Visual Aspects in Urban Woodland Management and Planning

Åsa Ode
Department of Landscape Planning
Alnarp

Doctoral thesis
Swedish University of Agricultural Sciences
Alnarp 2003

Acta Universitatis Agriculturae Sueciae
Agraria 380

ISSN 1401-6249
ISBN 91-576-6420-X

Abstract

Ode, Å., 2003. *Visual aspects in urban woodland management and planning.* Doctor's dissertation.
ISSN: 1401-6249, ISBN: 91-576-6420-X

Urban woodland is an important component of people's everyday environment, both as an attractive environment to visit as well as being an intrinsic part of the surrounding landscape. This thesis focuses on one specific aspect of the urban woodland - the visual. The visual aspect is how most people experience the woodland, both when visiting and as part of their everyday landscape. In order to take visual aspects into account there is a need to have tools and approaches for analysing and describing these.

This thesis highlights the importance of management context as well as providing tools for the spatial analysis of visual aspects. The methods used are a combination of predictive modelling, literature reviews and visibility analysis. Based on landscape aesthetic theories, a set of visual concepts were distinguished that were also supported by management guidelines. These visual concepts are: diversity, scale, visual accessibility, stewardship, naturalness and coherence. Visual concepts are presented both in relation to their theoretical basis and to the physical attributes influencing them.

Visibility analysis was explored as a way of modelling visual aspects in urban woodland management and planning, with a focus on woodland as an important visual element in the landscape. Visibility models were developed as a way of analysing the contents of the view with regards to woodland. Using a case study area in Aberdeen, Scotland, the contents of the view were analysed both in relation to preferred forest types as well as for the concept of visual diversity.

In addition to the focus on visual aspects, this thesis also highlights facets of the management context that influence visual management. These are urban pressure, cultural context and management paradigm. These three factors are important for interpreting and understanding the way management and planning strategies are carried out and hence offer insights into visual resource management.

The result of the thesis provides a framework for including visual aspects in urban woodland management and planning as well as being a base for future research within the field.

Keywords: urban forestry, landscape aesthetic, spatial analysis, landscape preference.

Author's address: Åsa Ode, Department of Landscape Planning Alnarp, Swedish University of Agricultural Sciences, PO Box 58, SE-230 53 Alnarp, Sweden.

Content

Appendix

Papers I-V

The present thesis is based on the following papers, which will be referred to by their Roman numerals.

I Ode, Å.K. and Fry, G. A model for quantifying and predicting Urban Pressure on Woodland. *Submitted manuscript.*

II Ode, Å.K and Fry, G. 2002. Visual aspects in urban woodland management. *Urban Forestry and Urban Greening,* 1:15-24.

III Ode, Å. Research in urban woodland management and planning – two parallel paradigm. *Manuscript*.

IV Ode, Å.K. and Miller, D.R. Analysing the woodland content of views: A case study of Aberdeen, Scotland. *Submitted manuscript*

V Ode, Å.K and Miller, D.R. Assessing visual aspects of woodland diversity. *Submitted manuscript.*

Introduction

This thesis focuses on one important part of people's everyday landscape – the urban woodland. The thesis has further chosen to focus on one specific aspect of the urban woodland, the visual. The aim has been to explore what visual aspects are, what their role is in woodland management and planning, and how they may be encapsulated for the analysis of visual aspects. The thesis considers theories of landscape aesthetic explaining how we see and react to our environment. It strives to use these theories for tools to incorporate visual aspects in the management and planning of urban woodland. Through the use of case study areas both in Sweden and Scotland the intention is to provide knowledge that is not dependant on regional or cultural context, but is applicable on a broader European scale. Woodland can be strongly influenced by urban processes, and so may be defined, by dint of its spatial location relative to urban areas, as "urban woodland". This provides the woodland with unique characteristics and situation. Through its location in the urban landscape it is a woodland that people experience on a daily basis, making the visual appeal of the woodland important.

How can visual aspects be taken into account in management and planning? This thesis emphasise the role of woodland in relation to the urban area. Considering a number of different approaches, it provides a syntax for the inclusion of visual aspects in management and planning. Of these, the approach taken further for investigation has been the concept of "the woodland" as an object in space. As such "the woodland" may be viewed as one feature among many forming a landscape but it self composed of smaller objects (for example compartments). It is both the specific characteristics of component objects and the arrangement of these components in space, which is seen as characterising the higher level of "woodland – landscape". A consequence of focusing on the woodland as an object is that experience of woodland has been of less interest, and will therefore not be specifically stressed in this thesis, other then its consequences for the woodland characteristic. This thesis will subsequently emphasise the physical appearance of the woodland in relation to visual quality.

Urbanisation and the need for urban nature

Our society is becoming more and more urbanised. Urbanisation is a worldwide phenomenon with 70 % of the European population living in urban areas (EEA, 1999). Urbanisation is not only affecting the urbanised areas, urban processes exert an influence on the surrounding landscape. These urban processes cause among other effects fragmentation of forest (Medley, McDonell & Pickett, 1995) leading to a change in the landscapes spatial pattern as compared to the unaffected rural area (Antrop & Van Eetvelde, 2000). The process of urbanisation has lead to a decrease in available green spaces within the city and hence put pressure on the existing woodland.

The positive effect of urban woodland on the environment has been the subject of several studies, focusing both on the biodiversity and the reduction of pollution (*e.g.* Forrest, Konijnendijk &Randrup, 2000). In an urbanised society, green areas are also important for people as a place for amenity, contact with nature and

recreation. Green areas have been proven to have positive effects on peoples health and to reduce stress (*e.g.* Grahn & Stigsdotter 2002, Kaplan 2002). These benefits could be provided by urban woodland as one part of the urban green structure and could therefore be considered as an essential part of the urban fabric.

Urban forestry

Urban forestry is an expanding research field through Europe, with the focus on tree and forest resources in the urban or peri-urban area. Urban forestry is often described as an interdisciplinary and transdisciplinary field (Randrup & Nilsson, 1998) with researchers and practitioners from different backgrounds researching in and influencing the development of the field. Nonetheless, urban forestry could still be characterized as an area of applied research where the practical implications of research results are paramount, and the development of theories has been of less significance. There is a need for development of a stronger theoretical base within the field, as highlighted by Konijnendijk (1999). This thesis aims to contribute to such a base of theory for urban forestry, connecting it to the theory developed within landscape aesthetics.

The field of urban forestry has been growing since its start in North America in the 1960s, when Jorgensen coined the term 'urban forestry'. However, the definition of an urban forest varies within the field. Between Europe and North America a simplified distinction is that the North American tradition includes all vegetation within the city (Miller, 1997) and the European definition emphasises the meaning of forest as a forest ecosystem (Konijnendijk, 1997). Konijnendijk (1999) identified a further distinction within urban forestry – tree based and forest based. Since this thesis focuses on the forest element specifically, the term urban woodland is used to avoid confusion.

The definition of urban woodland for this thesis is an identification of the core of the urban woodland concept, rather than a distinction of the outer boundaries. The urban woodland is for this thesis therefore defined as:

- **dominated** by a **tree canopy**, though open areas and areas with bushes could be a part of the woodland.
- influenced by **urban processes**, mainly through visits by urban people.

This definition of urban woodland allows the more naturelike parks with a tree cover, as well as the urban influenced woods in the rural landscape to be included in the urban woodland concept.

The urban woodland has different origins, which in turn provide different context for management (Konijnendijk, 1999). However, the urban woodland will, regardless of origin, have to meet the demands of an urban society, demands arising from the benefits and value of urban woodland and nature as presented by several authors in the field (see Table 1). However, each of these values or benefits puts different demands on the woodland in order to be fulfilled and may even be contradictory with regards to their expectations of the woodland (*e.g.* Konijnendijk, 1999; Tyrväinen, Silvennoinen & Kolehmainen, 2002). In order to create acceptable solutions and rich environments for the urban population, management based on the values of the given urban society is required

(Konijnendijk, 1999) and would benefit from taking visual aspects into account in order to create solutions acceptable for the general public.

Table 1. *Benefits and values of the urban forest (based on Adams and Dove, 1989; Baines, 1995; Bradley, 1995; Bradshaw et al. 1995; Evans, 1984; Gordon, 1990; Grey & Deneke, 1986; Hodge, 1995; Hough, 1995; Konijnendijk, 1999; Laurie, 1979; Rydberg and Falck, 2000; Schroeder, 1989; Smardon, 1988; Wheater, 1999).*

Social/individual				Economical		Technical/Environmental		Biological
Emotional	Intellectual	Socially	Physically	Direct	Indirect	Climate amelioration	Engineering use	
- Perceived benefits - Freedom, - Peace - Solitude - Harmony - Spiritual refresh-ment - Contemp-lation	- Human and historical perspectives - Cultural heritage - indicator of historic events. - Evoke memories of other times and places - Amenity - Beauty, aesthetic appreciation - Architec-tural use -Aesthetic use	- A vehicle for community involvement - Recreation - Children play - Contact with nature and wildlife - Environ-mental amelioration - Education	- Children play and health - Improve-ment of health, both psychological and physiological - Higher perceived quality of life - Recreation	- Natural resource, timber and fibre - Forest productive industries - Land reserve - Estate value - Tourism and recreation - Biofuels	- Attracting development -Energy conservation	- Temperature modification - Reducing heat islands. - Microclimate - Summer shade - Wind protection - Air movement - Precipitation and humidity	- Erosion control - Improve water quality - Watershed protection, - Wastewater management -Noise abatement - Improve air quality by pollution reduction - Glare and reflection control - Traffic control - Noise reduction - Shelter - Dust traps	- Habitat for the urban fauna - Nature conservation - Ecological stabilisator - Ecological function - Ethic - own value - Block of native species - Provide microclimate for woodland plants - Preservation and maintenance of forest biodiversity

The significance of visual aspects

"The landscape is both inherently visual and also much more than simply visual." Lange & Bishop, 2001.

The visual aspects are just one quality of the landscape among many. However, since most people base their experience of their environment primarily on their visual senses it is an important quality for people. The importance of taking visual aspects into account in landscape assessment and planning has been stressed both in research (Lange, 1994) and application (*e.g.* Countryside Commission, 1993). However, studies have shown that the visual aspects are often only considered in the last phase of projects and impact assessments, to show what the impact on the visual resource would be from the exploitation rather then an integrating aspect through the process (Lange, 1994).

All landscapes are not under the same pressure for visual exposure, whether this be due to inherent qualities influencing the visibility of landscapes (*e.g.* Fisher, 1996; Miller, 2001) or purely through variation in the number of people present. The landscape in the urban fringe is a landscape that is among the most exposed to people through its being part of the everyday landscape for a large part of the population. It is the landscape that people see and use on a daily basis.

Within the field of landscape aesthetics there is a substantial body of theory to explain people's reactions to and preferences for landscape. These explanations are further represented by several different paradigms with different rationales for the explanations given (*e.g.* Lothian, 1999; Zube, Sell & Taylor, 1982). In the frame of this thesis some of these approaches will be further emphasised in an urban woodland context.

However, taking visual aspects into account in landscape management and planning is not about explicitly creating well-liked landscapes. It is also about

providing means of discussing and analysing the existing landscape, as well as methods for evaluating changes caused by natural processes or management and planning actions. Approaches for analysing and describing the landscape based on its aesthetic quality have been of interest in landscape research, with several approaches presented (*e.g.* Bell, 1998; Muir 1999). One approach for describing the visual component in landscape is through the use of visual concepts describing the spatial pattern of the landscape (Bell, 1998). Miller (2001) presents another approach, using visibility analysis of different land cover for evaluating changes in the visual quality of the landscape.

