# Aesthetic Values of Forest Landscapes

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Master Thesis no. 177
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*ABSTRACT*

The need of integrating aesthetic aspects into forest management has been stressed both in research and in practice. The current study aims at finding possible explanations for the public preferences on forest landscapes with special regard to young forests. The study consists of two parts. The first part is a literature review, which is dedicated to systematizing the existing information regarding the nature of human perception of forest landscapes. The second part presents the results of the survey. Two different methods of surveying public preferences were used. The psychological method was used while surveying people in the field, and the psychophysical method – for the indoor survey using photographs. The statistical treatment of the data was based on correlation analysis, and to some extent on principal component analysis. The study resulted in a set of findings, and most of them are reliable on the chosen level of significance (p=0,05). The results showed that the image of recreational forest differed to a great extent from the image of forest in general. Attractiveness of young forest, i.e. perceived aesthetic beauty, was mostly correlated with sense of easy access and safety. Thus, presence of deadwood, understory and high stand density were the most important factors towards negative attitude about the forest. Single tree characteristics (height, diameter) showed a small but significant positive correlation with aesthetic quality, which contradicts with previous studies, where those variables were the main predictors of the forest scenic beauty. Standing and total volumes had a very small negative relationship with scenic beauty. The results also indicated a correlation between aesthetic and ecological values within the group of respondents, who were not educated in forest ecology. This finding suggests about the influence of good-looking appearance of forest on the overall public attitude towards sustainability of forest management practices.

**Key words:** forest landscape, young forest, forestery, aesthetic value, human perception, attractiveness.

***АНОТАЦІЯ***

У теорії та на практиці неодноразово піднімалося питання про необхідность урахування показника естетичної цінності ландшафту під час ведення лісового господарства. Мета даної роботи полягала у знаходженні можливих пояснень щодо уподобань населенням лісових ландшафтів. Особлива увага приділялася молодим лісовим ландшафтам. Робота складається з двох частин. Перша частина – огляд літератури – присвячена систематизації існуючої теоретичної інформації про природу людського сприйняття лісових ландшафтів. У другій частині викладено результати анкетування населення щодо естетичної цінності лісових ландшафтів. Два методи визначення вподобань населення були використані у дослідженні. Психологічний метод ліг в основу опитування учасників безпосередньо у лісі, та психофізичний метод – анкетування з використанням фотографій. Статистична обробка результатів ґрунтувалася на кореляційному аналізі та, частково, на методі головних компонент. Переважна більшість результатів є значущими на 5% рівні. Результати дослідження показали, що респонденти мали принципово різні уявлення щодо зовнішнього вигляду лісу рекреаційного призначення та лісу загалом. Для більшості респондентів привабливість молодих лісових ландшафтів базувалася на відчутті захищеності та легкого доступу. Таким чином, наявність мертвої деревини та підліску, загущеність насаджень були основними негативними факторами впливу на сприйняття молодого лісового ландшафту. Індивідуальні характеристики дерев (висота, діаметр) позитивно корелювали з естетичною цінністю лісу, однак, зв'язок був досить слабким. Кореляційний зв'язок між запасом та естетичною якістю був негативним, проте, незначущим на 5% рівні. Група респондентів, які не мали знань з лісівництва та лісової екології, мали дещо схожі увлення щодо естетичної цінності та екологічної цінності лісових ландшафтів.

**Ключові слова:** лісовий ландшафт, молодий ліс, естетична цінність, сприйняття, привабливість.

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## *1. INTRODUCTION*

### 1.1. Multifunctional use of forests. Aesthetics as an important social function

The current view of forest sustainability comprises the persistence over time of several attributes produced by forest ecosystems and required by society. It is believed that sustainable landscapes are those which simultaneously fulfill ecological, economic and social functions. Accordingly, sustainable forest management is described as long-term management of complex habitats in order to premote their multiple functions into the future (Gustavsson et al., 2005).

A paradigm of multifunctional landscape requires a wide range of qualitative data on landscape functionality to be integrated into a management process. Along with data on objective physical attributes, there are landscape's qualities which are relatively subjective, e. g. aesthetic quality. Despite the difficulty of assessment, the need of integrating of aesthetic aspects into forest management has been stressed both in research and practice (Ode, 2003; Koivula et al., 2005).

There are several reasons which indicate the importance of taking visual appearance of a forest into consideration. First of all, aesthetics is a primary dimension of people-landscape interactions (Gobster, 1996). Most people experience forest landscape visually (Miller, 1995; Ode, 2003). The way the forest is managed influences its physical appearance and thereby perception by the general public. High aesthetic quality of forest has traditionally been viewed as an externality of well-managed forests (Ribe, 1989). For a general public visual attractiveness is always positively correlated to ecological sustainability. Thus, high visual quality is important for social perception of management practices, which is essential for achieving sustainability.

Further, scenic beauty attracts visitors to the forest for outdoor activities and nature-based tourism. Lindhagen et al. (2000) stated that today public's use of the forest in Sweden is shifting from direct towards indirect, from harvesting towards recreation. The same trend is observed almost all over the world and it is unquestionably that foresters have to consider the aesthetic impact of their decisions on forest.

Moreover, aesthetic beauty helps to achieve restoration and other well-being effects of nature like refreshing, relaxing, calming, mood enhancing etc. (Ulrich et al., 1991; Karjalainen, 2006). It is believed that improvement of visual quality of the forests would contribute a lot to human's mental and physical health, to positive aesthetic experience and to their wellbeing in general (Kaplan at al., 1989; Ode at al., 2002).

