the 20th century (during World War I) and successive epidemics of aggressive strains of the fungus (e.g. the famous one of the 1970s) have devastated the susceptible elms during the past century.

Infection starts when fungal mycelia or conidia reach a susceptible host, via insect vectors or root anastomoses. Once the fungus is in the vessels, the host reacts by producing gums and tyloses that block them and stops water flow. As a result, the vessels turn brownish and the tips of the top branches wilt and eventually die, producing vascular wilt. The elm bark beetles (*Scolytus* spp.) play a very important role. Some authors have suggested that the vector probably has a greater influence on disease incidence in the Mediterranean area where the climate is warmer, and less in northern European countries. Two groups of fungal strains can be distinguished: the less aggressive strains, responsible for the first pandemic of DED, and the highly aggressive strains, responsible for the current one.

Verticillium Wilt – *Verticillium* spp.

Verticillium wilt is an important problem in northern Europe, even if it is present also in warmer conditions. It is caused by two main *Verticillium* species, distinguishable only in culture: *V. dahliae*, a thermophilous species forming sclerotia, and *V. albo-atrum*, which stops growing at 30 °C and in culture only forms a dark resting mycelium. These anamorphic fungi are mainly soil-borne and infect the plant through rootlets in contact with the remains of previously infected crops. They can be transmitted also by tools. Frequently, plants are infected in the nursery.

The main host is *Acer*, but also *Aesculus*, *Fraxinus*, *Olea*, *Platanus*, *Robinia, Tilia* and *Ulmus* are mentioned. Affected trees can be killed in the first year of infection, or they can show chronic symptoms, with progressive dieback and sparse yellow foliage.

Cypress Canker – *Seiridium* (*Coryneum*) *cardinale* (Wagner) Sutton and Gibson

This anamorphic fungus lives in the bark of stems and twigs of different Cupressaceae (*Cupressus*, *Thuja*, *Chamaecyparis* species), where it forms girdling cankers that finally kill the distal part. The infection often begins in small cracks of the bark and becomes evident with the appearance of some resin flow. The fungus produces its asexual fruit bodies, recognisable as very small black pustules in the dead part of the bark, near or inside the canker. No sexual stage is known. Conidia are dispersed by the wind that carries droplets during rains. Some cypress beetles can also be vectors.

Canker Stain on Plane Tree – *Ceratocystis fimbriata* Ellis and Halsted f. spp. *platani* Walter

This ascomycete (Microascales) causes a destructive tracheomycosis in *Platanus* spp. The disease is present in the USA and in Italy, France and Switzerland. The name of the disease leads astray, as no canker is detectable on the stem, and the staining is an internal one, in the wood.

A single branch with sparse, more or less chlorotic foliage is usually seen first. On the side bearing this branch, the bark becomes necrotic, pale-brown, cracked and adheres to the tree. The edges of the lesions show no wood callus formation, and often extend in bluish-black filaments or veins, more evident when bark is peeled off. Infected trees die in 3–7 years. When a tree is felled, on the surface of timber the very evident symptom is a dark color, often in a radial pattern and along the younger woody rings.

Contaminated pruning tools and terracing machinery, which causes damage to the roots, transmit the pathogen. It may be transmitted also by root contact (anastomoses). Infected tissues of a dead plant can transmit the disease. In fact, the pathogen can survive for more than 5 years in woody fragments in soil. Sawdust from diseased trees is highly infective.

Plant Parasitic Nematodes – Nematoda

Parasitic nematodes are among the most important pathogens of cultivated plants. They are also frequently associated with trees. Most species cause direct damage to plant tissue, but some of them (e.g., *Xiphinema* spp. and *Longidorus* spp.) can also serve as important vectors of viruses. Economic losses of seedlings and young trees are occasionally reported from ornamental and forest bare-root nurseries and plantations. Several species of *Meloidogyne*, *Trichodorus*, *Xiphinema* and *Pratylenchus* were recorded on roots of broadleaf trees. Conifers are frequently infested with various species of *Haplolaimus*, *Tylenchorhynchus*, and *Pratylenchus* (Sutherland and Webster 1993). Information on nematode-related damage caused to mature trees is, however, very limited in temperate climates. So far no data is available on such cases in urban forests of Europe.

Recent establishment of the pine wood nematode, *Bursaphelenchus xylophilus* in Portugal (Mota et al. 1999) may, however, change this situation soon. The nematode is known to cause a devastating pine wilt disease, which presently spreads over the eastern regions of Asia, and North America. The disease can develop on various species of conifers, mainly pines (*Pinus* spp.), and in suitable environmental conditions it may kill even mature trees within only a few weeks. Infective juveniles of the nematode are transmitted by wood dwelling long horn beetles from the genus *Monochamus*. After reaching the host nematodes start to feed on epithelial cells of resin canals and cause fast wilting and subsequent dying of the infested tree. The nematode is presently subjected to strict quarantine regulations in Europe; however its control after establishment in the forest has shown to be extremely difficult. We can only hope that *B. xylophilus* and pine wilt disease will not manage to establish in other regions of Europe. Otherwise, this species could become a real threat to pine trees grown not only in open forests, but also in the urban environment.

Interestingly, a recent study of Braasch et al. (1998) has also revealed severe pathogenicity of two other *Bursaphelenchus* species, naturally present in Europe (*B. mucronatus*, *B. sexdentati*), to pine. Extent of this phenomenon in the field conditions is still under study.

12.6.3
Root and Collar Diseases

Root and Butt Rot – *Armillaria* Complex

A very broad range of hosts is attacked by this species complex, the most frequent being *A. mellea* (Vahl.) Kummer *sensu stricto*, mainly on broadleaves (*Acer*, *Aesculus*, *Quercus*, *Robinia*, *Alnus*, *Celtis*, *Platanus*, *Sophora*, *Tilia*, *Populus*, *Fagus*, *Fraxinus*, *Betula*) and *A. obscura* (Pers.) Herink = *A. ostoyae* (Romagnesi) Herink on conifers (*Abies*, *Larix*, *Picea*, *Pinus*, *Pseudotsuga*, *Tsuga*). It is a major pathogen in Southern Europe (France, Spain, Italy, Portugal and Greece), but also in the coniferous forests of northern Europe.

These basidiomycetes (Agaricales) are widespread along Europe causing white rot of root, collar and butt tissues due to the action of its celulolitic and lignolitic enzymes. They can cause progressive decay (yellowing, wilting, stunting and premature leaf fall) or sudden collapse of a tree previously suffering from drought. Fruit bodies can be found at the end of summer and autumn, but most characteristic are the dark rhizomorphs (Fig. 12.13) and white mycelial sheets.

Root and Collar Rot – *Phytophthora* spp.

These soil-borne pathogenic Oomycetes (Kingdom Chromista) affect the basal parts of the tree (roots and collar) producing a wide range of possible symptoms: root rot, progressive leaf chlorosis, wilting, die-back, resinous or non-resinous cankers, premature

Fig. 12.13. Dark rhizomorphs of *Armillaria* sp. (*photo:* M. L. Tello)

reddening of leaves, defoliation, stunting, sudden or slow decline and death. They enter through fine roots and/or wounds. Trees weakened by disorders or other parasites are more prone to infection. For example, either excess or lack of water in the soil can predispose trees to suffer from root rot. The damage produced by these pathogens in Europe is very important on ornamental trees and shrubs, although mainly in the nursery.

One of the most aggressive representatives in this group is *P. cinnamomi* Rands. It is a serious root-rotting pathogen with more than 1 000 host species. The most common woody hosts are *Acacia*, *Acer*, *Betula*, *Castanea*, *Chamaecyparis*, *Cupressocyparis*, *Cupressus*, *Eucalyptus*, *Fagus*, *Juglans*, *Juniperus*, *Larix*, *Magnolia*, *Olea*, *Picea*, *Pinus*, *Platanus*, *Prunus*, *Quercus*, *Rhododendron*, *Robinia* and *Taxus*. Known as an active pathogen in Mediterranean and temperate areas of Europe, its origin is controversial, with Asia or Australia being the two possibilities under discussion. *P. cinnamomi* is a facultative parasite, but very dependant on physical, chemical and biological factors in the soil, e.g., it prefers high moisture, soil temperature higher than 15 °C, pH $\cong$ 5.5 and low populations of microbial competitors in the soil. *P. cinnamomi* survives as chlamydospores and mycelium inside infected tissues and/or plant debris in the soil – it can survive as a saprobe for as long as 6 years in moist soil. When soil conditions are favorable (mainly temperature and moisture), it produces sporangia which release zoospores that infect new roots.

12.6.4 Wood Destroying Fungi

Wood-destroying fungi are serious problems of both trees and shrubs in urban conditions (Fig. 12.14). They cause wood rots of infected woody plants and not only have an unfavorable influence on the health of hosts but also on their aesthetic appeal. Although their harmful activity in association with trees and shrubs has been studied extensively, relatively few specific studies have been conducted on the urban mycoflora in Europe.

Fig. 12.14. Mature carpophores of *Polyporus squamosus* on a living branch of harmful damaged *Aesculus hippocastanum* (*photo:* J. Gaper)

Fig. 12.15.
Young carpophore of *Ganoderma adspersum* = *Ganoderma australe* on the trunk of a living *Aesculus hippocastanum* (*photo:* J. Gaper)

Species such as *Bjerkandera adusta* (Willd.) P. Karst., *Fomes fomentarius* (L.) J. Kickx, *Phellinus igniarius* Quélet, *Trametes versicolor* (L.) Pilát and some others are always common in urban areas (with a few exceptions) if the appropriate host is present. *F. fomentarius* and *Daedaleopsis confragosa* (Bolton) J. Schroet. (as saprotrophs only) were locally abundant in Helsinki (Finland). Species with a narrow host range show great differences in abundance when their hosts are distributed unequally. For example, *Phellinus pomaceus* (Pers.) Maire is associated with species of *Prunus*, which are not very common in public urban areas.

There are also some differences in the occurrence and distribution of particular fungal species according to the size of a populated area. The greatest species number was recorded in the largest cities. Some wood-destroying fungi such as *Ganoderma australe* (Fr.) Pat. occur almost exclusively in areas of human habitation or areas influenced by human activity (known as synantropic species; Fig. 12.15). From the phytopathological point of view, *Armillaria* spp., *Ganoderma* spp., *Laetiporus sulphureus* (Bull.) Murrill and some others are considered pathogens of woody plant species.

12.7 Control Methods Applied in Europe

12.7.1 Selecting the Appropriate Method

Before any control action is undertaken it must be determined if it is really needed. In fact, from the long list of agents affecting urban woody plants, only a few are able to cause significant damage, and still fewer of them require any control. Thus, close monitoring of the situation and experience of the personnel should help the urban parks and forest services to evaluate properly the potential of a real danger.

If the control action is really needed, it should be decided which of the available methods are to be used. The decision must consider the required level of treatment efficacy, proper timing of the intervention, potential threat to citizens and urban parks and forests visitors, and potential threat to beneficial organisms living within the treated area. It should be remembered that cultural and biocontrol methods are considered the safest for the environment and, therefore, priority should be given to them. However, in some cases these methods can have only limited success and the use of chemical pesticides may be necessary.

Effective control of urban tree pests and diseases can be achieved by a number of means. The available methods include (*a*) cultural practices such as sanitary pruning, removal of all infested parts of the tree, use of pheromones and traps, management of irrigation and drainage, etc., (*b*) biological: spraying with biological pesticides or releasing beneficial organisms (arthropods, nematodes, etc.), (*c*) chemical: by spraying, injecting, or drenching of selected chemical pesticides to the tree canopy, trunk or roots, (*d*) host resistance: using tolerant plant clones and (*e*) plant quarantine: preventing the introduction of pests or diseases via legislation. Integration of all these measures supported by a good monitoring system is possible and desirable and, at present, integrated control programs have been developed for several, most important pests and diseases.

12.7.2
Pest and Disease Monitoring

As information on the current situation in the field is essential for making decisions and proper timing of treatments, effective monitoring for predicting pest/disease outbreaks should be available. Unfortunately, for urban parks and forests monitoring systems are not sufficiently developed. Decisions on detailed examinations of present status of a pest or disease are frequently based on complains from residents or local park and forest administrators. Current methods of risk assessment differ, however, between countries. Computer phenology models for *Lymantria dispar* have been developed in the UK to aid the timing of eradication measures and to assess the risk of establishment elsewhere in the country by comparing environmental factors prevalent in southern UK with those recorded in the areas of earlier epidemics of *L. dispar* in central Europe (Head et al. 1998). In an American pest management program for *L. dispar* in urban parks decision on control treatments was based on number and size of egg masses, host susceptibility, and previous defoliation (Webb et al. 1991). Proper timing of spraying horse chestnuts against *Cameraria ohridella* in Vienna was possible by the use of pheromone traps developed for *Lithocolletis blancardella* (Blumel and Hausdorf 1996). In the case of *Erwinia amylovora*, symptoms of fire blight are not enough to diagnose the disease and isolation and cultivation of the bacterium are necessary. Modern biomolecular techniques, like Nested-PCR or ELISA-DASI, can contribute to its early detection.

No means to control the wood destroying fungi inside living hosts are known and there only remains the policy of prevention. Scouting for disease makes it necessary to know the biological-ecological characteristics of these fungi, one of the most significant features being spore liberation. The acquaintance of sporulation periods together with other factors enables one to foresee infection risk and to determine the most suitable period for treatments (cutting out, shaping, etc.).

12.7.3
Cultural Practices

Pruning and timely removal of infested branches and trees can be an effective method of preventing the spread of pests and diseases. That proved to be particularly true in the control of Dutch Elm Disease in Europe and North America. Systematic removal and burning of any potential breeding material for elm bark beetles was one of the most effective control measures. A similar approach directed at removal and composting of fallen leaves is presently developed in Europe to limit population growth and spreading of *Cameraria ohridella* (Marx 1997). For canker stain of plane trees, the only possible strategy is sanitation. In Italy, a decree settles the compulsory control measures: attacked or dead trees and healthy ones beside them have to be felled. When cutting, infected timber, sawdust and wood chips must be collected and eliminated. All living stumps must be removed or killed.

The control of plane tree anthracnose at present is basically restricted to prevention, using cultural methods such as pruning of dead branches and collection of fallen leaves (Intini et al. 2000). Among the possible control methods in already established plantations sanitary pruning offers the most promising results. It aims to reduce the amount of inoculum of the fungus and to limit future outbreaks of the disease. The disease is not eliminated and the treatment needs to be repeated, but the appearance of the tree is healthy and disease severity is kept at a low level (Tello et al. 2000).

There are many species-specific products available for attraction of bark beetles, moths and sawflies. Synthetic pheromones imitating sex pheromones of insects are widely used in forestry, mainly for monitoring purposes, but in combination with a variety of traps, pheromones can also serve as a control tool, especially if the pest population is highly dispersed. Most commonly used in urban forests are pheromone traps for oak and pine tortrix moths (*Tortrix viridana*, *Rhyacionia buoliana*) and bark beetles (*Trypodendron* spp., *Tomicus piniperda*, *Pityogenes chalcographus*).

12.7.4
Biological Control

Unfortunately, there is a limited range of biocontrol agents potentially effective in open field conditions. The biocontrol of pests is far more developed than the one of diseases. At present, a number of commercial preparations of the entomopathogenic bacterium *Bacillus thuringiensis* are available for plant protection where the strain or variety of the bacterium predetermines the range of potential insects to be effectively controlled. Bioinsecticides based on *B. thuringiensis* var. *kurstaki* are particularly useful against caterpillars of moths, e.g. they have proved to be effective against *Lymantria dispar*, *Operopthera brumata*, *O. fagata*, *Tortrix viridana* and *Euproctis chrysorrhoea* among others. Populations of early larval instars of *Altica quercetorum*, *Agelastica alni* and *Phyllodecta laticollis* were reduced by 80–90% with foliar application of *B. thuringiensis* var. *tenebrionis* (Tomalak 2002).

Many entomopathogenic viruses are known to cause epizootics in natural populations of pest insects. However, only a few records are available on the practical use of virus biopesticides against insects feeding on urban trees. Heavy infestation of urban poplars with *Leucoma salicis* has been significantly reduced after a spraying with nuclear polyhedrosis virus (SsMVPV) (Ziemnicka 2000). A different nuclear polyhedrosis virus has been effective against *Euproctis chrysorrhoea* in the UK.

Several species of entomopathogenic fungi are extensively used in biological control of agricultural pests, particularly in tropical regions. Preparations based on *Beauveria* spp., *Paecilomyces fumosoroseus*, *Verticillium lecanii*, *Metharizium* spp. and other species have been tested in Europe for control of scarab grubs, aphids and whiteflies. No particular references to trials against urban tree pests are, however, available in the literature. Nevertheless, natural epizootics in populations of pest insects can be frequently observed on urban trees and shrubs. Dense colonies of aphids are often infected and killed by numerous species from the Entomophthorales order.

For the last decade, entomopathogenic nematodes of the genera *Steinernema* and *Heterorhabditis* have reached a solid position in biocontrol of many agricultural pests, with commercial formulations available worldwide. As they are adapted to living in the soil only insects occupying this environment, such as scarab, weevil and fly larvae are challenged. Recent studies reveal that many important tree leaf beetles, moths and sawflies can also be effectively controlled (Franco Diaz 1994; Tomalak 2002, 2003, 2004).

Release of parasitoids and predatory insects and mites has only occasionally been examined against pests of urban trees in Europe. In field and laboratory biological control experiments in the Netherlands, *Adelges cooleyi* was successfully controlled on *Pseudotsuga menziesii* with the predators *Exochomus quadripustulatus* and *Coccinella distincta*. Both predators cleaned the needles of aphids so that the use of insecticides could be avoided (Moraal and Steingrover 1991). Numerous ladybird beetles (Coccinellidae), hoverflies (Syrphidae), midges (Cecidomyiidae), various parasitoid wasps (Braconidae, Aphidiidae, Ichneumonidae), and predatory mites are common on urban trees and spontaneously invade aggregations of aphids, moth, beetle and sawfly larvae.

12.7.5 Chemical Control

High standard requirements for human safety significantly limit the range of chemical pesticides allowed within the urban environment. Their use must be confined to absolutely necessary situations and all precautions related to pesticide selection and application methods must be carefully examined. In practice, the use of chemicals is usually limited to local actions and decisions on such actions are based on a real threat to trees.

Due to differences between local regulations existing in European countries the list of chemical compounds used to control urban tree pests and diseases cannot be discussed here in detail. In general, pesticides and methods of application with relatively low potential hazard to the environment are recommended. A priority is given to methods of treatment, which minimize potential accidental drifting of active ingredients to non-target organisms.

The use of contact insecticides (e.g., short-lasting pyrethroids) is limited to local situations were fast growing, dense colonies of a pest pose a real threat to infested trees. Nevertheless, phosphoroorganic insecticides, carbaminians, and amidine derivatives are also occasionally used on a limited scale, mainly against sapsuckers. In the control of aphids, scales and mites infesting urban trees, mineral oils have also proved to be effective. Phytotoxicity was, however, observed in certain species so tree response testing should be performed prior to actual pest control treatments.

Fungicide applications against plane tree anthracnose efficiently inhibit the fungal spores present at a certain moment (Neely 1977; Strouts 1991), but their results are erratic and not suitable as a curative treatment (Luisi and Cirulli 1983). The foliar spraying technique is not recommended for trees in urban conditions. Methods like soil injection or trunk insertion with systemic pesticides could become a solution. Even though the relative efficacy of soil injections with benomyl was reported some years ago (Neely 1977), the technique has not become popular. The trunk insertion methods are based on the introduction of a chemical pesticide directly in the trunk of the tree and are particularly suitable for urban conditions (Guillot and Bory 1999). It poses a relatively low hazard to humans and beneficial organisms. Active ingredients penetrate into the tree and affect only the parasite directly feeding on the plant tissue. Injection of plane trees with metasystox proved to be effective in controlling *Corythucha ciliata* in Switzerland (Mauri 1989) and several authors have reported some promising results against *Apiognomonia veneta* using thiabendazole, copper sulfate and carbendazim (e.g., Himelick and Neely 1988; Tiberi et al. 1988), but at present, their efficacy cannot be guaranteed (Intini et al. 2000) and further investigation is needed. Trunk injected systemic insecticides, such as imidacloprid, have proved quite successful in controlling insect outbreaks in urban forests in the United States. Injection from sealed pesticide capsules has proven to be both environmentally and urban friendly (Tattar, personal communication). In trials conducted in USA injection of abamectin into elm trees proved to be effective against *Pyrrhalta luteola*, a common pest of elms in Europe (Harrell and Pierce 1994). German studies on control of insect pests (*Aphis grossulariae*, *Pityogenes chalcographus*, *Lymantria monacha* and *Tortrix viridana*) in amenity and forest trees by applying systemic insecticides were carried out to determine whether the distribution of chemicals (imidacloprid and methamidophos) by injection, implantation or stem painting would show insecticidal effects. These different techniques showed to be effective methods for treating a limited number of trees (Scholz and Wulf 1998). Application methods and tree species could affect the insecticide vertical movement (Tattar et al. 1998). Although very effective, the injection method is costly and usually recommended only for protection of high value trees.

12.7.6
Host Resistance

Dutch Elm Disease is again a good example. European researchers have worked on three fronts: vector control, fungus control and host resistance. The most promising future for new elm plantations in Europe goes to plant breeding aimed at obtaining tolerant clones through hybridization between European and Asian species. In several countries there exist national collections of native elm clones or progenies, directed to evaluate and preserve that autochthonous material for breeding programs. Currently, there are several groups of European researchers actively working together under the EUFORGEN (European Forest Genetic Resources Programme) strategy, with promising results. Nevertheless, it is probable that the survival of the existing trees (re-shoots from stumps or young trees in natural areas) will highly depend on the fungus' own natural evolution, i.e. on its spontaneous mutation towards less aggressive strains.

Also for new plantations of *Platanus*, the use of tolerant clones against anthracnose seems to be the best option. The oriental plane *P. orientalis* is highly resistant, whilst *P. occidentalis* is susceptible. There seems to be a high degree of heritability of this resistance in interspecific hybrids (Santamour 1976).

12.7.7
Plant Quarantine

The classical way of preventing the introduction of dangerous pests and diseases is plant quarantine. This method aims to restrict the movement of plants and plant products that can carry pathogens not present in a certain country or geographic area by means of regulation and trade restrictions. There are several international organizations that facilitate the cooperation between countries and the establishment of a single system of 'pest risk analysis' (PRA). The World Trade Organisation (WTO), the International Plant Protection Convention (IPPC) and the European and Mediterranean Plant Protection Organisation (EPPO) try to establish a frame that avoids discrimination and unjustified barriers to international trade.

In Europe, the plant quarantine restrictions of each country should be in agreement with IPPC and EPPO recommendations. Within the European Union (EU), several regulations have been set via EU Directives that every member country must incorporate into its own national Law, so the EU is protected as a whole. Particularly, the Directives set the phytosanitary requirements that plants and plant products commercialized in the EU must fulfill in order to make sure that they are free of the undesirable organisms listed at each moment. In that respect, the phytosanitary passport (or phytosanitary certificate for non- member countries) has been legislated. However, a certain gap exists about seed movement, as seeds are able to carry some pathogens and they are not submitted to control.

An example can be the bacterial disease fire blight of Pomoideae. This pathogen was already included in the list of noxious organisms in the European Union Directive 77/93/CEE as a quarantine disease. The best control has been obtained up to now by using plant material free of the pathogen (certified), showing the benefit of the phytosanitary passport/certificate as guarantee of healthiness.

12.7.8
Integrated Control

Environmental and human health considerations have led to aim for the reduction in the use of chemical pesticides. Nowadays it is accepted that the most rational way of maintaining plant health is by means of integrated control, in which all the other possible methods are used, with the lowest possible contribution of chemical pesticides.

Two good examples of integrated control in urban trees are Dutch Elm Disease and root rot caused by *Phytophthora cinnamomi*.

A wide array of methods has been used against Dutch Elm Disease with different results. Among them, the most successful in many European cities have been: the constant surveillance of elms and elm forests (in order to recognise and detect promptly diseased trees), eradication of new outbreaks by diseased tree removal, chemical control of fungus and/or insect vector (lindane in the 1970s, thiabendazole later on and carbendazim + acephate now; first by spraying or at present by trunk injection), the use of pheromones, herbicides, biological control with *Pseudomonas* and *Trichoderma*, removal of root grafts, European Union legislation on import, export and movement of trees and tree products, etc. Unfortunately, the effect of all these measures has been diverse in different parts of Europe, perhaps due in part to incorrect application.

The control of *Phytophthora cinnamomi* is complicated due to the existence of long latent periods and asymptomatic diseased plants, very wide host range and the longevity of its survival structures in soil. Many methods have been tried to control it: nursery plant material free of the pathogen for new plantings, modification of environmental conditions (soil pH, drainage, irrigation, water quality, nitrogen fertilization, etc.), removal and destruction of infected plant material (cankers, branches or the whole tree), quarantine barriers, chemical control by fungicides specific against Oomycetes, soil fumigants and biological control (antagonistic organisms, mycorrhizae, suppressive soils, soil amendments). The adoption of some of these measures is not always easy or feasible under urban limitations, e.g. soil and water characteristics or soil fumigation. On the contrary others, such as chemical control, can be feasible in urban trees, whilst they are not in forest trees. In urban areas, it is recommended to promote tolerant vegetation, avoid soil movements (acting as vectors), and provide good drainage and maintenance of plant biodiversity (Erwin and Ribeiro 1996).

12.8 Conclusions and Perspectives

Urban tree health in Europe has suffered an important degradation in the last decades. The rising impact of non-biotic damaging effects has had a great influence on pest and disease incidence, intensity and prevalence. Several pests and diseases have spread throughout the continent compromising health and amenity values of our urban forests and trees. For some of them, a complete network of institutions and researchers have been created, involving the cooperation of most of the European countries affected, e.g. Dutch elm disease, cypress canker, horse chestnut leaf miner, etc. In other cases, each country has developed its own national group of experts with little cooperation with other countries, e.g., plane tree anthracnose, canker stain of plane trees, and so forth.

Another extremely important aspect is the increasing risk of invasions by exotic pests and microorganisms, which constitute key threats to the health of trees in Europe. Nowadays the world is more and more connected and trade fluxes are increasing rapidly. This results in the appearance and escape of exotic pests and diseases known to be destructive to native trees. It has already happened in North America, where in just a few years these exotics have become a major focus of pest control in the United States and Canada. Recent uncontrolled spread of the horse chestnut leaf miner, *C. ohridella* throughout Europe has shown that accidental introductions of exotic species continuously pose a real threat to urban trees. Such an introduction of *Bursaphelenchus xylophilus* to Japan at the beginning of 20th century, and recently to Portugal has led to devastation of millions of pine trees. A series of accidental introductions of the brown-tail moth, *Euproctis chrysorrhoea*, gypsy moth, *Lymantria dispar*, winter moth, *Operophtera brumata*, and elm beetle, *Scolytus multistriatus* from Europe to North America started repeated waves of extensive defoliation of many broad-leaved tree species, and substantially contributed to spread of Dutch Elm Disease in this region. The lack of natural enemies and thus, undisturbed mass reproduction of exotic species in newly invaded territories makes control of their populations particularly difficult. According to APHIS (the US Department of Agriculture Animal and Plant Health Service), attempts to eradicate the Asian long-horn beetle, *Anoplophora glabripennis* from the New York area have already caused the removal of more than 5 700 trees since the pest's discovery in 1996. The insect originates from China and within only a few years managed to establish strong populations in several localities around New York and Chicago. However, it has been detected in many more regions of the USA in imported wood warehouses. This species has been included on the EPPO A1 quarantine list, and recently intercepted in some European countries, such as Austria and Germany. Two other quarantine long-horn beetles, *Anoplophora malasiaca* and *A. chinensis,* have also been reported from Italy and The Netherlands, respectively. Fast dispersion of the highly destructive Siberian silk moth *Dendrolimus sibiricus* creates another potential threat to European trees. If not controlled, all these insects can establish and cause serious problems to European forests, including urban forests.

Pathogenic fungi like *Ceratocystis fagacearum* J.Hunt and *Phytophthora ramorum* Werres, De Cock and Man in 't Veld are good examples of possible threats to trees in Europe. *C. fagacearum* constitutes an important disease of oaks called 'oak wilt' in the USA, where it is spread over more than 20 states. Since the European oak bark beetle, *Scolytus intricatus*, seems to be a very effective vector, the risk of introduction of this pathogen is very high (Juzwik 2001). *P. ramorum*, is another fungus recently described as pathogenic in California and Oregon, where it causes a lethal canker disease on several species of oaks and foliar and twig blights on many other plant species. In Europe, it was first detected in Germany and The Netherlands on *Rhododendron* and *Viburnum* (Werres et al. 2001), but lately also in Poland, Spain, France, Belgium and United Kingdom on these and other hosts (Davidson et al. 2003). Quarantine measurements to prevent further spread have been already adopted by UK, USA, Canada and South Korea.

Potentially, many more foreign species would find suitable conditions for vigorous development in Europe. Undoubtedly this will constitute a very important factor that will greatly determine the health of our European forests, both rural and urban, in the years to come. Therefore, appropriate quarantine procedures should be strictly applied to all shipments of wood, wood products and tree planting materials to prevent the potential invasion of new territories by exotic species. In such situations the significance of a well-trained custom service cannot be overestimated.

The future also lays in the use of healthy trees of high quality and the implementation of integrated control methods, which requires further development of effective pest and disease monitoring, new application techniques, improvement of biological control efficacy through the use of a wider range of new and commercially available biocontrol agents and better knowledge of host-pathogen interactions. Active ingredients that are more specific, more selective and less toxic to humans and the environment for chemical control are needed. Screening tests for early detection of diseases, as is the case with canker stain of plane trees, Dutch elm disease, fire blight of Pomoideae, etc., and the integration of new technologies, like remote sensing or physiological indicators seem to be in progress. Moreover, more effort is needed to work on the study of complex diseases, whose etiology is currently unknown, e.g., cypress blight of *Cupressus* spp. in hedges or branch necrosis of *Robinia pseudoacacia* and *Sophora japonica*.

Probably the most promising results will come from breeding programs to obtain new tolerant clones. It is also crucial to try and reduce the harmful effect of abiotic factors in urban trees and forests, since this increases the trees disposition towards pests and diseases. But, undoubtedly, research focused on increasing the knowledge of pathosystems and parasites is the only way to improve all actual control methods.

Finally, more effort is needed on information and education related to pests and diseases of urban trees, by publication of books, manuals or leaflets, preferably written in national languages. Furthermore, cost-benefit analysis are needed, which could be applied to the pests and diseases affecting urban forests and trees in order to quantify in economical terms the actual damage and the profitability of investing money in keeping our urban trees healthy (money for research, planning and management). In this way we may be able to convince politicians and the public that it is a worthwhile effort.

Acknowledgments

We are grateful to Dr. Arne Sæbo and Dr. Terry Tattar for their critical reading of the manuscript and to our colleagues from COST E-12 who sent in their national data on main pests and diseases and made valuable suggestions to improve this chapter.

We also thank the Slovak Grant Agency VEGA (grant No. 1/8238/01) for supporting Dr. Gaper's research on urban trees and the Madrid Regional Government for funding Dr. Tello's research on anthracnose of plane trees with the project 07M/0019/2000.

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Glossary

Biological control (biocontrol): management of a pest/pathogen population of one organism by the use of another.

Chemical control: treatment of a pest/disease with chemical pesticides.

Disease: harmful disturbance of normal physiological processes in plant hosts induced by the continuous action of infectious (biotic) agents.

Disease incidence: frequency of occurrence of a disease

Disease intensity: amount of disease on an individual plant

Disease prevalence: proportion of crops or stands affected in an area

Disorder: disturbance of the normal physiology of the plant due to non-infectious (abiotic) agents

Endemic: native to one country or geographic region

Entomopathogenic organism: organism capable of causing disease or death of insects

Epidemic: general and severe outbreak of a disease

Epidemiology: science that studies the development and spread of diseases

Epiphyte: organism growing on the plant surface without causing infection.

Eradication: control of disease by eliminating the pest/pathogen after it has become established

Etiology: science that studies the causes of diseases

Facultative parasite: organism able to live both as a saprophyte and as a parasite

Host: organism (in this case, a tree) harboring a living parasite and providing part or all of the parasite's nourishment

Host range: species of plants capable, under natural conditions, of sustaining a specific pest/pathogen

Infection: establishment of a parasitic relationship

Inoculum: pathogen or its parts, responsible for establishing an infection

Instar: stage in the insect life cycle between successive moults

Integrated control: the complementary use of all the possible pests and diseases control methods, in order to reduce the use of chemicals

Larva: immature stage of holometabolous insects

Monitoring: a survey to determine pest population levels

Nymph: immature instar of hemimetabolous insects

Obligate parasite: organism capable of live only as a parasite on living tissue

Parasite: organism living on or in, and obtaining its nutrients from, its host

Pathogen: organism (mostly parasite) able to cause disease in a particular host or range of hosts

Pathogenicity: ability to cause disease

Pest: species, strain or biotype of animal injurious to plants or plant products

Pest and disease control: the use of methods directed to maintain the pathogen's population at a level at which it is no longer a problem

Pest management: the utilization of any procedure or combination of procedures designed to eradicate, suppress or manage pest populations at a level to protect agricultural and forestry resources

Pest and disease resistance: disposition of plant taxa towards pests and diseases. A plant can be resistant (it is capable of overcoming completely the effects of the pathogen), tolerant (it sustains disease without serious damage) or susceptible (it is subject to infection and damaged by it)

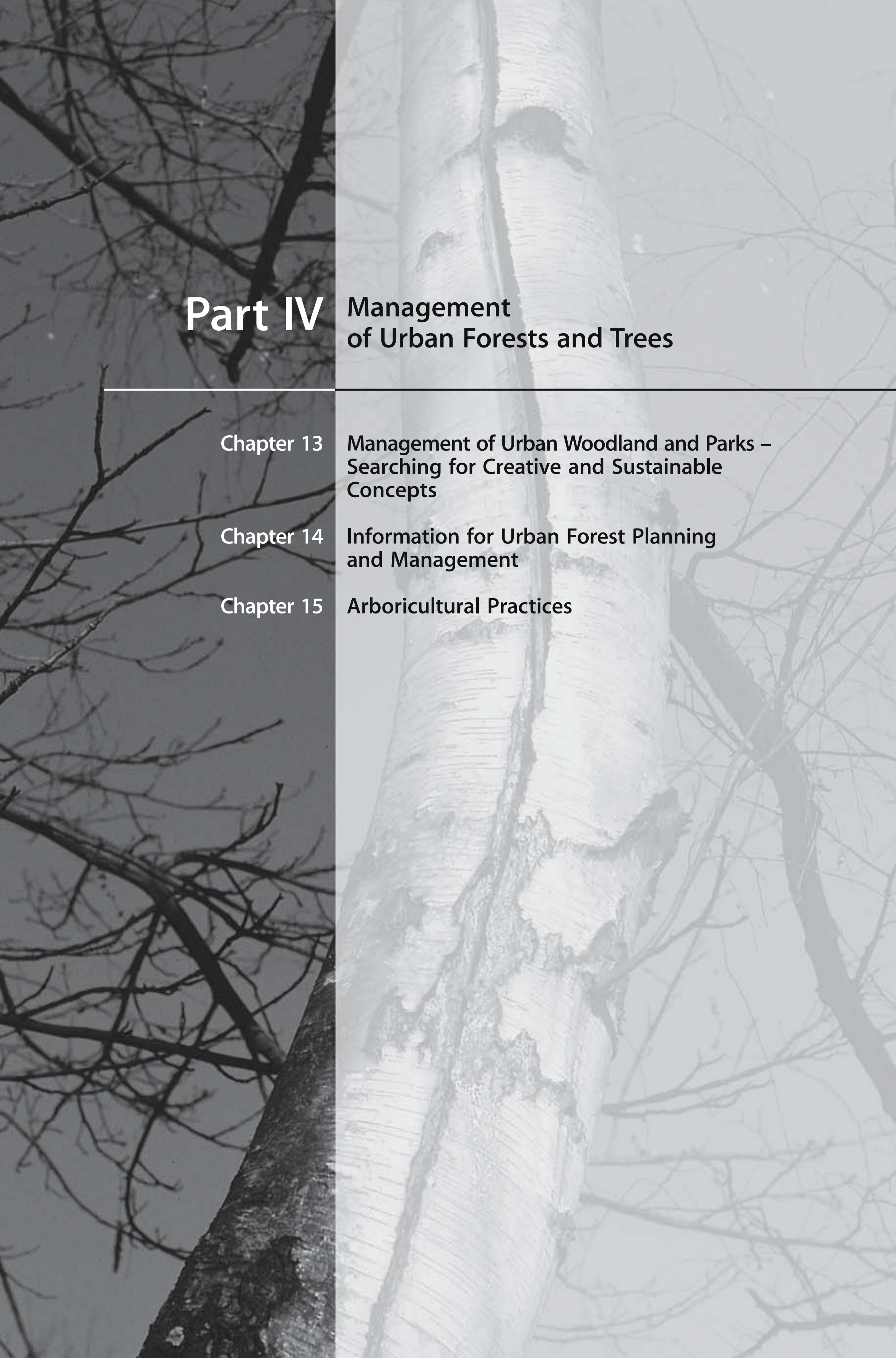
Saprotroph (saprobe): organism using dead organic material as food, and commonly causing its decay.