Visual aspects are a feature that is significant for most people's experience of the landscape and is hence an important character of the urban woodland. It is part of the everyday environment for people, both through visits to the woodland and as a component in the landscape. Management and planning for visual aspects in urban woodland provides one important approach for creating enjoyable everyday environments and is also a means for attracting people to recreation and contact with nature.

Objectives

In the research of urban forestry the need for new and creative strategic management has been stressed (Konijnendijk, 1999; Nilsson & Randrup, 1997). Konijnendijk (1999) found in his comparative European study of urban forest policy that there is a need for more innovative, strategic management, in contrast to the technical approaches in use today. "Urban forest management asks for appropriate, innovative methods and techniques…" (Konijnendijk, 1999). There is a further need for improving the knowledge base for planning, design and management, in particular for the translation of research findings into practical management principles (Nilsson & Randrup, 1997).

In his overview Konijnendijk (1999) stresses the need for improving the understanding of people's relationship to urban woodland, what they like and what they want, in order to include it in management and planning. To a large extent people experience the woodland visually and therefore the evaluation and reaction towards its appearance is important. As a research area landscape aesthetics has much to offer the urban-woodland manager. Several studies focusing on the experience of woodland and peoples behaviour has been taken through (*e.g.* Axelsson-Lindgren, 1999; Kardell, 1982; Lindhagen & Hörnsten, 2000; Koch & Jensen, 1988). These studies have provided an important knowledge base with regards to the relationship between people and woodland, both with regards to emotions as well as behaviour. However, within the research there has been little interest in providing a deeper discussion of spatially applicable concepts in order to analyse the visual resource of woodland (see Paper III for an overview of the research).

This thesis concentrates on new and innovative approaches for management and planning of urban woodland based on theories developed in landscape and forest aesthetics. In order to do so, technical aspect of management (such as thinning regimes) have been found to lie without the thesis framework.

Beside the more general aim of improving the theory base of urban forestry with regards to visual aspects, the following objectives for the thesis have been established:

- To explore selected factors influencing the context of urban woodland management and planning.
- To develop a method for describing urban woodland based on spatial variables and quality factors.
- To develop methods for describing and quantifying visual quality in urban woodland.
- To explore how visual concepts and visibility analysis could be applied in a management and planning context.

Theoretical framework and methodology

This thesis has come to focus on the visual aspects of urban woodland management and planning. The thesis focuses on one limited aspect with regards to urban woodland management and planning – the visual. The work with the thesis combines the knowledge available in two specific and distinct fields – urban forestry, and here explicitly urban woodland management and planning, and the field of landscape aesthetic. This thesis has limited itself to just focus on urban forest, excluding the research conducted in relation to for instance multiple use forest and landscape management, even though knowledge from these areas are clearly applicable also in an urban woodland context.

As a frame for the work with the thesis a general methodology has been chosen through a spatial approach. This is clearly excluding some parts of the field of visual aspects. However, the choice of limiting the thesis to a spatial approach means that a further depth could be reached with regards to that issue.

In the following sections the main approach for the thesis will be presented, and the field of urban woodland management and planning and landscape aesthetic will be outlined and presented in relation to the topic of the thesis.

Research methodology

The thesis is through its application of theory from landscape aesthetic on urban forestry using an explorative approach when discussing what visual aspects are and how they could be analysed and described in a management and planning context. Through reviews of literature the context of management as well as visual concepts are explored, providing a theory base for the further application of these concepts in an urban woodland management and planning context.

For the application of the theory in an urban woodland context, a spatial approach has been chosen. One of the main objectives for the choice of a spatial approach is that in management and planning communications is mostly done through maps. The focus through out the thesis is hence on the spatial structure of the urban woodland and its spatial configuration in the landscape, relating this pattern to visual aspects. For spatial analysis of patterns and structure, the uses of Geographical Information Systems (GIS) provide a powerful analytical tool, and have subsequently been used for management and planning in the forest (*e.g.*

Wing & Johnson, 2001). GIS has been described as: "An organised collection of computer hardware, software, geographic data and personnel designed to the efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. Certain complex spatial operations are possible with a GIS that would be very difficult, time-consuming, or impractical otherwise" Berry (1993, after ESRI 1991). GIS has further been used in visual resource management for a landscape context (*e.g.* Fisher, 1996; Miller, 2001).

Through the thesis explorative character, it does not strive to provide direct applicable and transferable result for the practical management. The thesis will rather show on innovative ways of analysing and describing visual aspects that through further development could be practically applied in management and planning.

Urban woodland management and planning

Planning and management are intertwined concepts, as elaborated by Steiner: "The management of resources may be a goal of a planning process, conversely planning may be a means of management" (Steiner 1991). The process of planning involves the establishment of goals, policies and procedures (WWWebster Dictionary 1998) and management are concerned with the accomplishment of the goals set in the planning process. Management is therefore the implementation of measurements (or none-measurements) in order to reach the desired end (Steiner 1991).

Within the context of urban woodland, the planning sets the goal and priorities for the management to be implemented. The goals and priorities are set by society, depending on the values and benefits they demand on the woodland. However, all management strategies affect the woodland, through the direct measurement and the natural dynamics of the woodland. The management (or non-management) affects the appearance of the woodland, and this appearance could subsequently be taken into account in the planning and management process.

Konijnendijk (1999) provides an overview of the European situation with regards to urban forestry as it stands at the turn of this century, the main emphasis being on the woodland element. His study shows that throughout Europe, the urban woodlands are predominately owned by municipalities, and hence managed by them. However, there is often a lack of competences and overall strategies for urban woodland management, with management focusing more on the operational level and less on planning and policies. Management plans often focus on the technical aspect of management rather then on the goals and strategies to reach those goals. Konijnendijk further identifies both private and public actors (mainly representatives on a local level; politicians, public, interest groups) involved in the planning and management process, with a varying, often low, degree of public participation. Though Konijnendijk (1999) found that throughout Europe the institutional setting for management is similar, there are still differences in management practice between countries (as explored in Paper II) that could be explained by the introduction of a wider management context.

Konijendijk stressed the differences between urban and rural forest management and the need for a change in approach when taking rural forest practice and transforming it to urban. Within the suburban landscape, there is a gradient of urban influence, changing the character and pressure on the landscape (*e.g.* Medley, McDonell & Pickett, 1995). An assumption is therefore that this gradient of urban influence is also found within woodland and thereby also a gradient in management strategies with regards to urban influence.

Urban forestry is a multi- and transdisciplinary research field, and the management of these areas are also done with several competences involved. Between disciplines in nature resource management different paradigms towards management could be found, relating to man's relationship with nature – the biocentric and the anthropocentric paradigm (*e.g.* Stanley, 1995). These paradigms affect the goals and strategies for management and planning. While the biocentric paradigm focuses on the ecosystem and ecological health the anthropocentric paradigm focuses on the human needs and benefits from the natural resource. In Paper III the two paradigms representation in urban woodland management will be examined.

Visual aspects - the field of landscape and forest aesthetics

We perceive the landscape and our surrounding environment through the use of our senses. Sight interacts with other senses, like hearing, smell and touch, but is considered to be the most important, contributing to 80% of our impression of our surroundings (Bruce, Green & Georgeson, 1996). While recognising the importance of other senses, this thesis has focused solely on the visual perception. With regards to explaining our reactions and preferences, several rationales exist and several frameworks for classifying these models have been developed, as presented in Table 2 (Daniel & Vining, 1983; Lothian, 1999; Zube *et al.* 1982). The first division found is with regards to a subjectivist and an objectivist paradigm (Lothian, 1999). For the subjectivist paradigm the focus is on the provision of psychological explanation to preferences and hence focusing on the responses. The objectivist paradigm on the other hand focuses on the physical appearance of the landscape.

Table 2. *Comparison of paradigms of landscape quality assessment, after Lothian (1999). Subjectivist paradigm*

Lothian, 1999	Subjectivist (psychological) paradigm			Objectivist (physical) paradigm	
Zube et al. 1982	Psychophysical	Cognitive	Experiential	Expert	
Daniel and Vining, 1983	Psychophysical	Psychological	Phenomeno-logical	Ecological Aesthetic	Formal Aesthetic

The subjectivist paradigm

Within the subjectivist paradigm three approaches towards landscape has been distinguished according to Lothian (1999), the psychophysical, the cognitive and the experiential. In the frame of this thesis the focus has been on the psychophysical and cognitive approach through its stronger links with the visual

quality of the landscape. Both the psychophysical and the cognitive approach have used empirical preference studies to build and form their respectively theory base.

For the psychophysical approach the focus for these studies has been the "liking" of landscape measured on a scale (Daniel, 1990). This aesthetic evaluation has then been explained through the measure of variables within the view, these including features like perimeter of vegetation and water (Daniel & Vining, 1983). The psychophysical approach to landscape has to a less extent come to focus on linking their result regarding preferred variables with explanation theories with regards to spatial arrangement. However, the psychophysical approach has been applied in forest management and planning through the development of the Scenic Beauty Estimation model among others (*e.g.* Daniel & Schroeder, 1979). Within the psychophysical approach several of the Nordic preference studies could be classified to, since the focus has been on providing information with regards to preference based on the ratings of forest environments rather than linking them to an explicit aesthetic theory (*e.g.* Hultman, 1983; Koch & Jensen, 1988). However, while the psychophysical approach as presented by Daniel (1990) focus on the combination of variables, the Nordic studies have in a higher degree come to focus on the environment as a whole or individual elements, in other words – not the interaction between several variables. Several of the findings from this approach has been presented by Ribe (1989) in his review of preference research in relation to forest attributes, showing:

- Open forest is preferred to dense
- Old trees are preferred over young trees.
- Ground slash and other evidence of harvest are disliked
- Ground vegetation increases preference
- Specie variety enhance preference

Beside the attributes provided by Ribe, there have also been findings from both the Nordic countries and the UK showing on the preference for mixed and broadleaves forests contrary to coniferous (*e.g.* Koch & Jensen, 1988; Lee, 2001).

Within the cognitive approach Kaplan & Kaplan (1989) provides an explanation framework for preferences relating to cognitive aspects of our environment. The framework has as its basis our need to obtain information about the surrounding environment in order to survive within it. This could be explained with the matrix presented in Table 3. The matrix is concerned with two dimensions: informational needs (understanding and exploration) and the readability of information (immediate and inferred/predicted).

- Coherence – the order and level of direction of attention, how the scene hangs together.
- Complexity – the amount of visual elements present in the scene, how intricate and rich a scene is.
- Legibility – the intuitive understanding of a place and how easy that place is to remember. While coherence is a spontaneous factor, legibility is dealing with both the coherence and the structure.
- Mystery – the promise of learning something more in the scene if we could walk further into it.

Table 3: *The Preference Matrix as developed by Kaplan & Kaplan (1989).*

		Informational needs	
		Understanding	*Exploration*
Readability of information	*Immediate*	Coherence	Complexity
	Inferred/predicted	Legibility	Mystery

For the cognitive approach it has been a rather strong focus on people's spontaneous and instant reaction towards the landscape, rather then the actual landscape. Based on the reactions, explanation and measurement of the concepts within the scene has been analysed (*e.g.* Daniel & Vining, 1983). There have been few studies trying to establish linkage between vegetation structures with the exception of Purcell & Lamb (1998). In their study they showed that the results from their preference study of vegetation formation and density and extent of view could be related to the informational framework. The higher preference for low sparse forest over scrub could be explained through the increase of legibility, mystery and coherence.

The objectivist paradigm

While the subjectivist paradigm as presented above mainly has come to focus on preferences and aesthetic as instant and spontaneous responses the objectivist paradigm is in a higher degree focusing on the respondent's prerequisite knowledge as a base for aesthetic appreciation. Within this paradigm Daniel and Vining (1983) distinguished two different approaches, the 'Ecological Aesthetic' and the 'Formal Aesthetic'. Both these could be referred to as belonging to an expert paradigm (Zube, Sell & Taylor, 1982), though with foundation in different theories.

