

Faculty of Biological and Environmental Sciences  
University of Helsinki

**Eco-experiential quality of  
urban forests:**  
Combining ecological, restorative and aesthetic perspectives

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ACADEMIC DISSERTATION

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# LIST OF ORIGINAL ARTICLES

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- I            Hauru, K., Niemi, A., Lehvävirta, S. (2012) Spatial distribution of saplings in heavily worn urban forests: Implications for regeneration and management. *Urban Forestry & Urban Greening* 11, 279–289.
- II           Hauru, K., Lehvävirta, S., Korpela, K., Kotze, D. J. (2012) Closure of view to the urban matrix has positive effects on perceived restorativeness in urban forests in Helsinki, Finland. *Landscape and Urban Planning* 107, 361–369.
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- IV          Hauru, K., Haapala, A., Lehvävirta, S. Multidimensionality of aesthetic experiences in natural and semi-natural environments - Review of concepts used in the recent research literature. Manuscript submitted to *Landscape Research*.

The articles are referred to in the text by their roman numerals.

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## Contributions of authors to papers of this thesis

	Paper I	Paper II	Paper III	Paper IV
Original idea	SL	KH, SL	KH, SL, SK	SL, AH, KH
Design	SL	KH, SL, KK	KH, SL, SK	SL, AH, KH
Data collection	SL	KH	KH, SK	SL
Data analyses	AN, KH, SL	KH, SL, JK	KH, SK, SL, JK	KH, SL, AH
Writing	KH, AN, SL	KH, SL, KK, JK	KH, SK, SL, JK	KH, SL, AH
KH = Kaisa Hauru, SL = Susanna Lehvävirta, JK = D. Johan Kotze, KK = Kalevi Korpela, AH = Arto Haapala, AN = Aki Niemi, SK = Saara Koskinen				

Paper I: KH was responsible of writing and submitting the paper, and interpreting results from data analysis. The analysis was planned jointly by all authors and performed by AN.

Paper II: The role of KH was integral in the planning and design of the study. She collected the data and analyzed it together with SL and JK. KH was also in charge of writing and submitting the paper.

Paper III: KH was responsible of the planning and design of the study, together with SK and SL. KH collected the data together with SK. KH analyzed the data in dialogue with all co-authors, and was in charge of writing and submitting the paper.

Paper IV: KH contributed to the design of the paper, reviewed the literature, and was in charge of writing and submitting the manuscript.



# Abstract

In this thesis I combined perspectives from urban forest ecology, environmental psychology and empirical aesthetics to determine whether ecologically beneficial urban forest planning and management can also be experientially good. The thesis consists of four interrelated papers, three of which are empirical research papers and the fourth a theoretical review article. All empirical work was performed in boreal forests in Helsinki, the capital of Finland.

In the ecological part of the thesis I concentrated on studying planning and management options that contribute to the ecological quality of urban forests, especially tree regeneration and biodiversity, as well as the vitality of native forest species. Previous studies have shown that urbanization, increasing edge effects as a result of forest fragmentation, and intensive recreational use affect the ecological quality of forests negatively. These negative effects can be reduced by keeping forest patches large enough to provide habitats for forest species, and maintaining the forest edge vegetation dense and multilayered to reduce edge effects. Furthermore, leaving natural barriers, e.g. decaying logs, on the forest floor to guide people's movement and to restrict intensive trampling, are likely to be ecologically sound options. In the first empirical paper, I introduced a new ecological forest management option called "sheltering group". It is a thicket of saplings occurring in forests that suffer from heavy wear, which can be used as a barrier against trampling to provide safe regeneration microsites for other saplings and forest vegetation.

Ecological forest management options may not always be favored in urban forest planning and management because they are generally thought to affect people's recreational, e.g. restorative and aesthetic, experiences negatively. In this thesis I examined whether this assumption is supported when people are taken into forests and their multisensory experiences investigated on-site. In two empirical papers I examined, using survey techniques, how closure of view to the urban matrix from the forest interior, which indicates dense edge vegetation minimizing ecological edge effects, affects the restorative experiences of residents, and do ecologically beneficial decaying logs on the forest floor affect aesthetic experiences of forest visitors. I showed that restorative experiences were better in forest interiors with closed views to the urban matrix than at the edges or edge zones with open or semi-closed views. Furthermore, decaying logs did not, in general, affect the aesthetic experiences of people in urban forests, and logs were well accepted by urban forest visitors. My results indicate that at least these ecological forest management options enhance or maintain experiential qualities of the studied urban forests.

In this thesis my aim was also to clarify concepts related to restorative and aesthetic experiences to better determine, assess and measure the experiential quality of green spaces in the future. In the fourth paper I concentrated on operationalizing aesthetic experiences and explored, through a literature review, what is a multisensory aesthetic experience in natural or semi-natural environments, and what dimensions it consists of. I concluded that aesthetic experience in natural environments is not the same thing as general preference and it is more than scenic beauty. I also suggested that aesthetic experiences consist of at least the following dimensions perceived in the environment: coherence – reflecting care and congruence of the environment, complexity – reflecting diversity and mystery, multisensory beauty, as well as sublimity. All these dimensions should be taken into account when assessing the aesthetic quality of green spaces.

I also provided recommendations for pluralistic planning and management aiming at eco-experientially good quality urban forests.

**Key words:** aesthetic experience, biodiversity, edge effect, forest management, perceived restorativeness, recreation, regeneration, urbanization, wear

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# 1 Introduction

## 1.1 Framing the eco-experiential quality of urban forests

Urban forests are woody green spaces located within or close to cities or towns, i.e. population centers of varying sizes that largely consist of built environments, such as residential and industrial areas (cf. e.g. Nowak et al., 2001; Randrup et al., 2005; Konijnendijk et al., 2006). Together with other urban green and blue spaces, e.g. parks, meadows, green roofs, rivers, ponds and coastal areas, forests form the so-called green infrastructure, i.e. a network of natural and semi-natural urban environments and features that is the basis for the various ecosystem services and benefits that contribute to human well-being (Tzoulas et al., 2007; Gómez-Baggethun et al., 2013). Urban forests consist of remnants of originally larger natural forest areas, especially in Europe (unlike planted forests common in North America; Konijnendijk et al., 2006), and the size of a single forest patch may vary from less than a hectare to several hundreds of hectares. A common feature to all urban forests, at least in the northern Europe, is that their undergrowth and other vegetation is forest-like, i.e. consists of naturally regenerating flora such as mosses, dwarf shrubs, herbs, grasses and tree saplings, and not planted vegetation and cultivated lawns (Lehvävirta, 2007; Vierikko et al., 2014). Furthermore, urban forests are usually not managed as intensively as built parks or street trees (e.g. Gundersen et al., 2005; Gustavsson et al., 2005; Lehvävirta, 2007).

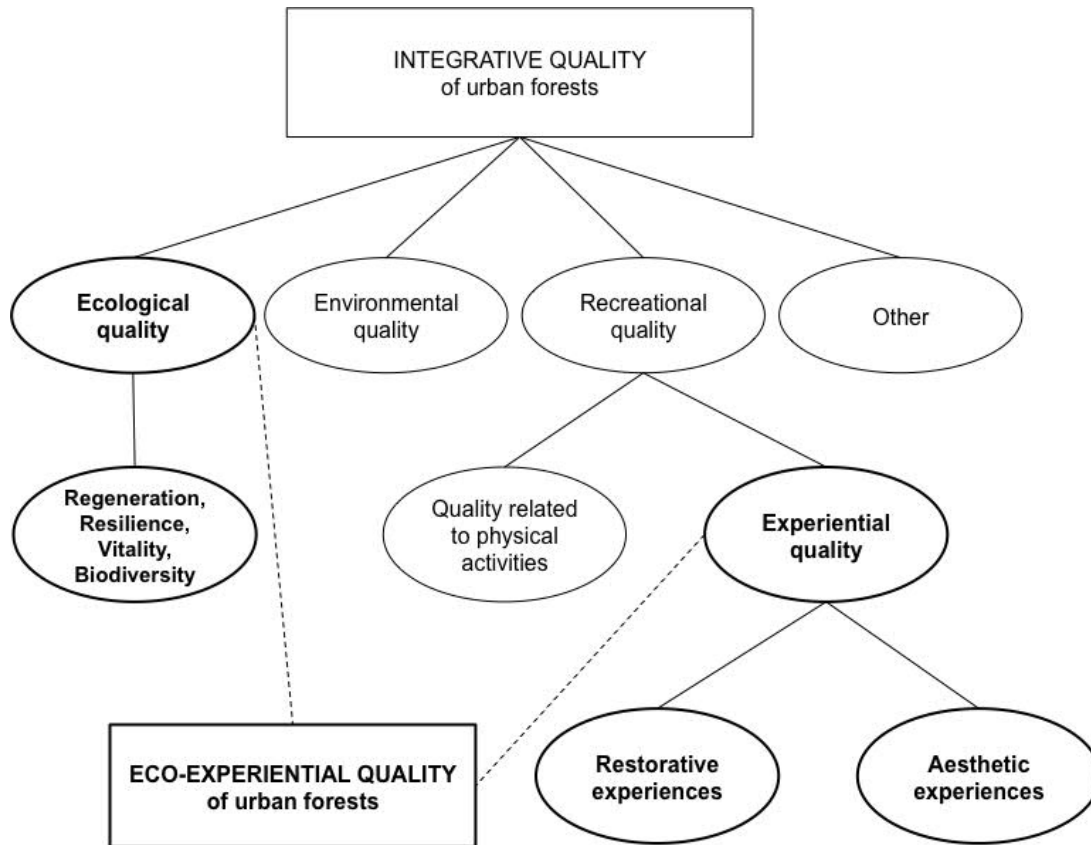
In the Nordic countries of Europe, e.g. in Finland where this study takes place, residents (herein meaning people living in cities or suburbs, and other potential or actual green space users) usually have free access to urban forests, thus these green spaces are visited frequently and used for various recreational purposes during all seasons (Gundersen et al., 2005; Kohtala, 2008; Saukkonen, 2011; Yli-Pelkonen, 2013; Hauru et al., 2015). Consequently, urban forests are often planned and managed to maintain and enhance recreational qualities, i.e. features and structures of forests that enable both physical activities (e.g. jogging, walking, cycling, playing and berry picking) and experiential benefits, such as recovery from everyday stress and aesthetic experiences (Ode and Fry, 2002; Gundersen et al., 2005; Löfström et al., 2006; Edwards et al., 2011; Hauru et al., 2015). Maintaining or enhancing opportunities for physical activity in forests can be done by providing easy access to forests by upkeeping the network of walking, cycling and skiing trails as well as removing obstacles such as fallen logs from routes (e.g. Humpel et al., 2002; Gundersen and Frivold, 2008; Saukkonen, 2011). Safety issues also need to be taken into account when encouraging physical activity in urban forests (e.g. Jorgensen et al., 2007; Kohtala, 2008; Saukkonen, 2011). This often means cutting down possibly hazardous

decaying trees, removing thick bushes to improve visibility, installing walkway lights, as well as signposts and other cues that may ease orientation in forests (e.g. Humpel et al., 2002; Herzog and Kirk, 2005; Jorgensen et al., 2007; Saukkonen, 2011; Jansson et al., 2013; Tang et al., 2014).