Strain: biotype, race, organism or group of organisms that differ in minor aspects from other organisms of the same species or variety

Symptom: indication of pathological processes in a host plant

Systemic: that it is translocated elsewhere in the plant

Vector: agent able to transmit a pathogen



Part IV Management of Urban Forests and Trees

Chapter 13

Management of Urban Woodland and Parks – Searching for Creative and Sustainable Concepts

Roland Gustavsson · Martin Hermy · Cecil Konijnendijk · Anne Steidle-Schwahn

13.1 Introduction

13.1.1 The Concept of Urban Forest Management

This chapter focuses on the management of urban forests and more specifically the management of two major components: urban woodland and urban parks. In Chap. 1 of this book, the concepts of urban forests and urban forestry have been introduced and discussed in detail. As was explained, urban forests constitute an essential component of urban green structures, i.e. networks of urban green areas. One could characterize urban green areas as urban areas of land primarily containing vegetation. Urban forests are those green areas containing trees as major elements, covering all from woodland to parks and individual trees in and near urban areas. Urban woodland includes all types of forest or forest-like vegetation within the urban forest. In this chapter, the term 'woodland' and 'forest' are often used synonymously as referring to this 'forest ecosystem' part of the larger urban forest resource. Urban parks can also contain a considerable number of trees, but elements such as lawns, pastures, garden elements and related infrastructure are more dominant, while forest stands are limited or absent. The more technical management of individual trees, which is the responsibility of arboriculture, is described in detail in Chap. 15.

When defining the concept of 'management' in an urban forestry context, a distinction should be made between management as an activity and management in terms of people and/or institutions (i.e. actors) carrying out activities. The latter could be characterized as 'organizational' management and is not so much the topic of this chapter. Studies, by e.g., Konijnendijk (1999) and Steidle-Schwahn (2002), have identified main urban forest management actors. In the case of urban woodland and parks, municipal organizations dominate management in Europe, primarily through municipal green area, park and forestry departments, although involvement of the private sector through outsourcing increases. Peri-urban woodland in particular may be managed by state forest services, while a significant urban forest resource is owned and managed by private actors. The latter can include individuals, private enterprises, societies as well as NGOs. It is important to note that a wide diversity in management organization exists among European cities and countries, e.g., as a result of historical, local political, social and economic conditions and traditions.

Management as being 'activity-oriented' addresses different levels. At the level of strategic management, the overall visions for management are developed. In line with policies and planning, objectives and targets are formulated, means are allocated and a time frame is set. Specific, well-defined tasks are defined and carried out in line with this at the level of operational management. While *strategic* management typically addresses a period of 10 years or more, *operational* management focuses on annual or biannual activities. As an intermediate level, tactical management brings the two together. Management is directed by objectives and targets, economic and other frames, and not in the least the type of green area concerned.

While the term management used here encompasses the strategic as well as the operational, 'maintenance' has a more technical and limited operational scope. Maintenance as a concept could also be associated with, e.g., to 'keep', 'preserve', 'conserve', or even 'freeze'. Management, in contrast, is a much more dynamic and creative concept embodying both maintenance and developmental aspects. Particularly for the latter it needs a considerable input from various actors, not in the least from the public. Participation and communication have been neglected in many cases in urban woodland and park management (see Chap. 8).

13.1.2 Challenges to Urban Forest Management

In line with the distinction between maintenance and developmental aspects, more attention should be given to the 'long-term management' of urban parks and woodlands. In a wider context of a modern society and its relations with nature it has become important to stress the basic meaning of management as an active process. It should deal with care taking and development in order to meet human demands and preferences for places, local landscapes, and the different natural and manufactured elements of urban forests. Too often the importance of management planning has not been fully recognised and the opportunities for raising quality have remained unseen across Europe and large parts of its urban green structures. Today, in the early stages of a new century, this trend seems close to being broken. Growing awareness and concern of long term management questions have started to lead to a higher engagement in management rather than maintenance.

In the future, those involved in strategic management – i.e. management planners – will probably (more than before) be key persons, acting in local situations as facilitators, integrating public participation, supporting ongoing developments, enabling what would not have been realized without their involvement. In an action-oriented perspective, management is maybe more than anything else the phase in which the past meets the future, ideas and intentions are realized (or not), different interest group are activated, professionals meet layperson, and people meet the landscape to create an all together active, positive relationship.

Another key challenge for urban forest management relates to developing *integrative approaches*. The management dimensions of the *intentional* (in search of new ideas and concepts), the *technocratic* (in search of practical management solutions), and the *communicative* (sharing and engaging, integrating both professionals and local people) tend to develop too much into individually separated knowledge fields, and the challenge is to enhance their integration. Within the technocratic part, for example, the relationship between the spirit of place, architectural expressions, technical aspects, biological processes and time aspects should be stressed in a much more integrated way (Gustavsson 1999).

The increasing needs as well as difficulties to think and act in a more *multidisciplinary* way have been pointed out by many. A reason for the lack of a multidisciplinary approach is that we most often tend to organize the world in black and white, opposing specialists and laymen; this trend is strongly supported by science focusing on specialization. This also strongly influences the field of urban forest and landscape management. Still, even though most people probably admit that it is important for a manager to have a wide view, most current educational programs are highly dominated by one particular, traditional discipline. Experts are mostly trained according to cultural *or* ecological tradition, biodiversity ethics *or* aesthetics, a countryside *or* an inner-city tradition, a technical-biological *or* design approach. Research has confirmed that different educational backgrounds highly influence the way of thinking. When considering some of the leading disciplines within green area and landscape management during the past fifty years, it becomes clear that managers with an educational background in forestry, landscape architecture or ecology differ in many ways in terms of thinking and acting (Jönsson and Gustavsson 2002).

The need for integrative and multidisciplinary approaches also relates to the *complex character* of urban forest resources. These consist of complex social networks of users and other actors as well as complex ecosystems. Elements include forested areas, grasslands, gardens, ponds as well as water streams and hard structures (e.g., buildings, monuments, paths and roads, recreational infrastructure) (Hermy and Cornelis 2000). These alternate in a mostly constructed design often reflecting a certain period of history (e.g., Thacker 1985). All elements have their own requirements in terms of management, while they should continuously be seen as part as an integrative whole – the urban forest – as well.

Fig. 13.1. The city forest of Zonienwoud in Brussels, Belgium is a large forest, in which forestry traditions have been conserved to a very large degree. Recently some parts of it have been left with no management as wilderness areas (*photo:* R. Gustavsson)

In a society that becomes increasingly urban, and with stakeholders and local communities that are becoming increasingly urban in terms of values, attitudes and lifestyles, linkages to older management styles are too easily cut off. A challenge exists in attempting not to lose the deep, *traditional management knowledge* which has so far been developed in a countryside context, but which potentially can be an important knowledge-base for many urban contexts as well (Fig. 13.1). This is not to say that traditional nature conservation, agricultural and silvicultural knowledge should be copied for use in urban situations, as these knowledge cultures have been developed for a different setting, focusing on crop production and biodiversity in the countryside. Furthermore, traditional nature conservation and forest management have so far, just to a minor part, integrated other social-aesthetic aspects or design skills, and much still remains to be done in terms of adaptation.

13.2 Developing Sustainable Management of Urban Forests

13.2.1 Ecological Perspectives and Concepts

Given the complexity of urban forest ecosystems and their multifunctionality, integrative and adaptive concepts and approaches have been called for. An example of a highly integrative approach arises from the Ecopolis-concept by Tjallingii (1995), which is based on urban ecology principles and stresses the dynamic character of management. According to the Ecopolis-concept, urban woodland and parks may be regarded as eco-device models with inputs and outputs, and being resistant towards certain influences from outside. They may be presented as a triangle in which the corners of the model refer to areas, flows and actors. Each of these is managed according to a certain motto. The motto for the areas could then be the Living Urban Woodland and Park (UWP), for the flows the Responsible UWP, and for the actors the Participating UWP (see Fig. 13.2). The Living UWP refers to ecosystem biodiversity in the broad sense, a com-

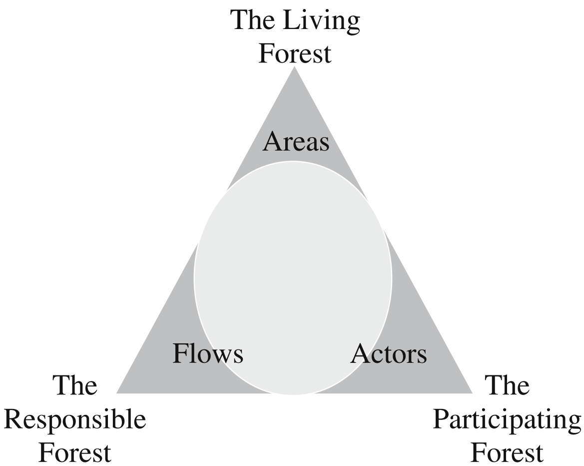


Fig. 13.2. The ECOPOLIS concept (Tjallingii 1995) of urban woodland and parks

plex system of which the number of species increases with the area and easily runs into the thousands. UWP management regulates flows, e.g., water flow, traffic and visitors, export of wood, and this should be done in a responsible way. The third theme (Participating UWP) refers to all users of the UWP. This includes the main management actors, including UWP managers and public authorities, visitors and other interest groups. All of these should participate in one way or another in order to meet the multitude of functions as well as the need for communication of values, preferences and knowledge. In this way a sustainable management system can be achieved.

13.2.2 Developing Sustainable Management

What Is Sustainable Urban Forest Management?

How can sustainable UWP management be defined and developed? Until recently, only little attention was given to the sustainable management of UWP ecosystems. Of importance in this regard is that management of urban woodland and parks has changed considerably during the past century. Due to high labor cost and increased political focus on public-private partnerships, management has become more extensive. Temporary green space is used less frequently and variegated collections of plants, so typical for the 19th century gardens and park styles, have almost completely disappeared (Duqenne 1990). The maintenance intensity has decreased considerably, giving more opportunities to natural developments. Consequently, the ecological aspects of management of urban green space have received more attention during the last decades (e.g., Baines 1985; Sukopp and Wittig 1998).

The concept of sustainable development is usually described as a development that provides for the needs of the current generation without compromising the needs and possibilities of future generations (e.g., WCED 1987; but see also Clark et al. 1997). Despite this definition, the implementation of the sustainability concept remains difficult. Translated to urban forests, sustainable management of UWP could be described as aimed at long-term management of these complex habitats in order to perform their multiple functions also in the future. But what does that mean in practice?

Adaptation to Local Conditions

In order to maintain a desired woodland, park situation or 'scenery', particular management is needed. Succession usually leads to a closed landscape in which trees dominate, and thus more usually open habitats will need management. Furthermore, a natural forest may be far from the most desired given the multiple functions expected from urban woodlands. In any case, long-term management is best guaranteed when current and future funding is secured. Management with minimal costs assumes that habitats can spontaneously exist and develop without much human help. As a result, the aim would be 'stable' communities where spontaneous processes of establishment of both animals and plants regulate community composition and only need minimal care. In general these communities will be well balanced, adapted to the local environmental conditions. They usually are characterized by a variety of native species that are part of fully developed food webs. However, many non-native (plant) species can survive and even regenerate without much human help as long as they are adapted to local climate (e.g., frost hardy) and soil conditions. Exceptionally, they can even be the most suitable for urban conditions. Yet their food webs are less developed as indicated by the lower number of insect species associated with exotic species (Kennedy and Southwood 1984). Exotic species may also cause great problems due to strong competitive ability, although this has so far been seen as less of a problem in Europe than for instance in North America.

The largest biological diversity of plants, fungi and animals is achieved through varied vegetation reflecting a varied environment. Indeed, particularly along gradual environmental gradients (such as light conditions or soil conditions) a variety of interesting and species rich communities develop. Species composition then gradually changes and offers great opportunities for a variety of wildlife (cf. Grime et al. 1988). This often strongly contrasts with the actual situation with sharp boundaries in UWP. Steep banks of lakes and ponds only offer limited space for wildlife. Environmental diversity increases tremendously if a gradual gradient from open water to land is created. For the same reasons, gradual transitions from grassland, via shrub to forest also offer a high biological diversity (Bradshaw et al. 1986; Jedicke 1994). The probability for a sustainable survival of taxa is much larger when environmental gradients slowly change compared with steep gradients that offer little space and opportunities for biological diversity. In practice a transition and biodiversity lead concept can be implemented by use of a combination between a 'soft' and a 'hard' line (Fig. 13.3).

Fig. 13.3. Combining use of a 'hard line' (distance for pedestrian walks or marked in the management plan) and a 'soft line' (trunks placed in the terrain to signalize: mowing up to here but not any further) to enable a transition and biodiversity lead concept in a practical management. Arnhem, Netherlands (*photo:* R. Gustavsson)

Using Natural Processes and Conditions

Ideally management should in a conscious way use the natural processes of spontaneous development of flora and fauna, and eventually take measures to increase the potential through directed, environmental interference. In practice, however, spontaneous development is not always feasible or desirable. It may take decades before natural regeneration of trees will occur and develop in a way attractive to visitors. A high proportion of luck may be required in terms of desirable plants entering the area first. Additionally it may be that seed sources, essential to regeneration, are not even present nearby. As a consequence sowing or planting may be required for regeneration or establishment of species. But native and locally indigenous generic material should be preferred when possible as this offers the best 'fit' to local conditions. If one prefers exotic or non-indigenous species it is essential to match the choice of species as closely as possible with these local environmental conditions. If this is not possible (for example with large collections of species on limited space) it is preferred to adapt environmental conditions, i.e. mainly soil, but also light regimes so that the long term survival of exotic species is possible under minimal management. Those management measures taken to create good starting conditions are grouped under the heading of habitat creation and/or restoration (Kendle and Forbes 1997).

Management Continuity

Sustainable management also requires continuity. If management measures change continuously, the vegetation has no time to adapt to the new conditions and it will probably not reach the targets set by management plans, particularly in systems which include living organism of great longevity (i.e. trees). Only few species adapt to frequent disturbance in combination with stress (Grime et al. 1988). Disturbance is considered here as any measure, which destroys part of the whole vegetation and thus lowers the biomass. Stress is defined in this concept as any event causing a shortage or suboptimal condition of growth (e.g., shortage of nutrients or light). Combinations of stress and disturbance have resulted in three basic evolutionary plant strategies, enabling a distinction between stress tolerant (S), ruderal (R) and competitive (C) species. These three primary plant strategy types may be divided further into secondary plant strategy types, while a separate system has been developed for regeneration phases of plant life (e.g., Grime et al. 1988).

In this view management measures are considered as disturbances in as far as they destroy biomass. Annual ploughing or spading does only allow ruderal strategies to persist, such as weeds on arable lands. Under conditions of low disturbance and high nutrients competitive species dominate (e.g., *Urtica dioica*), as in tall herb vegetation on river banks. Annual mowing of grassland with litter removal directs succession to the stress-tolerant and to some extent to the ruderal part of the spectrum. Thus the RCS theory enables us to understand the effect of various management measures as well as the important vegetation processes of dominance and species coexistence (see Grime et al. 1988).

In order to realize a well-developed vegetation type, it is therefore important to maintain a chosen management regime or measure. The longer this is done, the better communities may develop. Usually this results in an increase of species diversity and stability of the community, both of which are essential for achieving a more sustainable ecosystem. The management principle of continuity also assumes an a priori developed long-term vision or strategy for the UWP management of a particular site. The use of a comprehensive management plan is important in this respect.

Use of Chemicals

The use of chemicals in managing vegetation should be avoided as much as possible, as serious objections to it can be brought forward from the perspectives of the environment, public health as well as wildlife (see also Chap. 12). As many chemicals are not selective, they also affect other plants and/or animals than those aimed at. Wildlife (and in particular insects) may also suffer from the loss of food plants. Some specific pesticides may be needed – be it restrictively – for the maintenance of pavements or ruins (Spijker et al. 1998), but pesticides in general are not part of sustainable UWP management.

Water and Recreation Management

Urban forests are often open to the public and serve recreational purposes, including walking, sports, and relaxing. Different recreational needs demand different types of infrastructure and may thus be difficult to jointly accommodate (e.g., horseback riding, walking, mountain biking) (see also Roovers et al. 2002). The recreational function of urban forests is discussed in Chap. 4.

In order to meet recreational demands, at least minimal recreational facilities should be provided and maintained (e.g., Roovers et al. 2002). The higher the recreational pressure, the more open pavements can be, as trampling is a primary factor in controlling vegetation development. For a review of the ecological effects of recreation we refer to Liddle (1997). Open or half-open hardening also enables precipitation to percolate. Run-off increases when the soil-surface sealing increases. Management respecting or enhancing water infiltration and retention is important particularly in urban environments. Water management in which infiltration, retention and restrictive water use facilities are sought is another integral part of UWP management (e.g., Tjallingii 1995). All too often, water problems are 'exported' to neighboring areas.

13.3 Ecological Sound Management Measures for Urban Forest Elements

13.3.1 Urban Woodland, Tree-Rich Parts of Parks, and Shrub Areas

Sustainable management should focus on maintaining a variety of functions, from timber production – although this will in an urban context not be the main aim (see Chap. 4) – to nature conservation and not in the least recreation. Creating and maintaining an attractive and diverse forest image for recreational purposes will mostly be the main goal. When focusing on natural resources it should be kept in mind that spontaneous forest development will be the most suitable form of management, as investment and cost are at their lowest. But amenity values may be lower, at least during part of the forest development cycle. Moreover, in case of arboreta, and for many parks, as well, spontaneous development is not possible or desirable. Yet even here, more nature-like forms of woodland management will keep cost at a minimum.

Apart from non-intervention, woodland and wooded elements may be managed in a variety of ways. It has to be remembered, however, that radical changes in woodland management usually have large consequences, as many of the typical woodland plant species are typical for steady-state communities (Packham et al. 1992). Changes in woodland management practices therefore can only be implemented over longer periods of time, and consequently also here management continuity is an important principle. It also means, however, that traditionally managed parts, such as coppice or coppice-with-standards (Buckley 1994) or high forest should be maintained or only gradually changed (Peterken 1993, 1996). This is particularly the case where these traditional forms of management have resulted in valuable plant communities, often indicated by abundant carpets of spring flowers, for example *Scilla non-scripta* and *Anemone nemorosa*. Old forests are usually indicated by so-called ancient forest plant species (see Hermy et al. 1999 for an overview). Although considerable geographical variation occurs, these species all have in common that they only slowly colonize new sites. Slow colonization may be caused by short distance dispersal, low reproductive capacities and/or low recruitment (seed and/or recruitment limitation). Most of these species are also linked to traditional woodland management forms. Coppice cycles usually are in the order of 10–20 years, while shorter and longer cycles are possible. Cut lots could be distributed in time and space over the forested area. This will generate a variety of regeneration stages, each of which will be associated with typical wildlife, and which is motivated by aesthetic reasons as well. Cycles for standard are usually longer than 100 years. For an overview of the ecology and effects of coppicing we refer to Buckley (1994). Cycles may be prolonged to enhance amenity values of urban woodlands, yielding large trees that favor wildlife (such as woodpeckers) as well as epiphytes (Peterken 1993, 1996).

When aesthetical, social or ecological values of coppice or coppice-with-standard systems are low, it is better to convert these woodland areas to some form of high forest that requires less cost and is closer to nature. Most sustainable forest management mimics nature. In cases where a large forest area is available one may opt for completely spontaneous development, without any intervention, for some parts. The older and more varied the starting situation, the better and more rapid a more natural forest structure can be achieved.

Urban parks usually have no production function, although the value of timber may contribute to compensating management costs. Yet as said old and dead trees serve a wide variety of wildlife; heavy wood debris in particular is highly valuable for many animal species and fungi and old trees serve bird species and even bats. Old trees thus should be maintained as long as possible if safety of visitors allows this.

13.3.2 Water and Bank Vegetation

Many urban woodland areas and parks contain bodies of water. These serve a variety of functions, including water and fish production and providing amenity values. In many cases the transition from ponds and lakes to surrounding terrestrial vegetation is sharp, often enforced through a wooden or concrete edging. These offer few opportunities for wildlife. Sustainable management should aim to develop a gradual transition from water to land, thus creating smooth gradients from inundated and wet to drier conditions. Gradients provide excellent opportunities for both plants and animals. Large fish or waterfowl populations do not match large populations of hydrophytes. Management of the terrestrial part of the water 'ecotone' may involve an annual or biannual mowing regime. Moss (1998) has provided an overview of fresh water ecology. Even if hard edges cannot be removed, some form of mitigation is usually possible, for example through stepping-stones from the water or shallow water.

If reed marshes are present, management will involve a winter or autumn mowing regime with litter removal. This will usually result in vital reed marshes with considerable plant species richness. Autumn mowing can also be combined with bird conservation, as it yields shelter through reed re-growth in spring. Mowing from the ice during winter – where winter freezing occurs – may be the only easy way of working; fortunately reed needs not to be managed every year. Wet meadows (e.g., with *Caltha palustris*) or tall herb communities (e.g., *Filipendula ulmaria*, *Epilobium hirsutum*) usually are best mown every 2–5 years, in late summer or early autumn. During this time of year the ground water table is usually at its lowest. If not managed these areas will develop into willow shrub and/or ultimately into some form of black alder (*Alnus glutinosa*) forest.

Hydrophytes such as *Nymphaea alba* and *Nuphar lutea* may generate impressive 'pictures' greatly enjoyed by people. But apart from these flagship species many other smaller species may be present as well (e.g., Spellerberg et al. 1989). Water plants will only thrive when they obtain sufficient light, so shade-covered ponds are usually poor in wildlife. Managers of urban woodland and parks should also take all necessary measures to ensure the best water quality possible. This may involve the creation of a helophyte water purification system (e.g., Wissing and Hofmann 2001). As time passes all water bodies – and particularly shallow ones – will gradually turn into land. Succession will ultimately result in willow and alder marshes. With this in mind water bodies need cleaning from time to time. This will reverse succession into the open water phase.

13.3.3 Grasslands

Grasslands are often an important element of urban parks and woodlands, and therefore specific attention is given to them here. Even lawns are often essential elements. However, lawns that are not frequently used, apart from the edges along paths, should be replaced by meadows. These are mown once or – in case of heavily fertilized soils – twice a year during summer and a third time around October. A properly managed meadow flowers, apart from a short period after mowing, almost continuously from spring to autumn (Ash et al. 1992). As hay or freshly cut grass is removed, the regeneration niche and ultimately the coexistence of many plant species is assured (cf. Grime et al. 1988). To reach greater amenity values naturalized – originally non-native – plant species may be used (often geophytes, e.g., *Narcissus* spp., *Camassia* spp., *Crocus* spp.). Excellent examples include the meadows of Great Dixter in Sussex, England (Hobhouse 1997). In order to replace species poor grassland on nutrient-rich soils litter should always be removed and no fertilizing is allowed. Through mowing with litter removal the number of more stress-tolerant species increases gradually, allowing for greater coexistence of a large number of plant species (Grime et al. 1988). Haymaking is preferred to the immediate removal of the litter as it enables larger seed dissemination, although direct removal of litter may be less expensive. The application of this mowing regime will also reduce the annual biomass production considerably and thus will reduce the cost.

Particularly around the edges of forested parts – as described among the most important and rich parts of the urban forest system – it can be essential to mow the grassland only once every 2–5 years. This will allow for the development of specific woodland edge vegetation, creating valuable habitats for plants but also for butterflies and other invertebrates. Structurally this approach created a more gradual transition towards forest habitats and thus a gradual environmental gradient, where light intensity but also air humidity and other factors slowly change. In order to enhance the spring value of meadows naturalized plants with bulbs or tubers may be introduced. These may constitute spectacular displays highly appreciated by visitors. As these require no further specific management cost upon introduction, they are an integral part of sustainable urban park management. Most of these spring flowering species are to be found on richer soils, so for a sustainable result selection should follow local environmental conditions. For comprehensive reviews of habitat requirements of plant species we refer to Ellenberg et al. (1992) and Hansen and Stahl (1993).

In this concept lawns are limited to gardens, to the edge of paths or to places frequently used by visitors for activities such as picnicking and playing. Along paths lawns make gradients of height more gradual. But even on lawns spontaneous processes of germination and establishment may occur. If lawns are mown regularly, litter is removed each time and no fertilization is applied, gradually more species and particularly more herbs such as *Bellis perennis*, *Veronica filiformis*, *Trifolium repens*, and *Hypochoeris radicata* will establish.

More competitive species occur along the edges of forests; in the transition from grassland to woodland; on open, not frequently managed areas; and along ditches, rivers and ponds. Often vegetation with large herbaceous plant species is flower-rich (e.g., *Hypericum perforatum* and *Teucrium scorodonia* on nutrient-poor and dryer sites). Through their structure, these more competitive species are highly significant for wildlife: as nectar or food source for many insect species, as refuge for small animals, hibernation sites for invertebrates, as food sources for singing birds, and so forth. Non-wanted species may be of great importance for invertebrates. *Urtica dioica* is an important food plant for butterfly species such as *Vanessa atalanta*, *Inachis io*, *Araschnia levana*, *Polygona c-album* and *Aglais urticae*. In order to maintain tall herb vegetation it must be mown once every 2–5 years. Mowing intensity is lowest on poor soils. Most of the tall herb species – all related to the competitive plant strategy – are not well adapted to annual mowing regimes, at least during summer. When they are mown annually with removal of litter, grasses and other smaller plant species will take over (cf. Grime et al. 1988) and plant species diversity will increase. Mowing within urban parks is best distributed in time and space. This will yield seasonal peaks and an outdrawn flowing season to enjoy, through various phases of re-growth, and thus also shelter and food for a variety of wildlife.

13.4 Adapting Historical Management Concepts to a New Urban Context

13.4.1 'Woodland' and 'Open Woodland' in Park, Garden and Urban Nature Contexts

In both research and practice, woodland management is very much a field of knowledge focusing on the stand or habitat level. In a countryside situation, woodland will most often be described by its internal stands and its collection of trees or as habitats for certain groups of plants and animals. In an urban context, the meaning of 'woodland' may often differ a lot from a rural context. As already mentioned, urban woodland is seldom primarily associated with crop production. Biodiversity considerations relevant to a rural context will also differ from those in urban settings. In fact, it is important to stress that new urban functions imply that new meanings may need to be invented. Parallel to this, there is a challenge to rediscover several dimensions, which have been lost since earlier days. These may not be of value for modern or future conventional forest landscapes but more so in an urban context.

When considering management strategies it will be important not only to give attention to interior stands, but to the entire woodland area as well (see for this and following topics also Chap. 6). The latter should be seen with its relations to its surroundings, to woodland edges, and to a series of other elements that are integral elements of urban woodland systems, such as small waters, open view points, meadow corridors, roads, paths, and so forth. This also implies that focus should not only be directed towards stand management, something which becomes particularly true when the closed woodland landscape is left behind and focus is on forest park, nature park, meadow park and wetland park characters.

In an urban context as well as in a countryside situation, focus often is to be directed towards the interior stands, as is the case in traditional forestry and woodland conservation. However, due to the importance for human experience of woodland areas and their interiors, stronger emphasis is placed on vegetation architecture, stand structure, and undergrowth, which also include the main characteristics of the perennial flora. This is a major reason for the following identification of architectural types, their main functions and linked management methods. The need to have more 'precise' management based on sound knowledge of how to manage tree-rich habitats or systems at the level of the individual tree as well as when trees interact in both more open and closed systems, moreover, is certainly stronger. A particularly detailed understanding of the vegetation architecture, with an emphasis on the understorey and thus on perennials, may be needed for woodland character in a garden context, but similar articulated views are lacking but needed in many other urban situations as well.

13.4.2 Open Woodland and Silvi-Pastoral Systems

It is of crucial importance to rediscover the meanings related to more open woodland systems, as well as silvi-pastoral and wooded meadow systems. It may not be instantly clear that these provide even more interesting future perspectives, as they have been abandoned in favor of more production-effective closed forest systems, but within the urban context the focus may change and broaden again. Grazing and mowing could be more central again. Grazing was restricted in many European countries about 150 years ago due to regeneration and over-grazing problems, but today's situation is different. It provides many extra qualities, such as including more gradients between open and closed, and more open areas (e.g., Vera 2000). As a result, urban woodland management often leads to an interesting combination and bridging between city traditions linked to park traditions and arboriculture, and countryside traditions such as pollarding, coppicing, haying and grazing systems.

Many standardized park landscapes in Europe have a half-open, grazed 'savannah landscape' as ideal (Olwig 2002). Grove and Rackham (2003) define savannah as 'trees scattered among some other kind of vegetation such as grassland or heath'. For long-term developments and thereby for management in particular there are many good reasons to improve the mental linkages between the ideal landscape and living landscapes with similar physiognomy. A suitable example is the 'open woodland' of many regions of Portugal, and in particular the agro-silvipastoral (still existing) system of '*Montado*' (Pinto-Correia 2000). Study of how systems like this have changed through time will contribute further to development of new concepts. These types of grazed or hayed tree- and shrub-rich landscapes can still be found in the Nordic and Baltic countries. They are increasingly restored to become part of the urban landscape as well. Even in countries like Britain, where these systems no longer exist as such, one can find references by referring to medieval times and by studying landscapes expressed in ancient landscape terms such as *silva pastilis* (wood pasture) and *denes* (hog pastures) (Muir 2000). In The Netherlands, where no living remnants remain either, a somewhat similar half-open, grazed landscape is now seen as important part of the future landscape for recreation and nature conservation. Since the 1980s and 1990s, this type of landscapes has been successfully developed and reconstructed at various locations as a complex open or half-open landscape with character probably similar to the landscape of the early large herbivores before the 'farming culture' came to dominate the countryside (Vera 2000).

13.4.3 The Rediscovery of Historical Woodland Types

Not only open woodland types but also more closed forest types should be considered when providing a wide variety of forest types for future urban contexts. The references in the countryside of today mainly concern high forest types, developed for timber production or as growing 'wild' for decades through natural processes (Peterken 1996). The urban context, however, calls for a wider range of possibilities. History again can assist by pointing at interesting directions. Examples include landscape terms such as 'wood pasture', 'coppice woodland', 'lund/lound', 'holt' (a wood, perhaps single species), 'grove' and 'launde' (woodland, lawn) which can all be found in old British landscape texts (Muir 2000), while corresponding terms have been found in the Germany and the Scandinavian countries (Schama 1995; Wittrock 2001). These probably only provide some insight into the richness of woodland types and aspects that has existed through time. Many of these concepts will be more interesting for inspiration and as knowledge base for future development than what can be seen today and experts feel obliged to use in the design and strategic management of woodlands, parks and gardens.

13.4.4 Low Woodland and Coppice Systems

In most European countries the coppice system has been the leading woodland system for hundreds of years (Buckley 1994; Grove and Rackham 2003). It is a pity, therefore, that remnants of many coppicing variants no longer exist or are not managed as such as living landscapes for reference. Muir (2000) mentions several ancient terms, which provide some insight in the rich history of the coppice system and its traditional treatments. These include *silva minuta* (coppiced woodland), 'bolling' (top-pollarding), 'a waver', 'a blackbark', 'a lording' ('standard', i.e. individual tree in a coppice that had grown through one, two or three coppice cycles), and 'lound' (name associated with very old woods).

Few vegetation types are as interesting as coppice-based systems in urban contexts due to their effectiveness and robustness in small spaces, along traffic roads, for children's play, and so forth (Fig. 13.4). This implies many different uses and consequently the importance to recognise and understand a series of types rather than an optimal one, as well as new rather than traditional countryside. Still, some basic characteristics of traditional coppice systems can be recognised:

- They are often also called low woodland types because of shortness in height. Due to the species involved and the management regimes they seldom exceed ten metres in height.
- Maybe even more characteristic are the multi-stemmed trees and high shrubs.
- They can be entered physically, in contrast to shrub types, although their younger stages are difficult to penetrate due to their density.
- Traditional management never allows transformation into high woodland types. If this does occurs, the systems will be regarded as neglected or converted systems. After a period without management, characteristic rapid growth stops and the systems remain as low woodland for long periods, with or without standard trees here and there.
- 'Re-thinnings' which use the spontaneous re-growth of the species are arranged through rotation cycles, sometimes with short intervals of 6–8 years, or longer ones up to 20–30 years. This creates a dense mass of multi-stemmed individuals that has many similarities with high shrubs, but the anonymous and dense mass is higher than shrub vegetation. These systems are impossible to enter most of the time, children being the exception, and they have no visual openness. Physically and visually more 'open' types can be created, however, if longer intervals also include the 'overgrown' or 'left' stages, which could be of particular interest for many city contexts.

Coppice systems can be expected to undergo a renaissance in future management. Especially in northern Europe many experts have suggested that traditional coppice systems should be more frequently used in urban situations. In southern countries like Greece these systems are still more common, but many are converted into high forest systems to improve forestry production and reduce the risk of fires (see e.g., Chap. 11).

This has indirectly led to a rather low interest in coppice types in urban contexts. Could we gain something, one could ask, by introducing coppice systems into urban contexts? How could coppice systems be characterized and adapted within urban contexts in terms of their type, architecture, major uses, and management? In any case, the basic principles of traditional coppice systems should be understood (see e.g., Buckley 1994). It should be possible to apply traditional systems as well as those that are more neglected, overgrown and over-mature, and consequently not preferred from a countryside production perspective. The latter may even be more interesting for an urban context in which multifunctionality is favored, for example through their role for children's play and acting as air and water filters. Subtypes of coppice systems relevant to urban settings include:

- More open grown sub-types with close links to woodland meadow types. Management should respect these as mosaic complexes with a combination of treatment directed towards groups of trees, individual trees, renewing shrubs as well as the grass sward.
- Visually quite open sub-types, but 'visually open' because of the closeness in the low canopy. Character as well as management will differ if shadow or light providing trees will dominate the system. Management will also differ due to focus on creating regularity or irregularity.
- Very dense sub-types, similar to shrub types. These sub-types will be very close to traditional coppice systems with short intervals between the cuttings. They may not

Box 13.1 Adventurous woodland areas – Specific play areas for children

The importance of developing woodland which supports children, their development and creativity, be it individually as well as in group play, has repeatedly been stressed (Noschis 1992; Kylin 1999). However, how to design and manage for children is not a simple question. It seems the best current examples have been found by accident rather than by professional design and management, which of course could be seen as remarkable. There are exceptions, and one of the early ones was the Baloon Wood in Nottingham, England. This heavily-used adventurous woodland was one of the most influential examples of European woodland concepts for children's play during the early 1970s. During the 1980s, the ability for children's play was stressed in the design of Warrington New Town in northern England (Tregay and Gustavsson 1983). The intentions were to let the design be based on traditional coppice systems. This has later been followed up – sometimes successfully and sometimes not – in the management systems. Results over a fifteen years period show that those woodland that are to be popular with children need to have a high level of robustness in order to survive. This means, in particular, a focus on low woodland types with standards, or a strong support of undergrowth vitality. Open areas such as glades, and climbing trees situated in strategic positions should be integrated and supported through management. Children's activities result in a certain vegetation pattern. Damage of trees and shrubs does not extend beyond certain sites, however, demonstrating that children in most cases are not aiming to be destructive. Children create their places, a process, which can be rather 'violent', but then often stop. They want to actively shape a place for adventure. Research has also indicated that coppice is not something managers are used to, as its basic principles are very different from conventional management. Thus it needs to be respected, appreciated, and be well integrated in management plans more than currently is the case in order to produce satisfactory results (Fig. 13.4).

have a distinct architecture when individuals are considered, but it might be suitable for children's play, but also for enhancing safety along roads.

The sub-types above can be divided further if related to the presence of standard trees, but also in terms of height ('high coppice systems' and 'low coppice systems').

Park and garden character can be achieved by introducing park attributes like lawns, park benches, park lamps and so forth, but also by choosing more exotic plants and by treating the vegetation in such a way that every layer will be distinct and easy to separate from the others. A more natural character will be achieved if taking an opposite direction in the choices.

Key character species include hazel (*Corylus avellana*), lime tree (*Tilia cordata*), willow (*Salix* spp.), hawthorn (*Crataegus monogyna*), hornbeam (*Carpinus betulus*), oak (*Quercus* spp.), beech (*Fagus sylvatica*), rowan (*Sorbus aucuparia*), ash (*Fraxinus excelsior*), maple (*Acer* spp.), elm (*Ulmus* spp.), alder (*Alnus glutinosa*), birch (*Betula* spp.), and bird cherry (*Prunus padus*). For southern Europe, chestnut (*Castanea sativa*) should be mentioned as well.