The Formal Aesthetic has its foundation in design theories, linking the description of landscape with terms developed in the aesthetic philosophy and art, and later transferred to a landscape context. The aim of the approach has been to provide a language to describe the landscape with regards to aesthetic qualities, mainly in relation to design, planning and assessment (*e.g.* Bell, 1998). Within the Formal Aesthetic several concepts exist to explain the visual quality, both with regards to the physical attributes of elements but also their interrelationship (see Table 4).

Table 4*: Some of the aesthetic concepts found and used by the formal aesthetic paradigm (Bell, 1998; 1993; Daniel & Vining, 1983; Lucas, 1991).*

Physical attributes	Form/shape	Line	Colour
	Texture	Size	
Interrelationship	Diversity/variety	Spirit of place	Scale
	Shape	Visual force	Harmony
	Unity/harmony	Strength	Contrast
	Continuity	Rhythm	Symmetry

The assessment of the concepts put forward by the design approach requires formal training in order to interpret the concepts. The design approach shows a low reliability in tests, either when calibrating between experts or with the public generally (Daniel, 2001). This low reliability would argue that the concepts

developed are less valuable for visual assessments and analysis. However, the Formal Aesthetic is still contributing by introducing concepts that are useful in order to explain features in the landscape. The ability to get coherence and a higher knowledge with regards to the aesthetic concepts could probably be enhanced through training, as shown argued by Bell (1998).

The Ecological Aesthetic links aesthetics with ethics and sustainability and has also been referred to as 'Positive Aesthetics' (for use of the terms see Bishop, 1999; Parson & Daniel, 2002). At its base, it relates to Leopold's 'land ethic' (Leopold 1949), which advocates the moral consideration for aesthetic. As Carlson explains "…those landscapes we aesthetically prefer will typically be ones that express things we ethically prefer" (Carlson, 2001). This approach is emphasising the role of preconception and knowledge, particularly in relation to the sustainability of the ecosystem, rather than physical appearance alone (Carlson, 2001; Gobster, 1999). A concept that has been put forward by Nassauer (1995) and stressed by other researchers of this approach (see for instance Carlson, 2001) is the concept of care and stewardship. The concept of stewardship was put forward by Nassauer (1995; 1997) for explaining preferences for agricultural landscapes. However, while the main advocates of the Ecological Aesthetic stress ecological health as the basis for aesthetically pleasing landscapes, Nassauer (1997; 2002) emphasises the need for the understanding of what is perceived as being good for the creation of an ecologically healthy landscape. This concept of "perceived good management" has further been put in a forest context by, for instance, Sheppard (2001) stressing the need for visible stewardship. The ecological aesthetic provides a link between ecology and aesthetics where our aesthetic experience is linked to our ethical values. It has placed a focus on ecologically stable landscapes, stressing the appreciation of naturalness.

Two paradigms – one approach

The subjective and objective paradigm differ significantly in their rational for explaining and evaluate visual quality of the landscape. However, they are similar in that they evaluate the same landscape, with the same patterns found within, using the same type of main medium for perception – the vision.

This thesis focuses on the landscape and its patterns rather than the reaction and explanations for these reactions to the landscape. In relation to describing these patterns the different explanation models provide different clues and approaches for the spatial analysis. For the work with describing the visual aspects of urban woodland, the explanation models and their differences with regards to their rational for preferences and quality is hence of less interest. Both the subjective and objective paradigm could contribute to the development of concepts for describing visual quality, as shown by Bell (1998) who has shown on the value of combining the design approach and cognitive approach.

The main benefit of the subjectivist paradigm comes from its strong empirical base, for both woodland elements as well as the provision of the informational framework developed by Kaplan & Kaplan (1989). However, through its focus on people's reaction rather than on the landscape, some of the explanations are hard to apply. The objectivist paradigm is on the other hand focusing the landscape and

therefore provides concepts developed for the description of the spatial attributes. Though through its base as an expert paradigm, there has been harder to provide methods that are coherent and repeatable.

Based on the two paradigms this thesis builds a set of concept supported in theory and applicable in a woodland context. These concepts applicability will be focusing both on the woodlands visual quality from within the woodland as well as a feature in the landscape.

The studies

The thesis is based on empirical studies as well as review and synthesis of previous work related to visual aspects of urban woodland management. This has been done through the use of three separate studies:

- Modelling of urban pressure, southwest Sweden (Paper I)
- Literature review of both guidelines and scientific publications (Paper II and III)
- Visibility analysis, Aberdeen, Scotland (Paper IV and V)

Case study areas

The studies forming part of this thesis have taken place in two different contexts, southwest Sweden and the area of Aberdeenshire, Scotland, (see Figure 1).

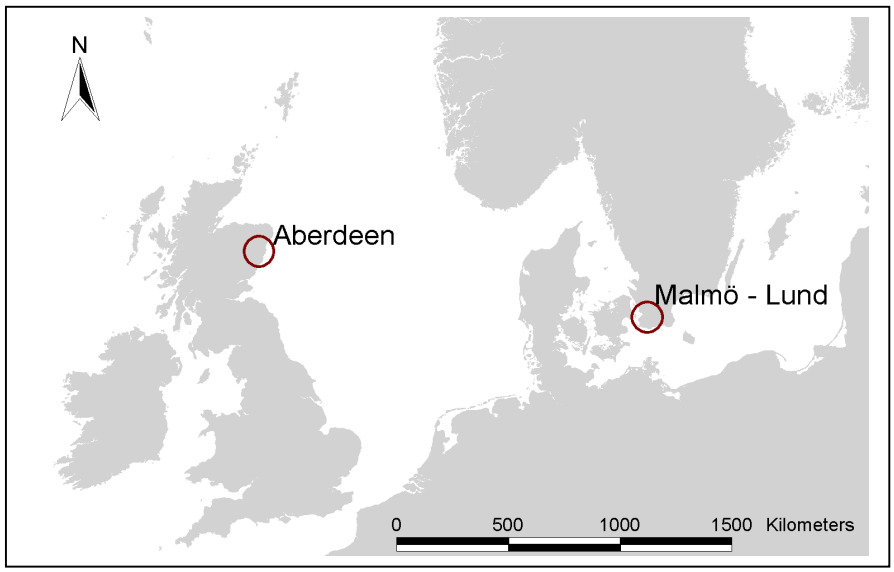

Figure 1: *The location of the two case study areas used for the studies.*

The study of urban pressure on woodland, Paper I, was carried out in the Malmö region in Scania, the most southern part of Sweden. The region surrounding Malmö has been identified as an urban area, with the rural landscape characterised by intensive agriculture and high density traffic networks (Germundsson &

Schlyter, 1999). The intense agricultural use leaves little land accessible for the public, in spite of the Scandinavian common right of access. For Malmö municipality, less than 20 % of the land is accessible to the public, and for some of the smaller municipalities in the case study area, accessible land is even more scarce (Germundsson & Schlyter, 1999).

The study of visibility in Papers IV and V was applied to the built-up area around Aberdeen, north-east Scotland, and is defined up to the boundary of the Aberdeen City local authority, an area of c.187 km^2. North-east Scotland is not a heavily urbanised area compared with the central valley of Scotland and much of England. The areas to the north and south of the city, and those along the sides of the Don and Dee rivers, are dominated by agricultural land and open fields, the principal woodlands are located in the western part of the area. The woodlands that are accessible to the public are predominantly those owned and managed by Forest Enterprise. Those woodlands also tend to be the largest of the woodlands within the area.

The two areas show similarities as well as differences between them. The similarities between them mainly concern the study areas themselves. Both are strongly urbanised, with populations for both areas expanding. For both the rural areas are dominated by intense agricultural use. However, there are also significant differences. While the Swedish case area is part of a larger urbanised region, the Scottish case study area is surrounded by rural areas with low population density. The woodland parts of the two areas also show variation between them, the Swedish mostly contains native species like *Fagus sylvatica and Pinus sylvestris* while the Scottish site contains a large amount of non-native coniferous species (*e.g. Larix europeae and Pinus contorta*). Beside these physical differences of the case study areas there are also institutional and cultural differences between the two countries. Some of the institutional differences as well as a more general discussion of the differences and similarities between the two countries are presented in Paper II.

Material and methods

Spatial modelling

In Paper I a spatial modelling approach was used in order to determine the degree of urban pressure on woodlands in the urban fringe. Through the use of Geographical Information Systems (GIS), opportunities exist to describe and analyse spatially explicit factors and processes (*e.g.* Kliskey, 2000). The general aim of the study was to classify woodlands by urban pressure rather than predict visitor numbers. The approach combined spatially explicit environmental and social parameters, developing an index of urban pressure from these. The steps used in the development of the model for urban pressure on woodland were:

- Identification of factors affecting public access and attraction
- Quantification of the factors identified and production of map layers.
- Weighting of layers and development of the model.
- Field inventories and validation of the model.

The attraction of woodlands to the public is based on several different aspects, which can be summarized by three main factors: distance, access and quality of the woodland (Coles & Bussey, 2000). The distance and accessibility factors were analysed through the application of a distance-decay function for each settlement and roads, providing a map of potential visitor numbers for the surrounding countryside. The resulting map presents total potential visitor numbers based on both the distance and accessibility. Quality was quantified based on commonly available data. The main dataset used was the land use map from which information regarding size, forest type (broadleaved or mixed/coniferous), and length of major footpaths could be derived. Information regarding nature protection status was obtained from the county administration. Based on preference studies, weightings for different factors were produced and applied to reach the overall composite map of visitor pressure on woodland. The model was validated through field data relating to urban pressure.

Literature review

Within the frame of the thesis two literature reviews were conducted, one of management guidelines (Paper II) and one of scientific, published, papers (Paper III).

Review of management guidelines

In Paper II, the literature review was taken through as a comparative study of management guidelines between Sweden and Scotland. For the study, 24 forestry guidelines were selected that included the management of urban woodland; 12 from Sweden and 12 from Scotland/UK. Guidelines were selected mainly through the use of Internet search engines, publication lists of organisations involved in urban woodland management, and reference lists in urban woodland literature. The choice of the guidelines was aimed to cover a broad range of organisations involved in urban woodland management, thereby providing a diversity of different types of guidelines with different objectives and foci. In addition to guidelines, information concerning factors believed to influence the management of urban woodland, and especially the visual management was collected (*e.*g. forest policy, accessibility).

The guidelines were analysed with special emphasis on the parts relating to urban woodland management. Each guideline was analysed and classified in relation to scale of management, degree of operationality, emphasis on visual qualities, visual concepts used and rational for including visual aspects. Concepts judged to be relevant and applicable to urban woodland, based on the theory of landscape aesthetic included scale, diversity, naturalness-continuity, stewardship, visual accessibility, and coherence and were subsequently tested in the review with regards to their applicability.

Review of research

Paper III is a review of scientific papers focusing on urban woodland management and planning. The selection of papers was, in order to avoid a biased sample, through a structured search in bibliographic databases, using the following search terms: urban + management/planning + woodland/forest/nature. From the hit list

produced by these terms only internationally published journal papers with an established peer review process were selected for further analysis. A further exclusion of papers not discussing urban woodland (*e.g.* focusing on single trees) was made. The selected papers were analysed with regards to their view of management (biocentric or anthropocentric) and the strategies suggested, as well as according to research approach (humanities, science and social science). The paradigms were mainly judged on the rationale given for management while the research approaches were based on the methodology chosen for the study rather than the disciplinary grouping of the author/s.