Forest features and structures that maintain or enhance experiential benefits may partly be the same as those maintaining physical activities. For example, accessibility and visibility have been shown to predict preferences and pleasure of environments (Staats et al., 1997; Herzog and Kutzli, 2002; Herzog and Kirk, 2005), and “aesthetics” and pleasurable scenery to encourage for physical activities (Humpel et al., 2002). However, there may also be conflicts, as e.g. low visibility and feelings of danger may be negative to some, yet for others they may affect positively through feelings of mystery, an essential component predicting preferences for environments (e.g. Kaplan and Kaplan, 1989; Herzog and Kutzli, 2002; Herzog and Kirk, 2005; Herzog and Bryce, 2007; Jorgensen et al., 2007). Therefore, both physical activity-based and experiential benefits should be taken into account when assessing the recreational qualities of urban forests.

Moreover, recreational forests are often important ecologically and environmentally as they can provide habitats for forest flora and fauna, maintain and enhance biodiversity, regulate local and regional climatic conditions, mitigate stormwater runoff and diminish strong winds (e.g. Tyrväinen et al., 2005; Gómez-Baggethun et al. 2013; Gómez-Baggethun and Barton, 2013; Konijnendijk et al., 2013). This means that some urban forests, or parts of them, can be maintained to enhance ecological and biodiversity values and/or regulate environmental conditions and hazards.

Urban forest planning and management usually aims to enhance recreational, ecological and/or environmental qualities (and benefits and values related to them), but they may as well provide other benefits, such as provisioning and economic, however these are seldom (at least in Finland) prioritized in planning and management strategies (e.g. Saukkonen, 2011). With a growing need for multifunctional green space planning and management (Gundersen et al., 2005; Gustafsson et al., 2005; Llausàs and Nogué, 2012) integrating different qualities at the same time, instead of targeting only one of them per forest, has become a leading trend (see Fig. 1). However, integration might not always be easy since different qualities (and benefits and values related to them) might overlap and some qualities may not even be recognized (e.g. Gustafsson, 2005). Based on my experience regarding forest management in Finland, and elsewhere in Europe, I argue that experiential qualities are often underrated in urban forest planning and management, compared to, e.g. physical activity-based qualities that are more easy to determine, assess and measure (cf. Hauru et al., 2015). Thus, in this thesis I concentrate on experiential qualities and study whether these can be integrated into ecological qualities to achieve eco-experientially good quality urban forests (Fig. 1).



**Figure 1** Conceptual framework of the most important qualities of urban forests. Qualities, on which I concentrate on in this thesis, are shown in bold. Ecological quality is determined by benefits and values related to regeneration, resilience, vitality and biodiversity while experiential quality means benefits and values related to restorative and aesthetic experiences (there may be other benefits and values related to the mentioned qualities, which are not discussed here). The “Other” category includes, e.g. economic quality related to forest products, and environmental quality e.g. regulating benefits.

## 1.2 Challenges of maintaining and enhancing the eco-experiential quality of urban forests

Ecological values of urban forests, at least in Finland, are usually best protected and enhanced in areas with a conservation status assigned by law (Finnish Nature Conservation Act 1096/1996; see also Löfström et al., 2006; Borgström et al., 2013). In Helsinki – the capital of Finland – for example, there are ca. 159 ha of woody nature conservation areas in the ca. 4000 ha of forests in total (Vierikko et al., 2014). Also, forests not protected by conservation status are an integral part of the green infrastructure network and in this way support the existence and qualities of conservation and biodiversity hotspots (cf. e.g. Gustafsson et al., 2005; Colding et al., 2006; Tzoulas et al., 2007). Many parts of urban forests outside conservation areas

also have ecological and biodiversity values (e.g. Saukkonen, 2011; Vierikko et al., 2014), but maintaining or enhancing these may not be easy, or even agreed, since these areas are constantly under pressure of land use changes. In this thesis, I concentrated on forests without conservation status.

Urbanization, and the related population growth and construction of new residential and other built areas, may result in a decrease in, and fragmentation of, urban forests (MacDonald and Rudel, 2005; Gong et al., 2013). Fragmentation results in the isolation of forest patches and increase in forest edge environments, which has several negative consequences on the ecological quality of forest (these consequences are reviewed in Section 1.4.1). Furthermore, an increase in the amount of residents using these forest remnants may result in overuse, meaning intensive trampling, erosion and wear of the undergrowth, which also affect the ecological quality of forests negatively (see Section 1.4.1). Fragmentation and the increasing number of forest users may also have negative effects on the recreational and experiential qualities of forests due to, e.g. fewer and smaller recreation areas to be shared with other recreationists, sometimes with crowding effects and incompatible uses, as well as visible signs of wear (Malmivaara et al., 2002). Fragmentation and the intensive recreational use of forests suggest that in some locations urban forest planning and management has to target at the preservation of basic ecological functions, such as natural regeneration of tree saplings and undergrowth, processes necessary for the vitality and survival of the whole forest (Lehvävirta, 2007; Saukkonen, 2011).

Responding to the above-mentioned challenges (related to urbanization, decrease in size and fragmentation of urban forests, the growing amount of urbanites using forests, intensive trampling, and the decrease in forests' ecological and recreational qualities) requires pluralistic and integrative approaches to be applied in urban forest planning and management (which in this thesis also includes the option for benign neglect, i.e. not implementing any management practices such as thinning and logging; cf. Gustavsson et al., 2005). Thus, besides inter- and transdisciplinary scientific or professional expert knowledge of forest ecological processes and ecosystem services, local residents' values, opinions, needs, concerns and experiences, here termed residents' knowledge or experiential knowledge, need to be taken into account in planning and management processes (Yli-Pelkonen and Kohl, 2005; Faehnle, 2014, p. 23; Faehnle et al., 2014). This means involving all stakeholder groups, e.g. professionals, scientists, governmental authorities, residents and other forest users, into the decision-making, planning and sometimes even management of forests (Colding et al., 2006; Faehnle, 2014).

Integrating experts' and residents' knowledge and experiences might not, however, be easy since experiences and understanding of residents do not always coincide with what forest planners, managers, ecologists or other scientists value as important. Even though residents' knowledge might contradict scientific or expert knowledge, it is necessary to acknowledge

them since these are the people who use and benefit from urban forests directly (cf. e.g. Faehnle, 2014).

Finally, preferences and opinions of both residents and other experts may change over time, and they are supposedly different in different parts of the world depending on, e.g. people's cultural backgrounds (see e.g. Stamps, 1999; Gundersen et al., 2008). Thus, there seem to be a need for regular updating of knowledge about different stakeholder's opinions, preferences and experiences of urban forests (and green infrastructure in general), and to develop ways to integrate these into planning and management aiming at good quality urban forests.

### 1.3 Aims and structure of the thesis

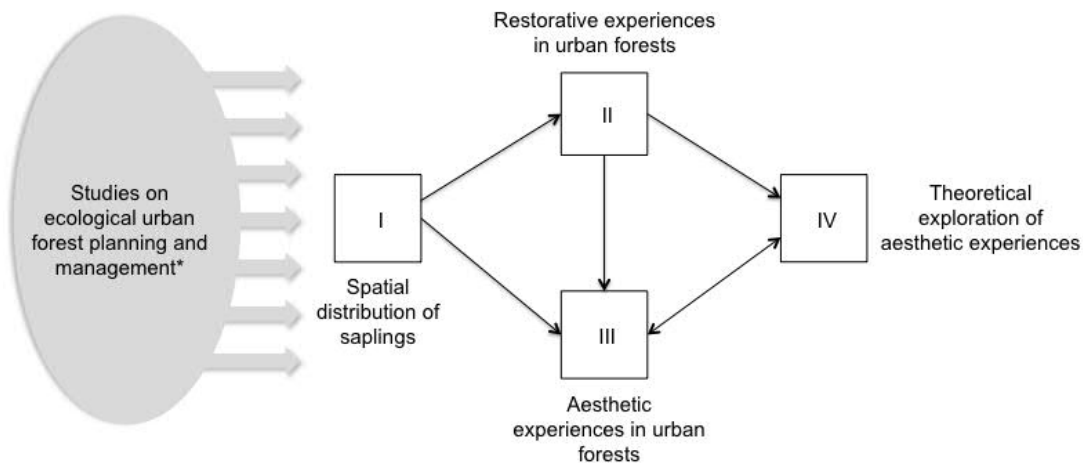
In this thesis I studied topics related to forest planning and management that aim at ecologically and experientially good quality urban forests. In other words, my aim was to study *whether ecological and experiential qualities of urban forests can be integrated, and maintained or enhanced at the same time*. By ecological quality I mean maintaining or enhancing e.g. basic ecological functions (such as decomposition and regeneration of tree saplings), resilience (an ecosystem's tolerance towards disturbances and ability to recover from them), vitality (ecosystem "health and well-being") and biodiversity. Experiential quality in this thesis means maintaining or enhancing experiential benefits, herein restorative and aesthetic experiences (defined in the following sections in more detail). I also aimed at investigating *what kinds of restorative and aesthetic experiences people obtain from urban forests with different physical features, and what aspects of these experience types should be taken into account when determining and assessing the experiential quality of urban forests*. My purpose was also to provide information and suggestions for multifunctional and pluralistic urban forest planning and management aiming at eco-experientially good quality urban forests.