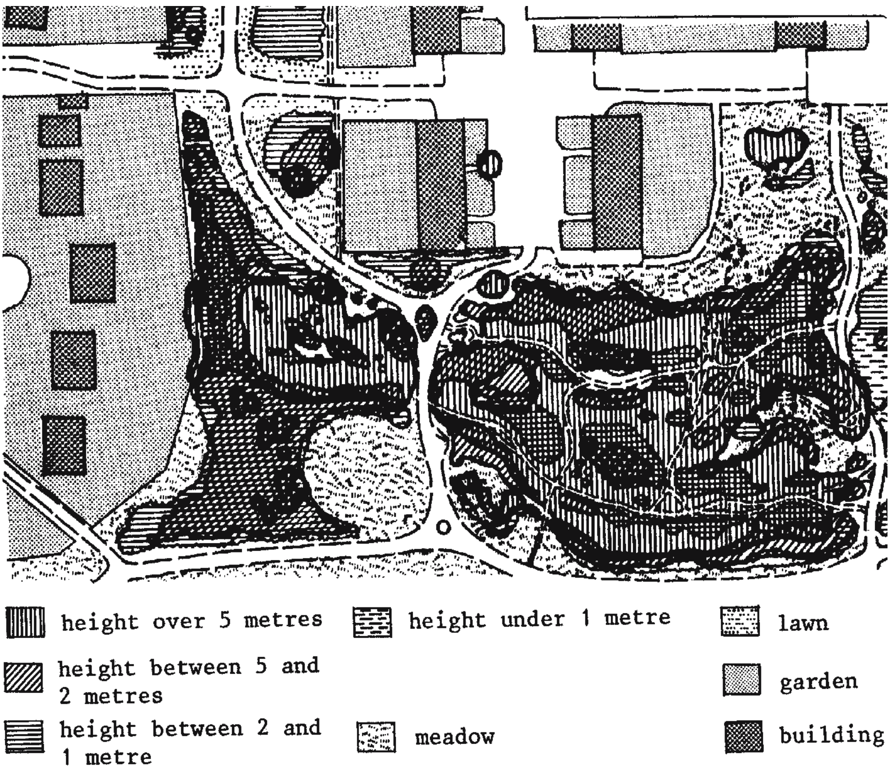


Fig. 13.4. Warrington New Town in England. A special emphasis on woodland design and management for children play has been made in Warrington. Some of the realized areas have been followed, since the middle of the 1980s opening up for questions like: why so successful in the early days, and why still today? (*illustration:* R. Gustavsson)

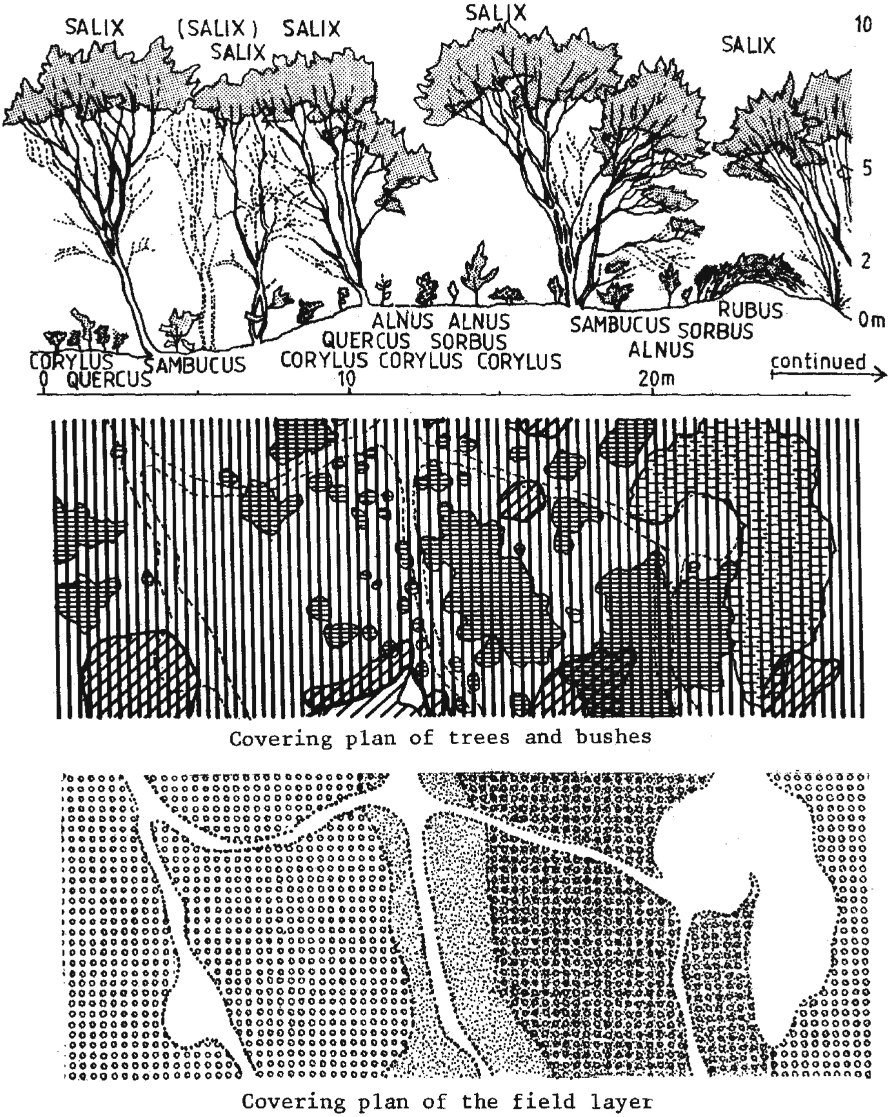


Fig. 13.4. *Continued* (*illustration:* R. Gustavsson)

13.4.5
Form and Species-Rich, Many-Layered Woodland Type

When looking at carefully managed woodland systems aimed at combining production with high aesthetic and biodiversity qualities, the form- and species-rich, many layered woodland types should be considered among the most valuable types for urban contexts. In forestry this type is mostly associated with oak timber production

Fig. 13.5. Ongoing thinning as a combination of selection cuttings and coppicing in a young woodland belt integrated into a housing area and its green structure in the city of Helsingborg, Sweden (*photo:* R. Gustavsson)

systems, with oak as the main tree and with recognition of the undergrowth as a quality-enhancer. Among the characteristics often to be found are open glades, meadow corridors, individually open grown trees, and thickets of shrubs as part of the structure. Selection cuttings are very much a basic management regime, but many other management types can be involved – in a mixture – as well, including more individual or group oriented approaches such as coppicing and pollarding (Fig. 13.5). If aesthetics and an attractive flora and fauna are favored, however, this type has a marginal history in former countryside. But there are important exceptions: many aspects and qualities can be related to one of the oldest woodland concepts, at least in Europe, i.e. the 'grove concept' (Gustavsson and Ingelög 1994). This concept culturally dates back thousands of years.

In the boreal zones of northern Europe, on poorer soils, a similar many-layered type dominated by spruce, pine, birch, and aspen has been part of cities as a vital system for many years (Rydberg 1998; Florgård 2000). It is obvious, however, that these types of systems become less species-rich compared to corresponding types situated in the countryside, in particular where small shrubs and ground flora are concerned. This is said to be partly due to sensitivity to trampling and thus specific management attention is needed (Malmivaara et al. 2002).

13.4.6 Dark and Light Pillared Hall Types

Woodland types resembling dark or light pillared hall types are among the most appreciated by leisure seekers. They articulate the experience of the inner room, with sometimes strong associations to a cathedral and its pillared hall. Its best-known European example is the beech (*Fagus sylvatica*) forest, which also is a good example of how production and general human appreciation can be jointly accommodated. Some of its basic characteristics include homogeneity, codominance between the trees, and an articulation of the woodland floor. One tree species should be chosen to dominate the scene by itself. Crowns should be lifted high; the trunks should be without lower forks. Examples of key character species for the dark pillared hall type are beech, maple, lime tree, horse chestnut, hornbeam, elm, and spruce. The light-giving pillared hall has a basic structure similar to the corresponding dark type, but because of the great distinction in light conditions the differences are drastic when concerning people's experience, field layer, and management need. Shadow-providing trees are not present and cannot help to reduce management needs. The extra needs may well be balanced, however, by the qualities that can be created. Moreover, as a middle-aged or old stand it can sometimes be used for grazing, which gives an even higher attractiveness. Other basic characteristics are a strong homogeneity due to a chosen codominance and high, uplifted crowns. Its character is created by the use of one species, or by a combination of two supplementary light-giving tree species such as poplar and ash, birch and oak or birch and wild cherry together. Solitary shrubs and small trees can be abundant in the undergrowth, but only if the area size is sufficient. Key character species are poplar (*Populus* spp.), birch (*Betula* spp.), ash (*Fraxinus excelsior*), pine (*Pinus* spp.), oak (*Quercus* spp.), and wild cherry (*Prunus avium*). For oak and cherry, as examples of less light-giving trees the distance between the trees should be increased to compensate.

13.4.7
Woodland Edge Types

Surprisingly little attention has been paid to woodland edges in urban woodland and park management plans. Recently woodland edges have thus often been left without management, with the obvious risk that interesting qualities are lost and that most edges will look the same. In the long term, particularly the outdrawn, shrub-rich and the visually-open short edges will disappear. Much can be won through a different attitude, incorporating more articulated visual qualities, flora and fauna diversity, hunting possibilities, or in terms of increased wind shelter for the adjacent woodland interior. The edge zone is also a preferred zone for children and their play. Here they can find shelter, construct huts, and good climbing trees from which the more open surroundings can be viewed. In terms of structure edge types can vary between the extremes, from a three-staged edge with an outdrawn profile to a one-staged edge, which could be created through conscious management as either a 'pulled-down' edge type, or as an open stem edge with an uplifted crown. When sufficient space has been provided, edges can obtain a depth of 30–50 m. Several zones can be identified, from the inner edge to the middle edge and the outer edge zones. In the inner edge zone a high woodland type with specific edge trees can be found. In the middle edge zone a low woodland type sometimes exists, but this is uncommon in practice. Finally, shrubs dominate the outer edge zone, but not all of it. Outside, an especially attractive grass- and herb-rich zone sometimes exists with species that favor having the shrubs and the edge trees in the back (Gustavsson and Ingelög 1994). Variation *along* the edge also needs to be considered. The same profile might be chosen to create uniformity and a great sense of harmony, or rather the opposite with all extremes compiled into one and the same edge can be chosen. Furthermore, specific elements should be considered as a contribution at 'area level'. These include glades placed within the inner edge zone, indrawn grass wedges like creeks or inlets, outdrawn points or tips of shrubs or trees, solitary trees and clumps placed as a forefront, and small waters and wetlands placed to maximize its function as a wildlife habitat and increase its beauty. Another such element is the edge path. The question how to incorporate this and other elements into a well-managed edge zone has characterized many well-known landscape designers through time.

13.4.8
City and Country Farms: Integrating Forestry, Agriculture, Allotments, and Wilderness Areas

City culture has long prioritized parks as outdoor, recreational areas without a crop production function. Perhaps more space should be provided for areas based on multifunctional concepts at the same time. Good examples of multifunctional areas exist in many European countries, indicating that opportunities do exist. Often these landscapes are found in the urban-rural fringe.

Many of the *English country parks* embody a park landscape in which recreation has become the main function, but agriculture or forestry are maintained as activities. In another variant people can visit *city farms,* which in most cases are highly focused on small animals belonging to a traditional farm. In almost all cases there is, at the same time, a major link to history and cultural heritage. In addition, it is important that citizens also reflect on the meeting between urban and countryside, or agrarian culture. Thereby, city farms should be complemented by *country farms*, which also relate to a surrounding landscape and are located in or close to a city. How these are managed is of crucial importance, not only just for keeping the intended vegetation character alive or for the crop output. It is also essential for how these farms are experienced: as authentic or as something artificial. It should also be stressed that such links provided by city and country farms not only relate to the past, although this is often the focus of their management. Rather they should through landscape, buildings and such signalize that they relate to the new, forward-looking way of living in cities.

13.4.9
Industrial Nature

In many parts of Europe within urban areas, old industries have been abandoned and vast areas open for new developments come available. In some cases these are built up, in other cases these industrial landscapes may be restructured, yielding a new kind of landscape with a mixture of spontaneously developing forests and scrub, large-scale gardens, and art. At the same time some of the infrastructure of the past, of which some is renovated and given new functions, is kept. An excellent example of such a development is situated in the Ruhr area in Germany. *The Emscher landscape park* originated in the early 1990s in the central Ruhr area between Duisburg (on the Rhine) and Bergkamen (in Westfalen). With a total area of about 320 km^2 and about 2 million people, a W–E length of 70 km and including 17 cities, this is a highly complex and huge project (Dettmar and Ganser 1999; see also Chap. 18). Another internationally well-known example is the nature park *Schöneberger Südgelände* in Berlin.

13.5 Integrating Design Aspects, Aesthetics and Biodiversity into Management

13.5.1 Using Shared Reference Landscapes and Landscape Laboratories

The development of innovative, integrative and sustainable management of urban woodland and parks can benefit from a reference landscape approach. This approach could help us to bridge between technical and biological aspects or facts, and facilitates finding concepts and providing physical form within design. Furthermore, it could help recall what may have been present in history, something which could stimulate and help to improve our understanding of 'ideal types' as living landscapes (Gustavsson and Ingelög 1994). Moreover, it could help us to go beyond history to find brand new concepts.

Today facts are often provided so fast that a culture of headlines and a feeling of a sense of knowledge exist rather than an honest belonging to knowledge. In the countryside as well as in the city interesting references become more and more difficult to find due to a simplification and a loss of more complex landscapes (Gustavsson and Peterson 2003). In many countries the landscape is either forested or open, and the transition zones are abrupt, while gradients in between are very rare. The same can be said for a whole series of possible woodland types, partly due to the fact that too few well-developed types exist as living types in the landscape of today. This definitely is the case with regards to woodland references in urban contexts.

Too easily woodland is associated with a thick green mass, or more precisely with a mixed forest stand with a lot of nettles and shrubs with no real visual attractiveness. It likely has no articulation between individual trees or tree layers, no interesting field-layer, and very little else one is inspired to slowly walk through. With such woodland in mind one might wish to prioritize more cultural and open park landscape types. Moreover, when reflecting upon long-term perspectives, different stages of maturity in biological systems, which all are fundamental for management issues, the fact is that there are actually very few examples that could be used as reference landscapes in urban contexts. Partly this is due to the simple fact that most European parks were created after the Second World War, when cities started to expand faster. This means that these parks are very young from an architectural and biological perspective. To come closer to a more positive and articulated meaning of urban woodland or park and their possible attractive qualities, there is a need to show what really can be won in a concrete way by a creative management revealing a world beyond normal thinking. Much could be gained, without a doubt, if particular landscapes could be found and used as good references to facilitate the identification of sound, concrete visions and to be able to lead the development rather than having to be led by it (Gustavsson 1999).

Using reference landscapes is also an important way to be able to understand each other. This touches upon what many see as the main problem of our time, i.e. to come down from the abstract and the general to the concrete, and to really understand and share. Furthermore, it is of great importance as an effort to discover design ideas that can be realized and trusted upon as 'long living'. This can even be taken one step further. To be able to develop, communicate and explain good management visions, there is a need to develop and 're-find' a differentiated language with a whole variety of words for describing different sizes, structural patterns, architectural individual life forms, and management regimes (Jönsson and Gustavsson 2002). To be able to find proper reference landscapes, and to develop proper landscape laboratories, it will also be needed to extend beyond the present, and dig into history (e.g., Rackham 1980; Vos and Stortelder 1992; Gustavsson and Ingelög 1994; Muir 2000).

In many countries, wooded meadows and other transitional habitats were removed from the landscape by farmers or abandoned as early as hundreds of years ago (e.g., Verheyen et al. 1999). Old postcards sometimes yield a dramatic picture of these land-use changes (e.g., Grand-Mesnil 1982). As a consequence, it is sometimes difficult to imagine tree-rich meadows or woodland as parts of possible and wished future landscapes.

The importance of reference landscapes in which concepts and management alternatives represented in a concentrated way can be studied may seem a dream in many cases. Mostly there are much too few cases that are really suitable. These are not easily found and geographically often distant from each other. To see and be able to study alternatives in an articulated and varied way, side by side, in the same geographical area or close to each other, is difficult in practice with its different goals and its compromises. To some extent, however, through the development of 'landscape laboratories' in Sweden and Denmark this has been realized (Rydberg 1998; Rydberg and Falck 1998; Gustavsson 2002; Gustavsson et al. 2002). These created landscapes enable the study of original design as well as the resulting dynamics and its consequences for the management of different landscape elements, such as a wide variety of woodland types, meadows and small bodies of water. Part of the concepts that can be found – in full scale – in these landscape laboratories are linked to traditional concepts that are also relevant for the future. Some other concepts had never been tested before in a landscape reality.

13.5.2 Design Aspects in Management

As also highlighted in Chap. 6, it is a misunderstanding to consider design as a question of aesthetics in a narrow sense related to 'free art' or just beautification. Design should rather be seen as a field of knowledge belonging to wide practical skills transferring our wishes into physical expression, and as being closely linked to ethics and to how we express ourselves as human beings (Carlson 2000). As a knowledge field it should be enlarged and deepened in its relationship to forestry, ecology, and to social and other functional aspects. Design should not be limited to the establishment phase of urban forestry, as it often is today. Very often design and management have been unluckily separated. Design is in fact a crucial part of our relationship to landscape dynamics and to sound, sustainable management. Design is discussed here from the perspective of long-term management.

A park is often an idealized landscape character type, and its design may be easy to comprehend. But it might also be that the actual state of art is insufficiently understood and that the question on how to develop design in the long term is not put forward. In the case of urban woodland design issues it might even be more difficult to grasp. Most urban woodland has become established through a very long process, with farmers and foresters interfering together with natural processes. This is not to say, however, that aesthetic considerations have been absent. They are often present but difficult to recognise due to for example incorporation into dominant woodland functions and natural processes. Moreover, professional designers with their particular style, when involved, could have supplied us with convincing documents demonstrating conscious design. Without such documents opportunities are reduced.

Some of the older woodland areas concerned have become incorporated – often rather recently – into cities as urban green elements, after which specific design efforts sometimes have been added. There are of course also older nature parks and urban woodland areas, which have been designed within a more formal scenic aesthetic tradition, as part of an old hunting park, a picturesque park or an English landscape-style park. These are rather few, however, and often natural processes have taken over to such a degree that design ideas have faded away. The design will become particularly difficult to 'read' over the time if the designer has used an informal style and succeeded well to integrate the area into the local landscape. This can imply that the original designers also are forgotten, as happened in the very well known case of Boston in USA, with one of Frederik Law Olmsteds' most successful projects, where people misunderstood the design and saw it as original nature (Spirn 1995). Design principles and aspects are more easily recognised in younger examples of afforestation projects. This is especially the case for those projects in which a very obvious, formal design has been applied according to modern or postmodern geometric styles. Recognizing the design should still be crucial for developing it further. To follow up initial ideas through creative, long-term management stressing design aspects may have been the intention of the designer involved at project outset. Consequently design aspects should be considered in both obviously designed areas as in nature parks and young, modernistic woodland areas. Moreover, design should be taken into account in the case of woodland areas that have been 'inherited' from countryside traditions. In the latter case, design aspects may even be more important as part of management and restoration strategies.

13.5.3
Aesthetics of Scenery, Care, and Wilderness, and Their Integration into Management

Environmental researchers have claimed that people are very sensitive to drastic changes as well as details revealing our relationship with landscapes. People notice if the landscape in question is managed with care or in a way that it reveals 'greediness' in terms of (over)exploitation of the land. In many cases modern forestry and agriculture can cause, without any doubt, problems related to a sense of greediness while the reaction might become the opposite in landscapes, where details are carefully considered. Below the aesthetics of scenery, care, and wilderness are introduced as complementary and overlapping concepts for management (Gustavsson 2003).

The scenic cult has over several hundreds years identified principles, views and working methods, which have resulted in many successful cases. When considering all the park landscapes that are part of recreational landscapes today, many European examples can be found in which the aesthetics of scenery have played a major role. Park styles such as the English landscape and picturesque style have contributed with specific design. During the last five or six decades, additional design contributions have been made by the dominance of modernism in landscape design and architecture across Europe. The aesthetics of scenery should also be considered as of crucial importance. Besides, new combinations and approaches are there to be discovered.

Influential authors like Pollan (2000) and Nassauer (1997) prefer to focus on an aesthetic of care rather than of scenery or wilderness. They stress the importance of active relationships between local people and different types of green areas, including people's involvement in decision-making and the active management of local areas. Nassauer (1997) mentions 'the aesthetics of care' as opposite to greediness. She sees this as the most important relationship between man and nature. To plan for an aesthetic of care, the landscape should be an important part of strategic management planning. To have wilderness in distant areas, some say, might be very good but not nearly as beneficial as having these areas in or near cities. The American philosopher Cronon (1995) discusses the concept of wilderness and argues that having wilderness concentrated in remote national parks is fine, but this does not benefit our daily relationship with nature, which has to be based upon a close and dialectic linkage between cities, people and nature.

Today, wilderness plays an increasing role in urban and park landscapes. Special wilderness zones become part of city contexts, as 'free-growing, non-managed zones'. Working with wilderness concepts thus has shown to be much more complex than the 'the further away, the wilder' approach. Moreover, the wilderness concept has been said to be for larger areas. Many examples exist, however, of smaller areas, e.g., in the heart of cities. Abandoned industrial areas are an example of this sort of urban wilderness which is such a useful concept for modern time. Important questions have been raised about the choice of size, providing possibilities to experience a certain character during a sufficiently long period of time, necessary high quality, as well as about advantages of introducing wilderness spots into areas, which basically represent the opposite. However, how to go further within this matter is an ethical question, and a question which also relates to design issues. To leave areas according to the *laissez-faire* idea may sometimes be too simplistic and has been criticized with the argument that ecology has paralyzed people to do nothing in situations where this could be strongly questioned. In the case of the equally-sized urban forests of Vestskoven (Denmark) and the Amsterdamse Bos (The Netherlands), for example, the former hosts only four managing staff, compared to forty people in the case of the latter. It could be discussed whether the lower number should be seen as the better, or rather the opposite (Box 13.2).

13.5.4
The Benefits of Restoring Biodiversity

The shift of attitude towards nature in European urban areas during the 1980s and 1990s was considerable (see also Sukopp and Wittig 1998; Wittig 2002). After a long period in which nature was not meant to be part of city character attitudes changed. What happened in many European countries might be illustrated by the Ecological Park Movement in Britain, which had as its motto 'every city with pride should have its own "ecological park" as part of its city centre, showing how central it is regarded in an urban culture' (Kendle and Forbes 1997). Baines' books *How to make a Wildlife*

Box 13.2 Adapting overall design principles to a particular local area, its context, and long-term management

When developing integrated design at area level as part of a long-term management, context questions like the following should be raised:

- Should special zones become highlighted with regards to raised ambitions for different kinds of aesthetics, which in practice could mean aiming for a natural character with strong emphasis on scenic values? Or should a cultural identity be stressed in *aesthetics of scenery* or in a combination with traditional forestry or agricultural methods and a production outlet as part of an *aesthetic of care*? Or rather: should extreme wilderness zones become included through areas with very marginal or no management input at all in an *aesthetic of wilderness*?
- What processes are important to start with and what should actually be avoided to provide for subsequent natural processes or cultural-social events?
- What is preferable when opting for a formal or an informal design language? How can strong and distinct atmospheres be created, as well as spans between harmony and chaos, uniformity and complexity?
- How does the local area relate to other open meadow areas, wetlands, woodlands, other recreation areas as well as housing areas and traffic zones, and how should it relate? Does it create an illusion of a world of its own with many surprises hidden inside? Or does it visually rather belong to the surroundings as a prolongation or extension which gradually changes in character, but stimulates contacts in between through openness along its fringes?
- How will users reach the local area? How can design underline landscape features that make the surroundings belong more to the main area? Or should the contrast rather be stressed in order to create a better variation as a whole? Will there be possibilities to create better links and to offer a whole series of alternative routes?
- How can different parts of the local area be recognised as a series of places, walks, entrances, landmarks, and zones in between? Are there reasons for a division of the local landscape into different landscape character types, habitats and zones, which should be articulated by design? How can main strategies be stressed, such as certain places for activities, places with a woodland, meadow, water or park character?
- Is it possible to distinguish between different routes in the area in a hierarchic way, considering length as well as atmosphere, and seasons? Or are broad walks, narrow paths, and rides, providing space for the more rational ones to those who want to socialize or feel secure, but also catering for those who want to be alone, feel closeness to nature, or are searching for more informal contacts?

Garden (1985) and *The Wild Side of Town* (1986) have provided inspiration since the 1980s. While reflecting on achievements so far, Baines (2002) mentioned that the reconstruction of habitats has been impressive in many ways as part of the successful, joint-up approach of nature conservation. In the future, even larger-scale projects, he felt should be developed. 'By working creatively with nature, we can realize all kinds of benefits for people – and rebuilding biodiversity will be a glorious bonus'. In The Netherlands, the Oasis-organization stated that the more artificial a city or society becomes, the more important it is to balance this with direct contact with nature and wilderness as centrally located as possible within the city (Leopold 1999). Looking back at what has happened during the last fifty years, few other knowledge fields have contributed so much to the change in management strategies as ecology. It has led urban people to learn to appreciate flora, fauna and biodiversity aspects much more than before. Much could still be gained (cf. Dettmar and Ganser 1999) however, if ecology could be applied in an extended and more integrated way.

13.6 Conclusions

In this chapter the need for more strategic and sustainable management of urban forests, here referring to urban woodland and parks, has been stressed, in contrast to defining management in a narrow sense, focusing on operational aspects of maintenance. A key role is reserved for management planners who can initiate, steer, coordinate as well as communicate within an active and dynamic process, focusing on the physical landscape, ecological and aesthetic matters as well as how to engage people and give meaning. This chapter should have made it clear that both practice and research need to give more attention to bridging the gap between design and ecological (and other) matters. Even if we argue for a more profound understanding of ecological matters this does not mean that design issues should play a diminished role; rather the opposite is the case. A lot remains to be developed in dealing with ecology, aesthetics, architecture, production aspects, and all technical matters, which come with management issues. Urban forests are highly complex habitats, with a multitude of elements as well as functions, of which recreation and enjoyment of visitors in most cases are considered the most important. The complexity of urban woodland and parks complicates the search for sustainable management concepts. The translation of this sustainability concept into practice is particularly challenging. By stressing this, an attempt has been made to provide suggestions on how this could be achieved.

Management visions accepted by all main stakeholders should be an integral part of comprehensive management plans, which are to guide long-term, sustainable management of urban woodland and parks. Multifunctionality is a starting point for most management approaches and measures, and this chapter has shown how management can assist in providing recreational, biodiversity as well as other benefits at the same time. In brief, relevant management concepts and measures have been presented and discussed. Aesthetics of scenery, care and wilderness are introduced as complementary and overlapping future concepts. Working with nature wherever possible has been promoted to enhance diversity. It has also been made clear that historical concepts adapted to urban situations have a role to play next to new concepts. The use of reference landscapes and landscape laboratories as framework for developing and discussing concepts and measures has been introduced. These can also assist with the needed integration within management and design of aesthetic, biodiversity, and production-directed considerations. Different urban woodland and park elements require different management strategies and measures, and a range of examples have been provided. Hopefully the chapter will provide inspiration for many future choices to be taken by managers and other actors, including local interest groups and visitors.

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Chapter 14

Information for Urban Forest Planning and Management

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14.1 Introduction

Different traditions of management, planning and design of urban forests and other green spaces each have their own specific information needs and knowledge cultures (see Chap. 13). Management strategies provide a framework for management decisions, based on available information, which means that reliable, comparable and up-to-date information is crucial for decision making. The need for reliable information on various aspects of urban forest resources and their use has led to the development of different methods, tools and systems to help collect, compile and use available information.

Information in urban forestry is needed to develop management concepts (see Chap. 13), make policy decisions (see Chap. 5), to determine the benefits of urban green space (see Chap. 4), to determine how green space should look (see Chap. 6), to decide which trees to plant where and how (see Chap. 9–12), and for many other reasons.

However, depending on its purpose information is needed on different scales and in different levels of detail. Local, more detailed information about, for example: tree and plant species, the number of users, and management costs, is primarily useful for green-space and tree management. An overview of all green space in a city is more useful for city development plans and city green-space policies. Information on national or even international level can be used in urban development strategies, health strategies, etc.

Besides the difference in scale, information is quite often available and used for certain topics only. For example, information on the biodiversity of a city's green spaces can be available and used in great detail, while information on environmental benefits such as reduction of air-pollution is virtually non-existent in the same city.

This chapter will start with defining what information is required for urban forestry planning and management. Three main types of information are used in this chapter, being essential basic green-space information, environmental and ecological information, and socio-cultural information. It then continues with a description of suitable methods to collect the different types of information. The chapter concludes with examples of the application of this information in urban forest management and planning.

14.2 Information in Urban Forestry

14.2.1 Data and Information

Data is in this chapter seen as the most basic form of information. Data is understood as the direct result of measurements, recordings or calculations. Data becomes information as soon as is it put in a wider context and a first analysis of the meaning of the results can be preformed. For example, recording the dbh of a tree is data until the number is entered into the inventory system together with other tree characteristics and made accessible and comparable with data on other trees.

Producing information that can easily be used in planning, management and decision-making for urban forestry is very important, as it is this information that will primarily be used in the decision making process. The logical procedure to reach a significant aggregation of data, producing usable information for decision-makers, can be described as (partly based on Tyrväinen et al. 2002):

- Collecting data by means of recording, measuring, calculating, or extracting data from existing sources
- Processing and compile of available data
- Assessing missing data
- Modeling or estimating missing data
- Extrapolating or aggregating data to be useable on different (geographical) scales
- Analyzing data and producing information
- Making information available and accessible
- Using information to develop scenarios to predict the implications of urban development

14.2.2 High Quality Information

It is particularly important to recognise that urban forest information needs to be prepared in a way so that it can effectively support urban planning, public involvement, and decision-making processes that have a strong influence on urban green spaces. High quality information is assumed to be objective, reliable, representative and comparable. Seen from an urban forest planning and management perspective, has several characteristics. First of all, it should be available and easily accessible, as mentioned above. Furthermore, it should be easy to use and easy to understand and it should not be too expensive to collect, use or update, both in terms of time and resources.

14.2.3 Information Types

The wide range of information needed for urban forest management can be divided in different information types in various ways. In this chapter the following main types of information are distinguished:

- Basic green-space information
- Environmental and ecological information
- Socio-cultural information

Basic green-space information includes, as the name suggests, the most elementary information to be used in urban forest management, such as the location of the green area, green element or street tree, and characteristics such as vegetation type or (tree) species, age, size, height, and so forth. Basic resource information also includes information for green-space maintenance, i.e. information on which management or maintenance activities are undertaken or planned for a certain green space.

Environmental and ecological information encompasses all information on environmental conditions that influence green spaces, as well as on the environmental benefits of green space (see also Chap. 4). It includes information on abiotic factors such as climate, water and hydrology, geology, air, soil and water pollution, noise, and solar radiation. This category also includes information on vegetation, plant and animal species.

Socio-cultural information includes socio-economic, psychological, aesthetic and cultural information. It deals with people's views, attitudes and preferences. User preferences, cultural values, aesthetics, information on health and other social services, as well as the economic benefits (see also Chap. 4) of green space are covered by this type of information.

14.2.4
Selection and Evaluation of Information

The decision-maker needs to be aware of what kind of information should be taken into account and how it can be valued within the specific decision-making context. Precise and comprehensive information can support transparent and successful decision-making. Furthermore, the values of different types of information should be considered, ranging from scientific information to local knowledge. New participatory planning approaches rely on diverse sources of information, which means that professional or expert knowledge alone will not suffice. Ideally, information should cover scientific, professional and public fields of knowledge (Tyrväinen et al. 2002). In reality, this ideal situation does not exist because policy-making and planning situations in urban forestry are characterized by limitations in time, available skills and resources (Konijnendijk 1999). Moreover, it should be stressed that the decision what kind of information is taken into consideration is an important part of the decision-making process.

In decision-making, data, information and knowledge are important resources. Because of the broad spectrum of different aspects, needs and information sources, information for urban forestry planning and management must be selected, popularized and, often, simplified.

During recent years, the use of indicators has been promoted in policy-making and natural resources management (e.g., Bossel 1997). Indicators can be seen as concise expressions of information or as tools to deliver information to decision makers in a usable, understandable form.

Indicators are not the only type of information tools. Especially public participation and involvement of several interest groups have led to the development of new instruments (see, e.g., Kangas and Store 2003). Information/knowledge resources are demanded to be increasingly based on scientific information and measured data that is popularized. Various information tools have been developed to serve decision-making. These include analytical analyses of hierarchical processes (Schmoldt et al. 2001), cost-benefit analyses (McPherson 1992; Tyrväinen 2001), criteria and indicator schemes, multicriteria evaluation methods (Beinat and Nijkamp 1998), models of recreational demand (De Vries and Goosen 2002), visualization programs (Karjalainen and Tyrväinen 2002; Tyrväinen and Uusitalo 2004), and geographic information systems (GIS) (Pauleit and Duhme 2000; Van Herzele and Wiedeman 2003; Germann-Chiari and Seeland 2004).

14.3 Collection of Information

14.3.1 Planning the Collection of Information

Before starting with the collection of information it is important to set clear goals and objectives (Wandall and Randrup 1999). Which information is exactly needed, and in what level of detail? Furthermore, it is important to determine what will be done with the information after collection; how and by whom will it be used? How often will the information be used and updated is another question that influences the collection and storage of information. Information will need to be updated in order not to become outdated, and a strategy for updating needs to be developed from the beginning. This also means that sufficient resources need to be allocated not only for initial recording of data, but also for future updates.

14.3.2 Recording Basic Green-Space Information

Information on green-space characteristics can cover a wide range of urban forest features and attributes such as size, location, vegetation type and structure, soil types, hydrology, land use, infrastructure and a range of technical aspects related to forest management. Information on the amount and location of urban woodlands is important, for example, to protect them against urban development projects or compensate the loss of green spaces; also, the implementation of laws requires precise definitions and boundaries. Several countries and cities of Europe apply norms for the per-capita provision of minimum areas of open space. Basic information on public and other green space is a prerequisite to assess current levels of provision against these green-space standards (see also Chap. 3). Basic resource information is also required for planning of maintenance activities.

Cities increasingly prepare a green-space inventory and monitoring system. A wide range of methods, tools and systems have been developed (e.g., Pauleit and Duhme 2000; Pillman and Kellner 2001). However, still many local authorities have only limited information available on green spaces in general, and specifically on the urban forest resource (Pauleit et al. 2003, see Chap. 3).

Remote Sensing

With the availability of aerial and satellite images and the development of methods for urban land use and land cover analysis (e.g. see papers in Jürgens 2003), a new potential for surveys on green space arises. The use of remote sensing methods has offered the chance for the implementation of a financially feasible and repeatable method for the assessment of a city's vegetation resources (Sukopp and Wittig 1998; Beisch 1998; Golibersuch and Wessels 1999; Pillmann and Kellner 2001). A green-space classification can be made based on an aerial or satellite image while only a limited number of field surveys are necessary to verify the results, thus greatly reducing the cost of a full inventory (see Box 14.1 and Fig. 14.1). The main problem with the system currently lies in difficulties with the classification of the aerial images, which can still be a rather time-consuming and complicated task (e.g., Myeong et al. 2002, see also various papers in Jürgens 2003).

In the project MURBANDY the development of urban areas in Europe was investigated (Joint Research Centre/Ispra 2000). Extensive datasets were used to study past and current land uses, trying to understand urban dynamics on the basis on indicators and forecast

Box 14.1 Biotope mapping in Vienna (Pillmann and Kellner 2001)

BiotopMonitoring Vienna was launched in 1991 with the goal of creating an information system designed to provide in depth information on Vienna's green spaces and urban forests.

In a surveying flight over Vienna in 1991, aerial color images and air-borne multi-spectral scanner data were taken simultaneously for the whole city area (413 km^2). To create a time series on the status of green spaces, surveys were also carried out in 1997 and 2000. During each flight the entire city area was depicted on color infrared aerial pictures, taken from a height of 2 000 and 3 700 m respectively, resulting in 650 images with a scale of 1 : 7 800 (23 × 23 cm resolution) and 100 images with a scale of 1 : 25 000.

Green spaces were distinguished as units with respect to their geometric form, function and surrounding areas. In the whole city 35 600 biotope areas, so-called phytotopes, were identified. The stereoscopic interpretation of aerial photographs enabled the identification and description of a wide variety of object features. Six main feature classes were used to describe the phytotopes:

- Green space structure type (describes the characteristics of green space within a city)
- Biotope type (describes the habitat function)
- Vegetation type (e.g. deciduous and coniferous trees, shrubs, meadows, lawns)
- Estimated number of trees in 5 stem diameter classes
- Crown condition (classes of tree vitality; crown defoliation, leaf discoloration)
- Surface cover types (percentage areas covered by vegetation, built-up areas, other impervious surfaces, etc.)

For management purposes additional information was necessary characteristic of alleys (density, regularity, gaps, number of sections), use of open spaces (e.g. playgrounds, sport, car parks, market places etc.), establishment and maintenance.

One major goal in the further development of BiotopMonitoring will be to improve the cost efficiency of this method through automation. Scanner data and image processing methods can be used for change detection purposes. The data presently available to us through BiotopMonitoring could provide an excellent basis for the evaluation of such new techniques. Now a rectified multispectral scanner image of Vienna is available with a resolution of 2.5 m in 11 spectral bands (visible, infrared and thermal) for further change detection using image processing methods. Highly resolved satellite images promise to be a source of data in the future.

Fig. 14.1. High resolution image of classified green-space vegetation (*Image:* USDA Forest Service, Northeastern Research Station, Syracuse, NY)

the development of urban areas. In the follow up study *MOLAND – Monitoring Land Use/Cover Dynamics*, detailed GIS data sets have been developed of land use types and transport networks at a mapping scale of 1 : 25 000, typically for four dates (early 1950s, late 1960s, 1980s, late 1990s), over the last fifty years, or for two dates (mid 1980s, late 1990s) in case of larger areas. Some of the results related to urban green spaces are reported in Chap. 3.