Visibility analysis

In Papers IV and V visibility analysis formed the basic method for analysing the quality of the view. A Digital Elevation Model (DEM), is used, showing the landform of the area, and "lines of sight" (straight lines uninterupted by other features) calculated. The visibility analysis focuses on the total areal extent a given location can see and results in a map where the locations are graded with regards to the amount which can be seen *from them* (Fisher, 1996). The visibility analysis were done as a grid operation in Arc/Info GRID (ESRI, 1998) following an approach developed by Miller (2001) and Miller & Law (1997).

The National Inventory of Woodland (Forestry Authority, 1997) was used as a basis for analysing the visibility of woodland types. This dataset distinguishes four types of woodland within the study area (broadleaves, coniferous, mixed and young trees), and for each of these woodland types the tree heights were estimated. The visibility analysis was calculated for each of the four woodland types.

For Paper IV each pixel was analysed using ERDAS IMAGINE (ERDAS, 1999) with respect to the visibility of each woodland type (Miller, 2001). Through applying results from preference research to the visibility of woodland type for individual locations the quality of the view through its woodland components could be described. Thereby identifying areas with high woodland view quality (*i.e.* containing a high percentage of broadleaved and mixed trees in the view) and those with a low quality of woodland view (*i.e.* areas containing a high percentage of coniferous and young trees in the view).

Analysing diversity

In Paper V the visibility of woodland types were further analysed with regards to diversity. The analysis of diversity is one of the key concepts found in landscape ecology, and for which there are a number of accepted methods (*e.g.* Forman, 1995). The Shannon diversity index (see Equation 1) is one of the most widely used and provides a method for quantifying the diversity based on the number of different patch types and the proportional area distribution among patch types (European Commission, 2000). Shannon's diversity index has been used in measuring diversity of land cover types in the landscape (*e.g.* Fjellstad *et al.* 2001; O'Neill *et al.* 1988) and in relation to scenic beauty (Hunziker & Kienast, 1999).

Equation 1

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$ ***Equation 1****: Shannon diversity Index.*

Where s = number of land cover type; p_i=proportion of land cover type i, after Forman (1995).

From the visibility analysis three different types of diversity indices were calculated using the Shannon's diversity index.

1. Spatial Diversity Index (SDI) – a diversity index calculated based on the amount of pixels covered by each woodland type.
2. General Perceived Diversity Index (GPDI) – a diversity index calculated on a summary of the visibility of the different woodland types.
3. Pixel Perceived Diversity Index (PPDI) – a diversity index calculated on a pixel level with the visibility of different woodland types as input.

Results and discussion of the studies

Spatial modelling

The result of the model is a classification of woodlands by an index of urban pressure, which varies 30 fold. Mapping the results (see Figure 2) shows that there is increasing urban pressure with decreasing distance to the large settlements of Lund and Malmö, the main exception being the larger rural woodlands that generally have a higher degree of urban pressure. The smallest woods generally have a lower degree of urban pressure. The result were highly correlated with the model result.

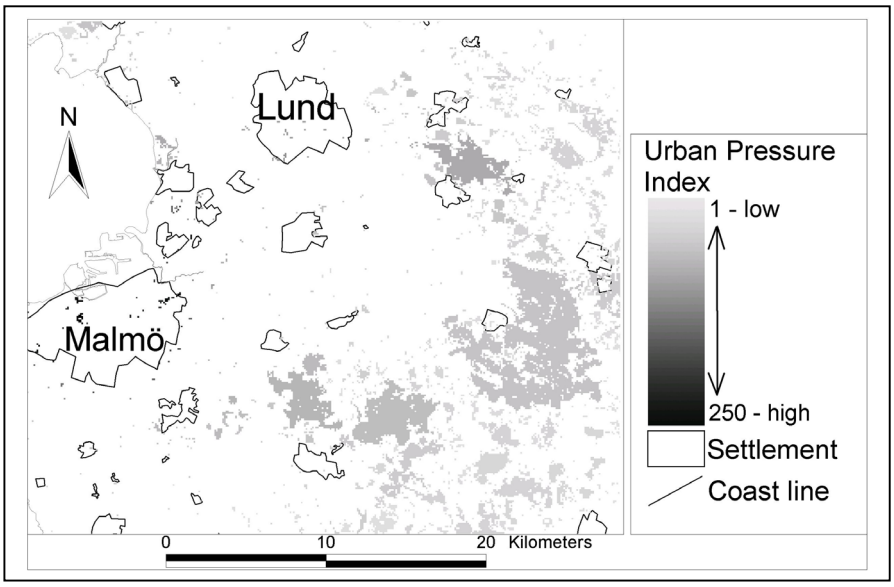

Figure 2: *The result of the model for estimating urban pressure for Malmö. © Lantmäteriverket 1998 , from GSD Terrain-map, dnr 507-98-4720.*

This study shows that by including quality data together with a distance decay function we are able to explain the spatial pattern of urban pressure on woodland, a finding which is supported by models developed by Brainard, Bateman & Lovett (2001) and De Vries & Goossen (2002). As a basis for determining quality factors as well as the importance of these, preference studies have been the main source of information. However, one important question that has been little researched is the role of different woodland qualities in determining the overall choice of which forest to visit? What is the relative importance of different woodland qualities and are these generalisable? Studies regarding peoples preference in relation to forests visits has mainly come to focused either on limited factors (e.g. Hörnsten & Fredman (2000) who focused on distance) or a limited amount of woodland (Lindhagen, 1996). An exception to these studies is the study by Coles & Bussey (2000) that has been focusing on the settlement of Redditch and there included all woodland.

Literature review

Literature reviews were conducted in order to increase the understanding of the state of the art with regards to both research and practice.

Urban woodland management in practice

The review of management guidelines (Paper II) focused on visual aspects and how they were handled in two different management contexts, Sweden and Scotland/UK. The study showed that the guidelines covered all levels of scale, operationality and emphasis. Visual aspects were justified both by an expert paradigm and by reference to public preferences for both countries. The use of visual concepts varied with regards to extent and how they were used. Between Sweden and Scotland some general differences were found concerning spatial scale used, the application of concepts, and the justification for inclusion of visual aspects, these being:

- In Scotland/UK the landscape level is more frequently discussed in relation to management actions, while the Swedish has come to focus on the stand level.
- Concepts are used more abstract in the Scottish/UK guidelines while in Sweden concepts were always related to specific elements or measurements.
- Visual aspects is in a higher degree motivated by public preferences in the Swedish guideline while the Scottish/UK guidelines more often justified them by an expert opinion.

The differences found between the two countries could be explained by differences in a wider management context (history, land owner structure, accessibility and forest policy). The review does thereby highlight the importance of context when transferring management guidelines and strategies – the context will change the management practice. The study further showed that the concepts tested (diversity, scale, visual accessibility, stewardship, naturalness and coherence) would provide a useful approach for analysing visual aspects.

Urban woodland management and planning in research

In the review process two basic and fundamentally different views towards urban woodland and its management and planning were represented:

- Anthropocentric - "interpreting environmental and resource issues solely in terms of human values and standards" (Gilpin, 1996). With regards to the urban woodland context the anthropocentric paradigm represents a management and planning system designed for human and societal values and benefits, where management and planning stresses the need to enhance the benefits for humans through various strategies.
- Biocentric - as directed towards the ecological system, with ecological health and integrity as an explicit goal of management (Yaffee, 1999). In the context of urban woodland, the woodland is viewed as an ecosystem with inherent ecological characteristics of value, often in need of conservation measures. Management is striving to increase the biodiversity and ecological stability while at the same time controlling the disturbance caused by humans.

These two paradigms are dominated by different research traditions. The anthropocentric paradigm is dominated by papers from the social sciences (mainly economic, geography and planning), while natural science (mainly ecology) dominates the biocentric paradigm. The two paradigms provide different approaches towards management which can be summarised according to two related aspects:

- The view of the human within woodland. The human to manage for, as within the anthropocentric paradigm, or the human as a disturber whose access must be restricted, as often presented by the biocentric view.
- The view of management itself. As a process with public participation, as for the anthropocentric paradigm or management as an often expert led conservation measure, as for the biocentric paradigm.

The two paradigms does hereby provide different context for visual management regarding both the importance of them and the way these could be included within management strategies suggested. In the biocentric paradigm the benefit of including visual aspects would be the provision of solutions that are acceptable for the users, while in a anthropocentric management paradigm, visual aspects could be the mean for communication between participants in the planning and management process.

Visibility analysis

The visibility analyses of woodland types for the suburban landscape around Aberdeen, as presented in Paper IV, showed that their visual contribution varied spatially throughout the area and between the different woodland types, see Figure 3. The most visible woodland type is the coniferous woodland, which has also the largest areal extent while mixed woodland and young trees contributed to a smaller extent in the view. However, the combination of visibility of woodland types varies through the area.

Visibility maps have previously been used, for instance to analyse changes in the landscape (Miller, 2001). However, through combining the visibility analysis with landscape aesthetics, possibilities are provided of creating a tool that could tell something about the quality of the view. This has been done in two different ways for this thesis,

- in relation to preferred forest types (Paper IV)
- in relation to the visual concept of diversity (Paper V).

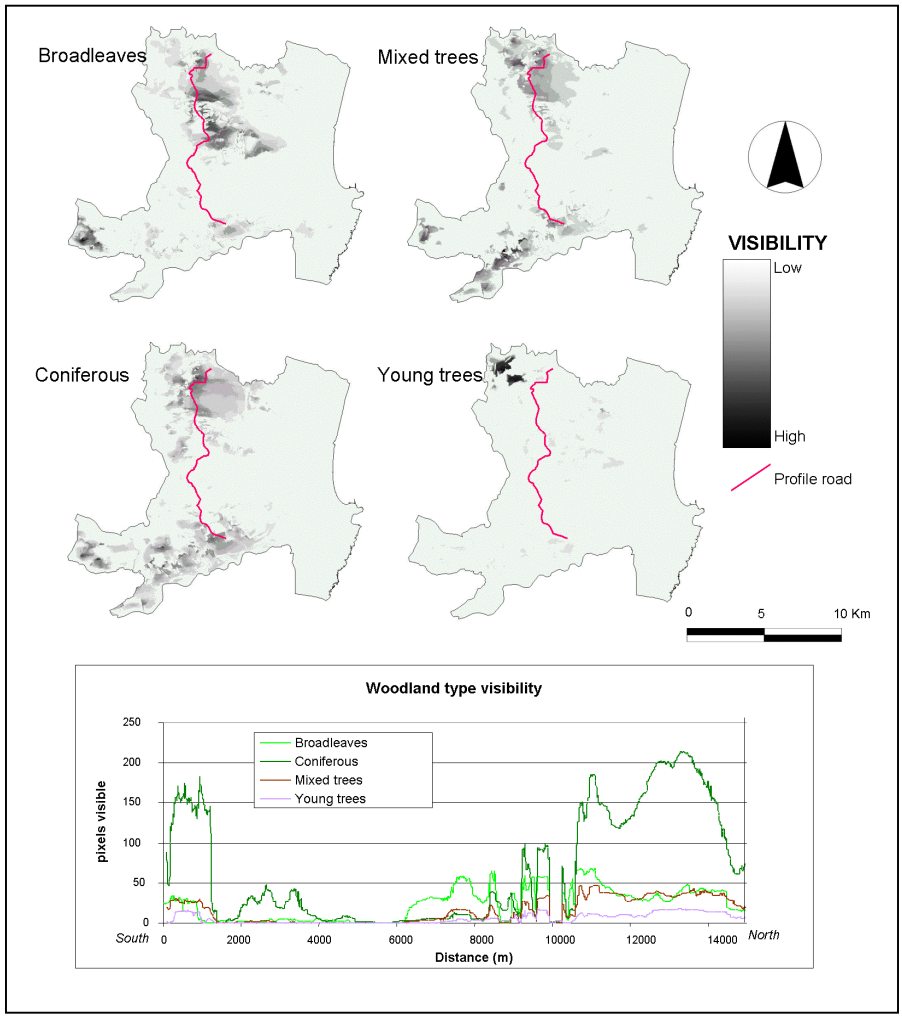

Figure 3: *The maps show the spatial results of the visibility analysis for each woodland type and the distribution for a road.*

Visibility analysis and the preference for woodland types

Through combining the visibility analysis result of what we see with findings from preference studies an index was developed regarding woodland view quality. This was for this study based on 'liking' of woodland types. It has been shown that mixed and broadleaved forest are preferred over coniferous woodland, and older and large trees are often preferred over young trees and having woodland in the view is preferred over not (*e.g.* Koch & Jensen, 1988; Lee, 2001; Ribe, 1989). Applying this to the quality of the view for the area around Aberdeen it is possible to identify areas with high quality of woodland view (*i.e.* containing a high percentage of broadleaved and mixed woodland) and those with a low quality of woodland view (*i.e.* areas containing a high percentage of coniferous and young woodland). The index is a principal example of how the views could be analysed based on the visibility analysis in the context of view quality.