Finally, it has been noted that scenic beauty of a forest has a nearly linear relationship with willingness to pay for it (Daniel et al., 1989). For some private forest owners scenic value may be the prime motivation for forest ownership (Karjalainen, 2006).

In conclusion, it is worth noticing that aesthetics is a relatively subjective quality and regardless of a large body of research in different fields, it is still a challenging issue when it comes to application. There is a lack of systematic knowledge about people's perception of forest landscapes. In most cases it is hard to predict the public response to changes in a forest landscape due tothe long time perspective from a human point of view and the complex and multidimensional nature of human perception.

### 1.2. Challenges around forest aesthetics

As it was mentioned above, aesthetics is regarded as highly subjective issue. It is still actively discussed if the aesthetic quality is inherent in the physical landscape or in the eye of beholder, i.e. the product of one's mind interpretation (Lothian, 1999). Daniel (2001) argues that the scenic quality derives from interaction between the physical attributes of the landscape and perceptual process of the observer. Thus, there is need to develop better theories and qualitatively new assessment approaches upon aesthetic qualities of the landscape.

Another issue for discussions is application of visual quality approaches to different types of landscapes. Differences in physical appearance between landscapes make it almost impossible to develop any universal approaches for assessing scenic beauty. Moreover, there may be differences alos in visual beauty patterns within one type of landscape. For instance, statistical models for estimating scenic beauty of Ponderosa pine forest in the USA developed by Brown & Daniel (1984) were not appropriate to other types of forest.

However, it is still possible to determinate the most important variables within forest landscapes that influence aesthetic quality. Although their relative importance may depend on forest type and management objectives, it is essential to be familiar with all of them.

The scales at which management decisions are made require somewhat different interpretation of aesthetic quality. It is important to distinguish the aesthetic quality of distant scenes and close in-stand views. Ode & Fry (2002) analyzed 50 management guidelines from the UK and Sweden. They concluded that British guidelines refer mainly to landscape level while Swedish ones regard treatment of separate forest stands and single trees. The guidelines provided by the US Forest Service (1995) and British Columbia Ministry of Forests and Range (2006) deal mostly with the landscape level.

Furthermore, aesthetic quality is not constant as the visual appearance of forest changes over time. It is believed that scenic beauty is positively correlated with forest age. Young forests usually have a small aesthetic value (Ribe, 1989; Pukkala, 1988). However, this correlation caused by increasing tree size and age per se, and doesn't give any relevant information for aesthetic quality in itself. The negative impact of harvesting operations on scenic beauty decreases with time. Thus, foresters should know about relative aesthetic quality of forest over a long period and under alternative management (Ribe, 1989).

The last but not the least important challenge is finding a balance between aesthetics, ecology and economy. There are always many conflicts between multiple functions of forests. The ways of resolving such conflicts is an essential part of research on forest aesthetics.

### 1.3. Defining forest landscape aesthetics

Being a subject of many fields of science, landscape aesthetics encompasses a lot of issues and can be interpreted in different ways. To avoid misunderstandings, explanations for the terms 'landscape', 'aesthetics', 'forest landscape aesthetics' and their synonymous used in the current study are given below.

The term 'landscape' is central to the study. The European Landscape Convention considers landscape as a 'key element of individual and social well-being'

(Council of Europe, 2000). O'Farrell et al. (2010) states that landscape is function of its biotic and abiotic components combined with its unique history of human intervention, thereby the result of natural and anthropogenic processes. Each type of landscape has its individual appearance and can be described by its physical attributes. Moreover, landscape includes both nature and art (Bourassa, 1988) and it is always regarded as a unit for human perception of environment. Such terms as 'forest stand', 'distinguishable forest stand' are interpreted as synonyms for 'landscape' as the size of study areas is not of concern in the research.

In its broad definition, aesthetics is how things are perceived by humans. Accordingly, landscape aesthetics refers to people's perception of landscape which usually involves judgment, evaluation and assessment.

Even though humans use all senses to gain information about the surrounding world, eyesight is the most important sense as it accounts for up to 87% of human perception (Bell, 2004). Beauty is the main category in aesthetics as it is the quality which gives pleasure to the senses (Panagopoulos, 2009). Dealing with landscape aesthetics we mostly discuss visual quality and scenic beauty of landscapes. While talking about aesthetics as a social function of landscape we often use the term 'attractiveness' (for visitors).

Thus, in the current study we will use such terms as 'landscape aesthetics', 'forest landscape aesthetics', 'forest aesthetics', 'aesthetic quality', 'visual quality', 'scenic beauty', 'aesthetic perception', 'visual attractiveness' and other.

### 1.4. Aims of the study

The current study aims at answering three questions:

- ✓ How and to what extent do silvicultural attributes of forest stands affect aesthetic quality?
- ✓ What are possible ways to improve visual appearance of forest at stand level?
- ✓ How can we cope with main conflicts between aesthetics and ecology?

The thesis includes a literature review and research based on a survey about public's perception of different forest stands. The literature review is an important part of the current study as it covers main issues concerning people's perception of forest landscapes and provides a theoretic framework for further research. Moreover, one part of the literature review is devoted to summarize empirical knowledge about influence of silvicultural systems on visual appearance of forests and its perception by the public.

The objective of the survey is to find out what kind of forest stands that are preferred by the public. Further research aims to relate achieved preference scores with silvicultural data on stands to see what attributes of forest are the main indicators of aesthetic perception. The questionnaire is designed to find the correlation between aesthetic and ecological values and to indicate the landscapes features which contribute both to ecology and aesthetics.