Urban Forest and Tree Inventory Systems

Recording green-space characteristics such as size, location, species, vegetation condition, and so forth sounds relatively straightforward but can be difficult in practice. A comprehensive inventory can be time-consuming and expensive. Surveyors need sound training in order to be able to collect high quality data. While measuring the height of a tree or the area of an urban park may be learnt more easily, determining the health status of street trees requires considerable expertise and a good classification system in order for measurements by different staff members to be comparable (see Box 14.2, Fig. 14.2 and also Chap. 15).

Since trees are a very important part of the vegetation in urban green spaces, many inventory systems are (street) tree based. Available systems typically collect field data using standardized data recording sheets, and increasingly laptop or palmtop computers for data recording in the field (Fig. 14.3). The data are compiled in customized database software. Links with other applications, such as standard databases and GIS are expected to become increasingly common.

Box 14.2 Tree registration in the UK

In the UK, an interesting approach was developed to provide a representative overview of the urban tree population. Trees were sampled in 66 towns and cities based on a classification of urban land uses (called urban morphology types, Department of the Environment 1993). This approach was further developed and applied to inventory the urban forest resource in the north west of Greater Manchester (Handley et al. 2000). Urban morphology units and types were distinguished and mapped in a geographic information system. Urban forest attributes such as the number of trees were recorded from aerial photographs in 200 m by 200 m plots selected at random in each of the urban morphology types. A field survey was then undertaken in a sub-sample of these plots for a more detailed assessment of the tree population. Attributes recorded included tree species, girth (diameter in breast height), height and spread, condition and location of the tree.

Such a survey produces a very good information base for strategic planning and management of the urban forest resource. For instance, Fig. 14.1 shows the density of trees in the different morphology units of the sample area. A wide variance could be observed, with inner city areas being particularly deficient of trees whereas low density suburbs proved to be particularly important for protecting the urban tree resource. Such information in combination with an assessment of environmental, social and economic benefits can be used to target specific programs and measures to protect and improve the provision of trees in urban areas.

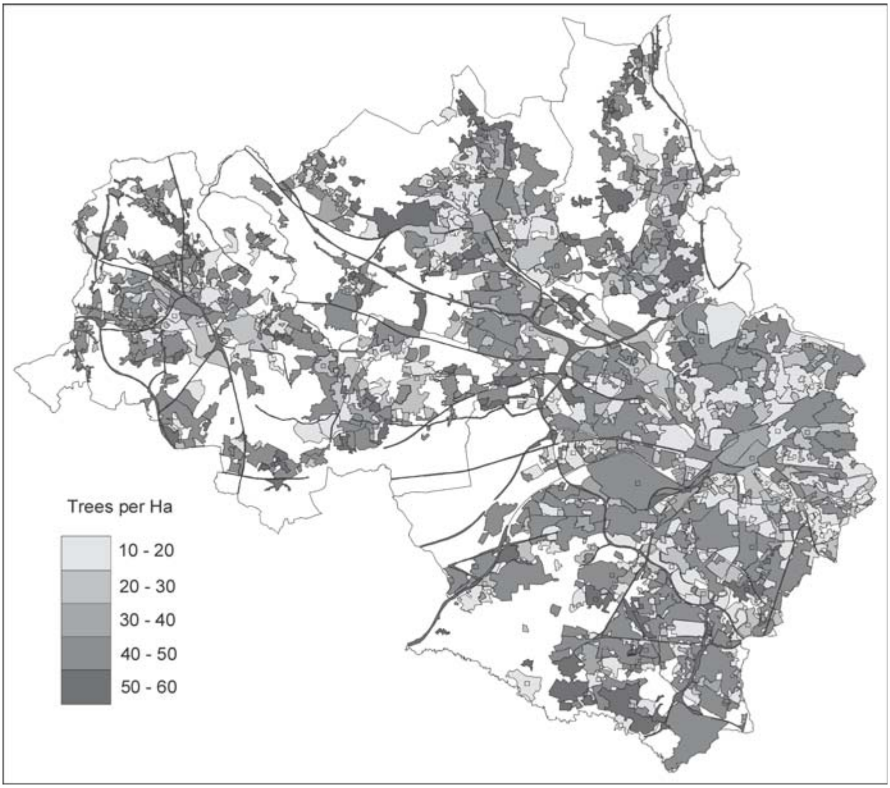

Fig. 14.2. Tree density in urban morphology units in the north west of Greater Manchester, UK (*source:* Handley et al. 2000)

Part IV

Fig. 14.3.
Example of a handheld computer with special software to record green space characteristics (*image:* USDA Forest Service, Northeastern Research Station, Syracuse, NY)

Three main types of tree registration systems can be distinguished (Wandall and Randrup 1999):

1. Number based registration systems. A system based on a certain number of trees that is registered, e.g. the entire population, per area, per species or a representative sample
2. Information-based registration systems. A system focusing on recording a specific type of information, e.g. about spread of diseases or the health conditions.
3. Frequency-based registration systems. A system based on how often data is recorded, e.g. periodically or continuous registration.

Electronic Tree Recognition

A recently introduced tool in urban tree management is the use of a computerized label, a so-called transponder. The transponder assists in identifying each individual tree and can store all main tree characteristics, including management treatments given to it over time. The use of transponders allows for quick consulting and updating of information on individual trees. However, there are still problems with the durability of the system, as some transponders are no longer readable after a few years due to growth of the tree. Also the initial investment costs needed for the system might be problematic, especially for larger cities.

GPS

The use of the Global Positioning Systems (GPS) is becoming more and more common as a tool to record the exact location of trees. The accuracy of the system is improving so that sub-meter precision can now be achieved. A GPS receiver needs to locate a minimum of three satellites to determine the horizontal position. When the receiver locates four or more satellites, the vertical position can also be determined.

The combination of GPS, palmtop computers and GIS is likely to develop further in the near future. This development will also simplify the computerization of data collection within urban forestry (Brockhaus et al. 2003).

14.3.3 Environmental and Ecological Information

Urban forests provide many environmental and ecological benefits to the urban population (see Chap. 4), for example by meliorating the urban climate, reducing air pollution, noise levels, storm-water runoff, controlling erosion, and protecting drinking water sources. Also urban forests play an important role in maintaining and increasing biodiversity in urban areas. However many of these benefits are threatened by urban development such as building activities and road construction. Reliable information on the environmental and ecological benefits is important for the protection of the urban forest. Moreover, urban areas are mostly characterized by difficult growing conditions for trees (see Chap. 11 and 12), and information about environmental conditions and stresses of trees is needed for tree protection and management.

Measuring the Environmental Effect of Urban Vegetation

Many European cities have environmental monitoring systems in place. For instance climate data, and data on air and water pollution are regularly collected. In some cases, detailed measurements of noise levels exist, especially related to traffic. Measurement methods are well established, however, the impact of green spaces on air quality, etc. has rarely been measured or modeled (see Chap. 4). Currently, several European research projects are working on methods and tools for green-space planning, including the assessment of their environmental benefits (e.g. the EU projects BUGS – Benefits of Urban Green spaces, and RUROS – Rediscovering the Urban Realm and Open Space).

Models have been developed to estimate the environmental benefits of urban green space such as increase of rainwater infiltration and improving the urban climate (see Chap. 4). Land cover data obtained from aerial photographs is the main input to run these models. For instance, in a study in Merseyside, UK, the following land cover classes were distinguished: built, paved, trees, shrubs, rough grass, amenity grass, flowerbeds, open soil, water (Whitford et al. 2001; Pauleit et al. in press). A stratified random sampling approach can be applied to collect this information for the different urban land uses (e.g., Akbari et al. 2001).

Biodiversity

During recent years, more attention has been given to the specific values of urban nature (e.g., Gilbert 1989; Goode 1998; Wittig 1998; Florgård 2000). Several cities have been able to maintain tracts of nature areas in or close to their boundaries and created opportunities for the spontaneous development of vegetation (see, e.g., Chap. 13).

The presence of natural vegetation and/or indigenous vegetation in urban areas have been studied in Europe as well as elsewhere (e.g., Florgård 2000; Breuste et al. 1998). A wide range of scientific studies on flora and fauna of European cities is available, including data on urban forests (e.g., Gilbert 1989; Sukopp and Wittig 1998; Breuste et al. 1998). Plant species, bird and butterfly species have been recorded in a number of cities. Biotope mapping is frequently used to survey habitats for urban wildlife. For instance, the city of Vienna (Austria) carried out an extensive survey of the biotopes within its borders (see Box 14.1). In a Danish study (Attwell 2000), vegetation cover and habitat quality were identified for a number of Danish towns revealing a potential for increased habitat and biodiversity values especially in low density residential and industrial zones.

Additional information on biodiversity is often supplied by extensive networks of volunteers and environmental NGOs operating in urban areas. In The Netherlands, a popular project called 'Nature Calendar' is coordinated by Wageningen University. People are asked to report their first sighting of selected bird and other animal species, as well as flowering of plants, to a web site. The study aims, for example, to establish the impacts of climate change on wildlife (for more information www.natuurkalender.nl). Thus it presents an interesting example of how different types of environmental/ecological information from scientific and 'local' knowledge can be brought together.

14.3.4
Socio-Cultural Information

Historically, especially in Europe, many benefits of urban forests are associated with social, aesthetic and economic functions of urban green space (see Chap. 4). However, the use of this type of information in urban forest management is still relatively new. General information on the social and cultural values of urban forests does exist in many countries but this information does not always reach decision-makers. Furthermore, the use of area specific information, e.g. the social values of a specific city park, is still rare. In the past years more comprehensive methods to assess the social benefits of urban green spaces have been developed in various European countries and these tools and methods now start to reach urban forest management (see Chap. 4 and also Tyrväinen et al. 2004).

One of the main aims of collecting social information is to find out how people think and feel about urban green spaces. Central questions are: What do they use green areas for?; how often?; when?; which areas do they prefer and why?; how should the management be done in their eyes?

14.3.5
Collecting User Information

The most used methods to find out how people use green spaces are by means of interviews and questionnaires. By means of for example on site or telephone interviewing, or through mailed, door-to-door, or even Internet surveys, users and non-users of green spaces can be asked about their use (or non-use) of specific green spaces and preferences.

In a Danish study a questionnaire was mailed to 3 600 randomly selected persons and 1 900 randomly selected associations and institutions in 6 Danish cities to reveal the use and importance of urban parks (Holm 2000). 98% of the population had visited an urban park a least once in the previous year. The results showed furthermore that the average citizen visited urban parks twice a week. The distance to the nearest park, having a dog and the age of the respondents had the strongest influence on the number of park visits.

In Vienna telephone interviews were conducted over a number of years to reveal how the population of Vienna used its urban woodlands (Bürg et al. 1999). The results for the period 1989–1997 showed that 68% of the randomly selected interviewees used the woodlands. The study provided a good overview of the average visitor, the most common activities and the revealed different types of users.

A Swiss study used the 'Theory of Planned Behaviour' and focused on the public acceptance of planned restrictions of recreational activities as result of the establishment of a nature reserve (Seeland et al. 2002). The study showed how different user-groups react on restrictions imposed on their use of urban woodlands. It seemed that most user groups were rather indifferent, but hunters and berry-pickers were opposed to restrictions.

Box 14.3 Social value mapping in Helsinki (Tyrväinen et al. 2004)

The Swedish social mapping method was adapted and tested in Helsinki in 2003 as part of an EU funded research project, NeighbourWoods. The case study area consisted of three housing areas in Eastern Helsinki. The total number of households in the case study area was approximately 9 000. The total population consisted of nearly 20 000 inhabitants. The study area was located 10–15 km from the city centre. The area had been selected primarily because of its variety, both in types of green areas and in housing types. It has high-rise blocks from the 1960s and 1970s, a large area with single-family homes dating from the 1920s to the 1950s, combined with many buildings built during the last decade. The city was planning to construct new homes in the area, but the exact locations for building had not yet been determined.

It was decided to use a mailed questionnaire with pre-coded questions to study the social values of the green areas in the case study area. A thousand questionnaires were sent out to randomly selected residents, with a good distribution between the different residential areas and different ages of the residents. The questionnaire consisted of four parts:

a respondents' opinion on green area values and functions in general
b values and characteristics of green areas
c use of green areas and opinion on management
d background information on the resident

For part b, a map of the case study area showing the different green spaces with a number was presented to the respondents. The respondents were asked to identify their favorite area, and also to describe area characteristics such as forest feeling, beautiful landscape, nice park, and so forth. This resulted in a range of maps of the area displaying the different values as identified by the residents (see Fig. 14.4a–c).

The response rate was around 40% and the collected information on social values provided a valuable insight in how the residents of these housing areas value their green areas, but also where development should definitely not take place.

The Regional Planning and Transport Office in Stockholm has developed a method to describe and map the experience values of local residents by means of questionnaires and interviews and combine the results with other planning data (*Regionplane– och trafikkontoret* 2001). The method used the following steps:

1. Different open spaces were identified and named, primarily based on existing classes such as parks, woodlands, grasslands, and so forth.
2. Background information on these areas was collected. Traffic noise models were used, for example, to determine noise levels. Moreover, cultural historic elements were identified, plant species data was recorded and tree age was assessed.
3. Questionnaires and/or interviews were used to obtain area-specific information from local residents about the social values of green spaces.
4. The information from these dialogues with the residents was combined with the other information into socio-cultural values for green spaces. Since all information was related to real areas, a map could be made displaying the specific (combination of) socio-cultural values of each green spaces.

The method has successfully been used in Stockholm and, in adapted form, also in Helsinki (see Box 14.3). Other Swedish and Finnish cities have expressed their interest in using the method as it provides, in a relatively easy and cost effective way, an overview of social values and can easily be integrated with other planning methods.

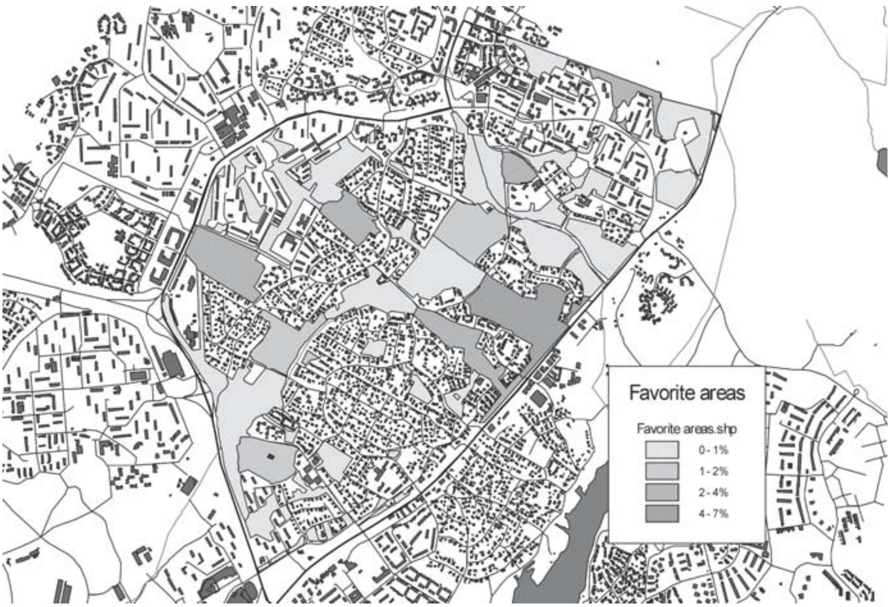

Fig. 14.4a. Percentage of respondents identifying one specific area as their favorite green area within the study area in Eastern Helsinki, divided in four classes (Tyrväinen et al. 2004)

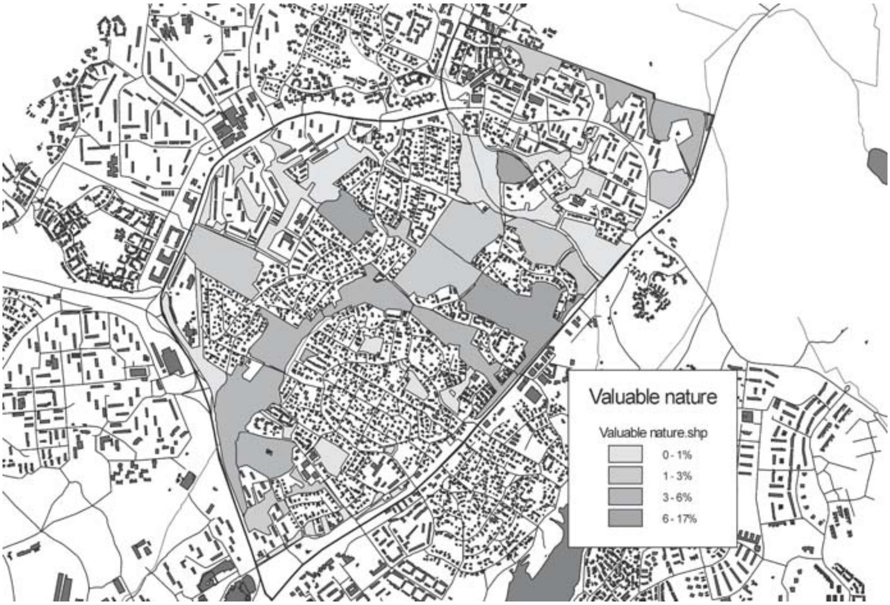

Fig. 14.4b. Percentage of respondents experiencing one specific area as a valuable nature area, divided in four classes (Tyrväinen et al. 2004)

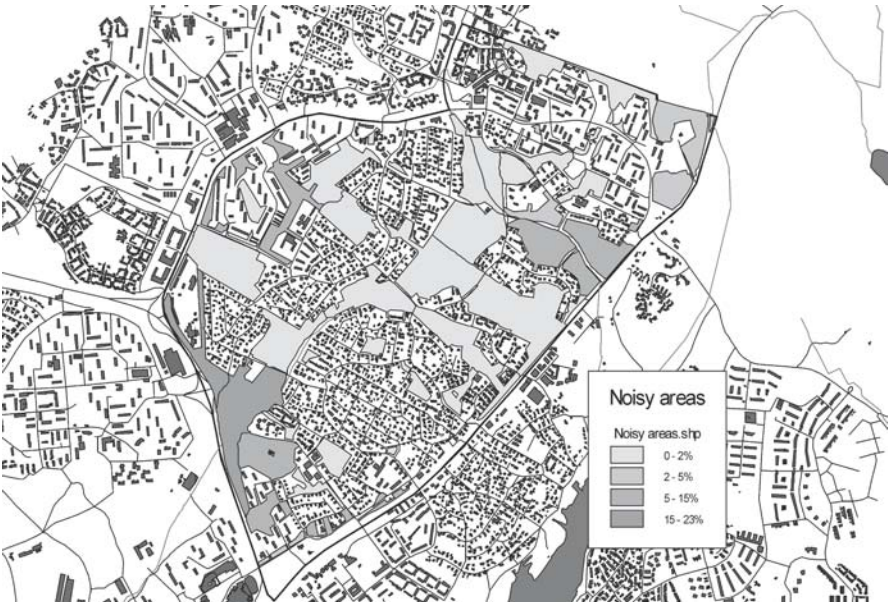

Fig. 14.4c. Percentage of respondents experiencing one specific area as a noisy area, divided in four classes (Tyrväinen et al. 2004)

14.4 Information Systems

During the course of the COST Action E12 Urban Forests and Trees a questionnaire was sent out to selected European cities and towns to reveal if and which information systems were used to collect green-space characteristics. This pilot study was by no means exhaustive, but it rapidly became clear that many different systems are being used for many different purposes by both researchers and urban forest managers. Table 14.1 gives an overview of the most commonly used tools and systems.

14.4.1 Databases and GIS

Comprehensive recording of green-space characteristics is only useful when the data is stored systematically and made easily accessible. The backbone of each inventory and information system is therefore formed by a database. Having a database with relevant green-space information that is (or could be) updated forms an important basis for all further use of the information. Furthermore, more and more cities realize that the location of green spaces in relation to each other and to other urban land uses is important. This is likely to result in an increasing use of geographic information systems (GIS), optionally combined or integrated with a database system.

In a small COST E12 survey 'computer applications in urban forestry' 53 organizations, primarily city administration departments, were asked which software was used for database and GIS applications. Smaller cities tended to use standard desktop software, whereas larger cities were more likely to have customized systems. The software packages that were most frequently mentioned in this pilot study were: MS Access, Dbase, Oracle, MapInfo and ArcView.

14.4.2 Green Structure and GIS

On city or even agglomeration level, it is important to look at the entire green structure, made up by all green elements in and around cities, i.e. individual trees and other vegetation elements, medium sized urban green spaces such as parks and urban and peri-urban woodlands (Konijnendijk and Randrup 2002). Besides the benefits of each green element as such, additional benefits occur because of connections and corridors between elements, which for instance, favor longer recreational routes and also provide additional ecological benefits. Also, a well-designed and developed green structure usually makes for a better spatial distribution of urban green (e.g., Pauleit and Duhme 2000), which, in turn, makes the benefits available to a larger part of the urban population (e.g., Van Herzele and Wiedeman 2003). Within urban forestry various studies have been done to study accessibility (e.g., Van Herzele and Wiedeman 2003; De Vries and Goosen 2002), distance to green spaces (e.g., Præstholm et al. 2002; De Vries and Goosen 2002) and recreational preferences and benefits (e.g., Van Herzele and Wiedeman 2003; De Vries and Goosen 2002). Through using GIS, different aspects can be combined into more integrative and informative information.

Table 14.1. Systems and tools used in European cities to assist urban green management (Schmied and Pillmann 2003)

	AT	BE	CH		CZ	DK	FR		DE							IT	NL	SK
	Vienna	Brussels	Bern	Geneva	Prague	Copenhagen	Lyon	Marseille	Berlin	Essen	Frankfurt	Hamburg	Hannover	Karlsruhe	Stuttgart	Milan	Amsterdam	Bratislava
Inventory/monitoring of green spaces	yes	yes		yes	no	yes	yes	yes	yes	no	yes	yes		yes	yes	yes	yes[c]	yes
Remote sensing	yes	yes[a]	No	no	yes	yes	yes	yes	yes	no	yes	yes	yes	[b]	yes	yes	yes[c]	no
Black and white aerial images											x	x	x		x	x		
Colour infrared aerial images	X	x			x			x	X		x		x		x		x	
Airborne multispectral scanner images					x	x	x											
Satellite images		x			x	x												
Computer assisted	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes[b]	yes	yes	yes[d]	no
Tree inventory software			X					x			x	x	x		x	x	x	
Geographic Information System (GIS)	X	x	X	x	x	x	x	x	X		x	x	x				x	
Database software	X	x		x	x	x		x	X		x	x	x	x		x		

[a] Only for street trees.
[b] Under construction.
[c] Without trees.
[d] In some districts.

Box 14.4 A monitoring tool for the provision of accessible and attractive urban green spaces (Van Herzele and Wiedeman 2003)

The methodology used in this study consisted of two main steps, firstly examining the preconditions for use, primarily accessibility, and secondly accessing the qualities that make a green space attractive for use.

To be able to calculate the accessibility of green spaces, four map layers were derived from various thematic maps. The densely built urban core area was identified, as well as relevant neighborhoods within the city. All green spaces larger than 10 ha as well as barriers and crosswalks (locations where the barriers are permeable) were identified. The accessibility of green areas was calculated with the cost distance module of ArcView and by mapping the sizes and distances of green areas.

The attractiveness of green spaces was assessed with the help of various parameters linked to physical features of green spaces. Parameters used were size, naturalness, cultural and historic values, quietness and the availability of facilities. Values for each of the parameters were assigned by experts.

The tool was used in four Belgium cities and the results showed that the provision of different types of green areas was not always sufficient. Especially the availability of so-called 'neighborhood green', an area of at least 10 ha (or 5 ha for a well designed park) within 800 m from home, was very limited. In the city of Kortrijk 95% of the population had no access to quarter green.

The method allows to compare different cities which each other, and also to reveal problems with green area provision within a city. Thanks to the combination of quantitative and qualitative information on urban green spaces with social information on a neighborhood level, the model gives an accurate overview of the recorded deficiencies in different parts of the city. Since the analysis can be performed at different functional levels, it can be detected to what extent problems and changes result from conditions and politics on different levels of decision making, e.g. local, regional, and so forth. Consequently, specific green-space policies and measures can be designed at the relevant scale. The use of aggregated quality groups also allows for relating the results to different policy domains, e.g. traffic, nature, among other.

Accessibility of green spaces has been mentioned as key to its social use. Several studies show that increasing distance to recreation areas decreases their use (e.g., Tyrväinen 1999; Hörnsten and Fredmand 2000). The key factor for active use is easy access to areas, which should be located preferably within walking distance of the home environment. The benefits of green spaces for urban quality of life greatly depend on the accessibility and qualities which people perceive from them. In Belgium, a GIS-based model has been applied to determine the supply and accessibility of green spaces (Van Herzele and Wiedeman 2003, see Box 14.4). The model was designed to allow the monitoring of the urban green spaces status through time and space against quantitative and qualitative targets. The tool is particularly aimed at assessing the effects of future policy scenarios.

14.4.3 Decision-Support Systems

Information becomes particularly useful if it can be used directly to support the decision making process. An important question many decision-makers like to see answered is 'what will happen if we change this or do that?' In order to make these predictions for the future, several models and other decision support tools have been developed

Box 14.5 CITYgreen, a GIS based decision support tool (American Forests 2002)

Because of the difficulties of comparing the value of urban green areas with the value of other urban land uses for decision makers, American Forests, one of the oldest NGOs in the USA has developed a GIS tool that can calculate the value of urban green areas. Calculations are based on extensive research done by USDA Forest Service in combination with the creation of a so-called green data layer (American Forests 2002).

The system is developed to analyze the effect of urban green areas on: storm water management, air quality, energy use, carbon sequestration and furthermore the system also incorporates a tree growth model that can be used to predict future scenarios. If all factors can be taken into account depends on the availability of data. Tree canopy data is the most important information.

Analyses can be undertaken for both small and large areas. For small-scale projects, a detailed inventory is possible, and required to give the best results. For application on a larger scale, it is necessary to use satellite or aerial images to determine urban forest canopy cover. This makes it possible, with good classification of the images, to develop a green infrastructure data layer (equivalent to e.g. data layers on road infrastructure, housing and utilities) for which benefits can be quantified for larger areas.

The system seems especially suitable to show, in a cost effective way, that is easy to understand for non-experts, how preserving green areas will lead to reduced expenses for storm-water retention and energy consumption. Furthermore air quality improvement and carbon sequestration can be estimated.

with natural resource management, but only very few have been adapted to an urban forestry context. This may be related to the complexity of urban forestry in terms of, for example, the diversity of green-space elements, the many different interests, and the difficulty to fully assess various urban forest benefits. Although most of the earlier mentioned methods also include an 'advise' or 'prediction' part, there often is a long way to a comprehensive decision-support tool.

One of the few examples of a decision-support tool used in urban forestry is CITYgreen (American Forests 2002), developed in North America (see Box 14.5). Dwyer and Miller (1999) tested the use of this tool in Stevens Point, Wisconsin, USA and concluded that it was a useful tool for obtaining a sound overall impression of the status of the urban green spaces in a city.

14.5 Conclusion

In many European cities there is wide range of information on urban green spaces available. And suitable methods, tools and information systems for measuring, collecting and compiling information are becoming more widespread. However, the available information is often spread over many different city departments and decision makers are not always aware of the existents of all information. Bringing all available and necessary information together and making it accessible to the wide range of professionals and decision makers that are involved with the management and planning of urban green spaces will be a major challenge in the coming years. Scientist and practitioners can together work on facing this challenge and improving the situation by developing and using more integrated information systems.

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Chapter 15

Arboricultural Practices

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15.1 Introduction

Arboriculture (from the Latin *arbor* = tree, *cultura* = tending or caring) is tree cultivation based on tree biology. The term arboriculture is often loosely used and includes the care of other woody plants such as vines (in the United States), wall shrubs (in England), and climbing shrubs (in Australia). This relatively young discipline generally focuses on single trees or small groups of trees, usually in urban areas. Arboriculture is an essential and integral part of urban forestry and is sometimes treated as a special type of horticulture. The goals of arboriculture are to establish and maintain healthy, aesthetic, and safe trees. These goals are met through the selection of suitable tree species for harsh urban conditions, proper planting, watering, fertilization, mulching, protection (stakes, supports), and formative pruning of new plantings as well as through proper training, regular pruning, vitality and safety inspections of mature trees.

This chapter deals with the assessment of trees and the most commonly applied tree care practices: pruning, crown stabilization and wound treatment. Targeted tree care should rely on knowledge of their growth and response to adverse urban conditions inducing the decrease of tree vitality and simultaneous increase of hazard problems. Among several methods for assessment of tree vitality, visual methods will deserve most attention due to their practical value. Identification of dangerous trees and decision for solution of the problem is a highly responsible procedure, which demands expertise in tree biology and diagnostic methods. Hence, the process of walling-off of infected and decayed wood tissue and a range of methods used for assessment of hazard trees will be considered in this chapter.

15.2 Tree Growth and Tree Architecture

A tree is a highly compartmented, compartmentalizing, perennial, woody, shedding plant that is usually tall, single stemmed, and long lived (Shigo 1986b). Growth of a tree takes place in highly specialized organs called meristems, which produce new cells by their divisional activity. New cells undergo differentiation; a complex process of maturation in which they become anatomically and functionally different from meristematic precursor and neighboring cells. Some cells must die at the end of differentiation to fulfill their function (i.e. conducting vessel members in wood) and others remain alive for many decades (i.e. wood parenchyma storing carbohydrates). There are two basic types of meristematic tissue in trees: primary, which enable the elongation of shoots and roots, and secondary, which enable trees to grow in diameter. There are two secondary or lateral meristems, vascular cambium and phellogen (cork cambium). Vascular cambium is giving rise to secondary xylem and secondary phloem.

The basic structural unit of trees are cells. Cells of similar anatomy and function build up tissues and these organs. Trees have five organs: leaves, stems, branches, roots, flowers and fruits. Tree architecture is based on the formation and relative arrangement of its parts. Tree architecture expresses a dynamic equilibrium between internal processes and external environmental constraints (Hallé and Oldeman 1970). Considering the tree as a whole, from germination to its death, four major architectural stages can be defined (Drénou 1999, 2000).

The Architectural Unit (Fig. 15.1)

The seedling or young sapling exhibits the basic architectural unit of that species. At the beginning of its development, a tree is a hierarchical branched system in which the axes of growth can be grouped into morphological categories including the type of growth (monopodial or sympodial), the growth direction (orthotropy or plagiotropy), the position of the flowers, and the phyllotaxis. The structure and function of each category is characteristic of its rank, and for each species, the number of axes categories is finite (3 for *Juglans regia* and *Fraxinus excelsior*, 4 for *Quercus robur*, *Castanea sativa*, 5 for *Platanus acerifolia* and *Cedrus atlantica*). In an architectural unit, the top of the trunk is the leader (apical dominance concept) and its damage by accident or pruning can induce a disorganization of the whole structure.

The plasticity of the shape is an important trait for trees growing in an urban environment, as they are subjected to repeated pruning for the purposes of liberating space. In regard to this plasticity, three kinds of tree architecture exist.

1. Species of *Populus*, *Fraxinus* and almost all the conifers, are monopodial in stem growth with the entire main stem produced by a single leading growing point or meristem. This strictly monopodial functioning explains their difficulty in reabsorbing traces of accidents occurring on the leading shoot (e.g., related to insects, freezing, wind, drought, topping). The tree tries to restore the missing part, but this regeneration is not always immediate and failproof. Two types of reaction can be observed: straightening of branches near the traumatized end of leader, and formation of one or several new axes in the vertical direction of growth, starting from latent buds. In both cases, the trunk will show a bayonet-shaped deviation if a single relay is set up, or a fork if two axes acquire an equivalent development (this case often takes place in trees with opposite buds such as *Fraxinus* spp., *Acer* spp., and *Aesculus* spp.). Therefore, when the leading shoot of a monopodial tree is damaged, pruning is required as soon as possible.
2. Species of *Platanus*, *Castanea* and *Tilia* are sympodial in growth: every year, the terminal bud of the trunk dies and a new growth axis, called a relay, sprouts from an axillary bud to ensure continued stem growth. This type of growth is inevitable, hereditary and perfectly normal for this group of species. In this case, trees can restore very easily the leading shoot after an accident, and selection of axes by pruning is not always necessary.
3. Still other tree species have stems formed as a sequence of forks, with growth being mainly along the horizontal plane. The basal part of each fork is elevated, resulting in stem height growth. Only one member of each fork persists, while the second member is shed like a branch. This method of growth is quite prevalent (e.g., *Robinia pseudo-*

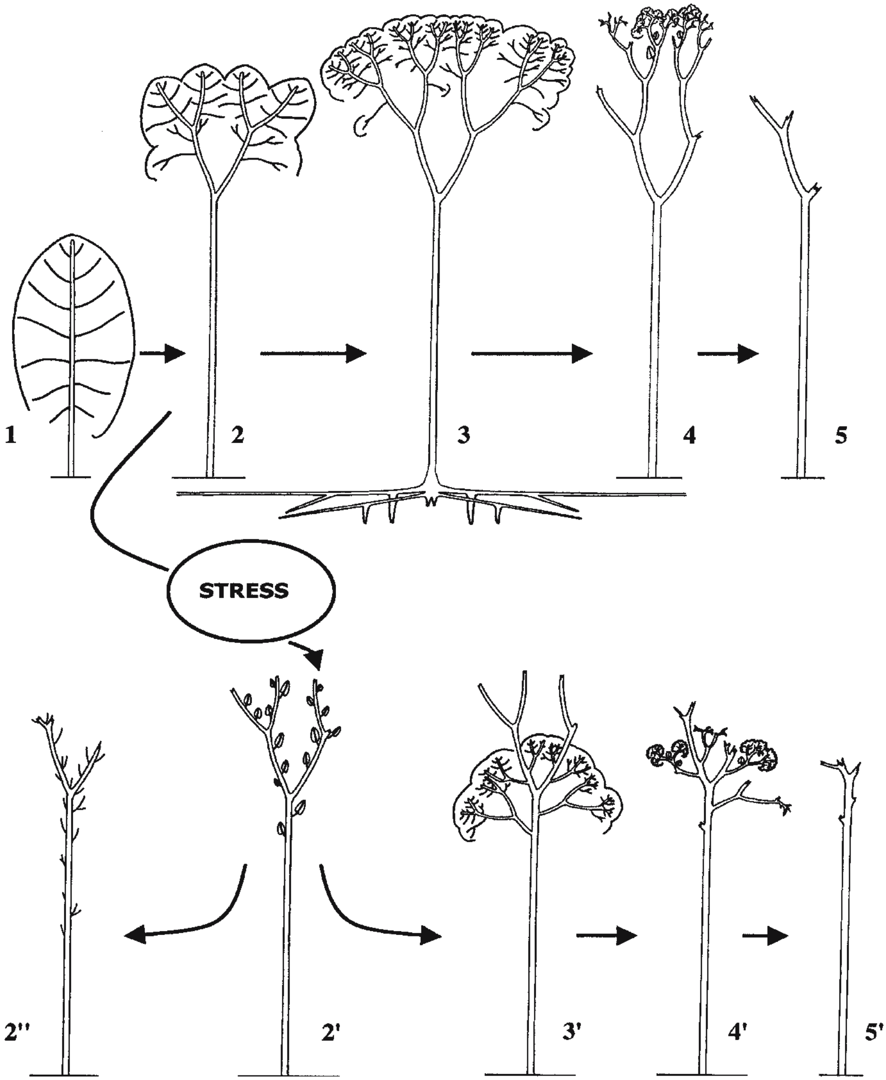

Fig. 15.1. The development of a tree includes different stages: the architectural unit (*1*), the young tree with the beginning of the reiteration process (*2*), the adult tree in its final volume (*3*) and the irreversible senescence (*4* and *5*). Stress may disturb this evolution. Some trauma can kill trees before their natural death (*2′* and *2″*). In other cases, epicormic shoots regenerate a new crown which follows the last stages up to senescence (*2′*, *3′*, *4′* and *5′*). Figures with the same number are at the same stage of development (*illustration:* C. Drénou)

acacia, *Ulmus* spp., *Zelkova serrata*, *Celtis australis*, *Gleditsia triacanthos*, *Cercis siliquastrum*). These forks generally reabsorb themselves. Therefore, formative pruning should not be performed with haste. It is only when a recurrent fork seems to persist after two years of existence that it should be pruned.

The Young Tree (Fig. 15.1, 2)

As the young sapling grows in height, the branches that develop one after the other are gradually straighter and straighter, and end up acquiring a trunk morphology (phenomenon called reiteration). An initial main fork is formed at this which will bear the main branches of the crown. The main fork marks the end of height growth for the main trunk, which then enters an enlargement phase. The first main fork gives rise to branches much shorter than the trunk, and these branches themselves fork, giving rise to still smaller branches, and so on.

When young trees are growing in a high density stand they do not form main forks. The result will be skinny trunks covered with suckers emerging as soon as they see the first light. On the contrary, in totally exposed spaces, when the main fork appears below the level of the desired height, it is advisable to prune lower branches to artificially lengthen the trunk.

For some species of conifers such as *Picea* or *Abies*, growth occurs without reiteration and the trunk becomes as high as the tree itself.

The Adult Tree (Fig. 15.1, 3)

A tree is considered to be an adult when it has reached its final volume and full sexual maturity. Development still proceeds as the treetop shoots become horizontal or pendant. The spacing between branch forks decreases.