Visibility analysis and the visual concept of diversity

In Paper V the visibility analysis from Paper IV was combined with one of the identified visual concepts, diversity, for the provision of two different perceived diversity indices. One pixel-based (PPDI) and one general for the whole study area (GPDI = 1.09). These were further compared with a spatially based evaluation for the study area (SDI = 1.04).

The pixel-based diversity index (PPDI) shows a strong variation throughout the case study area, see Figure 4, with values as high as 1.6, and hence also a variation with the two general indices.

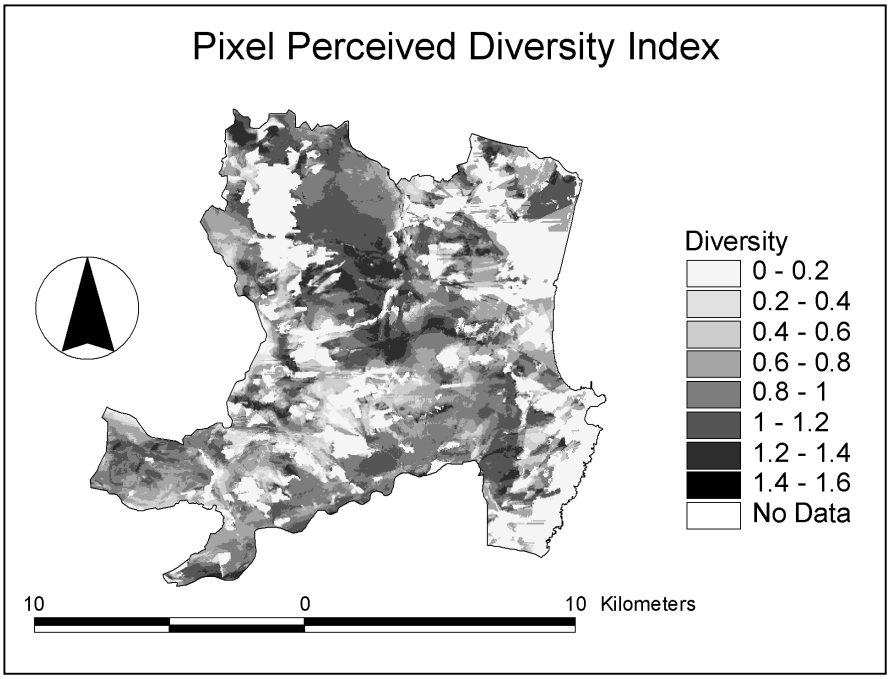

Figure 4: *The Pixel-based Perceived Diversity Index based on Shannon-Diversity Index. In the map, woodlands have been given a value of zero for perceived woodland diversity.*

The general method, with a pixel level analysis of the view, which was used for both studies, could be developed based on the parameters of interest and concept to analyse. This type of index could be applied to analyse the degree of naturalness of the woodland view if right data is provided for.

Methodological considerations regarding visibility analysis

Although the general approach provides an interesting method for analysing the visual quality of the landscape with regards to urban woodlands, when using visibility analysis for analysing view quality several shortcomings need to be considered.

The first issue is the DEM used which may lack the resolution needed for the more detailed output information desired. The test taken through in Paper IV shows that the addition of features like line and point vegetation data has a limited overall effect, however it is significant for some localised areas. The visibility operation itself has also been shown to be sensitive to errors in the DEM used (Fisher, 1996). Further, similar operations with regards to hydrological modelling have shown that there is a scale sensitivity to the result with regards to the DEM used (Wise, 2000).

A further issue is the influence of distance with regard to the clarity and appearance of the elements within the view, and with respect to visual quality. Studies have suggested that there are zones into which the view can be segmented (Baldwin *et al.* 1998; Palmer & Lankhorst, 1998). Pixels in the near ground area probably have a higher influence on the view than the background pixels. This is likely because of the potential for the observer to discriminate between different land cover types, and the apparent size of a feature in the foreground compared to the background (Bishop, Wherret & Miller, 2001).

In the two studies the input data for both types of quality indices has been woodland types, as identified in the National Inventory of Woodland. However, an important question is if these classifications are the most relevant with regards to people's perception? To what extent are people able to separate these classifications when relating it to view quality? There are also issues regarding the influence of the land cover on the perceived diversity compared to landscape objects like buildings and individual trees (which Palmer & Lankhorst, (1998) used in their study of visible diversity), including the significance of movement of features (*e.g*. flowing water or the swaying of trees).

For both studies it would be desirable to include validation data, both for testing the robustness and for the identification of threshold values. However, the approach is interesting for exploring woodland visual quality as a component in the landscape an outside perspective.

General discussion of visual aspects

The papers forming part of this thesis are designed to contribute towards increasing our understanding of what visual aspects are and to suggest methods for managing the visual resource that woodlands provide. While predictive modelling (Paper I) and the literature review in Paper III do not explicitly focus on visual

aspects, both papers provide important information with regards to the context of management and planning. In the case of predictive modelling this is held mainly within the discussion of the concept of the urban in relation to woodland, through modelling of urban pressure. This approach could thereby function as a useful tool for the identification of areas in need of taking visual aspects into account.

The literature review of research (Paper III) provides a context with regards to the management paradigms found in academic research, and considers the rationales behind the kinds of research conducted. The identification and discussion of management paradigms also provide an explanation for the comparatively low interest in visual quality in relation to its importance for people. Since the biocentric paradigm is less interested in the human and societal values of urban woodland, the visual outcome of management strategies is not considered in most papers from that area. The literature review further sets a frame for the inclusion of visual aspects within urban woodland management and planning based on the two paradigms.

Visual concepts

In Paper II the review elaborated around 6 core concepts for visual aspects, diversity, scale, visual accessibility, stewardship, naturalness and coherence. However, the concepts were not discussed within the paper in any further depth as regards to explicit theoretical references and how physical attributes contribute to the concept. The visual concepts have however been further developed within the frame of the thesis without being explicitly discussed in any of the papers. An outline of this framework is sketched in Figure 5 and is further discussed here for each concept individually.

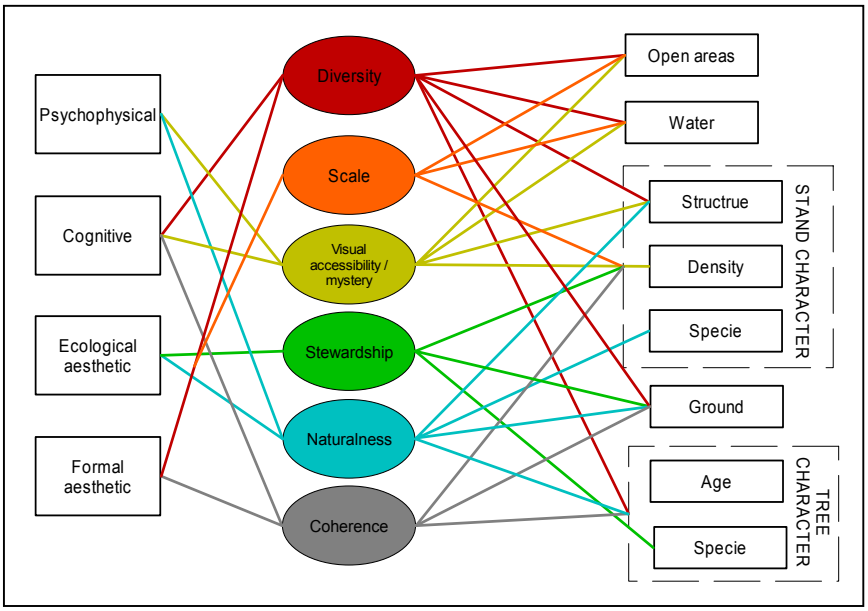

Figure 5: *A framework of the connection between concepts, theory relation and physical attributes contributing to the concepts.*

Studies regarding people's experience of woodland have shown that people are capable of notice changes in vegetation and between stands. These are suggested to relate to changes in stands with regards to tree age, tree species, and stand density and ground vegetation (Axelsson Lindgren, Gyllin & Ode, 2002). Within the woodland, other elements like open areas and water as well as the individual trees are other important elements of the visual experience of a woodland, and hence physical attributes contributing to the visual concepts distinguished.

So far, research that has worked with concepts of visual quality for forests (*e.g.* Lucas, 1991; Forestry Commission, 1989; USDA, 1995) has mainly come to focus on the landscape level, where the woodland is seen from a distant and as an element in the landscape. However, for the urban woodland both the visual quality within the woodland, that the visitors perceive as well as the visual quality of the woodland as an element in the everyday landscape for people is important to take into account in management and planning.

Diversity

The concept of diversity (including complexity and variation) has explicitly been raised by both the cognitive and the formal aesthetic approach towards landscape (Bell, 1998; Kaplan & Kaplan, 1989). In a landscape context this concept has been applied as an indicator for visual quality (*e.g*. Hunziker & Kienast, 1999).

In a woodland context it has been proved useful both for explaining preference and as a concept in the design of woodland (*e.g.* Axelsson-Lindgren, 1990; Forestry Commission, 1989; Gustavsson & Fransson, 1991). The concept focuses on the perceived variation of the woodland. Within the woodland, the concept of diversity is discussed at several levels (*e.g.* Paper II). There is the variation in forest density and open areas, providing an overall variation, further on there is the variation of stand types mainly based on changes regarding structure, species, density, and ages of the trees. However, there is also variation on a detail level, where the variation is based on the individual elements, which could be trees, bushes and special features and the variation in ground cover. On a landscape level, when the woodland is perceived from outside, the concept of diversity changes scale, with the focus on the woodland as an element in relation to other land uses (Forestry Commission, 1989; Lucas, 1991). However, the differences in woodland type and stand types are also visible from the outside and thereby a variable for diversity.

Scale

The concept of scale could be found in the formal aesthetic and deals with relative size. A special concept here is multiple scales, dealing with the presence of a hierarchy or range of scale (Bell, 1998).

In a woodland context, the scale relates to both the experienced size of features and the presence of details (Forestry Commission, 1989; Paper II). From within the woodland there are multiple scales present. It is the overall scale where the experienced size of different stands is of importance. Features like structure and density together with actual size of stand type are here the variables determining

scale. Within the same category of variables could open areas and water bodies be found, relating to visible rooms. Further on it has been suggested that also the height of the trees influence our perception of scale (Forestry Commission, 1989). The presence of details does also form our experience of scale, presence of details decreasing the experienced scale. This could be the presence of, for instance, characteristic trees that are allowed to stand out. On the landscape level, woodland together with landform is a key element for determining overall perceived scale of the landscape (Countryside Commission, 1993).