## *2. LITERATURE REVIEW*

The literature review provides a theoretic background on the issue of public perception of forest landscapes. In this chapter I have summarized the existing theoretical and empirical knowledge about how a forest landscape is perceived.

### 2.1. An overview of approaches determining public preferences on forest landscapes

Throughout the centuries the perception and preferences for landscapes by humans have been studied in such disciplines as aesthetics, environmental philosophy, landscape architecture, geography, ecology, psychology, social sciences and forest sciences (Bell, 2004; Daniel, 2001; Karjalainen, 2006). There are many understandings of what is a landscape and the interpretation of this term usually depends on research objectives (Bourassa, 1988; Daniel, 2001; Karjalainen, 2006). When it comes to landscape aesthetics a definition of 'landscape' as 'perceived environment' seems to be the most appropriate (Appletton, 1980).

As each of the mentioned disciplines applies its specific research methods and practices, a huge amount of approaches has been developed under different paradigms. A variety of landscape assessment approaches can be found, from those based on the physical attributes to those which focus on the subjective meanings held by individuals who observe the landscape (Lee, 2001).

The attempts to classify these various approaches can be observed in literature. Zube et al. (1982) divided all the approaches on landscape perception into four groups: expert, psychophysical, cognitive, and experiemental paradigms. Daniel and Vining (1983) developed a some what different classification. They divided all the approaches into formal aesthetic, ecological, psychophysical, psychological, and phenomenological approaches.

Lothian (1999) distinguished only two groups of methods for assessing the aesthetic quality of landscape: objectivist and subjectivist paradigms. The objectivist approaches tend to believe that aesthetic quality is constant and can be determined by physical attributes of a landscape. Whereas the objectivist paradigm claims that aesthetic beauty is in the eyes of the beholder, i.e. based on individual human's perception of a landscape.

Daniel (2001) divided all the methods into expert and perception-based approaches; further on he added that both approaches accept that landscape's aesthetic quality derives from an interaction between its biophysical attributes and perceptual process of an observer, but the difference is the relative importance of each component.

Lee (2001) proposed a four tiered model which is based on previous studies and include: the expert or formal aesthetic model, the phenomenological or existential model, the psychological model and the psychophysical model. The last approach aims at finding relationships between physical characteristics of the landscape and other overall measures of scenic beauty, derived by independent groups of subjects. This method is believed to provide a balance between objective and subjective components of aesthetic quality assessment and is the best way to incorporate public preferences into planning and management processes (Daniel, 1990; Daniel, 2001; Lee, 2001). Although the psychophysical models can provide concrete practical information for management, they lack a theoretic basis and cannot be applied to a wide range of landscapes (i.e., applicable to certain types of landscapes, forest stands etc.) (Ruddell et al., 1989; Ribe, 1990).

### 2.2. Factors influencing the public preferences on forest landscapes

There are many factors that influence the public preferences on forest landscapes. Bourassa (1990) introduced three categories of such factors: biological, cultural and individual. According to the author's paradigm, the factors can be described by aesthetic laws, rules and strategies. The aesthetic laws are genetically inherited thereby universal for all humans. The rules vary between cultures, and the strategies are dependent on individual. I have extended the Bourassa's approach to 5 categories of factors: biological, cultural, social, individual and contextual.

#### *2.2.1. Biological factors*

Biological, or genetic, sources that affect landscape perception by humans are mainly the subject for evolutionary psychology.

Grinde (1996) presented a ‘reward theory’ of visual aesthetics. The author suggests that something is perceived as visually attractive only if the brain gets positive stimuli, e.g. ‘rewards’ which are genetically prescribed. Further on he argues that the human visual system was developed for viewing natural objects, and the main elements of aesthetics are those positively correlated with humans’ survival (e.g., colors, curiosity and attention, movement, symmetry, functionality).

A number of researches advocate that landscape’s preferences are genetically predetermined and refer to human survival (Appleton, 1975; Ulrich et al., 1991, Kaplan, 1982). Ulrich (1991) argues that because humans used to live in a natural environment for a long period, modern people are predestinated to respond positively to more natural stimuli, favorable for their survival landscapes.

Appleton’s (1975) main concept is that an environment which appears to offer satisfaction of biological needs (e.g., self-protection) will be perceived as most attractive for a man (a ‘habitat theory’). Further investigations of the author resulted in a ‘prospect-refuge theory’ which postulates that ‘the ability to see without being seen is an intermediate step in satisfaction of biological needs’, thus ‘a more immediate source of aesthetic satisfaction’ (Appleton, 1975; Bourassa, 1988).

Although it is obvious that people prefer natural environments to artificial ones, an extent of naturalness (i.e. wilderness) in a forest landscape seems to be a challenging issue today and will be covered in the following sections of this study.

#### *2.2.2. Cultural factors*

Costonis (1982) suggests that the highest aesthetic pleasure derives from a landscape which contributes to cultural identity and stability. Ulrich (1983) states that cultural background affects cognitive appraisal of a landscape. Differences in aesthetic preferences between cultures (or similarities within one culture) were observed in many empirical researches as well (Zube & Pitt, 1981; Kaplan & Talbot, 1988; Hull & Revell, 1989). Moreover, the public preferences for environment seem to be slightly changing over time. Making comparisons of the few trend studies on forest preferences, Jensen (1999) concluded that Danish public preferences were quite stable over twenty years. Results of Swedish national survey about forest recreation showed that during the period from 1977 to 1997 Swedes have slightly changed their opinion about a virgin forest to be more positive, whereas a Scots pine shelterwood was regarded as less suitable for outdoor activities than before (Lindhagen & Hörnsten, 2000).