In an adult tree, the root system can be divided into a central and a peripheral part (Köstler et al. 1968; Atger and Edelin 1994). The central root system is at the base of the tree and extends away for two or three meters. It consists of the taproot (absent in some species), one or two layers of main roots, and several vertical laterals. The superficial horizontal roots are eccentric at the base where they join the trunk, and they taper rapidly to become cylindrical at about a meter from the tree. Other woody roots, horizontal or oblique, arise from the taproot below the topmost large framework roots. These are rarely as large in diameter, as eccentric, or as long as the ones above. The taproot is not a prominent feature of the adult root system, and generally is eclipsed by woody laterals that descend vertically and penetrate the soil as deeply as the taproot at an average depth of 1.5 m. In fact, this depth depends on the level of the water table and the mechanic resistance of the soil. Between the large diameter woody roots, there are a lot of rope-like, woody roots covered by thin non-woody roots. In many species, root grafts are common in the central root system where roots are close together and where they cross each other. There is also grafting between roots of neighboring trees of the same species.

The peripheral root system extends from the central root system outward for several meters and can exceed the crown projection many-fold. This system is mainly composed of superficial horizontal woody roots from which emerge non-woody roots growing upward into the forest floor.

The Senescent Tree (Fig. 15.1, 4 and 5)

The non-pathological decline of certain structures and functions take place as trees senesce: the frequency of branching, the length of new branches, and radial stem growth decrease, the branching architecture becomes disorganized, and the number of new shoots is reduced. Also reduced is the capacity for photosynthesis, the production of roots and fruit, and resistance to pathogens. These symptoms of aging appear first in the lower branches before a gradual invasion of all the axes.

The senescent stage is marked by death and gradual dislocation of the crown. The limbs progressively break heralding the death and the fall of the tree (Fig. 15.1, 4 and 5). Neither pruning nor cutting back can reverse this fatal evolution. The damage caused by the hurricane in Europe in 1999 showed this very well: if young trees were generally able to regenerate the parts lacking from their crown, the shoots that appeared on the old subjects were on the other hand few and remained small in size. Cutting back senescent trees no longer had any effect: sprouts from the stump showed a structure very similar to the ultimate axes of the old crown; they straight-away appear old. On a young tree, it is sufficient to remove experimentally the terminal bud of an axis to enable subjacent buds to push out from their state of latency. On a senescent tree this same operation gives no result because latency seems to be self-maintained even within the buds. Only *in vitro* culture of the isolated meristem can reveal the embryonic nature of buds and give rise in this way to a new individual.

15.3 Assessment of Tree Vitality

Numerous methods are used in Europe to diagnose the vitality of urban trees. These include mineral analysis of foliage, electrical resistance measurements of the vascular cambium, chlorophyll fluorescence measurements, infrared color photography, and computer tomography. However, most of these methods are experimental and not widely used. Consequently, visual assessments are essential. Two complementary types of visual indicators have recently been described:

- Vitality Indicators in the Treetop Shoots
  While regular surveys should be undertaken throughout the year, the best time to inspect and assess the health of trees is in the late summer when the external signs of disease are most visible. Trees should be inspected very carefully and systematically. Each tree that is being assessed should be numbered and have its location and condition noted on a tree report form. This will provide valuable data for subsequent re-inspections. Symptoms are the external or internal reaction of a plant to adverse biotic or abiotic factor. Symptoms can be apparent in the foliage such as premature leaf fall, discolored leaves, abnormally small leaves, leaf spots, leaf blotch, dieback, wilt, and miscellaneous. This should contrast sharply with adjacent healthy tree crowns displaying dense and vigorous green foliage.

  Distribution of symptoms on leaves and shoots is a factor in determining if the problem is disease related. In particular, the tree top shoots are good vitality indicators (Roloff 2001). Healthy, undamaged trees produce long axial and lateral shoots. Healthy crowns are evenly closed and without gaps. Weakened, declining trees have uneven crowns with mixtures of short and long shoots, some of which extend beyond the bulk of the reduced crown. The crown can take on a clawed, fastigiated, or whip-like appearance due to crown openings (Roloff 2001).

- Vitality Indicators from the Epicormic Shoots
  The epicormic shoots are also good vitality indicators. Epicormic shoots indicate environmental stress. These shoots arise from latent buds or meristematic points along the lower trunk, large branches, and pruning wounds (Edelin 1999). They are often associated with decreased vitality of canopy shoots (Fig. 15.1, 2'). The initiation and persistence of epicormic sprouting depends on the origin of the stress, the development stage of the whole tree and the species (some species such as several species of *Pinus* do not produce sprouts).

  When the stress is weak and transient, the topmost epicormic shoots can rebuild the damaged crown at the same height or at a lower level (Fig. 15.1, 3'). Such a tree can survive and grow until normal senescence (Fig. 15.1, 4' and 15.1, 5').

  In heavily damaged trees, only basal epicormic shoots persist. These sprouts may produce their own roots and become new, independent trees. In extreme cases, none of the epicormic shoots persist and the tree dies (Fig. 15.1, 2").

15.4 Assessment of Hazard Trees

Visual assessment can give an idea of the state of a tree's overall health, but may not predict the extent of an internal decay accurately. External signs of decay may be misleading, or trees may show no signs of internal defects.

Essentially all trees have some potential to fail. Consequently, trees cannot be strictly categorized as being hazardous or nonhazardous. Millions of trees in public and private landscapes are mature and many are declining. Trees become structurally unsound due to weak architecture, decay, cankers, cracks, and root loss. Strong winds, snow, and ice can place excessive loads on trees that cause breakage. Complete tree safety cannot be attained without removing most trees. A tree is considered to be hazardous if it is structurally unsound and there is a possible target, like vehicles or people. An unsound tree in an area with no target is not hazardous.

The evaluation of hazard tree is the systematic process of assessing the potential of a tree or one of its parts to fail. The most likely failure event combines structural defects with severe weather such as high winds or the accumulation of snow or ice. The extent of hazard depends on the type, size, and location of the defect as well as on the tree species, size, and age, site characteristics, wind patterns, and the target. The examination of the entire tree structure for defects begins with an examination of branches, limbs, stem, stem base and root crown.

Hazard tree assessment must occur on a regular basis, because site character and tree development may change over time. Ideally, the evaluation cycle or inspection interval should be every one to two years. Mature trees in urban areas may need to be evaluated twice a year. Additional inspection should be made following heavy rain, snow, ice, or wind storms.

The evaluator must understand the goals, techniques, and limitations of the hazard evaluation process. The human eye is the most important instrument for diagnosis. Most defects can be detected visually, for example, dead branches (Fig. 15.2), cracks (Fig. 15.3), hazard beams (Fig. 15.4), or fruit bodies of wood destroying fungi (Fig. 15.5). Also the knowledge of tree vigor and the type of fungus can be important. But in some cases there is a need for special tools to confirm or to find the existence of defects, especially decay

Fig. 15.2. Dieback of the upper crown of an old oak leads to dead branches (*photo:* Institute for Arboriculture)

and internal cavities. In the last 25 years many tools with different operating principles have been developed. Detection strategies include the resistance to physical penetration, the conductivity of sound waves, and the electrical resistance in wood. Nearly 20 different tools are available. Extensive scientific work in recent years has led to the development of guidelines for practical assessment of tree hazards (Matheny and Clark 1994; Mattheck and Breloer 1994; Wessolly and Erb 1998; Dujesiefken et al. 1999).

The evaluator must be competent in the assessment of all components of the hazard rating, he or she has to understand tree structure and the decay process, and must be familiar with the equipment to be used. Subsequently, some helpful tools for the detection of internal defects and decay in trees are listed below.

Sounding with a Mallet

The tree is struck with a mallet. The resulting tone changes in pitch in response to tree cavities, loose bark, or advanced decay. This method is non-invasive and can usually only detect advanced decay.

Increment Boring

The increment borer is a threaded tube equipped with a cutting tip that is capable of extracting a core of wood from the stem or branch. The core is visually examined for features of discoloration and decay. Also, a core can be cultured for decay fungi if collected aseptically. The detection is limited primarily to intermediate and advanced decay, unless the core is cultured. It is physically difficult to extract a core from some species.

Fig. 15.3.
Cracks in stems are important symptoms for the evaluation of hazard trees (*photo:* Institute for Arboriculture)

Additionally the core can be tested with a Fractometer. It measures the radial bending strength and fracture angle on an increment core. The meter requires a previous established measurement range for non-defective trees. Data obtained can be highly variable in some cases. One problem is the tendency for the core to snap along barrier zones that are present in otherwise sound wood.

The wound created by coring can allow spread of decay if the reaction zone between decay and healthy wood is penetrated. One problem is the tendency for the core to snap along barrier zones that are present in otherwise sound wood. The extension of the discoloration depends on the ability of the wounded tree to compartmentalize, which is influenced for example, by the tree species and time of wounding.

Drilling

To examine the extension of defects (e.g., wounds, cracks) a battery-operated drill with a 3 mm bit is used, a hole is drilled into the defect, for example a wound or crack. The operator notes of differences in resistance to drill torque and the color, odor, and tex-

Fig. 15.4. Typical hazard beam on a maple tree (*photo:* Institute for Arboriculture)

Fig. 15.5.
One of the common wood destroying fungi on old wounded trees: scaly polypore (*Polyporus squamosus*) (*photo:* Institute for Arboriculture)

ture of the wood particles in different depth of the defect. The evaluation is qualitative and relies in large part on the experience and expertise of the operator. It is limited primarily to advanced stages of decay.

There is possibility for spread of decay if the reaction zone between decay and healthy wood is penetrated. The size of the hole is small, however, and drilling is less invasive than using an increment borer.

Drill Resistance Instruments

The evaluation of sound wood and the amount of decayed wood in the centre of the stem can be done with drill resistance instruments. These instruments (e.g., Resistograph, IML-Resi, Teredo) consist of a needle with a diameter of 1–3 mm which is driven through the wood. The resistance to penetration as the needle rotates and progresses through the wood is recorded on a graph.

There is possibility for spread of decay if the reaction zone between decay and healthy wood is penetrated. The size of the hole is small, however, and also less invasive than an increment core. Evaluation of decay requires interpretation of the graph created. This method is limited primarily to advanced and intermediate stages of decay.

Acoustic Measurement Devices

These instruments (e.g., Metrigard Stress Waver Timer, Sound Impulse Hammer, Picus) measure the time required for a sound wave to travel from one side of the trunk to the opposite side. If a defect is present, transmission of the sound takes longer than if that portion of the tree is free of defects.

The technique requires the insertion of screws or nails through the bark into the sapwood. The presence of defects can be detected, but the type of defect cannot be distinguished (decay, cracks, cavities), nor the severity of strength loss. Some decay fungi cannot be detected, such as *Ustulina*. This technique requires comparison with measured radial sound velocity of defect-free trees.

Electrical Resistance

Tools such as the Shigometer, Conditiometer or Vitamat measure the changes in electrical resistance of wood caused by release of ions as fungi decay the wood. The testing requires drilling a bore hole, which is similar in invasiveness to drilling.

Considerable experience is required to interpret the patterns of resistance changes for individual species. This tool can detect early and incipient stages of decay in some species.

Pulling Tests

With this method (Elasto- and Inclinomethod) the wind load is simulated via a steel cable and winch connected to a dynamometer (stress gauge). The exerted stress causes compression and extension in the trunk. These length alterations are measured. Furthermore at the root flare the trunk inclination under the given load is recorded.

X-Ray

Electromagnetic radiation waves are passed through the tree to create a 'tomograph' of the internal condition. It is completely non-invasive to the tree, but there is risk to operators from radiation.

The procedure requires large equipment, is very expensive, and requires safety training to protect operators from radiation.

15.5 Compartmentalisation in Trees

Throughout their life span, trees are wounded due to abiotic and biotic factors (storm breakage, insects, birds, etc.) and activity of man (vandalism, car accidence, building operations, pruning, etc.). Wounding is a first stage in a series of complex events that can lead to wood discoloration and decay (Shigo 1984, 1986a,b). The damage to the tree depends, among others, on its active and passive defense mechanisms (Blanchette and Biggs 1992). Defensive function has been variously attributed to adverse micro-environmental factors, accumulation of phytoalexin-like antimicrobial compounds, cell wall alterations (suberisation) and deposition of insoluble polyphenolic compounds (Bauch and Baas 1984; Blanchette and Biggs 1992; Liese and Dujesiefken 1996; Pearce 1996). Such defensive elements had been assumed many years previously, but have received only limited attention until formulation of the compartmentalization concept proposed by Shigo and coworkers (Shigo and Marx 1977; see also: Shigo 1986a,b and 1991; and literature cited). This concept suggests that sapwood actively responds to injury and/or colonization by formation of boundaries, which tend to limit the affected tissue at a minimal volume.

15.5.1 Codit Model

For the explanation of the compartmentalization process, a model named CODIT was developed (Shigo and Marx 1977). CODIT is an acronym for *Compartmentalization Of Decay In Trees*. The CODIT system is a spatial model, which tries to explain the patterns of discoloration and decay developing in living trees. It is based on geometric orientation of existing and newly formed structural and chemical boundaries (Shortle et al. 1996). In the CODIT model, these boundaries, also called reaction zones, are referred to as walls that enclose any lesion or incipient lesion within a defined compartment. They are essentially static barriers preventing the further spread of decay. The terms 'marginal zone' and 'column boundary layer' have been used to describe the three-dimensional character of the reaction in the wounded wood (Shortle et al. 1996). Occasionally the boundaries are breached due to additional mechanical injury or the action of pathogens. New boundaries will form in living sapwood at increasing distances from the initial wound (Pearce 1991; Schwarze and Fink 1997).

The CODIT model has two parts. Part one occurs in wood extant at the time of wounding and part two occurs in wood formed after wounding (Shigo 1986a,b, 1991). Part one consists of Walls 1–3. Wall 1 act as a boundary to the axial spread of decays (Fig. 15.6). It is resulting from vessel-plugging responses (gums and tyloses) in the conductive tissues. Wall 1 is the weakest of the compartmentalization walls. Wall 2 resists the radial spread inwards from the wound. It is considered as a physical barrier represented by dense latewood layers within the growth rings. Therefore, Wall 2 is continuous from the top to the bottom of the tree. Wall 3 is a vital component, resisting the lateral (tangential) spread (see Fig. 15.6). Its relative strength has been attributed to the activity of ray parenchyma cells. Wall 3 is discontinuous in longitudinal and radial directions. In addition to Walls 1–3, the terms 'reaction zone', 'marginal zone' and 'col-

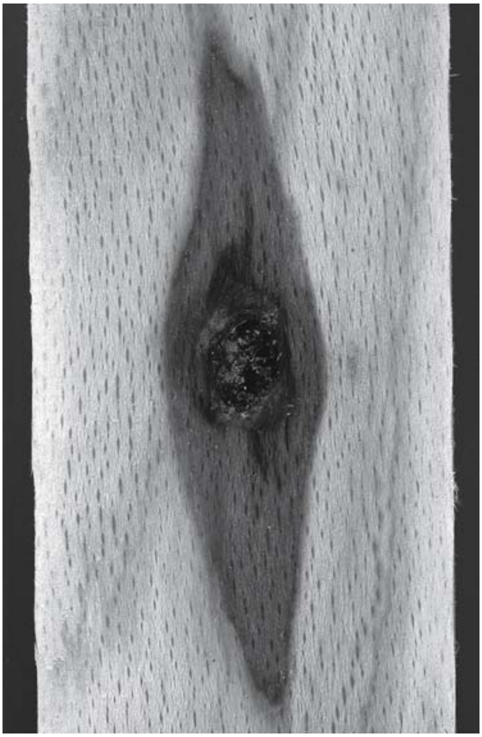

Fig. 15.6.
The elongated form of the discolored wood is due to the relative weakness of the compartmentalization wall 1. *Fagus* after boring (*photo:* Institute for Arboriculture)

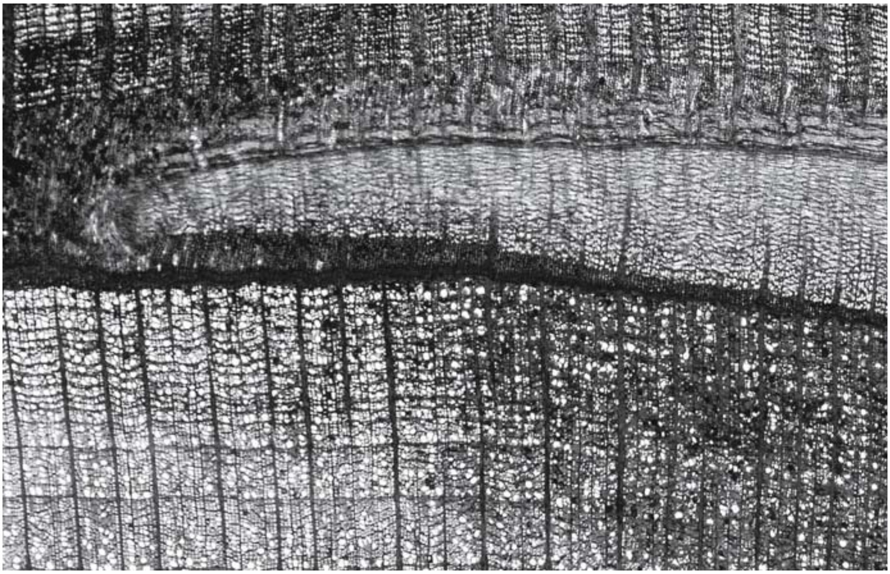

Fig. 15.7. Early stage of callus growth and the formation of a barrier zone (*photo:* Institute for Arboriculture)

umn boundary layer' are also in use to describe the dynamic and three dimensional character of the response in the wounded wood (Shortle et al. 1996).

Part two of the CODIT model is Wall 4, also called the 'barrier zone' (Shigo 1984). It is the strongest and most durable of the compartmentalization walls, comprising cells laid down by the surviving vascular cambium (Fig. 15.7). It differs from Walls 1–3 in that it is located in the plane of the cambium at the time of wounding. It forms a structurally homogeneous barrier separating the wood formed before wounding from the wood formed after wounding. Functionally, it is the most important barrier, preventing the spread of infection from the wood extant at the time of wounding into the wood formed after wounding. Wall 4 is therefore protecting the youngest wood and the cambium, both of which are vital to the continuing growth and survival of the tree. The extent of wall 4 depends on size, type and position of wound. Wall 4 in angiosperms is usually characterized by large amounts of parenchyma, fewer vessels and fibers, suberised cell walls, and cell lumina filled with pigmented components. In conifers, Wall 4 is usually marked by traumatic resin ducts.

15.5.2 The Expansion of the CODIT Model

The compartmentalization process postulated the active response of tree tissues to invading microorganisms. In addition to the proposed defensive nature of the compartmentalization, Liese and Dujesiefken (1996) revealed also the protective nature of this process. They suggested that in the first stage of response to wounding, tree starts to protect the conducting tissue with, for example pit closure, formation of tyloses and gums, resinosis against invading air. It was concluded that dehydration triggers compartmentalization. The structures created due to injury by physiological and biochemical processes act as protective structures, first towards invading air and in a later stage towards decay. The authors proposed expansion of the CODIT model in a way where the D does not stand for Decay, but for Damage. Damage also includes dysfunction and desiccation. The invasion of the discolored tissue by decay-causing fungi is the last stage in this process.

15.6 Pruning and Wound Treatment

Tree care is a young discipline compared to forestry and horticulture. In the early days, work at trees in urban areas was called 'tree surgery'. Many of the practices have changed over the years, e.g. the way of pruning and the treatment of wounds (Höster 1993; Balder et al. 1997; Harris et al. 1999). New knowledge about the compartmentalization in trees has changed ways of thinking about trees and arboricultural practice.

15.6.1 Pruning

The most commonly practiced procedure by arborists is pruning. Branches and stems are pruned for aesthetics, safety, and clearance from structures and utility lines, wound treatment and tree crown stabilization. For this work knowledge about tree biology, wound reactions and decay is needed. While extensive studies on the pruning of conifers have been available for a long time (e.g., Mayer-Wegelin 1952), detailed research on pruning of deciduous trees was carried out in the last thirty years. Today several good pruning guides for trees and shrubs exists (e.g., Shigo 1989; Dujesiefken 1991; Malins 1997; Drénou 1999; Pfisterer 1999; Gilman 2002) and national or international rules and regulation to this theme are available (International Society of Arboriculture 1995; European Arboricultural Council 1999; ZTV-Baumpflege 2001). Subsequently a summary of proper pruning cuts according to the attachment of branches to the stem is given. It is based on the Hamburg Tree Pruning System (Dujesiefken and Stobbe 2002) and is applicable independently of tree species and site, cause and aim of the pruning.

Branches with or without Branch Collar (Fig. 15.8 and 15.9)

Many branches, especially in the upper crown, do not have a branch collar and sometimes additionally have included bark inside the fork. If a branch without a collar is pruned with a slanted angle to the stem, the cambium at the lower margin will die back several centimeters. Therefore the wound size will increase, and at the lower margin of the wound a little dead stub will develop. The wound wood will grow only partially over the cut surface, so that the wound closure will slow down.

Branches with branch collars normally form a funnel-shaped reaction zone in the area of the swelling. The wound wood develops on the outer margin of the branch collar where the reaction zone contacts the cambium. In branches without a branch collar the shape of the reaction zone is different. Instead of a funnel-shaped an S-shaped reaction zone develops. On the upper side of the branch the reaction zone is formed near the branch bark ridge, like in branch stubs with a branch collar, but on the lower side the reaction is closer to the stem.

The points where the reaction zones contacts the cambium on the upper and on the lower side of the branch bases show the location for the pruning cuts: branches with collar should be removed outside the swelling at the base of the branch (mostly in a slanted angle to the stem; Fig. 15.8), and branches without collar should be re-

Fig. 15.8.
The branch collar must remain at the stem, because it belong to the stem tissue. The cut must be outside the branch bark ridge slanting downwards in accordance of the shape of the branch collar (*illustration:* G. Kleist)

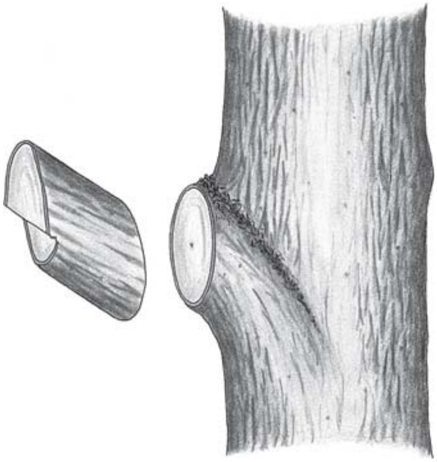

Fig. 15.9.
Branches without a branch collar must be pruned outside the branch bark ridge and the cut must be straight to avoid cambial dieback (*illustration:* G. Kleist)

Fig. 15.10.
Branches with included bark must be pruned outside the branch bark ridge and the cut must be straight. Despite proper pruning it is possible that there is no cambial growth on top of the wound. Because of the included bark the cambium in this direction is poorly supplied with assimilates (*illustration:* G. Kleist)

moved also outside the branch bark ridge, but with a more parallel cut to the stem to avoid the formation of a dead stub at the lower margin of the wound (Fig. 15.9). This cut is not a flush cut, because the branch bark ridge remains at the stem, and the cut is more outside the stem. The wound is a lot smaller than the flush cut and oval shaped. The cambium at the wound edges are supplied with assimilates; therefore the tree can wall off the wound directly from the wound edges. With this cut the smallest possible wound and the best closure are possible.

Dead Branches (Fig. 15.10)

Dead branches usually have a swelling of living tissue at the base. This tissue is formed by the joining stem rather than by the branch, which is invaded by various wood destroying fungi. Close to the stem, wood decay in the dead branch is particularly severe and creates a breaking point. In this case, decay usually does not penetrate the reaction zone in the xylem of the stem, when the dead branch is shed. Shedding of dead branches is termed 'natural pruning' in forestry practice. After snapping, the generally funnel-shaped discoloration in the swelling or collar is colonized by fungi. Just as branch collars should not be cut when pruning live branches, neither should swollen areas of living tissue at the bases of dead branches be removed. Applying wound dressing to the cut surface of dead branches is unnecessary and may even by detrimental to tree health in cases where wet wood is not allowed to dry out. Insufficient compartmentalization in the stem is usually observed in thick dead branches and in less vigorous trees. In these cases neither a visible branch collar nor a swelling at the base can be found, the cut should be made as at branches without a branch collar. Such cut wounds always require surveillance.

Branches with Included Bark (Fig. 15.11)

Included bark occurs nearly in every tree species, but very often in beech, cherry, and lime. It develops frequently in V-shaped forks and between codominant stems. Included bark means inner and outer bark that forms between the branch and the trunk. The vascular cambium turns inward within the branch bark crotch. The branch bark ridge turns also inward and forms a lip-like rib or ridge. Branches or stems with included bark in the crotch are poorly attached to the tree and these branches normally have no visible collar. They should be removed from the tree in an early stage, e.g., in the nursery or by formative pruning on the young tree. On mature trees, in order to prevent the breaking-off of branches with included bark, especially when there is a split in the fork, the reduction of the crown or the installation of so-called crown anchorages or cables are necessary.

When branches with included bark should be removed, they must be pruned outside the lip-like rib. This is no flush cut, but the cut must be straight parallel to the stem to avoid cambial dieback at the lower margin of the wound. The observation of older cuts showed that in spite of proper pruning on top of the wound no wound wood was developed.

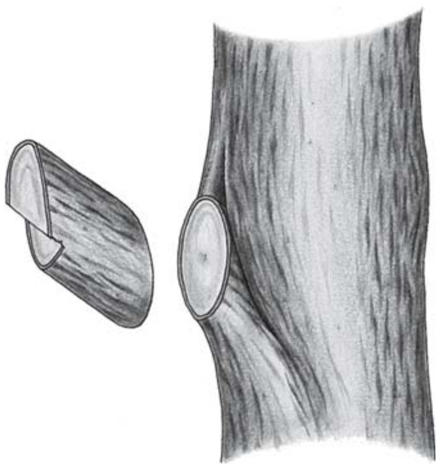

Fig. 15.11.
Pruning of dead branches: the distinctive swelling at the base of the branch must remain at the stem. The decayed wood on the cutting surface should not be treated with a wound dressing (*illustration:* G. Kleist)

Codominant Stems or Lateral Branches (Reduction Cut) (Fig. 15.12 and 15.13)

Codominant stems also occur in every tree species, but very often in e.g., ash, elm, lime and maple in the open landscape unless pruned. The development of co-dominant stems should be avoided by removing one stem in an early stage in the nursery or during formative pruning on the young tree. If the diameter of codominant stems gets over 5 or 10 cm in diameter, according to the tree species, at least one codominant stem should be shortened, rather than cut off completely. This reduction slows the growth rate of the cut stem, which helps to develop the codominant stem into a branch. Additionally, the pruning wound and the resulting discolouration and decay is far away from the fork of the codominant stems so that the reduction cut does not weaken the stem attachment. When removing codominant stems or by reducing lateral branches the cut must be made close to the remaining stem outside the branch bark ridge.

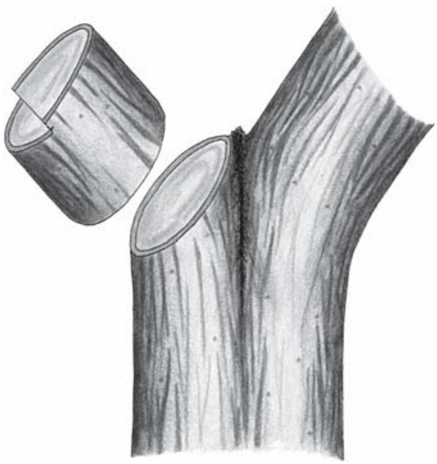

Fig. 15.12.
Codominant stems with more than 5 or 10 cm in diameter should only be partially rather than removed completely. If removal is unavoidable the cut must be made outside the branch bark ridge. Often the cambium at the lower side of the wound dies back several centimeters, because it can not be supplied with assimilates (*illustration:* G. Kleist)

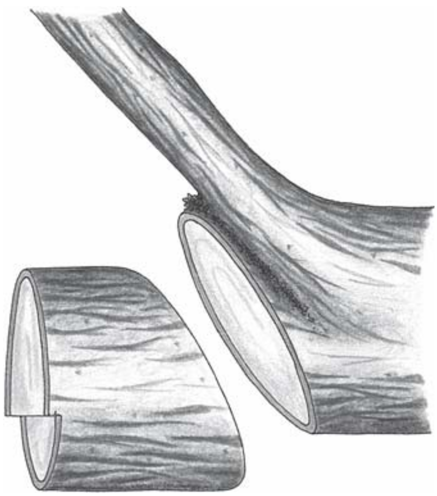

Fig. 15.13.
For pruning to a lateral branch (reduction cut) the cut must be made close to the remaining branch and opposite the branch bark ridge (*illustration:* G. Kleist)

Topping and Pollarding

Topping removes most or the entire crown by cutting off big branches or even stems. Topping leads to a physiological unbalance between crown and root system, and initiates widespread decay in the roots and in the cut stem (Fig. 15.14). Accordingly, topping leads to weak structure and a potential hazardous tree, and can shorten the life of a tree. Topping is not considered to be an appropriate pruning method.

Pollarding is a specialized training technique used to maintain trees at a desired height. Pollarding begins, when trees are young, and one to three years old branches, no more than 3 cm in diameter, are headed. All shoots have to be removed every one to three years back to the same position on the tree, and never below the original cut, where a so-called pollard head develops (Fig. 15.15). Pollarding does not initiate trunk decay and trees maintain a healthy structure; and pollarded trees can become very old.

Fig. 15.14.
Topping lead to extensive decay in the cut stem (*photo:* Institute for Arboriculture)

Fig. 15.15.
Development of pollard heads when all shots are removed every one to three years (*photo:* Institute for Arboriculture)

Differences between Tree Species in Wound Response

Even proper pruning can lead to extensive discoloration and decay inside the trunk. Essential parameters are the diameter of the branch and the ability of a tree to compartmentalize wounds. In general there are two groups of different compartmentalizing trees, although inside a genus there can be numerous structural and physiological differences (Dujesiefken 1991). Weakly compartmentalizing species include those of the genera *Aesculus*, *Betula*, *Malus*, *Populus*, *Prunus*, and *Salix*. Species which are effective at compartmentalising include those of the genera *Carpinus*, *Fagus*, *Quercus*, and *Tilia*.

The Maximum Wound Size That Will Be Effectively Compartmentalized

Different tree species have shown an exponential increase of discoloration and decay with increasing branch diameter (Dujesiefken and Stobbe 2002). This relation becomes more evident with increased age of the wound. Invading microorganisms are able to penetrate trees reaction zones and lead to bigger discoloration and decay after several years (Pearce 1991; Schwarze and Fink 1997). Long-term investigations of pruning wounds clearly demonstrated an increase of discoloration and decay in the wood, probably influenced by microorganisms with increasing wound diameter. Small pruning wounds, up to 5–10 cm in diameter, are usually compartmentalized effectively, within the ability of tree species. Microorganisms will degrade the discolored wood, but the reaction zone formed by the tree around the discoloration may resist the fungal attack. Bigger pruning cuts also injure older wood tissue that have a decreased ability to wall off invading microorganisms over a long period. Wood destroying fungi can penetrate the boundaries and the tree has to react with formation of a new boundary (wall) inside the initially healthy tissue. The discolored and decayed area behind the pruning wound increases.

Regardless of the time of year and the tree species, radical crown pruning, e.g., a drastic removal of crown parts or whole crowns, should not be a common practice. Branches greater than 5 cm in diameter of weak compartmentalizing trees, such as ash, birch, horse chestnut and poplar, and greater than 10 cm in strong compartmentalizing trees (e.g., beech, hornbeam, lime and oak) should only be partially reduced rather than removed completely. The same applies for multiple stems. In some cases, an installation of a crown securing system can render a hazard tree safe without any need of pruning. Crown pruning is best carried out at an early stage and in accordance to the guidelines given.

15.6.2 Wound Treatment

Wound dressings do not substitute the bark and do not prevent wound-initiated discoloration and decay (Shigo and Shortle 1983). But the application of wound dressing can promote the wound reactions of the tree. Wound dressings can reduce the cambial dieback at the wound margin especially in winter and when used for ring-porous tree species (Dujesiefken 1995). Accordingly, callus growth and wound closure can be stimulated slightly, as well as the compartmentalization inside the living sapwood. Wound dressings can stimulate fungal activity when applied after the pruning of dead branches and should not be used in those cases.

Fresh wounds caused by traffic accidents can be treated with opaque plastic wraps. If fresh wounds are wrapped a surface callus can be developed. In the woody tissue beneath the surface callus, neither discoloration nor decay occur (Stobbe et al. 2002a,b). The efficacy of this treatment strongly depends on the time elapsed between wound treatment and injury. Treatments more than two weeks after the accident are without success.

15.6.3 Tree Crown Stabilization

Breaking-off of crown parts and big branches is a frequent failure of urban trees. This may cause substantial damage to objects and persons, and subsequently the trees concerned are often damaged irreversibly. The reasons for failure is that the force, e.g., weight and wind, on the branch exceeds the strength of the wood. Wood strength is strongly influenced by weaknesses such as included bark between stem and branch, split forks, fractures in branches (hazard beams) and decay in branches.

The breaking-off of parts of trees can be prevented by various methods. Instead of severely reducing the crown, so-called crown anchorages or cables have been used for many years, whereby the tree's sections which are to be protected are connected with steel cables anchored with rods or bolts in the branch or trunk (Shigo and Felix 1980). The drill hole made to anchor the cable is a wound, but normally does not predispose the crown architecture to further failures of the system. Other equipment has been developed to secure crown elements without the need to injure the stem or branches to provide anchorage for support. An installation of hollow ropes and/or belts without any boring into branches or stems is possible (Lesnino et al. 2000; Stobbe et al. 2000). These systems were developed and tested in the last 15 years, mainly in Germany.

15.7 Conclusion and Perspectives

Arboricultural practices made a great evolution since the last twenty years in Europe. The most commonly used tree care operation remain pruning, although, hardly can be found any other practice being so harmful to a tree when done in a wrong way. Diverse pruning techniques are applied throughout the Europe. Several technical guidelines (e.g., European Arboricultural Council 1999; ZTV-Baumpflege 2001) established on extensive research synchronize this procedure in countries with longer arboricultural tradition. In others, pruning relays on traditional approach, personal experience and sense for a living being called tree. Indeed, approved destructive techniques like topping, flush cutting and stubbing are still practiced and huskily argued. With increasing pruning pressure, the percentage of the crown composed of suckers becomes higher, indicating a greater disorganization of the crown architecture. Such approach is affecting aesthetics, only apparently and temporarily enhancing vitality but actually generating hazardous problems and diminishing the value of the tree, irrespective of the growing stages of the specific tree species. Improper pruning, building of city infrastructure, vandalism, dishonesty or specific growth defects are the main cause of potential damage to the tree and target. More than 20 different tools are available for evaluation of hazard trees, being relatively simple when using and extremely complicated when interpreting the results. Deep knowledge on tree biology and applied method is needed when assessing trees for safety as well as for targeted tree care practice. This appears to remain so, even if trees with better genetic potential for survival in harsh urban conditions will be ever created and planted in our cities.

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Part IV

Part V Future Perspectives

Chapter 16

Research on Urban Forests and Trees in Europe

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16.1 Introduction

Urban forestry is an emerging and still developing subject field, not only in North America where it is believed to have its roots (see Chap. 1), but also in Europe. The concept of urban forestry as encompassing the planning, design, establishment and management of trees and forest stands with amenity value situated in or near urban areas, has become more widely accepted (Randrup and Nilsson 1998). This notion is in line with many North American urban forestry approaches (e.g., Miller 1997; Helms 1998).

Urban forestry is a new research field. Traditionally, studies on urban forests, including woodland, parks and trees seem to concern applied, small-scale research at the local (municipal) level (e.g., Hodge 1991; Konijnendijk 1999). This local focus for research, coupled with – until recently – a lack of suitable networks and institutions to facilitate coordination, means there is a high risk of duplication of effort. Now, when there is a mutual exchange of experiences and findings and subsequent joint efforts are undertaken, the efficiency and effectiveness of urban forestry research is expected to be improved. A second motive for improving urban forestry coordination in Europe results from the multidisciplinary character of the new research field. It involves a range of disciplines including horticulture, landscape architecture, urban planning, landscape ecology, social sciences, and forestry. The different perspectives and approaches can be an asset, as long as they are carefully coordinated under the common denominator of urban forestry.

16.2 Coordination Efforts

During the past few years, some multiple-country research overviews have been compiled in Europe, such as for the Nordic and Baltic countries (Randrup and Nilsson 1996; Sander and Randrup 1998), but these overviews were often more 'anecdotal' than comprehensive. In other cases, overviews touched upon specific urban forestry research topics or sites only. An example of this is the overview of studies on the perceptions and attitudes of people in Germany, Austria and Switzerland towards forests, with an important focus on urban forests (Schmithüsen et al. 1997). Another study provided an overview of urban forestry planning and management in Great Britain and Ireland (Johnston 1997; Johnston and Rushton 1999). Konijnendijk (1999) presented a brief overview of recent and ongoing research related to urban woodlands. This study acknowledged the fragmentation of research, the lack of international exchange of information and experiences, and the lack of research in specific areas, such as the monetary valuation of urban forest benefits.