The above-mentioned topics are dealt with in four co-authored papers (Papers I–IV; listed on page 4), the interrelations of which are shown in Fig. 2 below. All papers were based on a larger set of studies of the same research group that have investigated the effects of forest fragmentation, increasing edge effects and intensive trampling on forests' ecological quality (e.g. on the regeneration and vitality of the undergrowth and soil microbes), and provided recommendations for forest planning and management on how to diminish the negative effects of these human-related disturbances (see legend of Fig. 2 for the list of these studies). These studies, for instance, suggested that both edge effects and trampling strongly shape urban forests, and that dense edges, large forest sizes and certain natural elements that guide movement and trampling in forests might be used in management to



improve the ecological quality of urban forests (see Section 1.4.1 below for the review of these results).

In Paper I of this thesis I studied the regeneration and spatial distribution of tree saplings in heavily trampled urban forests, and asked what management options can be taken to improve the regeneration ability of trees. Papers II and III relate to ecological findings of our research group as they investigated how two features that are possible consequences of ecologically beneficial forest management practices (i.e. closure of view indicating dense forest edges or size of the forest, and dead and decaying logs acting as barriers against wear or indicating biodiversity) affect forest experiential quality, i.e. restorative and aesthetic experiences of forest visitors. Finally, Paper IV is a theoretical review paper in which I explored what an aesthetic experience in natural or semi-natural environments means, what dimensions it might include, and how it could be operationalized to better assess the aesthetic quality of urban forests, or other green spaces.



**Figure 2** Structural framework of the four interrelated papers of this thesis (I–IV), and previous studies that have influenced the development of this thesis (grey oval). The arrows indicate how each paper influenced the development of others. The two-way arrow means that Papers III and IV influenced simultaneously the development of each other. \* The main results of previous studies of the same research group that influenced the development of this thesis (e.g. Lehvavirta, 1999; Lehvavirta et al., 2004; Hamberg et al., 2008, 2009, 2010; Kohtala, 2008; Malmivaara-Lämsä et al., 2008; Kotze et al., 2012; Lehvavirta et al., 2014) are introduced in Section 1.4.1.

I provide more specific research questions in Section 1.5. Before that, I shortly present the theoretical background and previous research on the main topics of this thesis: ecological urban forest planning and management aiming at good ecological quality, as well as restorative and aesthetic experiences indicating experiential qualities of urban forests.

## 1.4 Theoretical background and previous research

### 1.4.1 Ecological urban forest planning and management

The ecological urban forest planning and management I focus on in this thesis include options that, hinder the harmful effects of 1) edges and 2) trampling (and consequent wear), and 3) maintain and enhance biodiversity. I will introduce the main results of studies that influenced the development of my thesis (listed in the legend of Fig. 2 above), and relate these to research from other parts of the world.

**The edge effect** is a common and increasing phenomenon in urban forests facing fragmentation. This means that, due to increasing edges more sunlight, wind and nutrients enter the forests, which alter forests to become lighter, drier and more nutrient rich, especially at edge habitats (e.g. Lehvavirta, 2007; Malmivaara-Lämsä et al. 2008, Collinge, 2009). This also changes forest species composition from the traditional forest species towards species tolerant to edges and open habitats. For example, Hamberg et al. (2008) showed that, in the Greater Helsinki area in Finland, edge effects changed the composition of *Myrtillus* type understorey vegetation in conifer-dominated boreal forests up to 50 m into the forest from the edge so that traditional forest species, e.g. blueberry (*Vaccinium myrtillus*), may lily (*Maianthemum bifolium*) and some mosses (e.g. *Pleurozium schreberi*) decreased while edge tolerant species, e.g. grasses, such as wavy hair grass (*Deschampsia flexuosa*) increased in cover. In the same area, Lehvavirta et al. (2014) showed that edge conditions affected tree regeneration at least up to 80 m from the edge towards the forest interior and promoted the survival of deciduous tree saplings, such as rowan (*Sorbus aucuparia*) and aspen (*Populus tremula*) near edges, while the effect of edges on spruce (*Picea abies*) was negative.

Edges also affect soil microbes and ground beetles, as shown by two other studies from the same research group. Malmivaara-Lämsä et al. (2008) showed that soil microbial activity was lower within a 20 m edge zone than further inside the forest, which was suggested to be due to the dryness of humus near edges. Kotze et al. (2012) indicated that edges affected the structure of carabid beetle assemblages at least up to 10 m into forests in Helsinki and Edmonton, but patterns were not that clear, possibly do to the dominance of generalist species in these fragmented forests, especially in Helsinki.

The above-mentioned studies of our research group are in line with studies from other parts of the world, which also showed fragmentation and edges to affect carabid and dung beetle assemblages in Belgium and Argentina (Gaublomme et al., 2008; Peyras et al., 2013), as well as growth and recruitment of red-cedar trees (*Thuja Plicata*) in Seattle, US (O'Brien et al., 2012). Furthermore, in Amazonia rain forests edge effects have shown to

affect tree-community dynamics as much as several hundred meters from edges to the interiors (Laurance et al., 1998).

The harmful effects of edges may be decreased by keeping forest patches large enough. For example, Hamberg et al. (2008) suggested that boreal urban forest fragments should be at least 2–3 ha in size and preferably of circular shape to allow for enough interior forest habitats, and Lehvävirta et al. (2014) concluded that the forest diameter should not be less than 160 m to support typical tree species in spruce-dominated urban forests. Soga et al. (2013) also called for large forest sizes (at least 1 ha if circular, but even 6 ha if irregularly shaped) to protect carabid beetle diversity in urban forests in Tokyo, Japan. Furthermore, Noreika and Kotze (2012) showed that the edge contrast (i.e. whether there is asphalt, grassland or moderate forest on the “urban side” of the forest edge) affected carabid beetle assemblages so that the more abrupt the edge the greater the effect. This suggests that, besides concentrating on the size and shape of a forest patch, managers should try to “soften” the edge contrast by allowing vegetated habitats on the “urban side” of the forest. Another option to hinder the negative effects of edges, especially in cases where the edge is sharp and the forest is already small in size, could be to maintain a dense and multilayered forest edge. For example, Hamberg et al. (2009) suggested woody edge vegetation density 225–250 m<sup>3</sup> ha<sup>-1</sup> to reduce the effect of edge on the shrub layer vegetation.

**Wear**, due to **trampling** and other user-based disturbances (e.g. wear due to dog walking or mountain biking), is another phenomenon affecting the ecological quality of forests negatively. Hamberg et al. (2010) showed that a low amount of human trampling caused wear of the undergrowth in *Myrtillus* type suburban forests in the Greater Helsinki area. In that study, vegetation cover decreased by 10–30% within a year when it was trampled 35 times, and by up to 50% when trampled 70–270 times. Furthermore, Hamberg et al. (2008) and Lehvävirta et al. (2014) showed that, in the same area, trampling affected undergrowth and tree sapling regeneration, not only directly on paths, but also several meters away from visible paths towards the seemingly untrampled vegetation. Trampling also affects soil microbial activity and carabid beetle assemblages in boreal urban forests, as shown by Malmivaara-Lämsä (2008) and Kotze et al. (2012).

Studies from other parts of the world show similar results. For example, Kissling et al. (2009) showed that, even the relatively short-term trampling (100–300 passes) decreased vegetation cover and plant height, as well as increased soil compaction in beech forests in Switzerland. Roovers et al. (2004) and Littlemore and Barlow (2005) showed that the effects of trampling on vegetation, soil and litter invertebrates were more deteriorating in the middle of intensively trampled paths compared to path margins and undisturbed ground. Godefroid and Koedam (2004) concluded that the effects of trampling (e.g. on plant composition) extend at least up to 10 m from the path towards the untrampled habitats in beech forests in Belgium.

The negative effects of trampling and wear on the ecological quality of forests can be decreased by, e.g. guiding and spatially limiting walking and trampling in forests (e.g. Lehvävirta, 1999; Lehvävirta et al., 2004; Roovers et al., 2004, 2006; Hamberg et al., 2008). One way to spatially limit movement in forests could be instruction and prohibition signs, however, this may be inefficient since people, at least in urban forests in Finland, have several motives for moving off the maintained routes (e.g. Kohtala, 2008). Lehvävirta (1999) suggested that natural elements, such as large stones, thick bushes, fallen logs and mature trees could be used to guide movement in forests and to protect vegetation from the harmful effects of trampling and wear. Indeed, Rooves et al. (2006) showed that grass and shrub layer vegetation high enough (54 cm at minimum) at the border of maintained paths acted as barriers restricting off-path movement to the woody environment.

**Dead and decaying logs** function in urban forests not only as “barriers against wear” (as suggested above; Lehvävirta, 1999) but also as features maintaining and enhancing biodiversity in boreal forests. Logs provide habitats for, e.g. decomposers and species benefiting from coarse woody debris (CWD), such as many polypores and saproxylic invertebrates (e.g. Esseen, 1997; Siitonen, 2001; Savola, 2015). In urban forests that have a drier microclimate and soil due to increased edge effects, logs may also increase moisture in their vicinity to, e.g. improve tree regeneration (cf. e.g. Lehvävirta, 2007). The potential exists for urban forests to provide dead and decaying wood to enhance biodiversity, and ecological quality in general, since economic interests related to wood production, at least in Finland, are usually small or absent (e.g. Löfström, 2006; Saukkonen et al., 2011). However, increasing the amount of logs may not always be favored since they are generally considered to be ugly, disliked or even dangerous elements in urban forests (Tyrväinen et al., 2003; Karjalainen, 2006; Gundersen and Frivold, 2008, 2011).