### *2.2.3. Social and individual factors*

Dearden (1984) argued that society is highly heterogeneous in terms of landscape preferences. In many studies it has been stated that forest landscape preferences differ across social groups. The main social factors that influence one's attitude towards forest landscapes are age, gender, level of education, occupation, residential location, ownership of forest (Tahvanainen et al., 2001; Silvennoinen et al., 2001; Gundersen & Frivold, 2008).

Even though there are cross-cultural and within-cultural similarities of aesthetics, it is obvious that landscape preferences vary a lot between individuals. Such sources as past experience, believes, needs, expectations, knowledge, memories, associations etc. shapes one's attitude towards a landscape to some extent. Many authors suggested that familiarity with landscape type is positively correlated with its perception (Buhyoff et al., 1978; Dearden, 1984; Kaplan et al., 1982). Fishwick (1992) observed a strong difference in perceptions of recreational settings between experienced and inexperienced people. Experienced individuals preferred to be surrounded by pristine nature, while those who were not familiar with natural environments, expressed their concern about being uncomfortable if far from civilization.

### *2.2.4. Contextual factors*

First of all, found preferences on forest environments may differ according to the methodology used by researchers. Furthermore, if observations are made outdoors, then weather conditions and part of a day may also influence a respondent's judgment (Jensen & Koch, 1998). In addition, Anderson (1981) showed that land use designations ('wilderness area', 'national park', commercial timber stand') had a significant effect on peoples' judgments of scenic beauty.

As we can see, there is a big variety of factors that influence people's attitudes towards landscapes in general and forests in particular. Moreover, these factors vary according to their affective strength and generality. Thus, it is important to know which of the landscape's properties that are appreciated throughout cultures and individuals and which are of specific value for a limited number of people.

## 2.3. Theoretical background for predicting forest landscape preferences

There are many theories for predicting the public preferences for landscapes. The theories vary in relation to their generality, the level of abstraction and empirical approval. Among the most important theories are information processing theory (Kaplan & Kaplan, 1989), psycho-evolutionary theory (Ulrich, 1986) and prospect-refuge theory (Appleton, 1975).

According to information processing theory, a landscape is perceived as attractive if it fulfils two main human needs: understanding and exploration. Accordingly, the most important landscape's characteristics are: coherence, legibility, mystery and complexity. Coherence and legibility help to make sense of the environment, whereas complexity and mystery provide opportunities for further exploration (Kaplan & Kaplan, 1989; Karjalainen, 2006).

Psycho-evolutionary theory postulates that people prefer secure, source-rich environments. The crucial landscape's attributes are: complexity, depth of view, ground surface texture, deflective vistas, treat and water (Ulrich, 1986).

Prospect-refuge theory is based on the assumption that people prefer sights where they can see without being seen, which is evolutionary prescribed. Important factors in a landscape are: surfaces, scale light-darkness, locomotion and other (Appleton, 1975).

Karjalainen (2006) analyzed the above mentioned theories in regard to their empirical approval. The author found that some of the variables of information processing and psycho-evolutionary theories were good predictors of the public preferences in empirical studies. Prospect-refuge theory didn't find approval in practice. Further, Karjalainen concluded that the most closely related to preferences are such variables as mystery, coherence, visual access and absence of threat. Smoothness of ground texture, ease of movement and complexity could also predict preferences to some extent.

Ode (2003) analyzed existing theoretic studies on landscape preference and defined six visual concepts which are believed to be relevant and applicable in forest environments: diversity, scale, visual accessibility, stewardship, naturalness and coherence.

Diversity (variation, complexity) is applied at landscape, woodland and stand level. At the landscape level woodland is seen as an element in relation to other land uses. At the woodland level the variation between the stands is taken into account (Axelsson-Lindgren & Sorte, 1987). At the stand level horizontal and vertical structure, species composition within a stand are of importance.

The concept of scale deals with relative size. Size of stand together with tree size, structure and density should be taken into account.

Visual accessibility is associated with depth of view (visual penetration), passability of the area (ease of movement), and openness. At the stand level the key attributes that effect visual accessibility are vertical and horizontal structure, density, ground surface texture, presence of paths and panoramic views.

The concept of stewardship argues that landscape is regarded as highly valuable when it is looked after. Most people like to feel sense of care in a forest (Sheppard, 2001). Removing slash after harvesting operation, regulating amount of natural deadwood, presence of paths are important factors for the public preferences.

Naturalness of a forest has always been regarded as predictor for the positive public attitudes. However, more recent studies show that people prefer 'managed naturalness' (Ode & Fry, 2002).

The concept of coherence refers to the extent of understanding of landscapes. In the context of this concept form and type of woodland are the most important.

### 2.4. Stand characteristics as predictors of preferences

Many earlier studies investigated the relationships between scenic beauty and physical attributes of a forest. Most of them indicated that the priority of a stand with respect to its aesthetic quality can be predicted to a large extent from stand characteristics. Among the key characteristics, which contribute to scenic beauty, is size of trees, species composition, stand density, vertical structure or stratification, amount of deadwood etc.

*2.4.1. Size of trees*

Gundersen & Frivold (2008) reviewed 53 quantitative surveys on forest landscape preferences from Norway, Finland and Sweden. They concluded that the common feature across the surveys was that people's preferences increased with increasing tree size and advancing stage of stand development. Reviewing studies on forest aesthetics, Ribe (1989) found that tree size was strongly correlated with scenic beauty whether trees were measured by diameter, basal area or height. Silvennoinen et al. (2001) found that the priority for stands was increased with increasing mean height and volume of large pines and birches. Age of trees is also shown to be strongly linked to aesthetic quality. However, scenic beauty may start to decrease as main tree species in a stand passes maturity stage (Gobster, 1996). In a Danish study by Jensen (1999) the correlation between stand age and the public preferences was stronger for broadleaved forests than for coniferous ones.