Better coordination has sometimes been achieved at the national level. An example of this is the overview of arboricultural research carried out in the United Kingdom (Bradshaw et al. 1988; Hodge 1991; Webster et al. 1997); although again, a conclusion to be drawn from this overview is that research on urban trees in the United Kingdom has been fragmented and inadequately coordinated. In France, examples of recent activities at the interface of science and practice related to urban trees were compiled and published in 1989 (Revue forestière française 1989), while the annual arboricultural reviews in Germany have also focused on the link between science and practice (e.g., Dujesiefken and Kockerbeck 2002). Other national coordination initiatives worth mentioning are the urban forestry research conferences which have taken place in the United Kingdom every five years since 1980 (Chambers and Sangster 1993; Davies et al. 1999) and in Ireland since 1994 (Collins 1996).

However, during the past few years, a number of coordinated research and development initiatives on urban forestry have been taken within Europe. A 'European Forum on Urban Forestry' was established in June 1998 with the ambition of bringing researchers and practitioners of municipal forest and park administrations together (Krott and Nilsson 1998). The first European research symposium focusing on urban greening was arranged in Copenhagen in 1999 (Randrup 1999), followed by an international symposium on plant health in urban horticulture in Braunschweig, Germany (Backhaus et al. 2000). Conferences were also held on forestry serving urbanized societies in Wageningen, Holland, in 2001, and in Copenhagen in 2002 (Konijnendijk and Hoyer 2002). One important reason behind this increased cooperation on a European level is the COST Programme.

The limited overview and coordination of research on urban forests and urban trees in Europe, particularly at the international level, was a major incentive for establishing COST Action E12 'Urban Forests and Trees' in 1997. COST stands for 'European Cooperation in the field of Science and Technology'. The COST-program aims at the stimulation and coordination of research via the establishment of networks, which are called COST Actions. There were about 160 of these Actions at the time of writing, their main focus ranging from telecommunications and medicine to forestry. The European Commission provides primary funding of the COST program, which is mainly used to finance meetings and seminars.

The overall goal of 'Urban Forests and Trees' was to improve the knowledge-base needed for the planning, design, establishment and management of urban forests and trees. In order to improve the working efficiency of the Action, it was subdivided into three working groups:

- Objectives and functions of urban forests and trees. The domain of this working group included the planning, design and assessment of urban forest benefits as well as aspects of policy.
- Establishment of trees in the urban environment, including identification and selection of species, provenances and cultivars for urban uses.
- Management of urban forests and urban trees. The domain of this working group included diagnosis of damaged trees, pruning, thinning and tree removal, as well as overall management methods, including computer-based inventory techniques and GIS.

For the first time, COST Action E12 launched several pan-European studies to collect information on the urban forest resources and their planning and management in larger European cities. These studies also collected information on: tree selection and establishment practice, the most important pests and diseases on common urban trees, as well as an overview of computer systems for urban forest and tree management and assessment. These pilot studies were a valuable first step towards integration of the scientific community, but they urgently need to be continued and extended to gather a comprehensive information base on the functions and challenges of urban forests and trees. Moreover, follow-up is needed to devise forward looking concepts for their sustainable planning and management.

16.3
State-of-the-Art

During 1998 and the first half of 1999, the national experts participating in COST E12 prepared state-of-the-art reports on research on urban forests and urban trees in their respective countries. These reports were standardized, edited and compiled into the report 'COST Action E12 – Research and Development in Urban Forestry in Europe', published by the European Commission in 1999 (Forrest et al. 1999). The book includes national reports from 20 countries; Austria, Belgium, Croatia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Lithuania, The Netherlands, Norway, the Slovak Republic, Slovenia, Spain, Sweden and the United Kingdom (Fig. 16.1). It is the first overview publication of research on urban forests and urban trees in Europe. With the publication of this book, one of the main objectives of COST Action E12 – i.e. providing an overview of recent and ongoing urban forestry research in Europe – was met.

Fig. 16.1.
Countries (dark shading) included in the state-of-the-art overview of urban forestry research in Europe

In all, 404 research projects dealing with urban forests and urban trees were specifically listed; some of these recently completed, some ongoing. Some of the main findings from the comparative analysis are presented below.

Who Is Carrying out the Research?

In Fig. 16.2, the research institutions involved in the 404 listed projects have been categorised according to their main institutional type. Universities and colleges are clearly dominating the urban forestry 'research arena' with involvement in 236 projects, with a significant role being played by state research institutes (129 projects). Private organisations, such as consultancy firms, take third place, while some municipalities also carry out their own research projects on urban forests and urban trees. Regional agencies, non-governmental organizations and 'foreign institutions', such as universities which are involved in research in a foreign country, all have a less important role in research within this field.

What Is the Main Institutional Expertise of the Research Organizations Involved?

The main disciplines of the research organizations involved in research on urban forests and urban trees is summarized in Fig. 16.3. The data are for the disciplinary background of the institute or department listed as 'research organization' in the country reports. Most of the research is carried out by forestry (188 projects) and horticultural (158 projects) research institutions. Planning sciences and (landscape) ecological institutions are both involved in less than ⅓ of the total number of projects that forestry institutions are. The other main disciplines involved are landscape architecture, nature conservation/biology and (plant) pathology.

What Are the Main Funding Sources for This Research?

Quite often, no information on the funding sources of relevant research is available or at least such information was not provided in the country reports. The disclosing of information on budgets, for example, may not have been regarded appropriate for strategic or commercial reasons. Source funding could be determined with certainty for less than 40% of all projects listed. Therefore, only a very tentative overview on the financing of research can be provided. It is clear however that state funding is involved in at least 50% of all relevant projects. Municipal funds cover another 25% of the projects, while private funding accounts for approximately 10% of the projects. Other funding sources include regional governments, non-governmental organizations, foreign institutions and the European Union. Although funding by the latter affects a small number of projects only, they do seem to attract a high level of funding. At least three projects with relevance for urban forestry have been financed by EU's 5th Framework Program:

1. Greenscom – Assessment of planning concepts and policy instruments for a sustainable development of the urban landscape (Greenscom 2004)
2. URGE – Development of urban green spaces to improve the quality of life in cities and urban regions (URGE 2004)

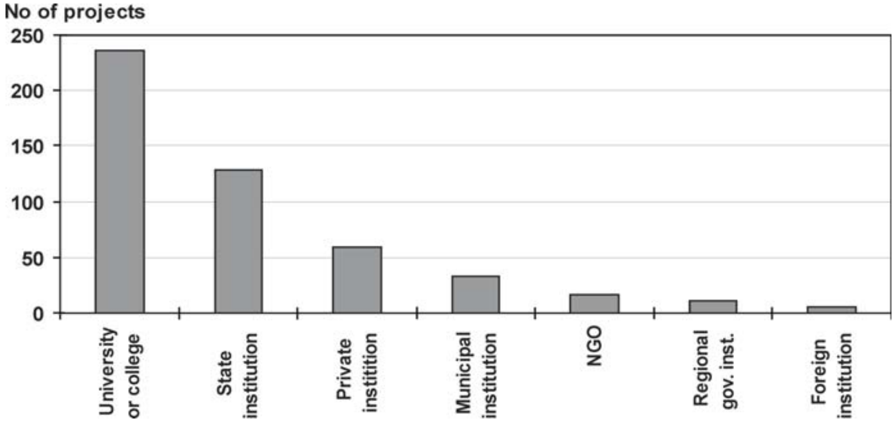

Fig. 16.2. Distribution by type of institutions for the 404 research projects on urban forests and urban trees in Europe listed in the state-of-the-art overview

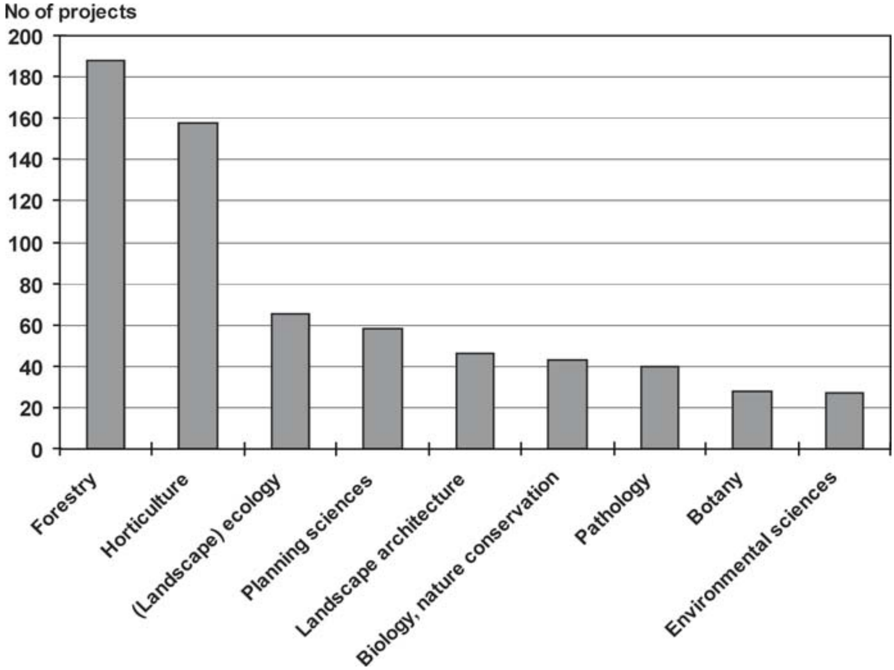

Fig. 16.3. Main disciplinary background of the institutes involved in research on urban forests and urban trees in Europe for the 404 research projects listed in the state-of-the-art overview (N.B. institutes can have more than one main disciplinary background)

3. NeighbourWoods – Advancing the quality of life and the environment of European cities through socially-inclusive planning, design and management of urban woodlands (Konijnendijk and Schipperijn 2004)

Which Urban Tree Locations Are Considered?

Woodlands, parks and street trees are given almost equal attention in terms of the number of research projects, as Fig. 16.4 indicates. Research projects looking at more than one location or even the entire urban forest are rather common.

Which Research Topics Are Studied?

The three main areas or categories of research encompassed by the three COST E12 Working Group topics are fairly evenly represented (see Fig. 16.5). The selection of plants and the study of their establishment in the urban environment is the most common type of research, followed by studies on objectives and functions, and the management of urban forests and urban trees. It has been found that some overlap in topics exists, for example between form, functions and benefits studies and management studies. Projects dealing with GIS and with inventories of trees and other vegetation, for example, could be ranked under both categories.

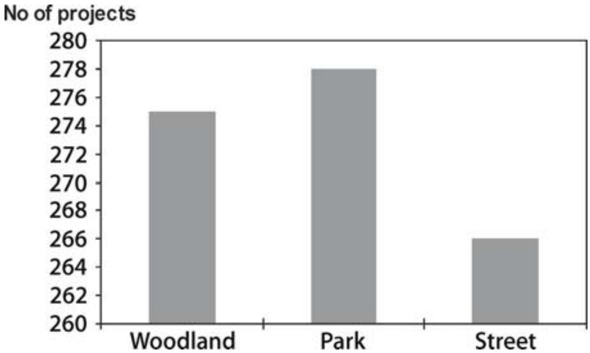

Fig. 16.4. Distribution of the urban forests and urban trees research projects listed in the European state-of-the-art overview according to focus on urban site. N.B. Projects may focus on more than one urban site and may deal with more than one category of research

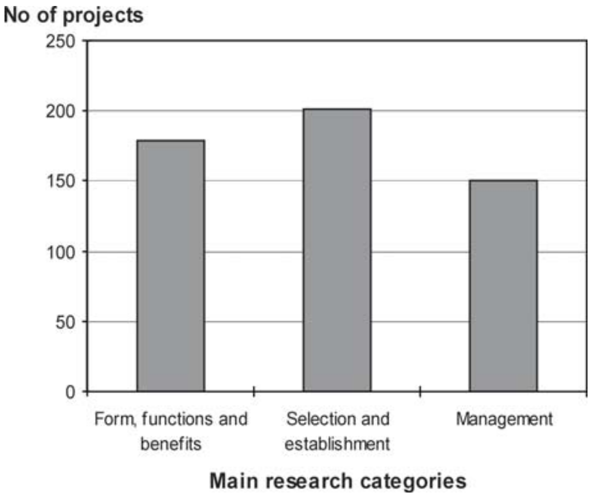

Fig. 16.5. Distribution of the urban forests and urban trees research projects listed in the European state-of-the-art overview according to main research category. N.B. Projects may focus on more than one urban site and may deal with more than one category of research

16.4
Research Topics

The authors categorized the research projects per working group theme, using key words appointed to the projects. This method is rather subjective and the grouping of projects might have been different if carried out by others. While accepting this, some conclusions can be drawn:

1. Projects within 'Objectives and Functions' (See Table 16.1):

The largest group of projects deals with urban forestry and green-structure planning, followed by various kinds of recreation studies (Fig. 16.6). The monitoring and typology of ecological values, as well as studies on benefits in general are also important categories. Quite a number of studies are dedicated to urban woodland and park design. A wide range of other types and topics are included, such as historical studies, policy analysis and the development of criteria and indicators for green area quality and public participation. Some studies have looked at psychological and health aspects of urban forests and trees, but these studies have been rare. Rarer still are projects that study the monetary valuation of the benefits of urban forests and trees.

Examples of research projects:

- Attitudes of citizens towards forest recreation and forest management (Austria, Denmark)

Table 16.1. Main types of projects within the theme 'Objectives and functions' of urban forests and urban trees. N.B. Projects have been assigned to the various categories by the authors, using abstracts and a list of key words

Project theme	Additional information	Number of projects
1. Urban forestry/urban greenstructure planning	These projects mainly deal with greenstructure planning or the planning of specific parks and woodlands	60
2. Recreation studies	Look at quantitative aspects, such as visitor numbers, divided over types of activities, as well as visitor perceptions and preferences towards landscape, forest and/or green areas	54
3. Typology and monitoring of ecological values	Involves the inventory of vegetation, including trees, as well as of 'special' natural values, e.g., for protection purposes.	45
4. Benefits and multiple use	Studies look at what kind of (multiple) benefits urban forests and trees have. Ten of the listed studies specifically look at determining the environmental values of urban forests and trees, such as air pollution reduction and climate modification	22
5. Design aspects	E.g., related to the design of new woodlands and parks	18

Fig. 16.6. Urban forest recreation, Amsterdamse Bos, The Netherlands (*photo:* K. Nilsson)

Fig. 16.7. Historical Garden, Villa Reale, Florence, Italy (*photo:* K. Nilsson)

- Monetary valuation of urban forest amenities (Finland)
- Psychological and psychosomatic effects of urban green areas (Netherlands, Sweden)
- Urban environmental indicators (Belgium)
- Communicating forests with people (Denmark)
- Use and abuse of urban woodlands (United Kingdom)
- Sustainable resource management in urban and adjacent rural areas (Denmark)
- Nature in cities (Germany, Norway)
- Design and management of historical gardens (Italy, Fig. 16.7)

2. Establishment and Selection (See Table 16.2):

The selection and testing of plant material for urban areas is the largest category within this theme, followed by establishment studies and research on growing medium, mixtures and soils. De-icing agents and roots and/or mycorrhizae are other main research topics. This research category also includes studies on specific topics, for example, rot and decay and specific pests and diseases.

Examples of research projects:

- Inventory of native forest genetic resources (Belgium)
- Selection of climate adapted trees (Norway)
- Selection of elm varieties resistant to the Dutch elm disease (France)
- Selection of new species for street trees (France)
- Eco-physiological evaluation of woody plants in urban conditions (Czech Republic)
- Effects of de-icing salts on trees and shrubs (Austria, Denmark)
- Establishment methods for harsh urban growing conditions (Denmark, Netherlands, see Fig. 16.8)
- Effects of nursery production methods and planting techniques (Italy, Fig. 16.9)
- Woodland establishment on derelict land (United Kingdom)

Table 16.2. Main types of projects within the theme 'Establishment and selection' of trees for urban uses. N.B. Projects have been assigned to the various categories by the authors, using abstracts and a list of key words

Project theme	Additional information	Number of projects
1. Selection and testing of plant material for urban areas	Studies on the tolerance of trees to diseases, the urban climate, pollutants, and so forth	60
2. Establishment of street trees and urban woodlands	Studies concerning the technical aspects of establishment, such as planting methods, protection and planting containers	48
3. Growing mediums, mixtures and soils		22
4. De-icing agents	Studies look at the effects of de-icing agents on vegetation as well as the projection of trees against damages	13
5. Roots and/or mycorrhizae		12

Fig. 16.8.
Root-friendly pavements, Copenhagen, Denmark (*photo:* K. Nilsson)

Fig. 16.9. Nursery production, Pistoia, Italy (*photo:* K. Nilsson)

3. Management (See Table 16.3):
Determining, preventing and managing biotic, abiotic and anthropogenic stress is the main focus of this research theme. General management and maintenance, and vitality and health assessment of trees are also of major importance. Other favored topics include management planning, and GIS, aerial photography and other management support tools. Also mentioned in the country reports were some specific studies on the restoration and transformation of urban green areas and studies aimed at improving management quality standards. Comparative studies on management styles, financial studies and research focusing on methods of closer-to-nature management have been rare. Very few studies focused on the care of individual trees, for example through pruning.

Examples of research projects:

- Management of urbanized, ancient woodland (Italy)
- New tools for urban woodland management planning (Ireland, Sweden, Fig. 16.10)
- Preservation and management of natural vegetation in urban areas (Sweden)
- GIS as a tool for management of urban trees (Austria)
- Effects of fragmentation and trampling (Finland)
- Wound response of trees (Slovenia)
- Pruning techniques (France, Germany)
- Health status of plane trees (Spain, Italy, Fig. 16.11)
- Interaction between external injuries and internal decay (Finland)

Table 16.3. Main types of projects within the theme 'Management' of urban forests and urban trees. N.B. Projects have been assigned to the various categories by the authors, using abstracts and a list of key words

Project theme	Additional information	Number of projects
1. Determining, preventing and managing biotic stress	Specific topics include how to deal with Dutch elm disease, cankers, moths, weeds	38
2. Determining, preventing and managing anthropogenic and abiotic stress	Anthropogenic stresses include trampling and wear by intensive use, while abiotic stresses relate, for example, to the climate (e.g., wind and temperature). Often, as in the case of air pollution, these two stresses are very much interrelated	31
3. General management and maintenance	E.g., research on specific management methods	29
4. Vitality and health assessment of trees	Studies develop and use (visual and other) assessment methods that look at the crowns and roots	18
5. Management planning	Included are studies of the organisation of actual management	17
6. GIS, mapping, aerial photography and monitoring	Studies look at methods aimed to deliver an adequate information base for management	15

Fig. 16.10. Urban woodland, Dublin, Ireland (*photo:* K. Nilsson)

Fig. 16.11.
Plane trees, Aranjuez, Spain
(*photo:* K. Nilsson)

Publications

The large majority of the publications resulting from the listed projects has appeared in the national language, and in national magazines and journals, which means that such source material is often hard to access for foreign researchers. When publishing in a foreign language, English is the language of preference.

16.5
Discussion and Conclusions

In Europe, not all countries show the same level of activity in research on urban forests and urban trees, nor is the focus of research always similar. Differences in activity and focus result from cultural, socio-economic, political and biophysical differences. In Italy, for example, historical gardens traditionally are a very important element of urban green-structures, and many studies specifically deal with these gardens. The issue of de-icing salt and its damage to urban trees is particularly pressing in the Nordic countries, as well as in other countries with harsh winters or mountainous areas. In Eastern Europe, for example in Poland, Croatia and The Slovak Republic, plant protection and selection of the trees for urban conditions is a research field of growing interest.

Differences can also be noted in terms of the types of research organizations involved. While state institutes in Denmark dominate urban forestry, in Greece relevant research is primarily undertaken by universities. In Austria and Belgium, mainly forestry institutes are mainly involved, while in Italy a mix of institutes with a background in forestry, pathology, horticulture and agriculture deals with urban forestry studies.

The focus of research may differ in terms of urban sites as well as study topics. Belgium and Finland express a rather strong research focus on woodlands, while in Italy attention is primarily given to trees in streets and parks. In Austria, research mainly looks at the form, functions and benefits of urban forests and trees. Specific and typical problems often direct research, such as the harsh growing conditions in northern Europe, pollution and fires in southern Europe, the need for new urban woodlands for recreation in highly urbanized western Europe, and political and economic transformation as well as air pollution in eastern Europe. In a number of countries, including Denmark, Finland, Italy, The Netherlands, Sweden and the United Kingdom, relevant research is more equitably distributed over the range of different aspects and urban sites.

To conclude, the review of recent and ongoing research on urban forests and trees in Europe has indicated that universities and state research institutes are leading the research efforts, while forestry and horticulture are the main disciplines involved. In this way, urban forestry research in Europe is probably not very different from North America. National funding is the main source of research money, even though urban forestry is seen as a local, municipal matter in almost all countries. Funding of urban forestry research by the European Union is still very limited and there seems to be great potential and need for researchers to increase their involvement in international projects.

The overview, even though not complete, also shows that a number of relevant projects are going on. These projects are widely spread among countries, institutes and disciplines, and research is fragmented and, in most cases, lacks coordination. Such coordination is complicated by the 'national' or sometimes even local character of research, and by the fact that publication and distribution of most findings is at the national level only.

Another main finding of the review is that integration between disciplines is still not very common. Forestry and horticultural approaches, for example, are mostly applied rather independently. Moreover, the traditional main 'domains' of forestry, park management and horticulture are still very present in most countries, even though quite a number of projects focus on more than one type of urban site.

16.6 Future Demands

The city of tomorrow asks for sufficient healthy and multifunctional green spaces. Therefore, a pressing need exists to enhance the conservation, management and development of these areas, while keeping in mind the many different values they have. Urban sites are harsh on most types of vegetation. Overuse, vandalism, soil compaction, de-icing agents, drought and traffic emissions, as well as severe diseases such as Dutch elm disease and cypress canker, are among the many threats to urban forest and tree health. A survey undertaken by COST Action E12 showed that there was widespread agreement among urban tree managers that these factors are the major impacts on trees. Up to 30% of newly planted street trees were vandalized in the United Kingdom, and the level of vandalism was inversely related to the quality of trees planted. Utility trenching and construction works are further major damaging factors to urban trees.

The scarce urban forest and tree resource base is under continuous stress. Planners and managers have to try to maintain a sustainable resource, while meeting the many demands of urban society. While doing this, their efforts are hampered by budget cuts, administrative reforms, challenges to the legitimacy of their actions, the demand for more public involvement, and changing public demands and preferences. As an example of the latter, development recreational use is changing towards more active, more nature-oriented, and more 'information-rich' forms.

This chapter has stressed the importance of a sound knowledge base for urban forestry. With the help of relevant and accessible research findings, urban forest planners and managers will be more successful in developing the right type of green space for the right place, be it a line of street trees, a small neighborhood park or a community woodland. This means, first of all, that the green area must be optimally adapted to local urban site conditions. These include biotic and abiotic factors such as soil, climate and other organisms, but also site-specific human pressures and demands, as shown in this book. These ecological and social conditions can be met by means of proper planning and design, plant selection and establishment, and management, while keeping the economic framework in mind. The latter implies that all costs and benefits of urban forestry have to be considered, not only in terms of management costs but also with regards to the many goods and services urban forests provide.

Fig. 16.12. Urban growing conditions, Amsterdam, The Netherlands (*photo:* K. Nilsson)

Research needs in Europe follow this line. More information is needed about the characteristics of urban sites, and on how to grow trees successfully on them. Quite a number of studies have been undertaken, but the exchange of results and experiences has been very limited so far. In conjunction with the need to study urban sites, there is a need to investigate and develop environmentally sound methods of urban forest management. Methods should be based upon a minimum use of herbicides, fungicides and insecticides, in order not to harm green spaces' natural values. On the other hand, techniques need to be efficient and effective. While striving for this, it has to be recognised that traditional approaches and research are not sufficient. Traditional forestry approaches applied in urban areas, for example, have evoked high levels of public criticism. Moreover, silvicultural practices have to be adapted to better take the primacy of the recreational function of urban woodlands into account, and focus less on wood production (see also Chap. 13). However, even adapted forestry will only be successful when integrated in an urban forestry approach that includes the contributions from other disciplines.

The demand-side of the relationship between people and urban trees is another main topic for future research. Changing urban demands for recreation opportunities have to be monitored and anticipated. Apart from a proper valuation of social functions of urban green spaces, more studies should be initiated which look at assessing their ecological and economic values. Only in this way can the full value of urban forest and tree resources be determined, which is a crucial input to policy-making and planning. This brings us to the need to develop multifunctional urban woodland and parks. Urban forestry promotes an integrated approach towards urban green-space planning and management. But for the sustainable development of urban green structures, urban green planning has to be properly integrated into overall urban planning. Moreover, urban green planning should not stop at the urban fringe. The English Community Forests are a fine example of how city and surrounding countryside can be planned in an integrated way. Experiences like this can be passed on and discussed via international cooperation. Recent coordination efforts have also shown that the challenges in urban forestry are often quite similar across Europe. For one thing, one basic premise of urban forestry always emerged: it is primarily about people meeting trees, on a daily basis, in their direct living environment.

There is also a need for more research on topics like health aspects and sustainable development, and how urban forestry researchers can contribute with their knowledge regarding them. It is a high priority area to assure the health and well-being of European citizens through a better understanding of the influence of environmental factors on human health. We know that access to forests, public parks and other green areas have a positive influence on people's physical and psychological well-being. But this knowledge is limited to a general level, while more specified knowledge of the opportunities of forests and trees to ameliorate trends like an increasingly sedentary population, increasing levels of mental stress related to urban living and contemporary work practices, and hazardous environments is missing.

Sustainable development is a central objective of the European Community. In this context, sustainable management of Europe's natural resources, e.g., its landscapes, forests and trees, is a high priority theme. Activities should aim at strengthening the scientific and technological capacities needed to be able to implement a sustainable development model, and to understand and control global change and preserve the equilibrium of ecosystems. There is a need for more focus on how the planning and management of urban forests and trees can contribute to a fulfillment of these ambi-

Fig. 16.13. Health aspects, old ladies in Dyrehaven, Copenhagen, Denmark (*photo:* K. Nilsson)

Fig. 16.14. Urban forestry in developing countries (*photo:* K. Nilsson)

tions. As an example, the role of urban ecosystems is highly underestimated when preservation of biodiversity is discussed.

Finally, the increased interest in urban environmental problems will probably mean a considerable increase in urban forests and trees over the coming decades. Most of these will be laid out in the larger cities of Asia, Africa and Latin America (Fig. 16.14). Obviously, we are all looking forward to this. Similar expansion of the green infrastructure was carried out in Europe and North America during the years after the Second World War and up to the 1970s. It was done with a strong belief in high technology, heavy machines and liberal application of chemical aids. Over the coming years, the main challenge is to ensure that the expansion and management of the green infrastructure of the world's urban areas will be implemented within the framework of sustainable development, without the use of a technology and methods inimical to man and nature.

When healthy and sustainable, urban and peri-urban forest resources provide a wide range of social, cultural, economic and environmental goods and services to societies. In industrialized countries the focus of urban forestry tends to be on social (including recreation) and environmental services. In developing countries, environmental services such as climate and water regulation are also of the highest importance. But much more than in industrial countries, urban and peri-urban forests contribute with many goods to people's subsistence. By providing essential additions to people's diet, a buffer to variability and access to nearby food, fodder and wood for fuel and construction, urban and peri-urban forests have an important role to play in ensuring food security and livelihoods of urban dwellers.

16.7 Future Prospects

Urbanization continues to take place throughout Europe. As more and more people live in towns and cities, the quality of the urban living environment becomes ever more important. Green areas are a vital part of any urban infrastructure, contributing environmental, social and economic benefits. Trees in parks and woodland, streets and gardens are the most important elements of such green areas, yet their benefits are often overlooked and their proper care neglected.

After five years of work, the most comprehensive study on urban forests and trees in Europe ended in 2002. One hundred experts, representing 80 institutions in 22 European countries developed innovative approaches for maintaining and developing the sustainable and multi-functional benefits of urban forests and trees. However, urban green space is continually under threat. Research has an important role to play in order to justify the benefits and costs of a green environment, to improve legislative and administrative instruments, and to develop and disseminate good management practices. Talking about research, five years is a very short period of time. But the established, multidisciplinary network of experts on urban forests and trees is a good platform for further cooperation and new research initiatives.

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Chapter 17

Urban Forestry Education

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17.1 Introduction

Urban forestry has emerged as a new profession and a field of scientific attention. Urban foresters contribute to making cities all over the world more attractive and more comfortable places in which to live and work (Miller 2001). Ample examples of urban foresters' works have been described in the previous chapters. But how are these urban foresters educated and trained to achieve this?

From the previous chapters it has become clear that urban forestry is a very challenging field. Planning and managing forest and tree resources on – often harsh – urban sites poses considerable challenges to the professionals involved. Given the wide range of skills and knowledge required to deal with both a varied natural resource and urban society, it is not surprising that many different disciplines are involved. The overview of urban forestry research in Europe (see Chap. 16) has indicated that applied sciences with a focus on natural science-oriented fields such as forestry, horticulture, (landscape) ecology and arboriculture dominate the research arena. On the other hand, disciplines and professions with a stronger societal character, such as landscape architecture and landscape planning, also play an important role. Johnston (2001) mentions the different professionals involved in urban forestry. He lists 'tree' professionals with a background in arboriculture and forestry; professionals dealing with planning and management of the urban landscape, including landscape architects, landscape and park managers, amenity horticulturists and urban ecologists; as well as non-plant related professionals such as urban planners, sociologists, public relations and marketing specialists. Moreover, others who are perhaps not directly involved in urban forestry, such as architects, civil engineers and builders, are also of importance. Overviews of research and good practice in urban forestry (e.g., Forrest et al. 1999; Konijnendijk et al. 2000) have stressed the importance of developing multi- and interdisciplinary approaches to studying, planning, designing, establishing and managing woodland and other tree resources in urban and peri-urban lands.

This chapter will answer the question how urban foresters are currently educated and trained. Firstly it will provide an overview of contemporary urban forestry education in Europe. Focus will be on higher or tertiary education, but attention will also be given to professional training and continuing professional development (CPD). The results of this European overview will be analyzed and placed in perspective by comparing them to status and developments in urban forestry education elsewhere. Based on the overview, a 'profile' of the professional urban forester in terms of the skills and knowledge such a person should ideally have to manage urban forest resources will be developed. Finally, a comparison of educational state-of-art with actual educational needs of urban forestry professionals is used to suggest improvements in European education.

17.2 What Is Urban Forestry Education?

Central to defining urban forestry education is a definition of urban forestry. As described in Chap. 1, urban forests can be defined as all forest stands and other tree-dominated vegetation in and near urban areas. In accordance with this, urban forestry education could be defined as education with focus on one or more of the following topics: function, planning, design, selection, establishment and management of urban and peri-urban woodland, parks, street trees and other tree resources. Urban forestry is not the same as arboriculture, a field with a longer tradition. Arboriculture is the management of individual trees (also referred to as 'tree care'), while urban forestry is the management of populations of trees (e.g., Miller 1997, see also Chap. 15). 'Management' is regarded here as a very broad term, covering all human interventions in urban tree resources. When describing urban forestry, Miller (1997) acknowledges that a problem remains to define the boundary of the rural forest and the urban forest.

'Education' has been defined as 'training and instruction … designed to give knowledge and develop skills' (Oxford Advanced Learner's Dictionary 1989). Education takes place at many different levels, aimed at people with differing needs in terms of knowledge or skills to be acquired. Johnston (2001) lists three main fields of education within urban forestry:

- Formal educational courses at different levels ('school' or university education).
- Training, as usually refers to the acquisition of basic practical skills.
- Continuing professional development, i.e. frequently informal education to keep professionals abreast of new developments and knowledge in their field.

Formal Education

Formal education occurs at different levels, from basic or primary via secondary to tertiary and advanced. All have a formal context within which knowledge and skills are transferred in common. The emphasis of this chapter is higher or tertiary education, i.e. college or university-level education leading to a minimum of a Baccalaureate (e.g., BSc) or comparable degree as described by Randrup et al. (2001). People following higher education in natural resource management typically are trained as scientists, policy-makers or higher-level practitioners. A distinction is often made between undergraduate (mostly at Baccalaureate/Bachelor level), and graduate or postgraduate studies (at Master or PhD level), with postdoctoral studies referring to formal education after the PhD degree.

A study of higher urban forestry education distinguishes between two key components of education (e.g., based on Schmidt et al. 1998):

- Degree programs or curricula
- Courses and modules, i.e. teaching modules on a specific subject, whereas a selected set of courses and modules (as elements of courses) comprise a program or curriculum leading to a degree

Urban forestry curricula and courses are mostly developed at the level of the department or section/unit level of educational institutions such as universities and colleges.

Training and Continuing Professional Development

Training has a stronger practical component than formal education. Oxford's Advanced Learner's Dictionary (1989) mentions that to train is to 'bring to a desired standard of efficiency, behaviour, etc. by instruction and practice'. Closely related is the term 'vocational education', i.e. an education relating to a certain occupation (such as forestry, arboriculture, or urban forestry) especially providing or undergoing training in practical skills (Johnston 2001). This implies that the emphasis is on acquiring practical skills rather than on acquiring new knowledge. As mentioned, continuing professional development refers to the different ways in which professionals can keep abreast with developments in their field throughout their careers (Johnston 2001), i.e. lifelong learning.

17.3 Present Status of Urban Forestry Education in Europe

17.3.1 Higher Education in Urban Forestry in Europe

A first comparative study of higher education focusing on urban forests and urban trees was carried out within the framework of COST Action E12 'Urban Forests and Trees'. Information from the study presented here is derived from Randrup et al. (2001) and Andersen et al. (2002). The study included information from 28 European countries and 180 institutions. The scope of this higher education survey was rather broad, including all types of education with a primary focus on aspects of urban forestry.

The results show that 61 educational departments at 49 institutions for higher education provide some sort of urban forestry education. In total these represented 31 full degree programs and 191 courses and modules. Among the 31 programs said to deal with urban forestry, only 8 explicitly had the term urban forestry (or community forestry as focusing on urban areas) in their title (Table 17.1). Other keywords in degree program titles were landscape architecture, design and planning, (landscape) gardening and horticulture. Four of the programs were titled 'arboriculture', thus suggesting a focus on individual tree care. Some titles suggest that programs had little in common with urban forestry education.

Table 17.1. Keywords in degree program titles identified through the questionnaire on higher education on urban forestry in Europe (Andersen et al. 2002)

Keywords in degree programme titles	No. of times the keyword appeared
Urban forestry, urban/community forest management	8
Landscape architecture/design/planning	8
(Landscape) gardening	6
Arboriculture	4
Horticulture	4
Other	28

Table 17.2.
The 38 disciplines and fields of attention (alphabetically listed) mentioned as main expertise of the department in response to the questionnaire on higher education on urban forestry in Europe (Andersen et al. 2002)

Agriculture	Geography
Arboriculture	Geology
Architecture	Horticulture
Biology	Hunting
Botany	Landscape architecture
Civil engineering	Landscape ecology
Construction	Landscape technique
Countryside management	Leisure studies
Crop production	Mechanics
Dendrology	Nature cons/man/prot
Design with plants	Planning science
Economics	Plant pathology
Electronics	Sociology
Environmental sciences	Soil sciences
Equine studies	Technology
Food technology	Town planning
Forestry	Tree biology
Garden art/design	Urban design
Genetics (diversity)	Water management

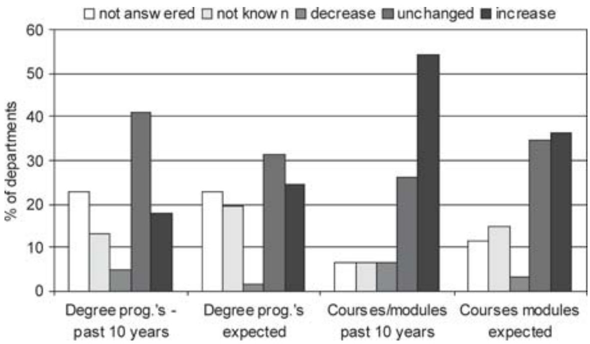

Fig. 17.1.
Development in urban forestry degree programs, courses and modules in Europe; based on study carried out during 1999–2000 (Randrup et al. 2001)

The previous chapters of this book have signaled the interdisciplinary or at least multidisciplinary character of urban forestry, with expertise from a wide range of disciplines involved. The survey supported this finding. Disciplines and fields of attention mentioned as key expertise by the 61 departments offering urban forestry education cover a broad spectrum (see Table 17.2). On average, there were found to be 3.4 disciplines per department. Departments offering a full program even averaged 5.6 disciplines when asked for their key expertise. Most frequently mentioned as department key expertise were arboriculture, biology, forestry, horticulture, landscape architecture and (landscape) ecology. These disciplines show considerable overlap with the main disciplines included in urban forestry research (see Chap. 16 and Konijnendijk et al. 2000). The multidisciplinary image of urban forestry education was also confirmed by examining the background of students enrolled in graduate programs. MSc or PhD-level programs averaged 3.5 different student backgrounds (i.e. previous degrees).