Besides decaying wood, other ecological management options (introduced above) may be difficult to promote in urban forests due to general beliefs about their negative effects on recreational quality. For example, many studies have shown that people generally dislike dense vegetation and bushes as they restrict visibility, accessibility and feelings of safety in forests (e.g. Ruddell and Hammit, 1987; Staats et al, 1997; Herzog and Kutzli, 2002; Tyrväinen et al., 2003; Herzog and Kirk, 2005; Gundersen and Frivold, 2008). However, it is not that clear how residents perceive these ecological management options when they mitigate the more unwanted effects (e.g. when dense vegetation restricts the visibility to an ugly environment). For example, Kohtala (2008) studied, in her Master’s thesis, forest visitors’ attitudes towards barriers restricting movement in heavily worn urban forests, and found that people generally liked the idea of barriers restricting erosion and wear. In her study, the most preferred options to guide people’s movements were man-made woodchip routes (although respondents also

thought it would ruin the image of a “natural-like forest”), thick bushes, downed logs and guiding signposts (logging residues, large stumps and fences were not liked that much).

In order to gain understanding of the usefulness and acceptability of the above-mentioned ecological urban forest management options, and to better integrate them into forest planning and management, specific designs are needed that test their effects on recreational (e.g. restorative and aesthetic) experiences.

#### **1.4.2 Restorative experiences**

Restorative experiences here refer to the recovery from psycho-physiological stress and/or “directed attention fatigue”, i.e. the depleted ability to direct attention after, for instance, a demanding task (cf. Ulrich, 1983; Kaplan and Kaplan, 1989; Ulrich et al., 1991; Kaplan, 1995). According to the prevailing theories on restorative experiences, i.e. psycho-physiological Stress Reduction Theory (Ulrich, 1983; Ulrich et al., 1991), and Attention Restoration Theory (Kaplan and Kaplan, 1989; Kaplan, 1995), environments in which these depleted psychological resources are able to recover are called “restorative environments”. Previous research has shown that especially natural and semi-natural environments tend to be restorative, meaning that walking or being in, or just looking at, such environments help people to recover from stress and attention fatigue (Kaplan and Kaplan, 1989; Kaplan, 1995; Hartig et al., 1996, 1997, 2003; Korpela and Hartig, 1996; Korpela et al., 2001, 2008; Laumann et al., 2001; Herzog et al., 2003; Berto, 2005; Korpela and Ylén, 2007; van den Berg et al., 2014; Tyrväinen et al., 2014; Bratman et al., 2015). Offering and maintaining good quality restorative environments in cities, and especially close to where people live and work, is important since everyday restoration may prevent people from cumulating and more severe stress-related symptoms and diseases, such as depression or cardio-vascular diseases (cf. Bowler et al., 2010; Hartig et al., 2011, p.133; Lederbogen et al., 2011).

Restorative experiences can be operationalized and measured in different ways depending on the focus. To study self-reported restorative experiences and outcomes, one can use survey methods, i.e. questionnaires and scales (e.g. Hartig et al., 1996, 1997; Korpela and Hartig, 1996; Laumann et al., 2001; Han, 2003; van den Berg et al., 2014), while physiological stress responses are examined by measuring, e.g. blood pressure, muscle tension and cortisol levels (e.g. Ulrich et al., 1991; Hartig et al., 2003; Park et al., 2009; Tyrväinen et al., 2014; van den Berg et al. 2014).

In this thesis I focused on people’s recreational experiences, thus I concentrated on their self-reported restorative experiences (and not direct physiological health effects). More specifically, I used the conception of restorative experiences that is based on the Attention Restoration Theory (ART; Kaplan and Kaplan, 1989; Kaplan, 1995). According to ART, directed

attention fatigue has many negative consequences, such as irritability and increased potential of errors in the performance of tasks that require directed attention (e.g. Kaplan, 1995; Hartig et al., 1996, 1997; Berto, 2005; Korpela et al., 2008). Restoring from such conditions requires moving to a space that possesses features that enhance attention restoration. These features reflect four informational components perceivable in the environment (e.g. Kaplan, 1995; Hartig et al., 1996; 1997): “coherence” (reflecting connectedness of features of the environment to one another and to a larger whole, as well as the physical or psychological scope and scale of the place), “being away” (getting away from everyday hassles and worries, and physical or mental movement to “another place”), “compatibility” (how well one’s desires, needs and intentions fit with the environment, and how the environment supports these desires) and “fascination” (being effortlessly enchanted or excited by the natural environment or some features of it). In other words, these four interlinked components are suggested to play a significant role in restorative experiences and thus, indicate the restorative quality of an environment.

As already mentioned, natural environments, in general, are high in their restorative potential, but it is not that clear what types of environments provide the best restorative experiences. Some indication exists that the level of naturalness (i.e. “how close a landscape is to a perceived natural state”; see Ode et al., 2009) affects restorativeness, however, there is no consensus how. For example White et al. (2013) showed that people tended to restore better in rural forests than in urban parks or open spaces in the countryside, and Korpela et al. (2010) indicated that restorative experiences of favorite places were stronger in waterside environment or an urban woodland than, e.g. in a built park or a sports field. Also Carrus et al. (2013) showed that perceived restorativeness increased with an increasing level of naturalness, i.e. the less built elements there was in evaluated photographs. On the other hand, Martens et al. (2011) showed that respondents’ psychological well-being was better when they walked in “tended” (with visible signs of management) compared to “wild” (i.e. not managed for many years) urban forests. Furthermore, some studies indicate that any kind of urban green space might offer restorative experiences. For example, Tyrväinen et al. (2014) and van den Berg et al. (2014) showed that both intensively managed parks, and the more natural-like urban forests provided restorative experiences, and that differences in the level of restorativeness between different green space types were marginal. Finally, it has been shown that even small public urban parks (area < 3000 m<sup>2</sup>, or < 5000 m<sup>2</sup> depending on the definition) can provide restorative experiences if they have at least some amount of vegetation, such as grasses, bushes and trees (Nordh et al., 2009; Perschardt and Stigsdotter, 2013).

Taken together, although previous studies agree that natural environments provide better restorative experiences than built ones, and that some natural elements in otherwise built, i.e. “gray”, spaces affect restorativeness positively, it is not clear what natural features, and what

combinations of them, provide the best quality restorativeness (cf. e.g. Nordh et al., 2009). Furthermore, possible reasons for inconsistencies in terms of the effects of naturalness on restorativeness might be that, 1) studies have used different scales or different versions of the same scale, and different concepts to study similar things, 2) some studies have used photography-based evaluation methods or visualizations while some have measured experiences on-site, 3) perceived naturalness is subjective, i.e. what is natural to one may not look like natural to another, which increases the variance of evaluations, and 4) naturalness is described differently in different types of green spaces, e.g. naturalness of a pocket park may mean a totally different thing than naturalness of a forest. I will discuss these issues in the following sections of this thesis.

### **1.4.3 Aesthetic experiences**

Defining aesthetic experiences of natural environments is a demanding task. Scholars have pondered on the essence of aesthetics of natural environments for centuries (see e.g. Lothian, 1999; Daniel, 2001, for reviews) and the same questions are still reflected in today's discussions (cf. e.g. Carlson and Berleant, 2004). Debated questions during the past decades include, e.g. 1) whether aesthetic experiences are emotion-based responses to the environment, or whether they are knowledge-based cognitive responses that require scientific and biological facts as back-up and to frame the experience to the "right" context, i.e. natural or semi-natural environments (Carlson, 1979; Gobster, 1999; Carroll, 1993/2004), and, 2) whether aesthetic preferences (i.e. preferences based on aesthetic experiences) are universal or sensitive to changes, e.g. as a consequence of accumulating knowledge and cultural background (cf. van den Berg et al., 1998; Gobster et al., 2007). A fundamental question is also, 3) where does the "aesthetic" lie in the framework of experiences of natural environments, i.e. what is its relationship to other types of experiences, such as the restorative, that determine the preference for environments (cf. e.g. Daniel, 2001; Karjalainen, 2006).

In this thesis I support the lines of thoughts that do not consider that there is only one (right) way of experiencing aesthetic (cf. Chenoweth and Gobster, 1990; Gobster et al., 2007; see also Paper IV of this thesis). Instead, I think that aesthetic experiences can be based on both emotion and knowledge (or either), and that aesthetic preferences may vary between geographical, cultural or personal situations, as well as with time (cf. Daniel, 2001; Brady, 2003). Still, it is possible that some aspects of aesthetic experiences are innate, i.e. based on evolution and thus, universal (cf. e.g. Hartig et al., 2011, p. 141; Fry et al., 2009). Furthermore, in accordance with e.g. Brady (2003, p. 123–128), I take aesthetic experiences of environments as not necessarily only visual, but also multisensory and multidimensional, not limited to any specific frames (as, e.g. a painting is) or to static

environmental situations. This approach also takes movement in place and changes in time into account (e.g. Brown and Daniel, 1984; Chenoweth and Gobster, 1990; Daniel, 2001; Brady, 2003, p. 121).

Aesthetic experiences have been widely dealt with in philosophical aesthetics, but empirical research has not reached the multidimensional aspects of aesthetic experiences that well (cf. Chenoweth and Gobster, 1990). Empirical research concerning aesthetic experiences of environments has often concentrated on visual or scenic beauty evaluations of photographs or slides (cf. Daniel, 2001; Karjalainen, 2006), or they have simply studied general environmental (or landscape) preferences, i.e. “liking” of an environment over another for some reason (this issue is dealt with in Paper IV of this thesis).

Emphasizing scenic beauty probably dates back to the 19<sup>th</sup> century aesthetics trend of picturesque in which painterly and postcard-like features, such as harmony, countryside idyll, and ordered beauty were appreciated as aesthetically pleasurable (cf. e.g. Gobster, 1999; Lothian, 1999; Carlson and Berleant, 2004). Seizing likeability as an aesthetic indicator probably leans on the prevailing theories from some decades ago that explain preferences for certain environments (such as semi-open savannah-like landscapes) by evolution-based theories and, basically, through one’s needs to survive (e.g. Appleton, 1975, 1984/1988; Orians and Heerwagen, 1992), or to understand and explore the environment. The latter assumption (understanding and exploration needs) is also the basis for a widely applied “preference matrix” theory by Kaplan and Kaplan (1989) that divides the two needs into four informational features perceived in the environment, either immediately (coherence and complexity) or after a while when getting to know the environment in more detail (legibility and mystery). Many studies have tested this cognition-based theory and shown that these four features predict preferences for environments (see e.g. Stamps, 2004, for a meta-analysis of these studies). The evolution-based theories have also met with criticism due to, e.g. a lack of reproducibility and comparability of the results (see e.g. introduction of Van den Berg et al., 1998; Stamps, 2004) and it may indeed be that being stuck in these points of view hinders understanding of the multidimensional nature of the cognitive-affective aesthetic experiences and, further, aesthetic preferences in constantly changing natural and semi-natural environments (cf. e.g. Daniel, 2001).