*2.4.2. Vertical structure*

The effect of vertical forest structure is not very clear (Ribe, 1989). Brown &Daniel (1984) found no link between stratification and scenic beauty. On the other hand Silvennoinen et al. (2001) observed a positive effect of tree height variation on the public preferences. The authors used skewness of the height distribution of trees for their landscape preference model and found it to be a good predictor of the public preferences. Skewness was highest in sparse stands of tall trees with an understorey of small trees.

Presence of understory of small trees and bushes in a forest in regard to its aesthetic quality has been investigated by many authors (Ribe, 1989; Gundersen & Frivold, 2008). Schroeder & Daniel (1981) concluded that understorey had a positive effect on scenic beauty of western US forests. Similarly, Savolainen and Kellomaki (1981) showed that undergrowth increased scenic value of a forest. Tahvanainen et al. (2001) found that removal of undergrowth had a negative impact on scenic beauty. However, understorey may reduce visual penetration, which is negatively correlated to aesthetic quality. In my opinion, the effect of vertical structure depends a lot also on other factors like forest type, species composition, visibility, passability, etc.

### *2.4.3. Stand density and its spatial distribution throughout a stand*

Stand density is a strong predictor of scenic beauty of a forest. The relationship between stand density and public preference may be described as being bell-shaped. In other words, it is undesirable when density is too low as well as when it is too high. In the first case the stand lacks structural diversity whereas in the second it is hard to be visually accessed. Ribe (1989) noticed that a low attractiveness of young stands can be explained by a high density. Jensen & Skovsgaard (2009) investigated how precommercial thinning regime in Pedunculate oak stands influences the public preference. Although the results didn’t indicate a clear relationship between the residual stem number and the public preference, it was found that stands of low and medium density were preferred over dense ones. Rydberg (1998) argued that that young forests of higher densities were regarded as more preferable by young people.

Spatial distribution of tree density may also affect forest landscape preferences (Ribe, 1989). Presence of both patches of high density and openings contributes to such attribute as naturalness, which is highly appreciated by the public. Natural openings in the forest are highly appreciable whereas openings created by clear-cuts are regarded as the strongest factor towards negative perception of forest landscape (Gundersen & Frivold, 2008). However, horizontal structural irregularity is preferable until it doesn’t reduce visual penetrability of a stand.

### *2.4.4. Species composition*

Inclusion of tree species variables into preference studies usually resulted in rather unclear results. Gundersen & Frivold (2008) concluded that people’s preferences for species composition are strongly dependant on other variables like tree size, openness, visibility as well as familiarity with forest type.

### *2.4.5. Amount of natural deadwood*

Dead trees and snags are generally disliked by the public (Tyrvainen et al., 2003). The presence of large woody debris creates a sense of lacking stewardship in the forest and is therefore perceived negatively by the public (Velarde at al., 2006). Schroeder & Daniel (1981) stated that natural downed wood is more acceptable by the public than slash from harvesting operations but the effect was still negative. However, today there is a trend of increasing acceptability towards deadwood by the public. Lindhagen & Hörnsten (2000) showed that virgin forest was found as more suitable for outdoor recreation for Swedes in 1997 than in 1977. Nielsen et al. (2007) reported that a few standing or fallen trees were accepted by Danish public as contributing to more natural appearance of a forest. Considerable differences between social groups in regard of deadwood tolerance were found. Younger, well-educated and environmentally concerned people are usually more positive to the presence of dead wood (Axelsson Lindgren, 1995; Tyrvainen, 2003).

### 2.5. Silvicultural management systems in regard to scenic beauty

All management operations concerned with timber harvesting have a negative immediate impact on aesthetic quality of a forest. Reduction of visual attractiveness of woodland is caused by creating slash, log landings and strip roads, and damaging of residual vegetation. However, the negative impacts of different silvicultural methods vary in strength and duration. Moreover, there are several silvicultural practices which can contribute to aesthetics of a forest in the future, such as removing of undergrowth, creating of openings, etc.

#### *2.5.1. Clear-cutting systems*

Clear-cuts are believed to have the strongest and the longest impact on scenic quality (Ribes, 1989; Ribe, 2005). The negative public attitude towards this system increases with increasing size of the clear-cuts and amount of slash, with poor adoption of clear-cut patches to the landscape, with closeness to the city (Gundersen & Frivold, 2008). Slash and disturbed soils are staying visible for at least two years after clear-cut. Moreover, the new generation is usually very dense and impenetrable, thus perceived as unattractive for most visitors (Johnson et al., 2009). Clear-cuts are more accepted in winter time, when slash and stumps are hidden under snow (Gundersen & Frivold, 2008). However, in some cases clear-cuts may contribute to scenic beauty of a forest landscape by opening vistas and enhancing the structural variety of a forest (Johnson et al., 2009).

Possible ways of moderating the impact of clear-cuttings are adaptation of clear-cuts to the landscape, reduction of the size of clear-felled areas, removal of logging residues and tracks, to leave edges intact and to retain seed trees.