According to the survey, the number of both programs and courses/models offered in urban forestry has increased (see Fig. 17.1). Out of all departments, for example, 80% reported an increase or *status quo* in the number of urban forestry courses/modules

Box 17.1. Example of urban forestry program – MA/MSc/PG Dip Urban Forestry, University of Central Lancashire (University of Central Lancashire 2003)

M.A./M.Sc./PG Dip Urban Forestry
University of Central Lancashire, National School of Forestry

- New program, validated during 2003.
- *Educational background of students:* entry qualifications are a BSc or BA in forestry, arboriculture, landscape architecture, horticulture, ecology and conservation, environmental management or planning (while a wide range of other subjects in the biological and social sciences will also be considered); relevant degree level qualifications such as the Professional Diploma in Arboriculture.
- *Courses included:* urban development and urban greening, establishment and maintenance of urban trees, project planning, design and management of urban woodlands, social science and urban forestry, sustainable management of the urban forest, research methods, dissertation.
- *Teaching methods:* teaching in modular form, lectures, group work, dissertation, etc.
- *Employment of graduates:* career opportunities regarded to be working with non-governmental organizations and urban forestry initiatives, local authorities, commercial companies, smaller scale contracting companies.

Box 17.2. Example of urban forestry program – Aristotle University of Thessaloniki, Greece (from Randrup et al. 2001)

Master in Urban Forestry and Landscape Architecture – Specialization within the program 'Forest production and protection'
Aristotle University of Thessaloniki, Department of Forestry and Natural Environment

- *Average student enrollment:* less than 5.
- *Educational background of students (Bachelor etc.):* forestry, horticulture, agriculture.
- *Staff expertise:* forestry, landscape architecture, (landscape) ecology, soil sciences.
- *Courses included:* compulsory elements are various forest subjects including forest botany, forest protection, silviculture, forest law, forest policy. Optional elements include sociology, urban silviculture, trees and shrubs in parks and tree avenues, public relations, forest recreation policy, pollution of the natural environment.
- *Teaching methods:* lectures, practical training and fieldwork, laboratory experiments, thesis.
- *Employment of* graduates*:* municipalities, research institutes.

offered. Those involved in curricula and course development expected further growth in the future. The number of students enrolled in higher urban forestry education still seems rather small in absolute terms, with typical programs and courses involving 11–20 students. However, student enrollment has shown an increase as well.

Finally, the study also obtained some insight in employment of students graduating from urban forestry programs. This showed that the private and public sectors are equally important in providing employment.

As mentioned, degree programs with urban forests and trees as main component are not very common in Europe. Boxes 17.1 and 17.2 provide some examples of such degree programs from different parts of Europe. They illustrate the diversity in staff (and student) background, limited student enrollment, course topics, teaching methods and graduate employment.

17.3.2 Continuing Professional Development in Urban Forestry

In contrast to higher education, some efforts have been made to establish a European-wide standard for professional education in urban forestry in terms of training and continued professional development. These efforts primarily concern the arboricultural component of urban forestry. The European Arboricultural Council (EAC) has harmonized the certification of tree care professionals through its European Tree Worker Examination (e.g., Dowson 2001). A set of teaching elements and evaluation criteria are available for different European countries so that tree workers may be equally accredited. International judges participate in the accreditation of applicants. The European scheme had its origins in initiatives of the International Society of Arboriculture (ISA), the main international organization for tree care (and increasingly also urban forestry) professionals. Continuing professional education of its worldwide membership is a main objective of the ISA. Professionals can, for example, be granted the status of ISA Certified Arborist, a professional vocational qualification obtained by passing a theoretical examination on tree care and management. Once qualified, each Certified Arborist is then required to collect 30 continuing education units over a 3-year period, for example through conferences, seminars, and completing questionnaires connected to publications. Several countries have adopted this scheme or developed their own, with differing success (Johnston 2001). Focus in the schemes mentioned has been tree care, although other skills needed for urban forestry have been included.

The International Federation of Park and Recreation Administration (IFPRA), a non-profit organization with headquarters in the United Kingdom, maintains contacts throughout the world with national professional bodies representing park, recreation, amenity, cultural, leisure and related services. Over 50 nations are represented within IFPRA. It offers a qualification scheme, which is designed to acknowledge qualified, competent, experienced, junior, middle and senior managers in park and recreation management. The objective of the scheme is for candidates to demonstrate their competence in and knowledge of practical aspects of parks and recreation management, as well as the relevance and implications of issues in the wider context of the industry. All candidates are required to plan and carry out a project that demonstrates their ability to analyze a practical problem, collect relevant information, assess that information, identify and debate alternative solutions and make recommendations using appropriate problem solving and decision making techniques. The project should also demonstrate the candidate's communication skills.

The IFPRA Qualification is offered at two levels. At each level, candidates are required to complete, as mentioned, a work-based, practical project to a standard set by the federation, addressing an issue or problem relevant to their work environment. Successful candidates are awarded a Certificate or Diploma signed by the President of the federation and entitled to use the initials IFPRA (Cert) or IFPRA (Dip) after their name.

Apart from several countries in Europe now offering ISA or EAC-type certification of (primarily arboriculture) professionals, urban forestry education remains fragmented. Dowson (2001) describes the situation in the United Kingdom where professional qualifications and/or the so-called 'chartered status' (a national certification of professionalism) can be gained in various ways. Qualifications offered are college ('formal') and professionally based. Apart from the earlier-discussed higher education degrees, college-based education leads to a wide range of certificates and diplomas. Professional qualifications which can be obtained include the Professional Diploma in Arboriculture of the Royal Forestry Society. Regarding the chartered status, membership of the Institute of Chartered Foresters is currently the most common option. Becoming a Chartered Forester (Arboriculturist) requires a minimum of five years of study and experience. Candidates must pass a rigorous exam and after qualification maintain high standards through a program of continuing professional development. Given the many qualification options for arboricultural professionals in the UK, Dowson suggests stronger harmonization of these. Johnston (2001) stresses the need for a professional body for tree care and management professionals, i.e. for all those involved in urban forestry.

In an overview of requirements for continued professional education in urban forestry, Johnston (2001) mentions how professionals can keep themselves up-to-date on their field. Means to this include academic journals and professional magazines, which increasingly are available on-line. Professionals can also participate in national and international conferences and seminars or access a wide range of Internet resources on urban forestry. Finally, they can involve themselves in networking and information activities of professional bodies such as the ISA or the IFPRA. Similar organizations – primarily for arborists and municipal green-space managers – exist nationally. The International Union of Forest Research Organizations (IUFRO) set up the European Forum on Urban Forestry in 1998 to serve as a platform for urban forestry practitioners (and so far primarily urban woodland managers) to meet with international colleagues (Konijnendijk 2003). COST Action E12 'Urban Forests and Trees' (1997–2002) focused on networking among European researchers, but practitioners were involved in the Action's networking activities (Nilsson and Konijnendijk in press). The National Urban Forestry Unit in the UK is an example of a national expertise centre and focal point for urban forestry; the Flemish Forest Organization is playing a similar role for urban woodland development and management in Flanders, Belgium. At the European level, the European Urban Forestry Research and Information Centre (EUFORIC), a topic centre of the Finland-based European Forest Institute, promotes coordination in urban forestry research and development (Konijnendijk 2003).

17.4 Urban Forestry Education in Europe in Perspective

17.4.1 Developments in Europe

The overview of relevant higher education in Europe has shown that, although still fragmented, urban forestry curricula and courses are developing and becoming more common. The United Kingdom has the longest track record in education in urban forestry, although a large part of it has been directed towards arboriculture. Also, because of the concept of urban forestry having an Anglo-Saxon origin, a large part of the urban forestry and arboriculture curricula listed in the European overview are based in the United Kingdom.

Across Europe, other institutions have developed urban forestry programs. Most have had a national scope, and many have in recent years experienced difficulties in rooting itself – in several cases due to lack of students. To our knowledge urban forestry related programs have been offered or are under preparation in the following countries: Ireland, The Netherlands, Germany, Norway, Greece, Italy and Denmark/Sweden. Examples of programs are provided in Boxes 17.1 and 17.2. Based on their long tradition in urban green establishment, forestry, landscape architecture and landscape planning, the Royal Veterinary and Agricultural University of Copenhagen, Denmark and the Swedish University of Agricultural Sciences have developed, jointly with other partners, a Master education in Urban Forestry and Urban Greening. This program will have an international scope and starts in autumn 2005.

17.4.2 The Global Perspective

How do developments in urban forestry education in Europe relate to developments elsewhere in the world? Urban forestry education is uncommon and fragmented outside Europe. The field is new in most parts of the world, although it has a longer history in its cradle, North America. Some years ago the ISA undertook a first survey of urban forestry education at the world level. The results of this survey are available through the ArbCat database (Wingate et al. 1995). A total of 99 programs were listed, 47 of which were defined as 'urban forestry' and the remaining 52 as arboriculture/landscape management. The limited scope of the database becomes clear when comparing it to the recent European review of urban forestry education: most of the programs listed in the latter are not included in ArbCat; some of these might have been developed after the ArbCat inventory. The database includes a wide range of programs also in terms of academic level, including Diplomas, Associate degrees, Bachelor degrees, Master of Science and Doctor of Philosophy degrees (see also Miller 2001).

The database clearly indicates that the larger part of activities within urban forestry education have taken place in North America and more specifically the United States, with close to half of the listed programs based there. Several reviews of urban forestry education in the US were carried out during the 1980s and 1990s (e.g., Miller 1994, 2001). One of the most comprehensive has been the study by Hildebrandt et al. (1993). In line with the European findings, it showed a significant growth in urban forestry as an educational discipline when results where compared to the first surveys of relevant education. The profession of urban forestry in the US has its roots in forestry. Graduates of forestry schools were frequently hired because of their biological, quantitative and managerial skills when municipal forestry programs developed throughout the 20th century (Miller 2001). This explains why Hildebrandt et al. (1993) targeted institutions offering forestry education at college or university level. They found that 30 of these schools offered urban forestry education at the time of study, compared to 11 in 1975 and 20 in 1980. Undergraduate curricula in-creased to 25 from 10 in 1975 and 18 in 1980. Graduate curricula had increased from 6 in 1975 to 9 in 1980 and 30 in 1990. Miller noted a further increase in programs up to 2002 (Miller personal communication). In line with this, student enrollment in urban forestry has also shown a clear increase. According to Miller (2001), there are large differences in programs, ranging from involving few students to those with a substantial student body.

Hildebrandt et al. (1993) also studied courses included in the various curricula. They found that forestry and other natural sciences were clearly dominating, in spite of the clear multidisciplinary character of the programs. The attention given to the urban context, e.g., through inclusion of elements of city and regional planning, proved to be minimal. Topics such as communication and social sciences were often covered, but again only as a minor element of the curricula when compared to forestry, biology, horticulture, etc.

One of the well-established urban forestry programs in the USA is that of the University of Wisconsin, Stevens Point (see Miller 2001). Since 1975, a BSc in Urban Forestry has been offered and student numbers have shown a steady increase, from 50–65 on average to about 120 in 2001. The Urban Forestry program is situated within the 'Forestry' major, implying the graduate is both a traditionally trained forester and urban forester. Students take the full range of forestry courses with an additional number of urban forestry courses. Examples of courses taught are urban forestry, amenity forestry, arboriculture, tree structure and function, turf management, recreation, landscape design, public relations and urban trees and shrubs. A small review by Miller indicates that employment opportunities for graduates have been excellent, with many starting at private sector entry-jobs such as employment with commercial arborists, public utilities, nurseries and landscape contractors. There are fewer public sector entry positions, but with a number of years relevant experience, employment in the public sector is possible. Moreover, the rise of state-supported urban forestry programs and the higher focus on urban trees within municipalities, for example, has led to better employment opportunities in the public sector.

Accreditation of urban forestry education is an important topic in the United States. The Society of American Foresters (SAF), for example, certifies forestry schools, but no special accreditation scheme exists as of yet for urban forestry programs. Urban forestry thus becomes accredited only through their affiliation with a general forestry school (Miller 2001).

Developments in urban forestry-related education are evident in other parts of the world. Plans exist, e.g., in Malaysia and New Zealand to set up urban forestry curricula. The interest of the forestry students community in the field can be seen from the involvement of the International Forestry Students Association (IFSA) which has had urban forestry as a main focus of its activities since the early 1990s (Konijnendijk 1995; IFSA 2003).

17.5 The Urban Forester of Tomorrow: A Profile

Before profiling the modern urban forestry profession, the question needs to be asked if there is a need for urban foresters. Could their tasks not be carried out by other professionals without a specific urban forestry education and/or training?

Miller (1997, 2001) signals a significant growth in the green industry, as well as a dramatic growth in urban forestry activities in the United States. US governments, at both federal and state level have set up urban forestry programs with substantial funding. Issues such as climate amelioration and air pollution reduction by urban trees have come in focus. At municipal level, tree inventories have quadrupled and there is a steady growth in for example urban forest plans. Most of the larger towns and cities in the USA now employ a municipal arborist or urban forester. Growth in urban forestry is not confined to the USA. According to Miller (1997), urban forestry is now a global enterprise and will continue to expand in scope and opportunity, and educators and scientists can and must be prepared to meet the needs of the globe's urban citizens. The growing international attention for urban forestry as a multidisciplinary approach might also be derived from the growth of the number of International Society of Arboriculture chapters outside North America and the emergence of various international networks of urban forestry scientists (e.g., COST Action E12 Urban Forests and Trees). At present many towns and cities in the United Kingdom have an arboricultural or tree officer with duties similar to those of the municipal arborists or urban foresters in the USA, i.e. to coordinate urban tree management across the entire local authority district (Johnston and Rushton 1999). In much of Europe, due to amalgamations in municipalities, the traditional divisions between, for example municipal forest services, green departments and environmental departments are disappearing (e.g., Konijnendijk 1999).

This book has described how urbanization has led to a growing focus on the quality of urban life and urban environment. Green structures are important contributors to better cities and forests and other tree resources are main elements of urban green. More strategic and integrated approaches to planning and managing green structures are required. The different green elements need to be treated as part of larger green structures rather than as separate elements. Moreover, urban green issues need to be connected to a range of social, economic and environmental agendas. Urban forestry as an integrated and strategic approach to planning and managing urban tree resources for multiple benefits provides a response to this (Miller 1997; Johnston 2001). Professionals are needed with understanding of both a tree-based natural resource located on high-pressure sites and the urban society who is using this resource in many different ways. These professionals can come from a wide range of different disciplinary backgrounds, as mentioned before, and different skills are required. When natural resource managers increasingly need to operate in urban environments, new skills are needed. These include, for example, social skills, public relations, communication with different stakeholders, public participation, conflict management, and so forth. Natural resource managers need to be aware that stakeholders who ask for a higher level of influence and information (Kennedy and Thomas 1995) challenge their traditional legitimacy of acting. Because of the large variety in knowledge and skills required, no single discipline or profession dominates urban forestry.

Thus, modern urban foresters have their roots in a wide range of scientific and professional backgrounds. What they have in common, however, is their focus on urban trees and their close relationships with urban society. Consequently they are anticipating the specific demands and characteristics of urban societies and environments. Moreover, they require basic understanding of and openness towards both the natural and the social science dimension of their field. They have to learn to speak the language of different professionals and stakeholders, from general public and local politicians to engineers and city planners, and become true team players. Urban areas are characterized by high dynamics and urban forestry professionals need to keep themselves abreast with developments in their field. Over the past 30 years there have been remarkable changes in the accepted theory and practice of urban tree management, for example related to pruning, wound treatment, tree biology, pathology and information technology (Johnston 2001). Changes have also occurred regarding public involvement and urban planning. Examples of these advances can be found throughout this book.

17.6 Educating the Urban Forester of Tomorrow

The United Nations Educational, Scientific and Cultural Organization (UNESCO) organized the first World Conference on Higher Education in 1998. Participants (over 4 000 administrators, educators and students) agreed on the need for drastic transformation of higher education. External factors, e.g., globalisation, democratization, progress of science and technology, and social exclusion have to be taken into account. Also environmental concerns in an urbanizing society, i.e. closely linked to fields such as urban forestry, were seen as a main driving force. Some of the major challenges for higher education identified included: the need to offer relevant and high-quality education based on societal demands, the need for (e.g., public-private) partnerships, need for multidisciplinary and transdisciplinary approaches, and the need to enhance international cooperation and exchange (UNESCO 1998). Study of higher education in natural resource management also stressed the growing importance of the urban dimension, as can for example be derived from recent studies on higher education in forestry where urban forestry has become incorporated to a greater extent (Schmidt et al. 1998; Lust et al. 2000).

Thus the stage is set for further development of urban forestry education. Its societal and educational context has been recognised. There appears to be a need for a modern education that incorporates expertise from a range of disciplines to deal with the challenges to plan and manage urban tree resources for societal benefits.

The COST E12 review of higher urban forestry education in Europe, however, noted a range of shortcomings in contemporary education and signaled various suggestions for improvement. First of all, the number of programs that actually follow an urban forestry approach is still limited. Only a few countries offer programs that aim at developing an integrated and strategic approach to planning and managing all urban tree resources. Most other programs continue to apply a disciplinary focus, concentrate on part of the urban tree resource, and tend to look only at part of the planning-design-establishment-management spectrum (see Chap. 1). In contrast, Miller (2001) mentions three main elements of any urban forestry program, i.e. arboriculture; the planning and management of populations of trees; and urban ecology as an ecosystem approach to urban forest resources, urban regions and their functions and values. Missing from this, however, are the much needed social disciplines and skills as described earlier in this chapter.

Moreover, interdisciplinary approaches that attempt to truly integrate disciplinary perspectives towards solving problems are underdeveloped. The need to go beyond single disciplines is the core of urban forestry. Various professionals who can make some contribution to the planning and management of urban forests need to work together as a 'green team' (Johnston 2001). As urban foresters will be required to work in these teams, education should prepare them for this. Less traditional teaching methods could be replaced by group work and development of personal student skills, for example through self-managed learning.

Urban forestry education needs to keep itself abreast with the many new developments in the field and in related disciplines. The rate of development is unlikely to decline. In some countries at the forefront of development, changes occur very rapidly and approaches and techniques have become increasingly complex and refined. In other countries urban forestry is still establishing itself as a domain. This favors, for example, better links between education, science and practice, as well as a higher mobility of staff and students than is currently the case. Experience has shown that international cooperation in particular can be highly beneficial for a field that is new, still fragmented but has a clear international scope. The challenges faced by urban foresters across Europe are often not so very different. The Sorbonne Declaration on Higher Education (Sorbonne Declaration 1998) stressed the importance of international mobility of staff and students. Student and staff mobility would be enhanced by some sort of European accreditation system for urban forestry programs. Straightforward and preferably international accreditation of vocational education is also required. But internationalization of education would go beyond a mere exchange of staff and students, although this activity has proven its merits, for example in European forestry education and EU Socrates and Erasmus exchange programs (e.g., Schmidt et al. 1998). Only few urban forestry programs in Europe have embarked on a true internationalization of their scope and curriculum, although some interesting developments are taking place in this respect, for example in the case of the Danish-Swedish initiative as well as in Great Britain. International programs will not only be dependent upon students from their own country.

The development of urban forestry education can only be arranged along the lines described above when the right framework conditions are present. According to Miller (2001), a successful academic program needs two things. First of all a person with urban forestry as a primary academic interest must be employed full time. Traditionally, urban forestry education often had to be provided as 'side activity' by a faculty member with other main interests. Secondly, successful urban forestry education is dependent upon the institution's willingness to provide both financial and curricular support for the program. Academic input from those with expertise in urban issues at large is crucial in developing urban forestry education.

17.7 Conclusions

This chapter has described how education on urban forestry in Europe, at academic as well as other levels, is still fragmented and not well defined. Existing education is centered within a more narrow or 'classical' disciplinary approach. Focus has often been on more technical aspects of urban green-space management, with emphasis on forest, individual trees or parks. The number of courses and curricula in urban forestry has shown a clear increase, in line with developments in other parts of the world and most notably in North America. Initiatives to develop more comprehensive and integrated programs incorporating strong natural and social science components have emerged. Moreover, the first steps towards internationalization of education have been taken.

These developments are important when catering for the urban forestry professional of the future. The urban forester may have had his or her primary education in a specific field, but is aware of and open to the contributions other natural and social scientific disciplines and approaches can make and can work as member of a multidisciplinary team.

In order to educate and train the above-mentioned professional, more specific urban forestry programs and courses will be needed. These should be based on the urban forestry concept of dealing with all tree-based and associated green spaces in and near urban areas. Integration is also required of the strategic aspects of urban forestry such as policy-making, planning and design to more tactical and operational activities. The balance between the natural sciences and social sciences within education and training should be improved. Moreover, more interdisciplinary approaches are called for rather than different disciplines looking at urban forestry from their own point of view. Transdisciplinarity through closer links between scientists and professionals from across a wide range of disciplines is also needed. As urbanization and urban forestry are truly international phenomena, and many of the challenges faced are rather similar, education and training will benefit from further internationalization.

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Chapter 18

Urban Forestry in Europe: Innovative Solutions and Future Potential

Alan Simson

18.1 Introduction

Experience would suggest that it can take at least thirty years for an idea to become firmly established and accepted by society at large. If that is so, then urban forestry is a concept whose time has come. It has been suggested that the concept of urban forestry is relatively new, having been originally conceived by Jorgensen in 1965 in Toronto, Canada (Jorgensen 1986). Simson (2002) however maintains that, although the phrase might originate from that period, the roots of an urban forestry philosophy, certainly in the UK, can be traced back to the beginnings of post-industrial thinking in the latter half of the 19th century. At that time, thoughtful planners such as Patrick Geddes and philanthropic Quaker industrialists such as Cadbury and Lever argued that treed, urban green spaces were important catalysts in regenerating run-down urban areas, and thus making them healthy, habitable and profitable for the then captains of industry.

So, not only is there some doubt as to when the concept of urban forestry was first conceived, there is also no agreed definition of exactly what it is, or whether it can be universally applied wholesale to the increasingly wide scope of European urban tree planting activities. Within each of Europe's four broad cultural forestry zones (see Chap. 6), there is some common ground to be found regarding urban forestry, but each specific country still has their own ideas or definitions of exactly what constitutes the concept of urban forestry. Thus, although there is still some confusion as to the precise scope and aims of urban forestry (Newton 1988), the concept does enjoy a broad acceptance across Europe; the lack of a simple, all-embracing definition has not unduly hampered the development of the culture of urban forestry (Forrest et al. 1999). What is generally agreed however is that it has had a long gestation period, and has not had a painless birth. Perhaps Bagehot was right when he said, '*One of the greatest pains to human nature is the pain of a new idea*' (cited by St. John-Stevas 1959).

If a new idea is to succeed and flourish, it has to evolve, change and adapt over time, even perhaps establish new meanings for old practices. The concept of urban forestry has been no exception to this. One of the prime changes that has occurred is the change in the scale of thinking and application now associated with urban forestry. It is no longer solely concerned with relatively small-scale activity on individual sites, or used merely as a 'green cosmetic' to soften poorly conceived architectural or development planning. It is increasingly being viewed as one of the prime catalysts for urban regeneration, a glue that can bind together the disparate results of the modern development process, the robust regional structure that can act as the pump-priming investment that will attract more inward investment.

Interestingly, it has been claimed that urban regeneration, like urban forestry, is a young, multi-disciplinary profession, and that it has only been acknowledged politically since the late 1970s (Campbell and Cowan 2003). As a result of this, again perhaps like urban forestry, it has not established a specific canon of knowledge like the older professions. Where such knowledge does exist, it tends not to be focused, but to be dispersed amongst the constituent members and disciplines of the new profession. This is exacerbated by the fact that most urban regeneration professionals, including urban foresters, did not originally train in the subject but rather transferred from other professions such as planning, architecture, landscape architecture, forestry or housing. The tendency has been therefore to pick up on initiatives that appear to be successful, disseminate them as good practice and attempt to emulate them, often with only scant understanding of why such initiatives worked or knowledge of the specific locale in which they operated.

In spite of this, urban forestry has made significant progress, and the work of COST Action E12 has established the genre in the eyes of the EU as a specific scientific domain in its own right – in other words, urban forestry has come of age in Europe. Whilst an agreed definition of urban forestry might remain elusive, it is generally agreed that the concept is challenging, complex and adaptable, and it is exactly this complexity that makes it so valuable in the evolving urban regenerative debate that is currently sweeping Europe.

Accordingly, this chapter considers some of the innovations that have assisted this process and considers some of the most significant milestones that have been established along the way. It concludes by speculating on how the spectrum of urban forestry might be widened across Europe and some of the possible directions that it might take in the future.

18.2 The 'Coming of Age' of Urban Forestry in Europe

The word innovation is sometimes misunderstood. It is often taken to mean 'of the future' or 'something that has not been tried before', but in reality it means 'to renew', 'to introduce as something new', or 'to make changes' (Collins 1986). There are therefore a number of innovative projects in urban forestry that have been implemented over the years that can, in retrospect, be considered to have made changes, and thus be considered to be significant milestones in the development of the concept in Europe. The key to successful urban forestry innovation and future potential lies in the adoption of a multi-disciplinary approach. Urban forestry encompasses the professional remit of many design, technical and managerial disciplines, and to be successful, has to understand and accommodate the human, natural and economic processes of the culture within which it is working. Increasingly this also has to include all aspects and levels of the community in the decision-making processes associated with the planning, design, implementation and subsequent management of the urban forest.

This reflects current thinking of course, and such approaches to urban forestry have not always been applied. That said, aspects of a multi-disciplinary approach can be traced in all the truly innovative projects that have contributed to the coming of age of urban forestry in Europe. Broadly speaking, such initiatives fall into one of three categories; those that have been part of an expansion program of an existing settlement, those that have featured in the creation of new settlements, and those that have been party to programs for the reclamation, regeneration or reinstatement of degraded, post-industrial landscapes.

18.2.1
The Expansion of an Existing Settlement – The Amsterdamse Bos (The Netherlands)

The Amsterdamse Bos was the first significant, innovative new urban forest landscape of the 20th century. It was originally conceived by the architect/planner Hendrike Berlage in 1913 as part of his second development plan for Amsterdam Zuid. This plan formed part of the general expansion plans for the City of Amsterdam at the beginning of the 20th century (DRO 1994). Berlage was vehemently opposed to the concept of the Garden City, a concept that was being promoted at this time in the United Kingdom by Ebenezer Howard and others. Instead, Berlage preferred the planned expansion of existing urban settlements, and his ideas for Amsterdam Zuid were accepted by the city and implemented, including the provision of linked green space and parks. This did not however include the Amsterdamse Bos. The intervention of the First World War meant that Berlage's plan did not get underway until 1917, and this meant that detailed proposals for the new park were not considered until 1929.

In retrospect, this delay was fortuitous, as it enabled new thinking to be applied to the project and, as a result, a multi-disciplinary team of academics, botanists, biologists, engineers, architects, sociologists and town planners was assembled to carry out the work. Of particular significance was the inclusion of Lo Mulder in the design team, one of the first urban designers of Amsterdam, who worked on the plan for the new park from 1932–1937. The original concept was to create a recreational park of over 400 ha that would take on the character of a north-west European forest and be managed under ecological rather than the conventional silvicultural principles. This concept, coupled with Mulder's thoughtful design and subtle manipulation of microclimate, caused Eckbo (1950) to exclaim that the park had '*dynamic planting, as seen in the rural countryside, with such natural features as meadows, and groves of trees boldly exploited with the full sweep of Man's creative imagination, allied with the rich variety of free natural growth*'.

The Amsterdamse Bos was arguably the first modernist landscape in Europe based on urban forestry principals (Fig. 18.1). It swept away many aspects of the picturesque, romantic traditions of the English landscape school that had hitherto been very much in vogue, in favor of a new set of values centered upon the de Stijl Arts Movement's ethos of a new economic, social and functional order (Jellicoe and Jellicoe 1987). This resulted in a logical plan/concept that established an urban forestry landscape based upon ratios of 1 : 1 : 1 of water, woodland and meadow although, as has been pointed out by Konijnendijk (1999), these ratios have evolved over the years and are not now as they once were.

So what was innovative about the Amsterdamse Bos, and why is it such a significant milestone in the development of urban forestry in Europe? First, it introduced to the European urban landscape an entirely new set of Modernist values centered upon a social, functional and economic order. Up until then, designed landscapes had been essentially passive and for the exclusive use of certain people (Fig. 18.2). The Amsterdamse Bos on the other hand made provision for organized activity, both informal and formal, and was therefore essentially a democratic, people's landscape (Ruff 1979).

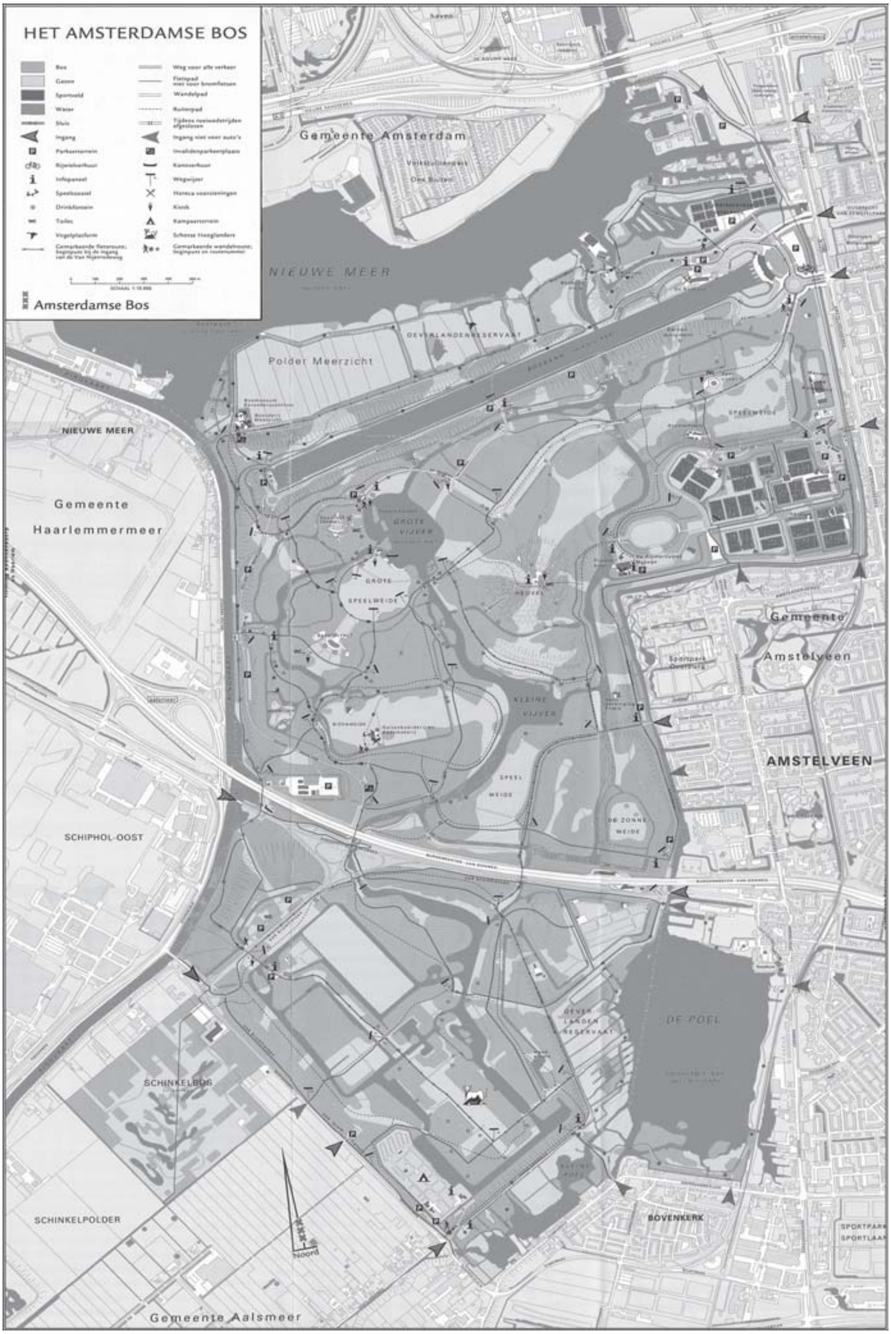

Fig. 18.1. The Amsterdamse Bos: the first 'Modernist' landscape in Europe. (*illustration:* Gemeente Amsterdam, Geo-informatie Amsterdam)

Fig. 18.2. A subtle blend of woodland, water and meadow in the Amsterdamse Bos, the view framed and accentuated by a fringe of standard trees (*photo:* A. Simson)

Secondly, it introduced to the developing urban landscape of Europe an aesthetic based upon nature rather than fine art, a wooded urban environment to which all people could respond, irrespective of their level of knowledge or education (Fig. 18.3). It is no coincidence that the Bos was one of the formative influences behind the development of the Community Forest projects in the 1980s in the United Kingdom. Pleas for such naturalistic landscapes continue to be made of course, such as that made by Nicholson-Lord (1991) when he expressed the view that '*cities are one environmental problem piled on top of another, and forests are probably the purest and most generic form of wilderness. We need to unmake cities and bring forests back into them, and we need to do it as soon as possible*'.

The third innovative aspect of the development of the Amsterdamse Bos, and perhaps the most important, was the introduction of the concept of resource management into the urban landscape equation. This suggested that, as a resource, an urban landscape – particularly an urban forestry landscape – requires investment, development and management in order to realize an optimum return. Although urban foresters are aware of these issues, they have not always been successful in communicating these lessons to the policy makers in our town and city administrations throughout Europe. As a result, not only have our urban landscapes not often realized an optimum return, but they have all too often been seen as a financial liability. It is interesting to note that in the current drive to make European urban areas commercially competitive and healthy, attractive locations in which to live and invest, the concepts behind the development of the Amsterdamse Bos are having to be re-learnt.

Fig. 18.3. One of the intimate green areas created in the Amsterdamse Bos, where microclimate is used and manipulated to create a comfortable 'sense of place' for people's enjoyment (*photo:* A. Simson)

18.2.2 The Creation of New Settlements – Telford New Town (United Kingdom)

The links between the concept of urban forestry/urban greening, attracting inward investment and thus obtaining an optimum return are to be found in the UK's New Town Movement. As successors to Ebenezer Howard's concept of the Garden City, the rationale behind the New Towns, particularly the Third Generation New Towns such as Milton Keynes, Telford and Warrington, was relatively simple and straightforward. They were to provide development relief for the large, congested, existing urban areas by designing and developing self-contained and balanced settlements for habitation, employment and recreation. Opinion, particularly professional opinion, is divided on whether it is wise to develop new settlements as opposed to revitalizing and extending existing urban areas. It is not appropriate here to rehearse the various opinions that exist regarding the development of New Towns. Berlage was not the only sceptic, and the pro and cons of such developments have been well documented by others (e.g., Fishman 1977; Hardy 1991; Hall 1996; Petersen 1997; Hall and Ward 1998). There is general agreement however that the New Towns have turned out to be more than just a means of coping with urban overspill. They have become integrated developments, effective growth points, good at attracting inward investment and stimulating local economies, and they have produced high-quality, designed environments, particularly their urban forestry and urban green-space networks.

The author is of the view that the development of some of these New Town green networks has provided some of the UK's most significant and innovatively designed new urban landscapes of the 20^{th} century, landscapes that have subsequently proved to be significant milestones in the development of urban forestry in Europe. As a typical example of such a landscape, it is proposed to focus upon the creation of the green network of Telford New Town, which illustrates how urban forestry can successfully be used to structure large areas of new development.

Telford covers an area of some 78 km^2 and is located in the West Midlands region of the UK. The basic plan for the New Town attempted to draw together the existing pattern of small communities with the new road and transport systems, new housing areas, schools and the new industrial, commercial and retail areas, by embedding them all within a network of urban forestry. The latter comprised some 40% of the designated area of the town (approximately 1 620 ha), a figure considerably in excess of the then national planning norms for the provision of urban green space. The vehicle for delivering this green network was the Landscape Master Plan (Fig. 18.4), which had five key principles:

- The preservation of existing tree and woodland cover wherever possible
- The establishment of major belts of tree planting along road corridors to create green links throughout the emerging town and to link up with existing areas of woodland
- The provision of a network of footpaths, cycle-ways and bridle-ways to further link areas of housing, employment and recreation into the green network (Fig. 18.5)
- The establishment of a hierarchical system of open space, ranging from a 180 ha central park, through a series of district and neighborhood parks to local green spaces associated with small groups of dwellings
- The planting of over 6 million trees and 12.5 million shrubs to provide an urban treescape that encompassed and dominated both existing and proposed areas of development

The basic concept was to ensure that the new built form of the town remained subservient to the dominant topographical and wooded character of the landscape, so that the town would eventually appear as a new settlement *in* a landscape, rather than take on the more conventional character of a new settlement imposed *on* a landscape. This was described in the Landscape Structure Plan as a townscape 'dominated by a hierarchy of amenity green space, defined and delineated by a comprehensive tree and woodland structure, comprising a mixture of fast-growing, short-term species interspersed with a number of long-term, dominant species' (Telford Development Corporation 1971).

This townscape had largely been completed by March 1991, and was deemed to be a success with both old and new landscape having been 'melded into an industrial, residential and environmental force in the West Midlands, with a strong city-in-the-forest image' (De Soissons 1991). This seemed to be confirmed when the international chartered accountants KPMG (1999) highlighted the benefits of Telford's urban forestry network when they published a major research study comparing the cost-effectiveness of inward investment in 64 towns and cities in the G7 countries. Within Europe, their research ranked Telford first above fifteen other European cities, and the town was deemed to be a rising star for inward investment in Europe.