There is a field of landscape aesthetic studies that have searched for the different dimensions and concepts that characterize different types of landscapes (by landscape I here refer to the visual or perceived environment, see Daniel, 2001). More specifically, these studies (e.g. Coeterier, 1996; Tveit et al. 2006; Ode et al, 2008; Blumentrath and Tveit, 2014) have examined the “visual character” of the landscape and suggested that at least features such as stewardship, coherence, disturbance, historicity, visual scale, imageability, complexity, naturalness and ephemera, together characterize visual landscapes. They also suggested that these features can be assessed



directly from the landscape by a trained expert who measures and evaluates certain physical or formal indicators, such as trees, lakes, flowers, forms, lines, structures and their combinations, and determines the landscape character (and further, quality) based on these, rather than psycho-physical responses of the individual perceiver to the environment. These studies mainly rely on objectivist and expert-based assessments of the physical character of landscape, and not on the perception-based evaluation of qualities (cf. Daniel, 2001), yet they recognize the need for empirical testing of the relationship between these characters and landscape aesthetic preferences (cf. Sevenant and Antrop, 2009). Furthermore, these studies, even though based on mostly defining visual character of the landscape, are important in environmental aesthetics in the sense that they take the character (and further, quality) of the perceived environment as a combination of different interlinked components, and not e.g. as an indication of one single thing such as scenic beauty.

In summary, the above-mentioned approaches to aesthetic qualities are all useful in studying aesthetic experiences of natural environments and green spaces: philosophical aesthetics exploring what is aesthetics and aesthetic experience in natural environments, psycho-physical or cognitive models concentrating on preferences for environments (see also Karjalainen, 2006, p. 20–23), and landscape architectural, expert-based approaches searching for measurable landscape features that indicate different components of the landscape visual character. In this thesis I aim at combining these approaches to explore multisensory and multidimensional aesthetic experiences to determine the aesthetic quality of urban forests. Furthermore, I believe this “empirical environmental aesthetic” approach is applicable to assessing aesthetic qualities of other green spaces as well.

## 1.5 Operationalization and research questions

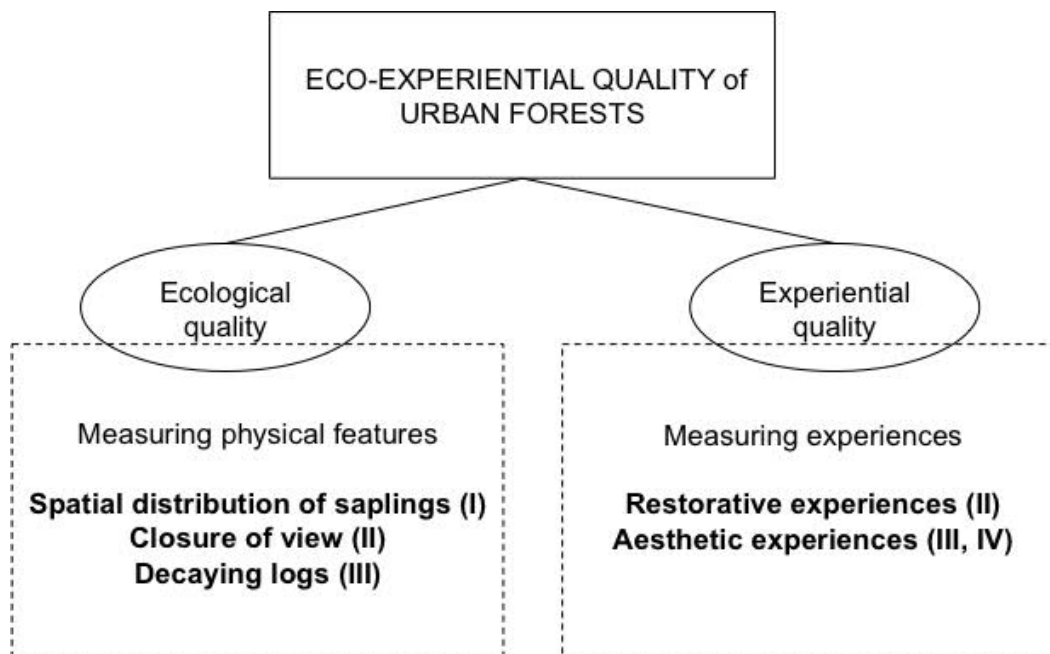
To remind the reader, my aims were to determine i) whether ecological and experiential qualities of urban forests can be integrated, and maintained or enhanced simultaneously, as well as, ii) what kinds of experiences people obtain from urban forests, and what should be taken into account when determining and assessing the experiential quality of urban forests.

I concentrated on three forest features that indicate different aspects of the ecological quality of urban forests: **spatial distribution of tree saplings** in relation to the level and distribution of wear (indicates the ability of trees to regenerate under different wear intensities, and in relation to barriers against wear), visibility from the forest to the urban matrix, i.e. **closure of view** (indicates vegetation density at the forest edge, or distance between the edge and the observer, and thus the size of the forest), and **decaying logs** (indicates biodiversity). These physical features can be measured on-site and ecological quality can then be determined based on

these measurements and the relevant reference criteria (e.g. amount and distribution of saplings, vegetation cover and dead wood volume).

Besides physical features, I concentrated on two types of experiences indicating the experiential quality of urban forests: **restorative** and **aesthetic**. Experiences cannot be assessed by measuring the physical features of forests, but instead by inquiring perceivers' experiential responses to the environment in question. This approach reflects the so-called subjectivist paradigm, in which the quality of an environment is taken, not as intrinsic (like in the objectivist paradigm, see the "expert-based approach" described in Section 1.4.3), but as a product of the perceivers' experiences (Lothian, 1999; Daniel, 2001). Following the subjectivist approach, however, does not mean that the quality assessment is subjective in its narrowest sense, i.e. that quality is determined subjectively by only one person or a uniform group. Instead, by using proper scientific methods, it is possible to determine experiential quality objectively (i.e. to find similarities and discrepancies between single subjective assessments).

Fig. 3 shows the three physical forest features (indicators of forest ecological quality) and the two experience types (indicating forest experiential quality) in a framework that illustrates the two methodologies for assessing the eco-experiential quality of urban forests: ecology-based (on the left side of the figure, based on measuring physical forest features) and experience-based (on the right, based on measuring experiences).



**Figure 3** Methodological framework for assessing the eco-experiential quality of urban forests. The three physical features in this thesis indicate the ecological quality of forests, and the two experience types the experiential quality of forests. Roman numerals refer to papers in which each feature or experience type is dealt with.

The three physical features and the two experience types are dealt with in the research questions, which I introduce under the two aims:

*Aim I: To study whether ecological and experiential qualities of urban forests can be integrated, and maintained or enhanced at the same time*

As mentioned earlier (Section 1.4.1) I decided to concentrate on management options that decrease the negative effects of 1) trampling and 2) edges, as well as those 3) enhancing biodiversity, as these are among the most critical factors affecting the natural dynamics of urban forests (cf. Lehvävirta, 2007).

Concerning the effects of trampling, I concentrated on “natural barriers against wear”, which are expected to decrease the negative effects of trampling and thus enhance the regeneration of saplings and other vegetation. More specifically, in this thesis I studied the spatial distribution of saplings indicating the regeneration ability of saplings in heavily worn urban forests. The research question was:

- 1) In which parts of heavily worn forests tree saplings are able to regenerate? More specifically, do large trees and thickets of saplings function as barriers against wear, providing shelter and promoting the regeneration of saplings and other vegetation?

Concerning edge effects and biodiversity, I concentrated on two potentially beneficial forest management options: closed view to the urban matrix, indicating large forest sizes or dense edges that are shown to decrease the negative effects of edges, as well as leaving decaying logs in forests to promote biodiversity. More specifically, I studied how these two features affect restorative and aesthetic experiences, i.e. the experiential quality of urban forests. The research questions were:

- 2) How closure of view from the forest to the urban matrix affects restorative experiences of forest visitors?
- 3) How decaying logs on the forest floor affect forest visitors’ aesthetic experiences?

*Aim II: To clarify what kinds of restorative and aesthetic experiences people obtain from urban forests*

Since I assume that experiences of environments are multisensory and multidimensional, this aim was dealt with in the following research questions:

- 4) What is a multisensory and multidimensional aesthetic experience in natural or semi-natural environments?
- 5) What dimensions do restorative and aesthetic experiences in urban forests (as well as other green spaces) consist of?

## 2 Materials and Methods

### 2.1 Empirical research papers (Papers I–III)

#### 2.1.1 Study areas, sites and data collection

Field work of Papers I, II and III were conducted in spruce-dominated urban forests in Helsinki, the capital of Finland, during the summers of 1998 (Paper I), 2007 (Paper II) and 2012 (Paper III). Spruce (*P. abies*) is the most common tree species, along with pine (*Pinus sylvestris*) in most urban forests in Helsinki, which belongs to the hemi-boreal vegetation zone (Gundersen et al., 2005; Saukkonen, 2011). The population of Helsinki in 1998, when the first study of this thesis was started, was 546 317, and in 2012, when the last field work was conducted, it was 603 968. In the Greater Helsinki area (that includes Helsinki and the neighboring cities of Vantaa, Espoo and Kauniainen) population was 933 669 in 1998 and in 2012 it was 1 075 014.

In Paper I (concerning the spatial distribution of saplings) the study sites were heavily worn, i.e. the undergrowth in many parts had disappeared, while in Papers II and III (in which we studied the effects of closure of view and decaying logs on experiences) we selected unworn sites as we did not want the visible signs of wear to affect the experiences.