### *2.5.2. Retention of trees*

Tonnes et al. (2004) investigated the impact of retention trees on the scenic beauty in clear-cutting areas. They concluded that retention trees had a positive impact on aesthetic quality of clear-cuts. The number of trees was also to be positively correlated with scenic beauty. Leaving less trees than corresponding to a volume of 3 $m^3$ per ha did not have any significant effect on the visual quality of the area. The findings of the survey conducted by the British Columbia Ministry of Forests and Range (2006) showed that harvesting operations are accepted by the public if at least 24% of the trees remain. Ribe (2005) concluded that retention of 40% dispersed and 75% aggregated trees in harvests is highly percepted by the public and is believed only to have a slight impact on scenic beauty. Karjalainen (2006) showed that a quality of retention trees was an important factor for the public perception. Big-sized trees in a good condition, was regared as high quality and increased attractiveness considerably, whereas trees of poor quality did not improve the visual quality of clear-felled areas at all.

Many studies indicated that evenly distributed retention trees were preferred to clusters of trees (British Columbia Ministry of Forests and Range, 2006; Tonnes et al., 2004; Ribe, 2005).

### *2.5.3. Shelterwood system*

Under the shelterwood system harvesting operations occur on two or tree occasions during the rotation. Unsightly damages to the residual vegetation may be present at each harvest. The shelterwood stage provides a park-like appearance of a forest which is perceived as visually attractive for the public. Advanced growth of understorey during the shelterwood phase helps to reduce the evidence of tree cutting activities (Johnson et al., 2009). After the last shelter trees have been removed, the stand becomes uniform and similar to one regenerated by a clear-cut method (Gundersen & Frivold, 2008). The method of natural regeneration through uniform shelterwood is regarded as the most suitable method for Swedish recreational forests (Holgen at al., 2000; Lindhagen & Hornsten, 2000). However, the Swedish public preference towards shelterwood system has significantly decreased in the period from 1977 to 1997 and need of reconsidering the current recommendations may arise (Lindhagen & Hörnsten, 2000).

*2.5.4. Selection-cutting system*

Under the selection-cutting system low intensity logging activities occur quite often. It may require more roads and skid trails than other harvesting methods. A nearly continuous overstorey cover helps mitigate the negative impact of harvesting operations. Creation of openings may increase penetration and result in a diverse and visually attractive stand structure (Johnson et al., 2009). According to a Swedish study by Lindhagen (1996) the group-selection method was preferable to the clear-cutting method in even-aged stands of Norway spruce. The single tree selection method is perceived more positively than the group selection method. Most studies on the public preference indicate that the tree selection method has a low impact on scenic quality and is perceived as positive by the public (British Columbia Ministry of Forests and Range, 2006).

*2.5.5. Intermidiate thinnings*

Tending of young stands and thinning of older ones usually have a positive effect on aesthetic quality (Johnson et al., 2009; Tyrvainen et al., 2003). In the study by Tahvanainen et al. (2001) thinning decreased the visual attractiveness of forest stands. However, for this study the authors used a computer simulation method and the same number of trees was prescribed to be removed in thinning from each stand regardless of initial density. It resulted in too sparse tree distribution after thinning in the stands which were not very dense originally. Silvennoinen et al. (2002) showed that leaving the most vigorous and attractive trees during thinning resulted in a significant visual improvement of the young stands.

*2.5.6. Free development*

Absence of any human disturbances in a forest is perceived as the most positive alternative for the public. However, unmanaged stands usually accumulate large amounts of deadwood, which has a negative impact on scenic beauty. Recent studies arrived at the conclusion that people prefer “managed naturalness”, i.e. when they sense a care of woodland (Ode & Fry, 2002).

## *3. MATERIALS AND METHODS*

### 3.1. Description of study areas: the Alnarp and the Snogeholm landscape laboratories

The study has been conducted in the two young landscape laboratories[1] of Alnarp and Snogeholm, which both are located in Southern Sweden (Figure 1). The landscape laboratories are important reference landscapes in Southern Sweden and are being widely used for demonstration purposes, teaching and research (Jönsson & Gustavsson, 2002).


**Figure 1.** Location of the Alnarp and Snogeholm landscape laboratories in Southern Sweden

[1] The concept of landscape laboratories was developed by the Swedish University of Agricultural Sciences. The main idea behind this concept is to create a platform, where scientists and professionals with different backgrounds could meet and collaborate on planning, design and management of urban forests.

*The Alnarp landscape laboratory* (further the Alnarp LL) is situated in Alnarp, Southern Sweden, 10 km from Malmö (coordinates: 55$^{o}$ 39' N, 13$^{o}$ 04' E). It was established in 1991 by the Swedish University of Agricultural Sciences (SLU) in cooperation with a wide range of professionals and scientists from forestry, landscape architecture and agriculture. The laboratory is located on flat land. Sandy soils with shallow clay pans are in some places predominate on the area.

The laboratory consists of two parts, 'Tor Nitzelius Park' and 'Västerskog'. Tor Nitzelius Park was planted in the 1980s and was aimed at creating of multilayered forest edge of both native and exotic species. Västerskog was planted between 1993 and 1999. It focuses on developing new creative methods of managing young woodlands.

*The Snogeholm landscape laboratory* (further the Snogeholm LL) was established in 1994. It is located at the horst Romeleåsen, Southern Sweden, about 40 km east from Malmö (coordinates: 55$^{o}$ 35' N, 13$^{o}$ 40' E). The district is a transitional zone between open agricultural land and forested areas. The laboratory is located on hilly terrain, between the lakes Ellestadssjön, Snogeholmssjön and Sövdesjön, which is formerly agricultural land.  Soils vary between the stands and within them. The conceptual context of the Snogeholm LL differs from the Alnarp LL mainly due to differences in location. The Snogeholm LL focuses to a large extent on timber production integration of recreational aspects and creative management practices.