Visual accessibility/Mystery

The concept of visual accessibility has not explicitly been defined in any of the theories. It is, rather, a combination of several key concepts: openness, perceived possibility for locomotion and depth of view that could be found within the psychophysical, the formal aesthetic, and the cognitive approach. The reason for combining them here is that they focus on extent of view and visibility, with increased visibility increasing the visual accessibility. A related, and in this context included concept is that of mystery (Kaplan & Kaplan, 1989). The concept has been defined as the possibility to see a continuing area, though with a blocked view.

When looking at the concept from within the woodland the presence of open areas and water as well as the stand type and its structure and density are the key variables for this concept, through its effect on the visibility. Included in the stand structure is the presence of understorey. For this concept the path, through its direction and width, is actively contributing to the concept (Kaplan & Kaplan, 1989). A special feature within this concept is the views where the panoramic view provides a large view and hense high degree of visual accessibility, while the focused and filtered view provides limited view and thereby a lower degree of visual accessibility, though often a high degree of mystery. For the landscape level the landform is significant in determining line-of-sight (Fisher, 1996) and thereby the concept of visual accessibility. Woodland itself further limits the line of sight. On a landscape level, when considering the concept applied to the woodland, the visibility of the woodland it self can be argued to be the key feature. The amount of woodland seen forms our opinion of how much is accessible. Though this definition does not change significantly from the inside definition since both are concerned with how much woodland is visible and hence perceived as available.

Stewardship

The concept of stewardship has been put forward by Nassauer (1995; 1997) for explaining preference in an agricultural landscape. Stewardship concerns the presence of human influence in relation to ‘cues of car’.

The presence of the human is one important component for the visual quality of the woodland through the presence of signs of care. Sheppard (2001) and Gobster (1999) have argued for a theory of visible stewardship in forestry where the evidence of human activity is increased, however the management should be appropriate and designed. However, what these signs of care are contributed of, beside an involvement of people, Sheppard (2001) does not give a clear answer to.

However, an appropriate design and management measure imply that the management should be "inkeeping" with the area. This clearly has an effect on all woodland elements. In order to show signs of care there is a need for a detail management, emphasising the small measurements, like for instance the care of characteristic trees or other special features along paths, as suggested by Gobster (1999). Other cues of care on a woodland level would be the maintenance of facilities, removing of litter and care of the ground and the field vegetation in management operations, thereby providing a feeling of a landscape that is looked after. Looking at the concept of stewardship from an outside perspective, the woodland in the landscape, it could largely be applied as people management. For instance providing and planning for the infrastructure for people to get to the woodland and for on-site management operations running smoothly. But it is also about how to show signs of care when natural disturbances occur, for example major wind-throw.

Naturalness

The concept of naturalness has been shown to be an important factor for explaining preference (see for instance Purcell & Lamb, 1998), and is further the key concept of the ecological aesthetic (Gobster, 1999). Naturalness as a concept is the proximity of woodland to a (perceived) natural state. This concept ranges from untouched nature, which have a high degree of naturalness, to the highly manicured (e.g. rose beds in formal parks) with a low degree of naturalness. In this case it is important to keep in mind that having a high degree of naturalness is not always perceived as positive for preference (*e.g.* Lindhagen & Hörnsten (2000) have shown that the virgin forest is not perceived as particularly positive).

Naturalness on a woodland level is mainly based on the structure of the forest, where generally a multi layered forest with natural species is perceived as more natural than a pillar-hall of exotic trees (Forestry Commission, 1991). Also the ground cover, presence and its component, plays an important role for the forming of the concept of naturalness. For the woodland level as well as the landscape level, the concept includes the idea of continuity – how long has there been a forest or for how long there has been a continuity of tree. The presence of old and big trees would therefore increase the perception of naturalness. At the landscape level the forest type is also the key variable for the concept of naturalness, where the combination of mixed and native species is perceived as more natural then the coniferous plantation.

Coherence

Coherence is defined here as the degree to which the landscape is easily readable and understandable, how well it connects and the logic of the landscape. Coherence as a concept has been put forward by Kaplan & Kaplan (1989) as well as by Bell (1998). In the design approach the terms unity and balance are used, which are close to the Kaplan & Kaplan concept of coherence and are here included in the definition. This as a landscape that shows balance and unity would have a strong coherence. Another concept put forward by Kaplan and Kaplan was the concept of legibility. While the concept of coherence is the immediate

response to the landscape legibility is predicted response. However, within the concept of coherence legibility is included since legibility is dealing with both coherence and structure.

When discussing coherence the degree of repetition of similar features is important as well as the arrangements of elements (Forestry Commission, 1989; Kaplan, Kaplan & Ryan, 1998). On a woodland level this repetition could include tree specie and the structure of the woodland, as shown in Gustavsson & Fransson (1990), but also the repetition of field vegetation. Through letting species and structures re-appearing the sense of coherence could be increased. On a landscape level, the concept of coherence is concerned with the logic of the elements and the repetition of similar features (Bell, 1998). For instance, a landscape where the woodland types are similar and have natural forms, shows a higher degree of coherence compared to a landscape with a wide variety of non-natural woodland types in linear forms. This means that both the form, as well as the woodland type is of importance for the concept of coherence.

Opposing concepts

Some of the concepts identified in this thesis could be characterised as dualistic opposed, see Figure 6. These include the concept of visual accessibility, within which is incorporated the concept of mystery as reducing some degree of visual accessibility, but also coherence and diversity or stewardship and naturalness. However, while they are representing different ends of a spectrum, they are not necessarily opposed in terms of preference.

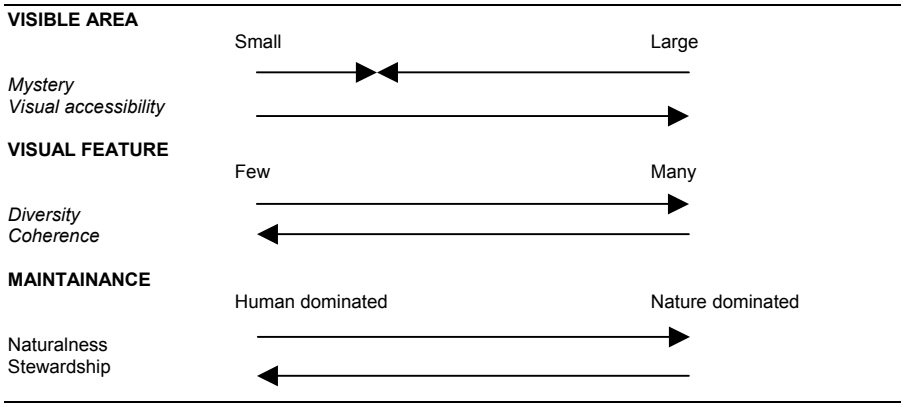

Figure 6: *The figure shows concepts of visual aspects that to some extent are in opposition to each other.*

Both the concept of visual accessibility and the concept of mystery deal with the amount of visual area, how long is the line of sight and how much woodland do we see? While the concept of visual accessibility increases with the amount of visible area, the concept of mystery decreases with increased amount of visible area. However, when the visual area is very small visual accessibility as well as mystery are low.

Diversity is about the amount of different visual features in the landscape, the more variety the more diversity. Coherence could be seen balancing this one. Generally diversity increases when coherence decreases, however having a diversity that takes repetition into account and provides logic in where to find different features could increase the perceived coherence without loosing diversity.

When increasing the sense of stewardship, in other words making the human presence noticeable in the woodland, the degree of naturalness decreases. However, it is not necessarily a direct opposition, since both are relating to perceived status of the woodland, an urban woodland perceived as natural needs to have management in order to limit the negative traces of humans (*e.g.* removing litter).

Combining visibility analysis with visual concepts

The spatial analysis of visual concepts have in this thesis been explored in relation to visibility analysis, and then mainly the concept of diversity. Through the visibility analysis revealing what is visible, there is a possibility to further analyse the view with regards to content and hence visual quality. However, the area has so far not received any great attention, which has been explained by the problems with lack of detail of the input data as well as the need for computer resources (Bishop, 1999).

Visibility analysis with regards to visual quality, rather than visual impact assessment, has in previous studies mostly been applied to the visibility of land cover (*e.g.* Miller, 2001). However, the studies in this thesis show a difference compared to previous in the links with concepts adopted from landscape aesthetics, including:

- Forest preference research in relation to preferred forest type.
- Diversity, as a visual concept for quality.
- The focus on the woodland element explicitly.

While previous studies have mainly focused on the visibility of land cover and change (Miller, 2001; Gaspar, Miller & Fidalgo, 2003) with just general discussion of preferences in relation to this, the study presented in Paper IV links directly with the findings in preference research. This makes it possible to build an index that could measure something of the view quality with regards to woodland rather simply the total viewable area. The approach could further be applied for the identified concept of naturalness and visual accessibility, based on forest classes categorised for degrees of naturalness and total woodland respectively.

The links between visual concepts and visibility analysis provide an interesting research area for describing the quality of the view. In this context, paper V shows a method for applying the concept of diversity in relation to woodland cover. The choice of the concept of diversity was mainly based on its strong support in theory as well as being a concept applicable also for other aspects (*e.g.* ecology).

Some of the other concepts presented have been analysed elsewhere in relation to visibility analysis in a landscape context. Methods for analysing mystery have

been applied by Lynch and Gimblett (1992) and Baldwin *et al*. (1998). The concept of naturalness and scale has further been applied for the Scottish Highlands in Miller *et al* (2003). However, the combination of visual concepts remains an area that could be further developed through:

- Testing it towards validation data of how people experience the landscape.
- Analysis of other features than land cover. However, a limiting factor is often the lack of sufficient data for other features.
- Development of methods for taking distance and visual penetration decay functions into account.

While most of the studies have been taking place on a landscape level and in the open land, there are few studies with regards to the experience of the woodland from an inside perspective and visibility analysis. Here it is clearly the lack of sufficient data that is restricting research, since vital information for exploring visual concepts spatially, like stand structure is often missing.

From the inside perspective it might be argued that the visibility analysis is less applicable, and that is true in its current form. However, with the option of taking visual penetration levels of forest stands into account visibility analysis could prove to be applicable also for an inside woodland context. However, visibility analysis for the inside would need more detailed height data to prove truly applicable.

Implications for urban woodland planning and management

Analysing visual concepts in management

This thesis has showed that visual concepts are formed by physical attributes. Physical attributes can be spatially evaluated and hence described. Through identifying the contributing physical elements, both on a landscape and a woodland level it should then be possible to develop a tool for describing visual quality. In this context it is important to point out that a description of visual quality does not automatically imply a scale of "good" or "bad", but rather "more" or "less". However, in order to describe most of the concepts there is a need to collect complementary information that presently is lacking in the forest management plans (*e.g.* stand structure).

Through the provision of an analysis of the concepts there is the foundation for an objective tool to assist in the management of urban woodland, both for analysis and communication of visual quality in woodland. Developed further to an index tool, it becomes possible to compare sites and analyse changes over time with regards to visual quality, and hence be an important complement to other types of indicator data used (ecological and recreational). Such an index would be valuable for providing an overview of the situation and compare scenarios, and can function as a base for further field studies and inventories. However, there is a need for further investigatin of the linkage between the concepts and their physical attributes in order to identify the most significant parameters.