In Paper I, 18 rectangular or quadratic study plots (225–500 m<sup>2</sup> in size) were mapped in order to explore the spatial distribution of saplings in forests with high levels of wear. The idea was to explore whether saplings tend to grow randomly, whether they form clusters with other saplings, or whether they grow close to mature trees in different segments (see below) with different levels of wear within each plot (as suggested by Lehvävirta and Rita, 2002). Mapping of the study plots consisted of drawing the forest floor into segments according to different wear classes or the dominant vegetation species, and then locating all trees (distribution at breast height  $\geq 5$  cm) and tree saplings (30–200 cm in height) within the plots. Trees were also mapped within a 5 m zone outside the plot to be able to study the effects of these trees on sapling distribution within the plot. The level of wear for each segment was determined visually (according to the criteria explained in Paper I), after which every segment in the forest plot were given a value from 0 = unworn to 3 = heavy wear (see fig. 1 in Paper I for an example of a study plot). The dominant sapling species across the plots was rowan (*S. aucuparia*), and dominant tree species were spruce (*P. abies*) and rowan (for frequencies of all saplings and tree species, see table 2 in Paper I).

Study sites of Paper II were located in nine forest areas that each bordered either a housing area or a road environment, i.e. “urban matrix”. There were three “sampling points” within each of these nine forest sites at

different distances from the forest edge, in which the respondents filled in a questionnaire that measured restorative experiences. The sampling points were situated, 1) at the forest edge with an open view to the urban matrix, 2) at the edge zone with a semi-closed view to the urban matrix (situated 13–27 m from the edge), and 3) at the forest interior with a closed view to the urban matrix (44–80 m from the edge). Each respondent visited only two of the three sampling points because our pilot tests suggested that visiting all three points would have been too much and probably affected the results. The order in which the respondent visited the first and second sampling points was randomized so that some people walked from the edge towards the interior (e.g. edge first and edge-zone second) while others vice versa (e.g. interior first and edge second) (see fig. 2 in Paper II).

Data of Paper III were collected from twelve study sites distributed in four forest areas so that each area included three sites with either 1) old logs, 2) newly downed fresh logs or 3) no logs. Each respondent filled in a questionnaire that measured aesthetic experiences (the content is explained below) in one of these twelve sites, standing at the edge of a sandy walkway looking towards the site with or without logs.

Sampling in Papers II and III were done on-site in the forests by asking passer-byes to participate and in Paper II also by invitation letters distributed to e.g. households located close to the study sites. The number of participants in Paper II was 66 (total  $n = 132$  because each respondent answered the questionnaire twice), and in Paper III it was 283. The response rate of Paper III was 30.9% but we could not calculate the response rate for Paper II since the number of respondents refusing to participate was not recorded. Respondents of both of these studies (Papers II and III) consisted of Finnish speaking adults (age 15–82 yr.) mostly living in the Grater Helsinki area. More detailed information of demographics is given in Papers II and III.

### **2.1.2 Questionnaires and data analyses**

The statistical analysis of Paper I was based on spatial point process (see e.g. Diggle, 2003; Illian et al., 2008). We set the Poisson process, representing complete randomness, as a “benchmark model” for spatial patterns of saplings. We studied sapling locations separately within each wear class in each study plot, taking into account variation in sapling density per study plot and wear class. Then, we tested the distributions of saplings against complete spatial randomness to find out whether saplings tend to cluster together with respect to their nearest neighbor sapling of the same species (with distances of 0.1–0.6 m between saplings), or to the nearest mature tree (within distances of 0.1–2 m). The spatial analyses and interpretations of the results were based on calculating the nearest neighbor distance distribution (NNDD) functions, repeated simulations from Poisson process, and rankings

of the NNDD function values. Methods are explained in more detail in Paper I.

To examine restorative experiences (Paper II) we used the Perceived Restorativeness Scale (PRS; Hartig et al., 1996, 1997) that consists of 16 statements assumed to measure the four components of perceived restorativeness (coherence, being away, compatibility and fascination; see appendix A in Paper II). Respondents evaluated each of the 16 statements according to how well they agreed with them (on a scale from 1 = not at all to 7 = completely) at the sampling points they visited. Loadings of the 16 statements on the four hypothesized components were tested by factor analysis (Principal Axis Factoring, Promax rotation), which resulted in a four-factor solution, i.e. the statements formed the four hypothesized components (although a two-factor solution was also appropriate, as discussed in Paper II, and in Section 3.2. below). The internal consistencies of the four components were also high (Cronbach's alpha's 0.77–0.93), and we considered it legitimate to calculate the mean scores for each component for further analysis. We also studied overall perceived restorativeness, which was the mean score of all 16 statements of the scale. Then, we tested, using generalized linear mixed model (GLMM) analysis, whether the “closure of view” to the urban matrix (i.e. open at the edge, semi-closed at the edge zone or closed at the interior) affected overall perceived restorativeness, as well as the four components (see electronic supplementary material, appendix B, Paper II).

We built a new scale for specifically studying aesthetic experiences in Paper III. This scale included 24 statements that we suggested to reflect six components of aesthetic experience: multisensory intuitive experience, coherence, aesthetic diversity, biodiversity, restorativeness and order. However, factor analysis (Maximum Likelihood extraction, varimax rotation) resulted in only five of these components since the multisensory intuitive experience component was not formed. In addition to these aesthetic experience components, we also studied the acceptability of forest sites with or without logs by three statements, and finally, at the end of the questionnaire, we asked the respondents directly, with four additional statements, whether they like or accept dead and decaying trees in general (see appendix A and the methods section in Paper III for a more detailed description of the questionnaire). Again, the respondents evaluated each statement according to how well they agreed with them (on a scale from 1 = not at all, to 7 = completely) in the place where they stood (i.e. looking at the forest site with either old, fresh or no logs). We calculated the mean scores for each component (i.e. coherence, aesthetic diversity, biodiversity, restorativeness and order, as well as for the acceptability of site, and compared the mean scores between forest sites with old, fresh and no logs by two-way variance analysis.

## **2.2 Theoretical review paper (Paper IV)**

The last paper of this thesis was a literature review of recently published (in 2013 and the first half of 2014) papers dealing with aesthetic experiences and landscape preferences in natural and semi-natural environments. From the reviewed papers we searched for concepts related to aesthetic experiences and aesthetic quality, and analyzed them qualitatively by categorizing concepts under similar themes that represented the different dimensions of experience. Our purpose was not to conduct statistical analyses or a meta-analysis of all existing concepts, or to deal with aesthetic experiences of environments comprehensively, but instead to explore and show the ambiguity related to these conceptualizations. The number of reviewed papers was 39 (see Paper IV for the review method), which we considered sufficient for showing the variety of concepts (the concepts we found started to repeat themselves during the review, suggesting saturation) and for making the conclusions.

## 3 Main Results and Discussion

### 3.1 Integrating ecological and experiential qualities of urban forests

The results of Papers II and III showed that integrating ecological and experiential qualities is possible, at least when it comes to the themes introduced in this thesis. These papers showed that the two ecologically beneficial management options we studied, i.e. closed views (indicating dense edges or long distance between the observer and the edge, and thus larger forest sizes) and decaying logs (indicating biodiversity), enhance, or at least maintain, experiential qualities of urban forests.

A closed view to the urban matrix from the forest interior resulted in better restorative experiences compared to semi-closed or open views at the edge zones and edges (see tables 3 and 4 and fig. 3, as well as electronic supplementary material, appendix B, in Paper II). This indicates that, even though we did not measure vegetation density *per se*, but instead determined the level of closure of view visually (see fig. 1 in Paper II), dense vegetation might enhance the restorative experiences in urban forests as it hinders visibility to the urban matrix, in our case a housing or a road environment. In other words, keeping vegetation dense and multilayered at forest edges might not only be ecologically beneficial (as shown by, e.g. Hamberg et al., 2009) but also an experientially good option, especially in small and fragmented urban forests, in which interior forest conditions cannot be reached via a great distance from the edge. Nevertheless, a better option (cf. ecological studies by Hamberg et al., 2008; Lehvävirta et al., 2014) would be to keep forests large enough (e.g. diameter no less than 160 m; Lehvävirta et al. 2014) to maintain enough interior habitats for both forest species and people.

This result is somewhat contradictory to previous studies that have suggested that people generally dislike dense vegetation and closed views as these features hinder the visibility and understanding of the environment, and decrease perceived safety, thus possibly causing attention fatigue and stress (Ruddell and Hammit, 1987; Herzog and Chernick, 2000; Herzog and Kutzli, 2002; Gatersleben and Andrews, 2013; Jansson et al., 2013). In our case the situation was different, probably because the closed view hindered visibility to the urban matrix, a supposedly less restorative and perhaps even more dangerous environment (at least the road matrix) than the forest (cf. e.g. Herzog and Chernick, 2000). This reflects the notion of Nordh et al. (2009) who suggested that the effects of single features on nature experiences largely depend on the context and the type of green space in question, so that an otherwise “negative” feature, such as dense vegetation,



may be a positive feature in another case, e.g. at the edges of fragmented urban forests where it restricts the unwanted effects of urban distractions.

Another ecologically beneficial forest feature studied in this thesis, decaying logs, did not, in general, affect aesthetic experiences of forest visitors (Paper III). Differences in experiences between sites with old, fresh or no logs were marginal and statistically insignificant, except for the components coherence and order that showed statistically significant, although small, differences between site types. Coherence was highest in sites with fresh logs, and order was lowest in sites with old logs (see table 4 in Paper III). Furthermore, respondents accepted decaying logs in urban forests, as shown by the mean acceptability values of sites with old and fresh logs: 6.45 and 6.65, on a scale from 1 to 7, respectively (the mean acceptability value of sites without logs was 6.56; see Paper III). Also, the acceptability of dead wood in general (i.e. non-site specific acceptability) that we inquired at the end of the questionnaire was high (mean = 5.94 on a scale 1–7).