### 3.2. Description of study plots

Within the laboratories there are different models of woodland types represented. The woodland types include both traditional commercial forestry management concepts and new, innovative concepts, which focus on recreation and ecology (Jönsson & Gustavsson, 2002).

Most of indigeonous species are represented in the landscape laboratories (Table 1). All the plots may be divided into tree categories with regard to complexity of species mixture: monocultures, simple mixtures with two-three tree species and mixtures with up to fifteen woody species.

Table 1. *List of woody species represented in the landscape laboratories*

| **No** | **Latin name** | **Common English name*** |
|---|---|---|
| 1 | *Acer platanoides* L. | Norway maple |
| 2 | *Alnus glutinosa* L. | Black alder |
| 3 | *Betula pendula* Roth. | Silver birch |
| 4 | *Carpinus betulus* L. | European hornbeam |
| 5 | *Corylus avellana* L. | Common hazel |
| 6 | *Crataegus* sp. | Hawthorn |
| 7 | *Euounimus europaeus* L. | Spindle |
| 8 | *Fagus sylvatica* L. | European beech |
| 9 | *Fraxinus excselsior* L. | European ash |
| 10 | *Larix x eurolepis* Henry | Hybrid larch |
| 11 | *Malus sylvestris* (L.) Mill. | European wild apple |
| 12 | *Picea abies* (L.) H.Karst. | Norway spruce |
| 13 | *Pinus sylvestris* L. | Scots pine |
| 14 | *Populus tremula* L. | Aspen |
| 15 | *Populus x wettsteinii* Hämet-Ahti | Hybrid aspen |
| 16 | *Prunus avium* L. | Wild cherry |
| 17 | *Prunus padus* L. | Hackberry |
| 18 | *Qercus robur* L. | Pedunculate oak |
| 19 | *Quercus petraea* (Mattuschka) Liebl. | Sessil oak |
| 20 | *Ribes alpinum* L. | Alpine currant |
| 21 | *Salix caprea* L. | Goat willow |
| | *Sorbus aucuparia* L. | Rowan |
| 22 | *Tilia cordata* Mill. | Small-leaved lime |
| 23 | *Ulmus glabra* Huds. | Wych elm |
| 24 | *Viburnum opulus* L. | European cranberrybush |

* Futher in the study the common names are mostly used (oak, lime, etc.).

Only highly distinguishable stands with the most contrasting visual characteristics were selected for the study. All types of species mixtures were represented in the study stands. Except for species composition attention was paid to the presence of undergrowth and deadwood and to the texture of ground cover. In the

Alnarp LL 14 study plots were chosen among overall 34 plosts (stands). The characteristics of the stands are shown in the Table 2.

Table 2. *Description of the study plots in the Alnarp LL*

| No of plot | Species composition | Type of species mixture | Under-growth | Dead-wood [a] |
|---|---|---|---|---|
| 1 | Cherry | monoculture | - | - |
| 2 | Oak, hybrid larch | simple mixture | + | + |
| 3 | Oak, birch | simple mixture | + | + |
| 4 | Aspen | monoculture | - | + |
| 5 | Birch, cherry | simple mixture | - | + |
| 6 | Birch | monoculture | - | - |
| 7 | Maple | monoculture | - | - |
| 8 | Lime | monoculture | - | - |
| 9 | Elm, ash, lime, hazel, cranberrybush, goat willow, apple, spindle, beech, oak, hawthorn, alder, hackberry (Alnarps lund) | complex mixture | + | + |
| 10 | Hornbeam | monoculture | - | - |
| 11 | Beech, hybrid larch | simple mixture | + | + |
| 12 | Ash, hybrid aspen | simple mixture | + | - |
| 13 | Ash, hybrid larch | simple mixture | - | + |
| 14 | Oak, alder | simple mixture | + | - |

[a] Both standing and lying deadwood was taken into account. However, standing dead trees were present only in the aspen stand.

In the Snogeholm LL 30 study plots were selected out of 69. Data obtained during an inventory conducted by SLU in 2008 are shown in Table 3.

Table 3. *Description of the study plots in the Snogeholm LL (14 vegetation periods after establishment)*

| No of plot | Species composition | Type of species mixture | Mean height, m | | Mean diameter, cm | | Standing volume, $m^3 ha^{-1}$ | Total volume, $m^3 ha^{-1}$ | Under-growth | Dead-wood |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | max[a] | weighted[b] | max | weighted | | | | |
| 1 | Hornbeam | monoculture | 8,2 | 8,2 | 5,8 | 5,8 | 45 | 59 | - | - |
| 2 | Hornbeam, hybrid larch | simple mixture | 13,5 | 11,3 | 20,0 | 14,4 | 70 | 166 | - | + |
| 3 | Beech, birch | simple mixture | 12,9 | 9,8 | 15,0 | 13,2 | 39 | 69 | - | + |
| 4 | Beech, alder | simple mixture | 10,7 | 9,7 | 14,2 | 9,8 | 80 | 126 | - | + |
| 5 | Oak, maple | simple mixture | 8,5 | 8,8 | 7,5 | 8,7 | 49 | 68 | - | + |
| 6 | Ash, cherry, oak, hazel, elm, hornbeam, hawthorn, hackberry, lime, Norway maple, currant, apple, cranberrybush, birch (Artrik lund) | complex mixture | 12,6 | 8,4 | 13,5 | 6,3 | 40 | 97 | + | + |
| 7 | Cherry, alder | simple mixture | 9,6 | 9,5 | 11,5 | 10,8 | 43 | 92 | - | - |
| 8 | Cherry, birch | simple mixture | 16,3 | 14,3 | 15,1 | 15 | 68 | 146 | - | - |
| 9 | Beech, hybrid aspen | simple mixture | 20 | 13,1 | 30,9 | 17,4 | 43 | 178 | - | + |
| 10 | Cherry, hybrid larch | simple mixture | 14,5 | 12,6 | 15,4 | 12 | 105 | 151 | - | - |
| 11 | Hybrid aspen | monoculture | 19,9 | 19,9 | 18,4 | 18,4 | 167 | 279 | + | - |
| 12 | Aspen, birch, alder, goat willow | complex mixture | 14,6 | 12,2 | 15,1 | 10,7 | 73 | 150 | + | + |
| 13 | Scots pine, beech, hazel | simple mixture | 8,8 | 8,4 | 12,4 | 9,9 | 52 | 95 | + | + |
| 14 | Hybrid larch | monoculture | 14,2 | 14,2 | 16,4 | 16,4 | 128 | 253 | - | + |
| 15 | Pine | monoculture | 9,3 | 9,3 | 9,8 | 9,8 | 220 | 245 | - | + |
| 16 | Birch | monoculture | 11,8 | 11,8 | 9,9 | 9,9 | 59 | 113 | - | - |
| 17 | Birch, alder | simple mixture | 12,6 | 12,5 | 13,7 | 12,3 | 77 | 140 | - | - |