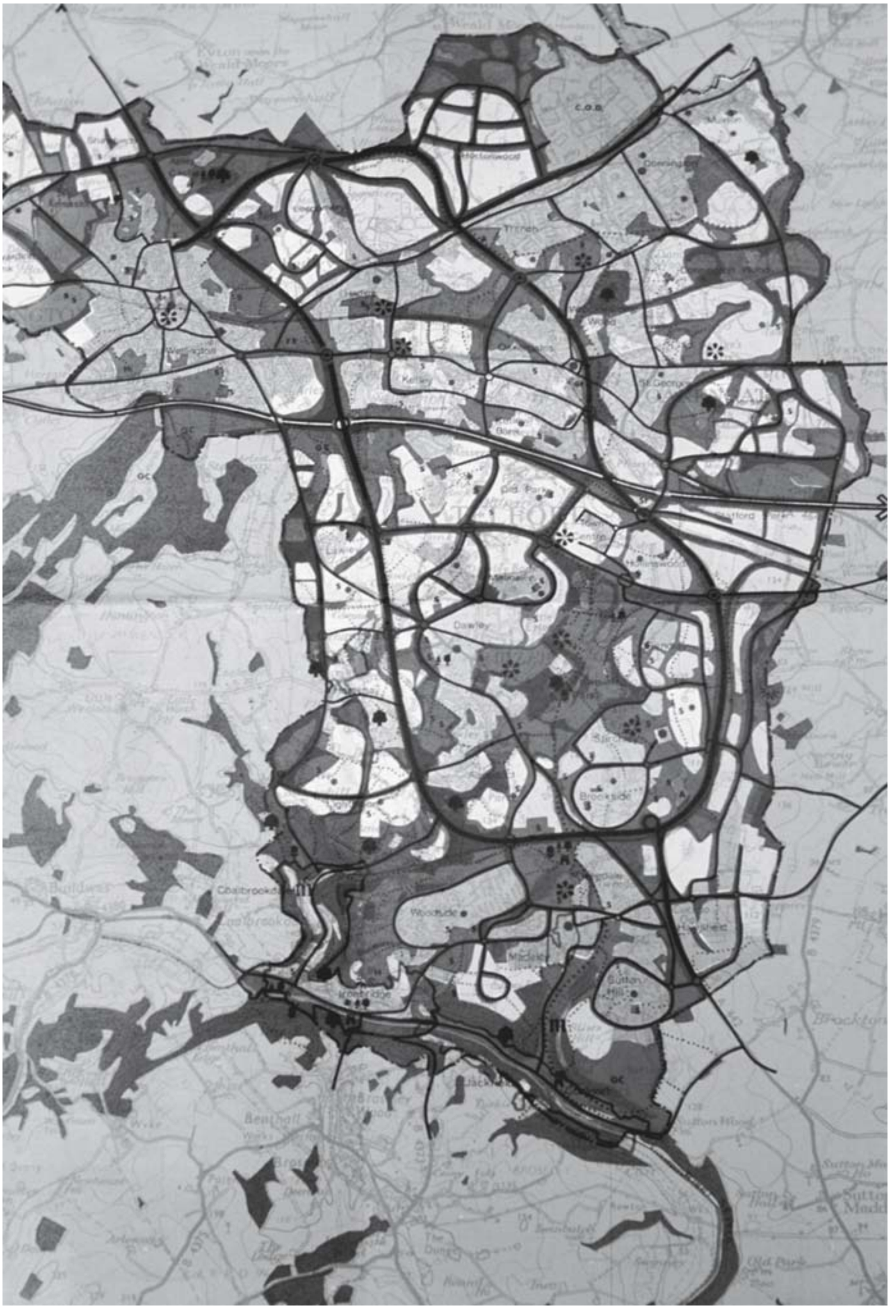

Fig. 18.4. The Landscape Structure Plan of Telford, a designed town of 78 km^2 in the English Midlands, where urban forestry-inspired green space covers some 38% of the Designated Area (*illustration:* Telford Development Corporation/Landscape)

Fig. 18.5. A footpath/cycleway in Telford, threading its way along an urban forestry "green link" connecting areas of housing, recreation and employment (*photo:* A. Simson)

Innovation in urban forestry thinking contributed to this success. First, Telford was the first town in the United Kingdom to have some of its existing woodland areas granted Dedicated Woodland status by the Forestry Commission for amenity purposes. Hitherto, such status had been reserved only for commercially productive woodland. The acquisition of this status was a big step forward for urban forestry, as it recognised that amenity was a valid commercial output for urban woodland. This did not preclude more traditional commercial activity however. In 1998 for example, the local authority realized over €16 500 from the sale of timber from management activity in their urban forest. Although not a large sum, it was over 10% of the total management budget, and does suggest that income from multi-functional green networks does not always have to be of the 'invisible earnings' kind.

Secondly, the technique adopted in Telford of planting pioneer/fast growing tree species, interspersed with the more long-term, long-lived species, was important in getting the new woodland established quickly physically, psychologically and politically (Fig. 18.6). Both the general public and the political decision makers are impatient, and it is always better to have the choice of thinning or modifying healthy, vigorous tree growth than trying to re-establish poor, weak stands. The benefits of this approach were realized in 1998 when the local authority was the first town in the UK to be granted Forest Stewardship Council (FSC) approved certification for the quality of its urban forest and urban forestry management.

The ability of the New Towns to successfully create a setting for attracting inward economic investment by using advanced mass tree planting and an associated green landscape structure began to be recognised as an innovative approach to the development process. This recognition implied that urban forestry was perhaps more than a

Fig. 18.6. An area of new amenity urban woodland in Telford, established using fast growing, pioneer tree species, now undergoing "modification" with the introduction of a footpath and a more exotic understory (*photo:* A. Simson)

specific site based activity. Arguably it had broader connotations that could be considered on a town-wide basis, and perhaps even develop as a philosophical approach to the design and management of the whole mosaic of urban open space provision town-wide, or even regionally. Also, why limit the philosophy to new development? Could existing areas of development that had fallen on hard times be given a helping hand to regenerate themselves by adopting a similar approach to the development process?

18.2.3 Reinstating Degraded, Post-Industrial Landscapes – The Emscher Park, Germany

One area in Europe that has proved that such an approach is feasible is to be found in the Emscher Region of the Ruhr Valley in Germany. Here a vast regenerative enterprise has achieved success by demonstrating that the standard approach to regeneration is not always the most appropriate; it is sometimes necessary to evolve a new kind of politics and administration to achieve success. Part of this enterprise, the Emscher (Landscape) Park, has also developed new, innovative concepts in dealing with the problems of creating a viable after-use for post-industrial landscapes on a regional scale that includes urban forestry as part of the rationale.

Since the nineteenth century, the Emscher area of the Ruhr Valley served as one of Europe's major industrial and manufacturing centers. The coal mines, coke smelters, steel mills and chemical plants of the region were the powerhouse behind the economic success of Germany in the twentieth century. However, as with so many of Europe's heavy industrial areas, the region could find no shelter against the winds of change that blew in the latter half of the twentieth century, with its changing international markets, over production and lack of competitiveness. This resulted in the closure of these older heavy industries, and created in their stead unemployment, depression and psychological resignation amongst local communities and a dawning realization of the ecological damage and environmental degradation that had occurred over the years as a result of intensive industrialization. Although the Emscher Region still contained a population of over 2 million people, it had turned into a vast 802 km^2 brownfield site or rust belt with mounting social, economic and environmental problems.

The Federal State of North-Rhine Westphalia realized that the scale of the dereliction and the potential astronomical cost of conventional reclamation was not a viable option, and thus in 1989 devised an alternative approach by setting up the International Building Exhibition (IBA) to carry out the work. The IBA was not an exhibition in the conventional sense but a 'process with activities' (IBA 1994). It was given a ten year mission to achieve the ecological, economic and urban revitalization of the Ruhr Valley and the Emscher River area through the creation of collaborative partnerships with the seventeen local authorities, private industry, professional associations, environmental groups and local communities. This mission was successfully completed by 1999. It is not appropriate here to review the whole ten-year program; others have covered this in depth, notably Shaw (2002). It is pertinent however to focus upon the creation of the Emscher (Landscape) Park itself, arguably an expansion of the term 'park' that suggests how powerful the concept of a park can be once we move beyond the boundaries of traditional definitions (LaBelle 2001).

The creation of the Emscher (Landscape) Park (Fig. 18.7) was the central driving force behind the restorative plans of the IBA, and as a result has become 'a symbol as well as a stimulus for urban, economic, social and environmental change' (Brown 2001).

Fig. 18.7. An overview of the relationship between the regenerating urban forest and the relic industrial structures in the Emscher Park (*photo:* B. Schrader)

The project has been innovative and ground breaking in many ways, but there are three key concepts that have been employed at Emscher that are of interest to urban forestry:

- Harnessing the power of ecology and natural processes as the central theme and integrating concept for the whole regenerative initiative (including the use of natural regeneration to establish nascent woodland, where feasible)
- The use of art as an unconventional approach to engaging with local communities as part of the regenerative process
- How a strong emphasis on the design of place and the re-use of industrial buildings and landscapes can be instrumental in convincing sceptical local communities of the validity of the Park project, and the development of 'imaginative landscapes' as Latz and Latz (2001) have described it

The physical focus of the Emscher Park is the River Emscher itself, which, with its tributaries, provides some 350 km of waterway throughout the region (Fig. 18.9). These rivers were, to all intents and purposes, open sewers, acting as surface drains for all the adjacent industrial processes and human habitation, and returning them to good heart was central to the proposals for the Park. This included a program for re-establishing the natural vegetation and riparian woodland, which quickly provided a highly visible symbol of positive change. Associated with this was the creation of seven green corridors to form a comprehensive system of open space. The design of these corridors intentionally picked up the visual cues of the old industrial landscapes, and incorporated a network of driving, cycling and pedestrian routes to make the open space accessible, both for the local communities and for the growing number of tourists who were beginning to discover the region (Fig. 18.8).

Fig. 18.8. A visual cue: an entrance to the Emscher Park at Duisburg (*photo:* B. Schrader)

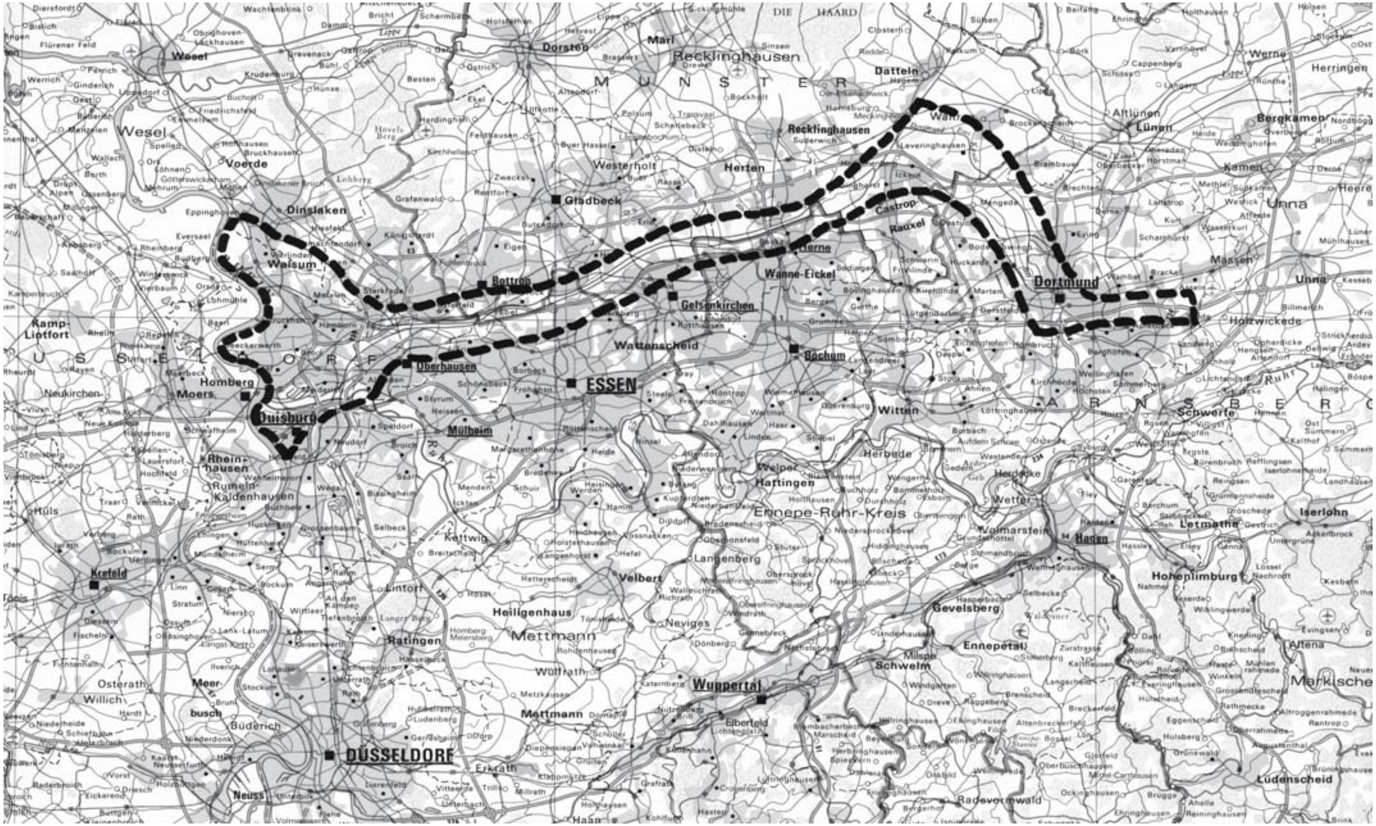

Fig. 18.9. The Emscher Park; a huge, inspirational and innovative regional regenerative project that encompasses some 802 km^2 of brownfield sites. (*illustration:* John Bartholomew & Son Ltd.)

The use of art and artists in this process initially proved to be controversial, the cost of such work being deemed by the local communities to be better spent elsewhere. The IBA persevered however, being well aware that although the cost of art might be expensive, an artist's thinking need not be. So although several high-profile international competitions were organized by the IBA to commission artistic installations for the new landscape, artists were also involved in the multi-disciplinary building and site design teams as part of the ethos that good design was a critical factor in the regeneration of the economy as well as the physical environment. The bespoke design of many of the pedestrian bridges is a good example of this involvement, as is the local distinctiveness and identity engendered by the placing of sculptures, both large and small, in the public green-space areas.

The themes for many of the artistic interventions are taken from the various industrial activities that hitherto were present on site. The whole identity of the region, its history, its economy and its culture, was associated with these old industries and the despoiled landscapes that they produced. The Emscher Park has gone to great lengths to preserve and re-use as much of this old infrastructure as possible, both in terms of built form and the landscape. The IBA considered that it was very important that local communities understood that the ecological devastation of the area had been a function of a specific set of geographical, political and economic forces, and that the people who had created and sustained these activities had been inventive and skilled. A successful future would not be achieved by questioning the past, but by considering how the qualities that created those past successes could be utilized to forge a successful future.

Although the new urban forestry landscapes of the Emscher Park are still relatively young, and will take a generation to mature, they have made a very valuable contribution to the success of the Emscher Park project. The innovation shown by the IBA in promoting an ecological or urban forestry rationale as the catalyst for the reclamation and re-invention of the region, rather than embarking upon the usual site by site approach, has created a unique project in Europe. The IBA's skill in 'bringing the past through the present into the future' (LaBelle 2001) has contributed significantly to the coming of age of urban forestry at the end of the twentieth century, just as the Amsterdamse Bos paved the way at the beginning of the century or the New Town Movement contributed in the middle years. The innovation employed in the delivery of these projects has shown that urban forestry has begun to grow and develop as a dynamic, multi-disciplinary principle of urban design and development. It can be applied with equal success to the restructuring of existing urban areas, as much as to areas of new or extended urban growth and is central to developing the new urban agenda that is unfolding across Europe. What is this new agenda and can urban foresters embrace the changes that this will bring?

18.3 Embracing Change

In the mid 1990s, when the idea of establishing a European research project to look into urban forestry was first being mooted (subsequently to materialize as COST Action E12), there were great changes taking place across Europe with regard to the increased pace of urbanization and variable quality of the results. If anything, this pace has increased, and this phenomenon has been thoroughly documented and discussed in first chapters of this book. It should be borne in mind however that as new thinking takes place, and new scenarios are established, they do not wholly replace the previous ideas but simply add another layer to our depth of knowledge. This applies just as much to urban forestry as it does to anything else.

What has begun to emerge at the beginning of the 21st century is that urban forestry is not just about trees and woodland, nor is it about people as has often been suggested, although the melding of both is of course an important aspect of the concept. Urban forestry is emerging as a philosophical approach to having an overview of the planning, design, implementation and prospective management of the whole mosaic of a town's, a city's or even a region's urban and peri-urban green space, and all the implications that that has to engaging with the associated social, economic and environmental issues and strategies. Urban forestry is a big idea, a big concept, but now that it is established in Europe, the question must be, can it embrace the huge changes that are afoot? What innovations are required to accommodate these changes and establish urban forestry as the metaphysic of urban development that it truly is?

Large-scale projects are beginning to emerge across Europe, and are indicative of the innovation and evolution that is taking place in urban forestry thinking. As the scale of the thinking increases, so does the potential for conflict, particularly in the case of land-based activities such as urban forestry, where continued success depends, to a large extent, on the release of scarce resources in terms of land and finance, both of which are subject to commercial confidence, development pressures, political whim and community demands.

That said, it is beginning to be accepted by politicians and developers alike that in the urban areas that are most in need of regeneration, the occurrence of under-utilized land, derelict industrial land or poor housing areas can place an immense drag on an area's social, environmental and economic well-being. It contributes to social deprivation and to a downbeat image that can inhibit significant economic growth or recovery. As the commercial competition for regeneration increases across the regions of Europe, relying upon the traditional commercial 'hard-end' developments to deliver the required urban regeneration is proving to be unreliable. New and innovative 'soft-end' uses have to be devised. In particular, the multiple benefits that can flow from a cogent structure of urban woodland are being recognised as having great potential to act as a catalyst for urban regeneration on a regional or sub-regional scale. One sub-regional area where this approach is being put into practice is the Thames Gateway in the United Kingdom.

18.3.1
The Green Gateway, Thames Gateway Project

The Thames Gateway Partnership is a sub-regional alliance of thirteen local government authorities, five universities, the East London Learning and Skills Council and the London Development Agency. Their aim, working with the private sector, local communities and other strategic agencies, including the Forestry Commission and the National Urban Forestry Unit (NUFU) is to deliver the economic, physical and social regeneration of London's Thames Gateway (DETR 2000). The project area stretches from Tower Bridge in the centre of London to Dartford along the southern bank of the River Thames, and to Thurrock and the east coast along the northern bank. It covers an area of over 2 200 km^2, which includes most of the 103 km^2 area covered by the Thames Chase Community Forest (Fig. 18.10). Over two million people already live and work within the Thames Gateway area, and this will rise dramatically over the next few years as the area has been identified as one of the National Regeneration Priority Area by central government. Although the regeneration and development of the Thames Gateway is seem as a long-term, market-led project, stretching for perhaps twenty or thirty years into the future, it is anticipated that over 70 000 new homes will have been completed by the year 2006.

The character of the existing landscapes vary considerably, from inner city office and apartment courtyards to peri-urban farms, from established public urban parks and playing fields to small areas of incidental open space and private gardens (Fig. 18.11 and 18.12). Although there are attractive areas existing within the Gateway, and a number of sites protected for the quality of their wildlife (including Ramsar Convention sites and Special Protection Areas designated under the EC Birds Directive), there is also much dereliction, abandoned industrial sites and areas of excessive environmental degradation.

The Planning Framework for the Thames Gateway has five key principles:

- The most should be made of the opportunities in the Gateway area
- A vibrant and sustainable pattern of communities should be created
- Land use and transport must be related
- Life must be brought back to the river and the river frontages
- A new environmental standard is required, calling for better quality design and aftercare of both the artificial and the natural environment

Fig. 18.10. The Thames Gateway is a partnership of thirteen local authorities, and covers an area of 2 227 km^2 to the east of London. It is part of *LOTUS 2000+*, a joint project of four European urban and peri-urban regeneration areas who have adopted a strategic approach to urban forestry as a means of delivering greater sustainability. The other partners are Palermo (Italy), Leipzig (Germany) and Aspropyrgos (Greece) (*photo:* A. Simson)

Fig. 18.11. One of the many landfill sites on the north bank of the River Thames, destined to be reclaimed as part of the Green Gateway Urban Forest (*photo:* A. Simson)

Fig. 18.12. The natural, estuarine landscape of the Green Gateway is relatively flat and unstructured. Here, new urban forest structure planting in the Thames Chase Community Forest begins to construct a vegetative framework in the landscape (*photo:* A. Simson)

Central to achieving the latter principle was the setting up of an urban forestry strategy – the Thames Gateway London Urban Forestry Initiative, now known more simply as the Green Gateway (NUFU 2002). The Thames Gateway is partner in Lotus 2000 + (Long Term Sustainability beyond 2000), the other partners being Palermo (Italy), Leipzig (Germany) and Aspropyrgos (Greece). All partners have identified the need to adopt a strategic approach to urban forestry as a means of delivering sustainable development to a higher standard, and although there is mutual support and encouragement, the site-specific objectives of each partner can differ. For the Green Gateway, this has meant the adoption of the following key objectives:

- Identifying the location and extent of existing trees and woodland in streets, parks, gardens and informal open space, and assess the availability of land where more trees and woodland could be introduced either through planting or by natural succession
- Increasing tree cover and improving existing woodland areas, whilst taking account of other valuable habitats and competing land-uses
- Work within local and regional planning frameworks to protect existing trees and woodland and to add to the forest by the development process
- Raise awareness of the benefits that trees can bring to the people of Thames Gateway London
- Promote good practice and encourage the exchange of experience and resources
- Work in collaboration with public, private and voluntary organizations and with individuals to add to the urban forest by planting appropriate trees and to deliver broader aspects of the strategy through a collaborative partnership approach
- Maximize resources in support of the urban forest strategy, particularly by capitalizing on the combined strength of multi-sectoral partnerships

The merits of partnership working, and the types of partnerships that can exist, have been discussed in this book, and for such information, the reader is referred to Chap. 7. Multi-sectoral partnership working has been the only viable means of achieving the program objectives of an urban forestry project the size of the Green Gateway. To maintain the viability of a partnership that contains such a wide variety of participants and to retain their interest over a long time-scale, it is important that they all realize some of their ambitions early in the project. Thus criteria have been agreed within the Green Gateway Partnership that ensure that all partners, whether they are political partners or public, private or voluntary sector, will be able to report back to their various constituencies that 'the Green Gateway has delivered for us'. What this means in reality is that planting sites in the early stages of the project could not just be opportunistic or be focused on the relatively easily selected sites. They had to conform to strict political guidelines, and had to deliver

- sites in the 10% most deprived political wards
- sites in or adjacent to school grounds
- sites within 100 m of major transport routes
- industrial and employment sites and development sites
- areas which already have a regeneration initiative in place
- sites within large areas of underused amenity grassland

Thus in high profile, sub-regional schemes such as the Thames Gateway, urban forestry is being utilized as a catalyst to assist in the delivery of hard-nosed, politically-driven, regenerative outputs. Such an approach is not without its risks for urban forestry. The key to succeeding on the political stage is delivery, and whilst urban forestry can, through its soft-end uses, embrace change and help to deliver the hard-end use outputs required by the urban regenerative targets set by government, there is still a danger that it is viewed as conceptually opportunistic rather than strategic.

Whilst the support of politicians, land-use planners, developers and the community is vital for the innovative use of urban forestry as a regenerative or restorative tool, such support can still be subject to the cold winds of whim, opportunism and subjective application. This is particularly so in the densely-populated urban regions of north-west Europe where competition for scare land and fiscal resource is high, but where quality of life issues are steadily working their way up the political and social agenda. In such areas, even the declared political support for urban forestry cannot always convince the skeptics or control the availability of land that comes on the open market. Thus even within substantial projects such as the Thames Gateway, it may be difficult not to avoid the present piecemeal, opportunistic approach to the establishment of urban forests, rather than adopt a more strategic, analytical, regional approach. What is required, if urban forestry is to successfully embrace change, is an innovative genuinely apolitical methodology that is transparent enough to be accepted by skeptics and yet be robust and credible enough to have a good chance of delivering a critical mass of urban forest. Such an innovative methodology has been developed in Flanders, Belgium.

18.3.2
The Land-Use Structure Plan of Flanders

The Land-use Structure Plan of Flanders is a ten-year plan that has been adopted by the Flemish Government as the blueprint for sustainable land-use planning throughout the Community. The central aim of the Plan is to improve the quality of life in urban areas by strengthening and augmenting the open space structures in and around urban areas, including the creation of large, recreational urban and peri-urban forests.

Although only a relatively small country (30 528 km^2), Belgium's location has put it politically and economically at the heart of Europe. Flanders is the largest of the three Communities that comprise Belgium, and it contains well over half the population of the country (nearly six million people). Thus population densities are high (over 400 people km^{-2}), and the Community sustains less that 10% forest cover, which is distributed unevenly across the region (Embo 2001).

In such a densely populated and sparsely wooded region, the creation of sustainable urban forests became an important objective of the social policy of the Flemish Government and as a result, several studies were carried out into the feasibility of establishing large-scale urban forestry projects for this purpose. The experience gained in carrying out these feasibility studies highlighted the need for an objective methodology that would select the most suitable and feasible locations for the establishment of such large-scale urban forests, with a view to achieving the highest chance of successful implementation.

Such a methodology was devised, and it has been described in depth by Van Elegem et al. (2002). It was applied to a number of pilot projects in both east and west Flanders, and this resulted in the methodology undergoing a number of improvements and refinements. This culminated in utilizing the technique to seek the most appropriate site(s) for the establishment of a new, large urban forest adjacent to the City of Gent (Van Elegem et al. 1997).

The methodology comprised a three stage, step-by-step multi-criteria approach:

- The 'Excluding Stage' which, through the application of excluding criteria, lead to the initial identification of a number of locations that were potentially viable sites for urban afforestation (11 potential sites were located)
- The 'Suitability Stage', where the potentially viable locations were assessed on their suitability for urban afforestation, a process that lead to theoretically the most suitable locations for such development (potential sites reduced to 4)
- The 'Feasibility Stage', where the most suitable locations were subjected to the rigors of practical feasibility criteria associated with other competing land-use categories. Such analysis lead to the selection of the most 'acceptable' locations for viable urban afforestation. Two sites were identified – the 1 200 ha Kastelensite/Scheldevelde/Rosdam site (Fig. 18.13) and Vinderhoutse Bossen

Thus, although it is a time consuming process, this multi-criteria approach has proved to be invaluable in objectively locating appropriate sites for the establishment of viable

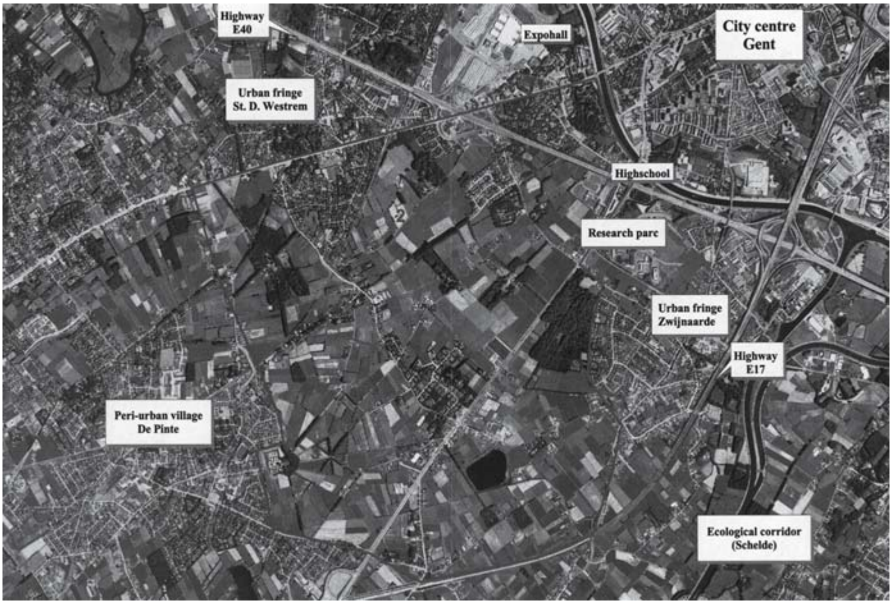

Fig. 18.13. The 1200 ha area to the south-west of Ghent selected for development as the new 'Parkbos' for the city. (*illustration:* Vereniging voor Bos in Vlaanderen (VBV)

Fig. 18.14. Historical continuity: relic elements of the existing landscape – a disused railway line – that will be incorporated into the Ghent 'Parkbos'. Note the line of old pollarded willows that will be retained in the new design (*photo:* A. Simson)

Fig. 18.15. Design continuity between the old and the new: a line of fastigiated trees in Ghent city centre – the linear theme will feature in the new Parkbos (*photo:* A. Simson)

urban forests adjacent to the City of Gent. The establishment of large areas of new urban forest tend to be controversial wherever they are proposed, and this can result in such projects finding it difficult to gain political and financial backing, particularly over the long-term. An essential aspect of this innovative Flemish approach to solving this problem is the skill with which scientists, other professionals, politicians and the representatives of all the local stakeholders are incorporated into each step of the process, which in turn generates broad support and acceptance by all the constituencies involved. In short, all constituencies have a vested interest in the project succeeding.

Such a broad consensus tends to make it easier for controversial projects of this nature to find the necessary favor of both national and local politicians and policymakers. If urban forestry is to successfully embrace the fast-changing urban agenda that is unfolding across Europe, it must widen its spectrum, rise up the political agenda and successfully compete for the scarce resources of land and finance (both capital and revenue). To do this, it will have to gain the trust and respect of politicians, policymakers, commercial developers and the general public, and this can only be achieved by employing robust, transparent, apolitical and socially-inclusive methodologies for the identification of viable development sites, such as that adopted by the Flemish Government.

18.4
Widening the Spectrum – Potential Future Directions for Urban Forestry

In spite of the popularity of reading our horoscopes in our daily papers, predicting the future is not an exact science. The examples of innovative urban forestry projects cited in this chapter highlight some of the positive directions in which urban forestry is going in Europe, how it has successfully come of age and signpost potential directions for the future. These are milestone projects of good urban forestry practice because they show how urban forestry can successfully be used to tackle problems in the round, rather than adopting the more usual stance of dealing with individual issues or sites in isolation. It is tempting therefore, when considering these projects and thinking about the future of urban forestry, to agree with the sentiment expressed by Lincoln Steffens (in 1921, cited in Steffens 1968) when he claimed that *'I've seen the future and it works'*. But what might the future hold for urban forestry and urban foresters in Europe, particularly if we want to expand the concept of tackling problems 'in the round'?

Without a doubt, one of the biggest problems that Europe faces is the problem of urban change. Towns and cities across Europe are subject to constant change, and no urban area is likely to be immune from the forces that bring about that change. Indeed, as the twenty-first century progresses, it is likely that the pace of change will quicken (Brotchie et al. 1995), and this process will bring about a number of re-adjustments to urban areas. Places that once were prosperous may slip into decay and physically or commercially decline, whilst other areas that are currently deemed to be poor or run-down may experience a regeneration or revival. The reasons for this state of affairs are many and varied of course, and paradoxically can have as much to do with image as with physical re- or degeneration (Shaw and Robinson 1998) – a potential opportunity for urban forestry perhaps?

What is constant however is that governments, both local and national, are keen to attract public and private monies and initiatives to try to maintain the status quo, or to try to reverse a declining situation, whilst at the same time increasingly pursuing a low tax, low spend approach to the maintenance of the public realm. Ignoring change is not a viable medium or long-term option for successful politicians and policymakers. It could be argued that a failure to engage convincingly with the changing urban agenda has, in some parts of Europe, led to an exacerbation of their urban problems. Some sectors of our communities are developing a growing urban disenchantment with the failure of urban living to live up to the hype of the political new-urbanism. In extreme cases, this has mirrored a corresponding rise in the fortunes of the political right as a last resort to try to rectify the situation and make urban areas worth living in.

Urban forestry cannot come up with all the answers of course. A number of factors impact on inward investment decisions, including the labor market, the proximity to commercial markets, grant incentives, transport infrastructure and the supply chain, to name but a few. However, inward investment decisions are also affected by the environmental quality of a region or a city. The European Structural Fund Programmes for example (Objectives 1 and 2) place great weight on the role that an attractive and thriving environment has on a region's economy and the quality of life that ensues. This suggests that urban forestry could be cast in the role of a regenerative tool, a catalyst for change and improvement, the positive link between environmental improvement, quality of the landscape and investment decisions and most importantly, the prime driver behind pushing the new urban agenda of livability forward.

Opportunities abound across Europe for urban forestry to assume this role, particularly with the development of initiatives such as the European Spatial Development Perspective, approved in Potsdam in 1999 (ESDP 1999). The thinking behind spatial development within Europe is based upon three policy guidelines:

- The development of a balanced and polycentric urban system, with a new urban/rural relationship
- Securing parity of access to infrastructure and knowledge
- Sustainable development, prudent management and the protection of natural and cultural heritage

The ESDP is not a master plan for the development of the European Union as a whole, but a commitment from Member States to take it forward by producing their own national and regional planning policies and plans. Balanced development is to be promoted by integrated approaches, both across policy sectors and also across levels of administration. Integration in terms of administrative levels is particularly important in relation to the European Commission's emphasis on building cross-border regional networks and programs, and the production of national spatial development frameworks is well underway in many member states. It is to be hoped that urban forestry can put forward a convincing argument to engage with developments at this level. Indeed, if it is to progress conceptually, it is crucial that it does, and it again underlines the necessity for urban foresters to be aware of the big picture of pan-European policies and activities and be able to act in concert to address them. This can be partially achieved by supporting and developing initiatives such as EUFORIC (The European Urban Forestry Research and Information Centre) and further developing and nurturing an inter-active network of European urban foresters.

In pursuit of this big picture, urban foresters increasingly spend much of their time extolling the virtues of the urban forest to anyone who will listen, focusing on the multiplicity of benefits that trees can bring to urban areas, as if this is the only way that we can generate the necessary public, political and financial support to justify the urban forest. Future progress may however depend on us heeding Spray's (2000) cautious comment that suggests that such a narrow focus may be a flawed concept, as it sees trees as only service providers. He suggests that this concept does not go far enough. To progress, we require new thinking, particularly into the complex questions surrounding the establishment of values for trees, the host of ethical questions that subsequently arise, and the necessary shift from a quantitative approach to urban trees to a more qualitative approach.

This would suggest that there is no room for complacency in promoting the concept of urban forestry in the future. Talking to or writing for nodding heads, something we urban foresters are most comfortable at doing, could be deemed to be an exercise in complacency. If we do what we have always done, we will achieve what we always achieve, and we know that this is not likely to be good enough. Working in partnerships is currently an important, effective and rewarding way of ensuring that the urban forestry message is delivered on the ground. This will continue and expand of course, but if urban forestry is to progress further and engage with the new urban agenda, new alliances will have to be forged and new advocates found, particularly amongst non-tree people.

Success in the future will increasingly require urban foresters to engage with working at the policymaking or political level, both locally, nationally and perhaps internationally, so that urban forestry is integrated into the fabric of social, economic and environmental policymaking thinking. This will certainly involve us in antagonistic cooperation, where surprising and productive relationships can exist between people who normally would be somewhat suspicious of each other, but who recognise that, by dint of such communication and cooperation, both have a better chance of achieving their goals. And as Evans (2002) has observed, such communication might be improved if we occasionally engage with a less anthropocentric, scientific-technological approach to trees in favor of one that recognises and promotes their cultural dimension.

The future of Europe is going to be organized around cities. As Castells (1993) states, '*major cities throughout Europe constitute the nervous system of the economic and political body of the continent. The more nation-states wane, the more cities emerge as the driving force in the making of a new European society.*' However, such cities will probably not be the sort of cities that we are familiar with today. There is no agreed blueprint for what a city of the future should be. The post-industrial city is still evolving (it is still so young), and seems to have more in common with its pre-industrial counterpart than with the design-fest approach of contemporary urban design philosophies. Indeed, we may even have to unmake cities to help reconnect people, both psychologically and physically, with natural processes. (Nicholson-Lord 2003). This will involve considerable and rapid change, and for many people, including policymakers, such change is likely to be difficult because the present is relatively comfortable for us Europeans.

Change will come however, and urban forestry has the potential to be an integral part of that change. The innovative projects outlined in this chapter have shown how urban forestry has evolved, and how challenging, complex and adaptable it can be. It is exactly this complexity that makes it so valuable. But if it is to gain its rightful place on the new urban agenda, urban forestry must continue to evolve, continue to develop new meanings for old practices, and emerge as a genuinely multi-disciplinary exercise. Research and practice also have to continue to break the walls of the traditional professional disciplines and co-opt perspectives and methodologies from all of them, particularly drawing upon the expertise of urban design, the planning, social and natural sciences, forestry, landscape architecture, arboriculture, horticulture, the arts and development economics, to name but a few. A tall, theoretical order perhaps, but as the social scientist Kurt Lewin (1951) said, '*There is nothing so practical as a good theory*'. Maverick views? Well, perhaps, but it should be borne in mind that today's maverick views are often tomorrow's orthodoxy, and Evans (2001) is right when he says that '*the challenge for all of us who understand that trees matter is to find ways of reaching that promise*'.

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Index

A

H

I

M

N

O

Q

R