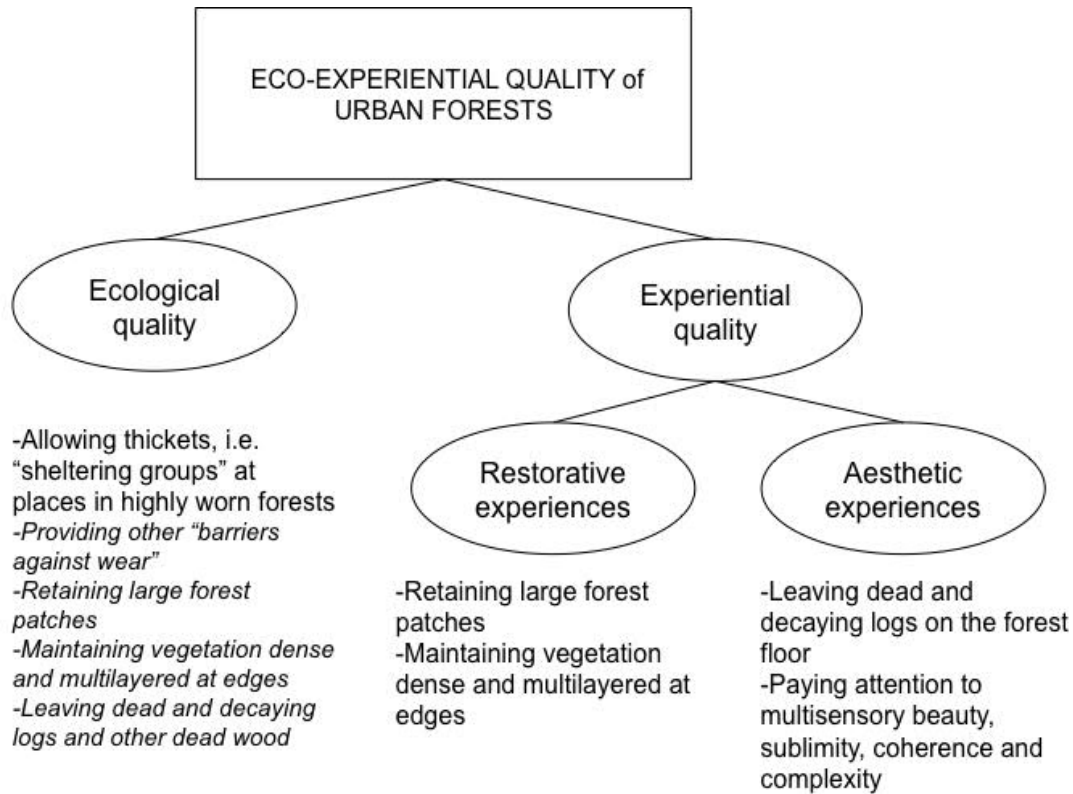
These results indicate that at least small amounts of ecologically beneficial decaying logs on the forest floor (in our study, a maximum of five visible logs, see dead wood volumes in table 1 in Paper III) may maintain or even enhance experiential qualities of urban forests. This is contradictory to most previous studies that have shown that dead wood is an unwanted and ugly feature in forests (Brown and Daniel, 1986; Tyrväinen et al., 2003; Ribe, 2009; Gundersen and Frivold, 2011; Edwards et al., 2012). This contradiction might be due to the methods used in previous studies that have mostly been based on evaluating photographs or visualizations, while we conducted the surveys on-site, in realistic forest conditions. As we speculate in Paper III, on-site, where a person usually uses multiple senses and observes many features at the same time, single elements, such as logs, might merge with the background and with other interesting features more easily than in photographs. In our case, however, we made sure that the logs were visible in the landscape so that their effect would have been possible to capture if there were any. Furthermore, the generally positive perceptions towards decaying logs in our study might be a consequence of the increased ecological knowledge among the forest users during the past years, as it has been shown that knowledge affects the acceptability and attitudes towards ecologically good features, and can in that way also modify aesthetic experiences and preferences (see e.g. Gobster, 1999; Gobster et al., 2007; Bjerke et al., 2006; Gundersen and Frivold, 2011). However, Hill and Daniel (2007) showed that the effect of ecological information given with the evaluated photographs did not generally affect scenic beauty or acceptability ratings of nature scenes. The effects of increasing knowledge on aesthetic experiences and acceptability of logs, and other ecologically beneficial management options should be studied more in the future.

The third feature of ecological quality dealt with in this thesis was the spatial distribution of saplings that indicated the ability of trees to regenerate

under different wear intensities and with respect to other saplings and large trees. In Paper I we showed that in forests that suffer from heavy trampling and wear, saplings tended to grow close (i.e. within 0.1–0.6 m) to other saplings (usually of the same species), and that saplings were generally randomly distributed with respect to mature trees in every wear class. Furthermore, the tendency of saplings to cluster together increased when the level of wear increased (see also Lehvävirta et al., 2004 that showed similar results). Thus, we suggested that growing in a thicket may shelter saplings from harmful effects of trampling, offering them “safe regeneration microsites” (cf. Harper, 1977). We also suggested that these thickets may shelter other vegetation and, further, enhance the regeneration and ecological quality of urban forests. Thus, we termed the sapling thickets “sheltering groups” and considered them as barriers against wear, along with other natural features such as downed logs, large rocks and mature trees suggested by, e.g. Lehvävirta (1999). These natural barriers against wear should be favored, at least here and there, to enhance the ecological quality of highly worn urban forests.

However, sheltering groups or other natural barriers against wear, even though ecologically beneficial, may not be favored by urban foresters for the very same reason, i.e. because they hinder accessibility and movement and, further, possibly decrease the recreational quality of urban forests. Furthermore, it may be that sheltering groups are considered harmful for the experiential quality because bushes and dense undergrowth are often considered unwanted and are disliked features in forests (Tyrväinen et al., 2003; Bjerke et al., 2006; Rooves et al., 2006). But it is not clear how people perceive thickets, or other barriers against wear in heavily worn urban forests, and we do not yet know how “sheltering groups” affect experiential qualities. Kohtala (2008) provided some indication of the effects, showing that the most preferred options for guiding people’s steps in forests were bushes, and not fences or other “artificial” barriers. To tackle presumptions concerning the negative effects of natural barriers, these elements could be designed and placed in forests so that they do not look like abandoned, messy or ugly features, but instead so that they would remind the observer of care and stewardship, the supposedly preferred attributes of urban green spaces (Nassauer, 1995, 2011; Gobster, 1999; Gobster et al., 2007).

The results, i.e. management options to maintain or enhance the eco-experiential quality of urban forests, are summarized in Fig. 4 below. I emphasize that these options should always be considered on a case-by-case basis, and their impacts on the integrative quality (see Fig. 1) of urban forests, and the whole green infrastructure, should be studied and assessed.



**Figure 4** Planning and management options dealt with in this thesis that may enhance the eco-experiential quality of urban forests. Options in italic are results from previous studies (reviewed in Section 1.4.1) to which this thesis relates.

## 3.2 Dimensions of restorative and aesthetic experiences

My second aim in this thesis was to investigate what kinds of restorative and aesthetic experiences people obtain from urban forests. More specifically, I studied what dimensions of these experiences should be taken into account when assessing the experiential qualities of urban forests. My focus was on multisensory restorative and aesthetic experiences, i.e. I studied the experiences on-site, under more realistic forest conditions than, e.g. in photographs or visualizations that are the preferred methods in many similar studies (see references in Paper IV; and e.g. Tyrväinen et al., 2003; Karjalainen, 2006; Gundersen and Frivold, 2011).

In Papers II and III we attempted to capture the multidimensionality of experiences by using questionnaires with which we measured different components of the restorative experience (Perceived Restorativeness Scale, PRS; Paper II) and aesthetic experience (our own scale; Paper III). PRS is claimed to be a valid method for measuring the four components of restorative experiences (i.e. coherence, being away, compatibility and fascination) despite the fact that some studies have indicated that statements

of the scale also tend to load on two instead of four factors in the factor analysis (e.g. Hartig et al., 1996, 1997; Korpela et al., 1996). In Paper II we also found that the statements tended to load on two factors (the one being coherence and the other a combination of being away, compatibility and fascination), but we decided to use the four-factor solution, mainly for two reasons: first, to be able to compare our results with previous studies that also relied on four factors (e.g. Hartig et al., 1996, 1997; Korpela et al., 1996), and second, to explore the full multidimensionality of restorative experiences, as there is evidence that the four components weigh differently in different situations (e.g. Purcell et al., 2001; Herzog et al. 2003; Tennenart Ivarsson and Hagerhall, 2008; Nordh et al., 2009). However, since another recent study has shown that the two-factor solution is valid (Tyrväinen et al., 2014, even though their scale was different from the original PRS), it might be better to study “general restorativeness” (a combination of being away, compatibility and fascination) as one, and “coherence” as a separate component in the future.

Coherence has been shown to be a strong component of restorative experiences, but also of landscape preferences in general (Kaplan and Kaplan, 1989; Purcell et al., 2001; Tennenart Ivarsson and Hagerhall, 2008). Thus, it might be that coherence is not a component of restorative experience *per se* but that it actually indicates something else, e.g. visual character of the environment, or aesthetic quality (e.g. Paper III; Ode et al., 2008). Indeed, coherence has often been studied as a variable predicting general preference for the environment, together with other “informational” variables perceived in the environment, i.e. complexity, legibility and mystery, similar to Kaplan and Kaplan’s (1989) preference matrix (see Section 1.4.2. above and e.g. Pazhouhanfar and Kamal, 2014; Tang et al., 2014). We studied coherence as a component of aesthetic experience in Paper III, and again it appeared to be a strong component, together with perceived biodiversity, aesthetic diversity, order and restorativeness. Even though coherence is a strong and frequently studied component in the landscape preference literature, there seems to be great inconsistencies in how it is defined and understood, which makes its operationalization difficult and, furthermore, comparing results concerning it impossible. For example, coherence has been characterized to reflect “internal harmony”, “uniformity”, “wholeness”, “understanding”, “repeating patterns” (e.g. Tennenart Ivarsson and Hagerhall, 2008; Blumentrath and Tveit, 2014; Tang et al. 2014; Paper III), “maintenance”, “order”, “accessibility”, “familiarity” (Sevenant and Antrop, 2009; Tang et al., 2014), “extent”, “scope”, “vast”, “being in another world” (Kaplan and Kaplan, 1989; Sevenant and Antrop, 2009; Peschardt and Stigsdotter, 2013), and opposites to “chaos” and “confusion” (Hartig et al., 1996; Paper II). As such, some harmonization of the inconsistent conceptualizations might benefit its use in practice.