An approach for using structure in management planning has been presented by Gustavsson & Fransson (1991). In this work 18 different stand types were identified based on their structure rather then specie. These stand types relate to some of the identified concepts, mainly diversity and visual accessibility but also, to a lesser extent, concepts of naturalness and scale. An evaluation of the project (Ode, 2000) showed the managers considered the approach useful, through its inclusion of dimensions that were otherwise not considered. However, it further showed that based on the unfamiliarity with this approach (which differs from the traditional forest plan used for the management of these kinds of areas) there is a demand for extra input in the initial stage. The experience of Furulunds fure implies that the linkage between stand structure and the visual concepts could provide one useful approach for analysing the components of the concepts and hence a tool for design with the concepts.

Through the use of stand types there is available a tool for communication within a public participatory process. Where the focus is the visual quality that stand type must fulfil, rather than using terms like specie, density, age, thinning or volume, general indicators of overall success in that goal might be used. Studies have suggested that the forest management terms are perceived as rather abstract and hard to understand for the general public (Tahvainnen *et al.,* 2001). Through using the stand types as presented by Gustavsson & Fransson (1991) the goal is the focus and its visual features the means.

Visibility analysis and concepts in planning and management

Visibility analysis provides an approach for assisting in the management of the visual resource through analysing what is seen, thereby identifying the visible properties of locations. This type of analytical tool focuses on the visual contribution of woodland to the landscape rather then the experience of the woodland from within. The within experience is what usually is experienced at forest visits, the outside experience is a more frequently encountered image, through its contribution to the landscape and should therefore be of interest in the management of urban woodlands. The woodland is an important feature within the landscape, often contributing positively to the view. Objective measures to take the woodland view into account should provide useful information in various planning contexts (*e.g.* housing development, recreational paths planning).

At a basic level the approach could provide knowledge on what is seen from different locations. In the context of woodland it could be applicable when wanting information on:

- Identification of locations with woodland visibility.
- Visual significance of woodlands.

This kind of information is valuable when wanting to manage the woodland with regards to their perception in the landscape, answering questions such as:

- From where is management operation visible?
- How much is visually affected by suggested management strategies?

Through their combination with visual concepts and findings in preference research, the visibility analysis could provide information with regards to:

- Quality of the view with regards to woodland from different locations.
- Analysis of change of visual quality with regards to woodland over the years.

The information these provide could be used in a process when wanting to enhance the visual contribution of woodland through management operations. The ability to assess the visual quality for individual sites has an important role to play in the support of decision-making with regard to recreation management and planning (Wing and Johnson, 2001).

In this thesis the focus has been on the woodland resource in the urban fringe. In Papers IV and V the visibility analysis are combined with knowledge based on preference studies and landscape aesthetics, thereby showing possibilities to analyse the quality of the view. An analysis of view content, together with the location and identification of areas with a high diversity of views, could prove a useful tool when routing new paths through the countryside, in which woodland views are identified as important and a diversity of the view is sought. The use of the index and visibility map could further be used in a participatory processes. For example as tools for testing different options in discussion with local people and users of the area. However, the visibility analysis would function as a method to gain an overview of sites that are interesting for further fieldwork, rather than a tool providing the absolute basis of decision-making.

Conclusion

The management and planning of urban woodland is the target audience for this thesis. In the frame of the thesis, management and planning perspectives have been discussed in relation to the concept of urban pressure, how it could be determined and the role of quality factors including visual quality. Defining and quantifying urban pressure for individual woodland could help in strategic woodland planning and management including the allocation of resources. The provision of quantitative indices allows us to rank woodlands by urban pressure. Other factors that have an impact on management and hence the resultant visual appearance of woodlands are the cultural context and view of nature, the anthropocentric or biocentric gradient.

For woodland, the visual aspect is an important feature due to it being a character that most people can relate to. It is, thereby, an important feature to discuss when assessing the consequences of management actions. In addition to providing a comprehensive reference to the theoretical material available in this area, the specific contribution of this thesis to management is the application of this knowledge through:

1. Providing a set of visual concepts that could be applied in an urban woodland context. These concepts being: diversity, scale, visual accessibility, stewardship, naturalness/continuity and coherence These concepts were supported through a review of practical management guidelines and also by theories of landscape aesthetics. The thesis also revealed that the application and use of the visual

concepts could vary between countries based on the cultural factors affecting management context (these include landowner structure and accessibility rights).

2. The use of visual concepts provides an approach for describing the visual quality of woodlands. Through linking visual concepts to physical attributes, it is possible to develop an approach based on spatial analysis to form indices of visual quality for use in management. This index does not necessarily have to be value based, but should rather be seen as providing a description of visual attributes that interact with each other to define the visual character of a woodland.

3. Providing tools for analysing the visual contribution of specific woodlands to the view within a landscape.

4. Developing the use of visibility analysis for analysing the quality of the view with regards to woodland. These methods have been developed by linking knowledge within landscape aesthetics on preferred features and visual concepts.

This thesis has, hereby, shown several approaches for improving the inclusion of visual aspects in management and planning through the use of visual concepts and visibility analysis, as well as demonstrating how to link the two together.

Future research

Through the broad approach that this thesis has taken, there are several potential fields of research that could build on the knowledge developed here. These include:

1. Exploration of the linkages between urban pressure and visual significance of the woodland.

2. The concepts developed and identified in this thesis have been justified by their support in theory as well as in management guidelines. However, a further exploration of their robustness in relation to people's woodland experience and the physical attributes influencing these concepts would be desirable.

3. A further exploration of the applicability of the various concepts in a management context.

4. The use of the developed concepts in design. One approach could be the linking to the design work on stand structure.

5. To further develop the link between visibility analysis and visual concepts through capture of validation data based on people's experience of woodland from an outside perspective.

6. Further exploring of the concept of visual diversity through the linkage with validation data and testing of other elements than woodland type.

7. In relation to visibility analysis, to explore the possibility to take visual penetration of stands and distance into account to improve the ability of visibility analysis

This thesis does through its exploration of visual concepts and the use of visibility analysis provide a base for future research within the field.

References

Adams, L.W. & Dove, L.E. 1989. *Wildlife reserves and corridors in the urban environment*. Columbia. National Institute for Urban Wildlife.

Antrop, M. & Van Eetvelde, V. 2000. Holistic aspects of suburban landscapes: visual image interpretation and landscape metrics. *Landscape and Urban Planning 50*, 43-58.

Axelsson Lindgren, C. 1990. *Upplevda skillnader mellan skogsbestånd - rekreations- och planeringsaspekter*. Stad & Land 87. Doctoral thesis.

Axelsson Lindgren, C. 1999. *En semantisk modell för skogsupplevelse.* Rapport 99:3, SLU, Department of Landscape Planning Alnarp.

Axelsson Lindgren, C., Gyllin, M. & Ode, Å. 2002. *Skogsupplevelse: Fältförsök i Tranemåla*. Rapport 02:6. SLU. Department of Landscape Planning Alnarp.

Baines, C. 1995. Urban areas. In: Sutherland, W.J. & Hill, D.A. (eds.), *Managing habitats for conservation*. Cambridge. Cambridge University Press. pp 362-381.

Baldwin, J., Fisher, P., Wood, J. & Langford, M. 1998. Modelling environmental cognition of the view with GIS. Available at: *http://www.sbg.ac.at/geo/idrisi/gis_environmental_modeling/sf_papers/fisher_peter/baldwin.html*. Accessed 2002-12-17.

Bell, S. 1998. *Landscape: pattern, perception and process*. London. E & FN Spon.

Berry, J.K. 1993. *Beyond mapping: concepts algorithms, and issues in GIS*. Fort Collins. GIS world book.

Bishop, I.D. 1999. Modelling the view: perception and visualization. In: Usher, M.B. (ed.) *Landscape Character: perspectives on management and change*. Edinburgh. The Stationary Office. pp. 150-161.

Bishop I.D., Wherret, J.R., & Miller, D.R., 2001. Assessment of path choices on a country walk using a virtual environment. *Landscape and Urban Planning* ***52,*** 225-237

Bradley, G. 1995. Urban Forest Landscapes: Integrating Multidisciplinary Perspectives. In: Bradley, G. (ed.) *Urban Forest Landscapes: Integrating Multidisciplinary Perspectives.* pp 3-11.

Bradshaw, A., Hunt, B., & Walmsley, T. 1995. *Trees in the urban landscape*. London, E & FN Spon.

Brainard, J., Bateman, I. & Lovett, A., 2001. Modelling demand for recreation in English woodlands. *Forestry 74,* 423-438.

Bruce, V., Green, P.R., & Georgeson, M.A.. (1996). *Visual perception, physiology, psychology, and ecology*. East Sussex, Psychology Press.

Carlson, A. 1977. On the possibility of quantifying scenic beauty. *Landscape Planning 4*, 131-172.

Carlson, A. 2001. Aesthetic Preferences for Sustainable Landscapes: Seeing and Knowing. In: Sheppard, S.R.J. and Harshaw, H.W. (eds.) *Forests and landscapes - linking ecology, sustainability and aesthetics. IUFRO Researh Series, No 6*, CABI Publishing. pp 31-41.

Coles, R.W. & Bussey, S.C. 2000. Urban forest landscapes in the UK - progressing the social agenda. *Landscape and Urban Planning 52*, 181-188.

Countryside Commission. 1993. *Landscape assessment guidance*. Gloucestershire. Countryside Commission.

Daniel, T.C. 2001. Whither scenic beauty? Visual landscape quality assessment in the 21st century. *Landscape and Urban Planning 54*, 267-281.

Daniel, T.C. 1990. Measuring the quality of the natural environment – a psychophysical approach. *American Psychologist 45,* 633-637.

Daniel, T.C. & Vining, J. 1983. Methodological issues in the assessment of landscape quality. In: Altman, I. & Wohlwill, J.F. (eds.). *Behavior and the Natural Environment.* Plenum Press, New York, pp. 39–84.

Daniel, T.C. & Schroeder, H. 1979. Scenic beauty estimation model: predicting perceived beauty of forest landscapes. In: Elsner, G.H. and Smardon R.C. (eds.), *Our National*