Clarification is also needed with conceptualizing other components and dimensions of aesthetic experiences of natural or semi-natural environments,

as we showed in Paper IV. Even though we admit that it may not be possible, or even necessary, to define aesthetic experiences in very strict terms, we suggest that some characterization is needed to be able to operationalize this important indicator of the experiential quality of green spaces.

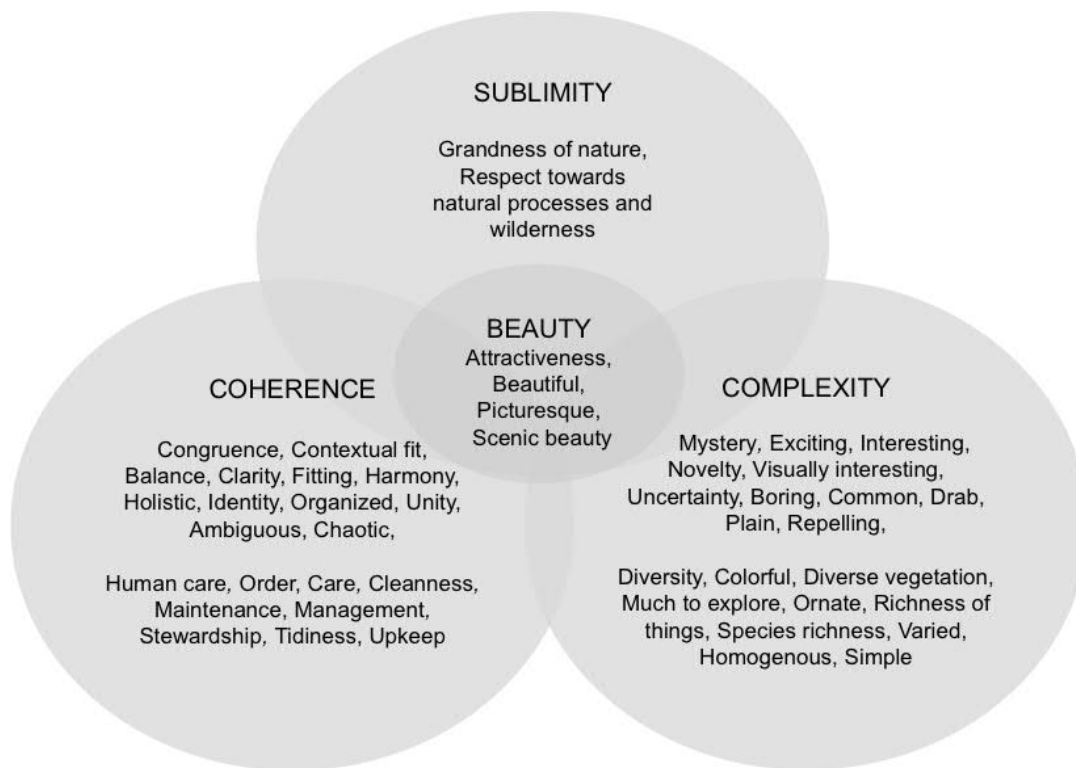
We argued in Paper IV that aesthetic experience is not the same thing as “general preference” and that it is more than “visual” or “scenic beauty” (see also Gobster, 1999). This means that it may not be enough to assess aesthetic experiences or, furthermore, aesthetic preferences, by asking “likeability”, or by evaluating the “visual beauty” of the landscape, but other methods – both quantitative and qualitative – are also needed to capture its multidimensional nature. The scale we used in Paper III was an attempt to capture this multidimensionality (and we indeed succeeded in this, as was shown above), although the method should be further improved by e.g. adding dimensions, some of which we suggested in Paper IV.

In Paper IV we listed altogether 135 terms found from the 39 reviewed articles (see table 1 in Paper IV) that related to aesthetic experiences of natural and semi-natural environments. After classifying terms under the main dimensions that we thought they represent, we concluded that at least the following dimensions characterize aesthetic experiences of (semi-)natural environments (see Fig. 5 below): multisensory beauty, human care, congruence, diversity and mystery. Of these, congruence and human care seemed to be closely related, and we interpreted they would actually reflect two dimensions of the nebulous concept “coherence” (see discussion on coherence above). Mystery and diversity also seemed to be closely related and to reflect two dimensions of “complexity” (structural diversity and the more abstract mystery that indicates the need to explore and to be surprised; see also Herzog and Bryce, 2007). Furthermore, we suggested that dimension “sublimity”, that represents the respect towards nature itself and its phenomena, should be taken into account when assessing the aesthetic quality of natural and semi-natural environments. Sublimity was not dealt with in the reviewed articles, but it has been an important concept of philosophical aesthetics for centuries, thus it should be included in the operationalization of aesthetic experiences (see e.g. Lothian, 1999).

The relatively narrow review of the recently published research papers might not fully capture the many conceptual conflicts related to aesthetic quality and aesthetic experiences of environments. However, I believe that Paper IV succeeded in showing the ambiguity of the concepts, and suggesting that something has to be done to better operationalize the multidimensional aesthetic experiences and, furthermore, aesthetic qualities of natural and semi-natural environments, such as urban green spaces.

Thus, considering the above mentioned findings, I suggest that to empirically study and measure aesthetic experiences in order to elucidate what good aesthetic quality of green spaces could be like, one should take the multiple dimensions of the aesthetic experience into account, for example by examining the dimensions presented in Fig. 5. It might be worth constructing

a scale (based, e.g. on the scale we presented in Paper III) that operationalizes these dimensions for future use of urban planners and managers. Furthermore, in Paper IV (see table 1 in Paper IV) we also listed other concepts that might be worth taking into account when assessing experiential qualities of green spaces. For example, perceived naturalness, place attachment and restorativeness (as shown in Papers II and III) have been shown to play a role in experiences and further, preferences, for natural environments and green spaces (e.g. Gobster et al., 2007).



**Figure 5** Aesthetic experiences of environments may manifest in different perceived dimensions that might overlap and occur simultaneously. Terms in the ellipses describe each dimension, and are collected from the review articles of Paper IV.

Furthermore, I emphasize that even though measuring experiences on-site might be laborious and resource intensive, studying people's multisensory experiences under realistic conditions is worth doing since, as shown in Papers II and III, on-site experiences may result in different outcomes than visual evaluations of, e.g. photographs. Furthermore, going to green spaces that residents use frequently might be an option to sample those people who do not necessarily take part in the official participatory decision processes (cf. Faehnle, 2014).

Finally, it should be remembered that surveys of this thesis were done in Finland where people, also the most urbanized citizens (Tyrväinen et al.,

2007), are relatively well connected to nature, both mentally and physically, which may have contributed to the very positive experiential outcomes of the studies in Papers II and III. Also, the relatively low numbers of respondents, especially in Paper II, mean that one should be cautious when generalizing the empirical results to larger populations (e.g. Stamps, 1999; Gundersen and Frivold, 2008). We did not test the effects of demographic attributes on experiences in either of the empirical Papers II and III (as the sample sizes were too small for adequate statistical power), but we did some explorations of the effects of background factors for the use of future studies (see electronic supplementary material, appendix B, in Paper II). Despite the methodological limitations, I believe the ideas and methods introduced in this thesis (i.e. combining ecological and experiential qualities at the forest stand level, using design in placing barriers against wear and other ecologically beneficial features, and measuring multidimensional experiences on-site) are also applicable to other green space types in other parts of the world.

## 4 Conclusions

There are different ways to assess the quality of urban forests and other green spaces. Each assessment method depends on the focus, i.e. in terms of what (e.g. ecology, recreation or environmental benefits) one wants to determine the quality (cf. Daniel, 2001). In this thesis I concentrated on ecological (i.e. regeneration, resilience, vitality and biodiversity) and experiential (restorative and aesthetic) qualities. These qualities, together with recreational activities (e.g. jogging, walking and cycling), generally are among the most important to be enhanced in urban forest planning and management. I argued that experiential qualities (and benefits and values related to them) are often underrated in the quality assessments of urban forests and, furthermore, planning and management strategies, perhaps because they are difficult to operationalize. In this thesis I attempted to clarify conceptualizations related to experiential qualities so that restorative and aesthetic qualities could be better operationalized and assessed in the future. I searched for possibilities to integrate experiential qualities with ecological qualities in urban forest planning and management and, indeed, this turned out to be possible since the studied ecological features (closed view and decaying logs) contributed to experiential quality in our studies.

Furthermore, I introduced a new ecologically beneficial management option, “sheltering group”, that could function as a barrier against wear, especially in very intensively trampled urban forests to enhance the regeneration of saplings and other vegetation. There is currently no evidence of the effects of “sheltering groups” on the experiential quality of urban forests. Thus, to facilitate the application of this management option, studies are urgently needed to shed light on the optimal frequency and spatial arrangement of such thickets. Also, effects of other barriers against wear (e.g. large rocks and decaying logs) on ecological, recreational and experiential qualities should be studied to better apply these to planning and management practices. This requires experimental co-planning with residents, planners, foresters and researchers.

In this thesis I also tried to clarify what kinds of experiences people obtain in urban forests, and what dimensions of these experiences should be taken into account when assessing the experiential quality of urban forests and other green spaces. Even though this work has only started and requires much more research, I suggest that experiences should be considered as multisensory and multidimensional, and not only as visual responses to landscapes. Furthermore, assessing general preferences, i.e. “liking”, without defining what the preference is based on, does not provide much information on the quality of the environment in question (see also Karjalainen, 2006). These results call for easy-to-use on-site survey methods with which to study multidimensional experiences properly. On the other hand, more in-depth



studies, such as interviews and other qualitative research, are needed to better understand the aesthetic and other experiences, as well as motives behind them, in different green spaces. Promoting these approaches would help in assessing experiential qualities of forests as well as other green spaces, and taking these qualities into account in planning and management of urban green infrastructure.

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