Landscape Conference on Applied Techniques for Analysis and Management of the Visual Resource. Rep. PSW-35, USDA Forest Service, Berkeley, pp. 514–523
De Vries, S. & Goossen, M. 2002. Modelling recreational visits to forests and nature areas. *Urban Forestry & Urban Greening 1*, 5-14
EEA, 1999. Environment in the European Union at the turn of the century - summary. European Environment Agency, Copenhagen.
ERDAS. 1999. *IMAGINE 8.4 Users Guide.* ERDAS Inc. Atlanta.
ESRI 1991. *ARC/INFO Data Model, Concepts, and Key Terms*. ESRI Inc. Redlands, CA.
ESRI, 1998. *GRID Users Guide*. ESRI. Redlands, CA.
Evans, J. 1984. *Silviculture of Broadleaved woodland.* London. Forestry Commission.
European Commission. 2000. *From land cover to landscape diversity in the European union.* The European Commission. Brussel.
Fisher, P.F. 1996. Extending the applicability of viewsheds in landscape planning. *Photogrammetric Engineering and Remote Sensing 62,* 1297-1302.
Fjellstad, W.J., Dramstad, W.E., Strand, G-H., Fry, G.L.A. 2001. Heterogeneity as a measure of spatial pattern for monitoring agricultural landscapes. *Norsk geografisk tidskrift 55,* 71-76.
Forestry Authority. 1997. *Inventory Report: National Inventory of Woodland and Trees: Scotland - Grampian Region: Woodlands of 2 hectares and over.* Forestry Commission. Edinburgh.
Forestry Commission. 1989. *Forest landscape design guidelines.* Edinburgh. Forestry Commission.
Forestry Commission. 1991. *Community woodland design*. London, HMSO.
Forman, R.T.T. 1995. *Land mosaic: The ecology of landscapes and regions.* Cambridge. Cambridge University Press.
Forrest, M. Konijnendijk, C.C. & Randrupt, T.B. (eds.) 1999.*Research and development in urban forestry in Europe. Report of COST Action E12 'Urban forests and trees' on the state of the art of urban forestry research and development in Europe.* Brussels. European Commission.
Gaspar, J.J., Miller, D.R., & Fidalgo, B.M. 2002, "Land Use Change and Visibility in the Landscape Protected Area of Serra do Açor" in *Proceedings of EGIS 2002*, in press
Germundsson, T., Schlyter, P. (eds.), 1999. *Atlas över Skåne. Sveriges Nationalatlas.* Metria, Uppsala.
Gilpin, A. 1996. *Dictionary of environment and sustainable development.* Chichester. John Wiley.
Gobster, P.H. 1999. An ecological aesthetic for forest landscape management. *Landscape Journal 18,* 54-64.
Gordon, D. (ed.) 1990. *Green cities*. Montreal. Black rose books.
Grahn, P. & Stigsdotter, U. 2002. Landscape architecture and stress: How a green city could affect people´s stress-related depressions and burnout syndromes. In: *Proceedings for Forestry Serving Urbanised Societies, IUFRO European Regional Conference, in collaboration with EFI*. Copenhagen, Denmark, 27-30 August 2002.
Grey, G. 1996. *The urban forest, comprehensive management.* New York. John Wiley & Sons, Inc.
Grey, G.W. & Deneke, F.J. 1986. *Urban forestry*. New York, Wiley & Sons.
Gustavsson, R. & Fransson, L. 1991. *Furulunds fure - en skog i samhällets centrum.* Alnarp, Movium/inst. för landskapsplanering.
Hodge, S. 1995. *Creating and managing woodlands around towns.* Forestry Commission Handbook 11. London. HMSO.
Hough, M. 1995. *Cities and natural processes.* London, Routledge.
Hultman, S-G. 1983. *Allmänhetens bedömning av lämplighet för friluftsliv. Del 2. En rikstäckande enkät.* Uppsala, Avdelningen för Landskapsvård, Sveriges Lantbruksuniversitet.
Hunziker, M. & Kienast, F. 1999. Potential impacts of changing agricultural activities on scenic beauty - a prototypical technique for automated rapid assessment. *Landscape Ecology 14*, 161-176.

Kaplan, R. & Kaplan, S. 1989. *The Experience of Nature.* Cambridge. Cambridge University Press.
Kaplan, R., Kaplan, S and Ryan, R.L. 1998. *With people in mind.* Washington D.C. Island Press.
Kaplan, S. 2002. Some hidden benefits of the urban forest. In: *Proceedings for Forestry Serving Urbanised Societies, IUFRO European Regional Conference, in collaboration with EFI.* Copenhagen, Denmark, 27-30 August 2002.
Kardell, L., 1982. *Hur Linköpingsborna utnyttjar sina stadsnära skogar*. Rapport 23, SLU, Avd. för landskapsvård, Uppsala.
Kliskey, A.D., 2000. Recreation terrain suitability mapping: a spatially explicit methodology for determining recreation potential for resource use assessment. Landscape and Urban Planning, 52: 33-43.
Koch, N.E. &- Jensen, F.S. 1988. Skovenes friluftsfunktion i Danmark. IV. Befolkningens oensker til skovenes og det åbne lands udformning. Det forstlige Forsoegsvaesen. Copenhagen.
Konijnendijk, C.C.K. 1997. *Urban Forestry: Overview and Analysis of European Forest Policies, Part 1: Conceptual framework and European Urban Forestry History.* Joensuu. European Forest Institute.
Konijnendijk, C.C.K. 1999. *Urban forestry in Europe: A comparative study of concepts, policies and planning for forest conservation, management and development in and around major European cities.* Faculty of forestry. Joensuu. University of Joensuu. Doctoral thesis.
Lange, E. 1994. Integration of computerized visual simulation and visual assessment in environmental planning. *Landscape and Urban Planning 30,* 99-112.
Lange, E. & Bishop, I. 2001. Our visual landscape: analysis, modeling, visualization and protection. *Landscape and Urban Planning 54,* 1-3.
Laurie, I.C. (ed) 1979. *Nature in cities.* Chichester. John Wiley & Sons.
Lee, T.R. 2001. *Perceptions, attitudes and preferences in forests and woodlands.* Edinburgh. Forestry Commission.
Leopold, 1949. *A sand county almanac and sketches here and there.* New York. Oxford University Press.
Lindhagen, A. & Hörnsten L. 2000. Forest recreation in 1977 and 1997 in Sweden: changes in public preferences and behaviour. *Forestry 73,* 143-151.
Lothian, A. 1999. Landscape and the philosophy of aesthetics: is landscape quality inherent in the landscape or in the eye of the beholder? *Landscape and Urban Planning 44,* 177-198.
Lucas, O.W.R. 1991. *The design of forest landscapes.* Oxford. Oxford University Press.
Lynch, J.A. & Gimblett, R.H. 1992. Perceptual values in the cultural landscape: a spatial model for assessing and mapping perceived mystery in rural environments. *Journal of Computers, Environment and Urban Systems 16*, 453-471.
Medley, K.E., McDonell, M.J. & Pickett, S.T.A. 1995. Forest-Landscape structure along an Urban-To-Rural Gradient. *Professional Geographer 47*, 159-168.
Miller, D. 2001. A method for estimating changes in the visibility of land cover. *Landscape and Urban Planning 54*, 91-104.
Miller, D.R, Bell, S., Wood, M., Morrice, J.G., Ball, J., Ward-Thompson, C. & Ode, Å. 2003. *Landscape Capacity Study for Windfarm Development in East and North Highland, and Moray.* Unpublished project report to SNH.
Miller, D.R. & Law, A.N.R 1997. Mapping terrain visibility. *The Cartographic Journal, 34,* 87-91.
Miller, R.W. 1997. *Urban forestry: planning and managing urban greenspaces*. Second edition. Prentice Hall, New Jersey.
Muir, R. 1999. *Approaches to landscape.* London. Macmillan Press Ltd.
Nassauer, J.I. 1995. Messy ecosystems, orderly frames. *Landscape Journal 14,* 161-170.
Nassauer, J.I. 1997. Cultural sustainability: Aligning aesthetics and ecology. In: Nassauer, J.I. (ed.) *Placing nature: culture and landscape ecology.* Washington DC. Island Press, 67-83.

Nilsson K. & Randrup, T.B. 1997. Urban and peri-urban forestry. In: Forest and tree resources. In: *Proceedings of the XI World Forestry Congress, 13-22 October 1997, Volume 1*. 97-110.

O'Neill, R.V., Krummel, J.R., Gardner, R.H., Sugihara, G., Jackson, B., DeAngelis, D.L., Milne, B.T., Turner, M.G., Zygmunt, B., Christensen, S.W., Dale V.H. & Graham, R.L. 1988. Indices of landscape pattern. *Landscape Ecology 1*, 153-162.

Ode, Å. 2000. *Skötselintentioner i plan och genomförande – fallet Furulunds fure.* Rapport 00:3. SLU, Department of Landscape Planning Alnarp.

Palmer, J.F., & Lankhorst, J.R.K. 1998, Evaluating visible spatial diversity in the landscape *Landscape and Urban Planning 43*, 65-78.

Parsons, R. & Daniel, T.C. 2002. Good looking: in defense of scenic landscape aesthetics. *Landscape and Urban Planning 60,* 43-56.

Purcell, A.T. & Lamb, R.J. 1998. Preference and naturalness: An ecological approach. *Landscape and Urban Planning 42*, 57-66.

Randrup, T.B. & Nilsson, K. 1998. Research note: co-ordination of European research on urban forests and trees. *Arboricultural Journal 22*, 173-177.

Ribe, R.G. 1989. The aesthetics of forestry: What has empirical preference research taught us? *Environmental management 13*, 55-74.

Rydberg, D. & Falck, J. 2000. Urban forestry in Sweden from a silvicultural perspective: a review. *Landscape and Urban Planning 47*, 1-18.

Schroeder, H.W. 1989. Environment, behavior, and design research on urban forest. In: Zube E.H. & Moore, G.T. (eds.) *Advances in environment, behavior, and design.* New York and London. Plenum Press. pp 87-117.

Sheppard, S.R.J. 2001. Beyond Visual Resource Management: Emerging Theories of an Ecological Aesthetic and Visible Stewardship. In: Sheppard, S.J.R. & Harshaw, H.W. (eds.) *Forests and landscapes - linking ecology, sustainability and aesthetics. IUFRO Researh Series, No 6*, CABI Publishing. pp 149-172.

Smardon, R.C. 1988. Perception and aesthetics of the urban environment: review of the role of vegetation. *Landscape and Urban Planning 15,* 85-106.

Stanley Jr, T.R. 1995. Ecosystem management and the arrogance of humanism. *Conservation Biology 9,* 255-262.

Steiner, F.R. 1991. *The living landscape: an ecological approach to landscape planning.* New York, McGraw-Hill.

Tahvanainen, L., Tyrväinen, L., Ihalainen, M., Vuorela, N. & Kolehmainen, O. 2001. Forest management and public perceptions - visual versus verbal information. *Landscape and Urban Planning* 53(1-4): 53-70.

Tyrväinen, L., Silvennoinen, H. & Kolehmainen, O. 2002. Can ecological and aesthetic values be combined in urban forest management? In: *Proceedings of Forestry Serving Urbanised Societies. IUFRO Regional Conference in collaboration with EFI, Copenhagen, Denmark, August 27-30, 2002*.

Wheater, C.P. 1999. *Urban Habitats.* London. Routledge.

Wing, M.G. & Johnson, R. 2001. Quantifying forest visibility with spatial data. *Environmental Management 27*, 411-420.

Wise, S.M. 2000. Assessing the quality for hyrdological applications of digital elevation models derived from contours. *Hydrological Processes 14,* 1909-1929.

WWWebster Dictionary. 1998. Merriam-Webster Inc.

Yaffee, S.L. 1999. Three faces of ecosystem management. *Conservation Biology 13,* 713-725.

Zube, E.H., Sell, J.L. & Taylor, J.G. 1982. Landscape perception: research, application and theory. *Landscape planning 9,* 1-33.

Acknowledgement

First of all I want to thank three persons that in different stages of my work with this thesis have been of great importance to me.

- Roland Gustavsson, for getting me interested in urban forestry and research, and also providing the possibility to do a PhD.
- Gary Fry, for guidance, encouragement and support throughout the whole, reading of drafts and discussion of ideas and research generally.
- David Miller, for valuable comments, inspiration and new ideas to this thesis and research generally.

Without these three persons it would definitely not have been this thesis.

Beside these three persons there are others I wish to thank specially.
Neil Sang, for your support and encouragement and not to forget all your reading of various drafts of this thesis.
Cecil Konijnendijk, for valuable comments on draft of this thesis.
Mattias Qviström, for being the pacemaker for this race.
Lars GB Andersson, for the help with GIS, company in field and general support and friendship.
My friends at the Macaulay Institute, and especially those in the Cunningham building, for providing new perspectives on research and company during a Scottish autumn.
My family, especially my mother and father, for supporting me both financially and mentally.
Anna, Gunilla and Karin for being such good friends through this process - it is good to know you are out there in the real world for me.

I would also like to give a general thank to my present and previous colleagues and friends at the Department of Landscape Planning at Alnarp for good support and companionship throughout these years. I would also like to thank Macaulay Institute for providing the possibility and facilities to do some of my work there.

This thesis was financially supported by Movium and the faculty research program ”Environmental resources of the urban and suburban landscape – developmental management and maintenance”at the Swedish University of Agricultural Sciences. The travel grants from KSLA, NorFa, SLU and Department of Landscape Planning are also gratefully acknowledged.