Table 3. *Description of the study plots in the Snogeholm LL (14 vegetation periods after establishment)*

| No of plot | Species composition | Type of species mixture | Mean height, m | | Mean diameter, cm | | Standing volume, $m^3 ha^{-1}$ | Total volume, $m^3 ha^{-1}$ | Under-growth | Dead-wood |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | max[a] | weighted[b] | max | weighted | | | | |
| 18 | Lime, birch | simple mixture | 14,4 | 11,2 | 15,8 | 10,8 | 114 | 133 | - | + |
| 19 | Oak | monoculture | 8,7 | 8,7 | 7,1 | 7,1 | 80 | 87 | - | + |
| 20 | Lime, oak | simple mixture | 7,7 | 7,7 | 8,6 | 7,3 | 86 | 113 | - | + |
| 21 | Beech, spruce | simple mixture | 10,4 | 9,5 | 13,6 | 11,5 | 68 | 144 | + | + |
| 22 | Alder | monoculture | 11,6 | 11,6 | 12,3 | 12,3 | 53 | 129 | - | - |
| 23 | Oak, hybrid larch | simple mixture | 13,4 | 12,8 | 16,0 | 14,9 | 95 | 182 | - | - |
| 24 | Oak, ash | simple mixture | 7,9 | 5,3 | 9,4 | 5,4 | 25 | 40 | - | + |
| 25 | Oak, aspen | simple mixture | 10,7 | 10,1 | 9,8 | 8,6 | 81 | 85 | - | - |
| 26 | Cherry, ash | simple mixture | 6,1 | 6,1 | 6,3 | 6,3 | 11 | 11 | - | - |
| 27 | Alder, lime, hackberry, rowan | simple mixture | 11,5 | 11,1 | 12,2 | 11,7 | 64 | 136 | + | - |
| 28 | Spruce, oak, hornbeam, hazel, birch, lime ("Bubbetorpmodellen") | complex mixture | 11,5 | 9,4 | 11 | 9,7 | 79 | 126 | + | - |
| 29 | Spruce, oak, hornbeam, hazel, birch, lime, ash, beech ("Sillesasmodellen") | complex mixture | 12,2 | 9,4 | 13,7 | 11 | 63 | 112 | + | + |
| 30 | Beech, oak, lime | simple mixture | 7,5 | 7,2 | 9,1 | 7,4 | 63 | 67 | + | + |

[a] The mean height/diameter of the highest/with the biggest dimensions tree species in the mixture (maximum of averages)
[b] The mean height/diameter, calculated using standing volume as a weight variable

### 3.3. The survey

The research involved a two-step inquiry. The first part was conducted in the Alnarp LL. It was held in the field in a form of a questionnaire with a following discussion. The second part was an assessment of pictures representing the forest stands in the Snogeholm LL.

#### *3.3.1. Inquiry in the field*

The inquiry in the forest aimed at finding the most important factors that influence the perception of the forest. The method used was similar to a psychological method described by Lee (2001) as it involved a detailed analysis of responses of small groups of individuals.

In the end of September 2010 a visit to the Alnarp LL was organized for 14 students from SLU. The students represented different countries, including Lithuania, Ukraine, Uruguay, Spain, Portugal, India, Iran, Poland and Germany.

Each student was given a questionnaire concerning forest landscape perception and was instructed how to fill in the forms. During the walk in the forest the participants were asked to give their opinions about each of the 14 visited stands. The respondents were allowed to discuss their decisions with each other; the main points of the discussion were recorded.

The questionnaire included 12 closed and open questions for every stand and a few questions about the whole forest in the end. In the closed questions the participants had to rank (1 to 10) the stand characteristics which were regarded to have the strongest influence on human perception (diversity, naturalness, visibility and passability). The open questions concerned general impression and psychological effect of the stands (Appendix 1).

#### *3.3.2. Photo assessment*

Previous studies have shown that assessment of photographs representing forest views may be successfully used in research on public perception (Lindhagen, 1996; Bradley & Kearney, 2007). Moreover, this method may be preferable to assessment on the sight as it reduces the effect of contextual factors, such as weather (Bradley & Kearney, 2007).

Color pictures of close views, that represent the study stands were taken in the Snogeholm LL in October 2010. The photographs were carefully exposed and selected to be as much representative as possible (Appendix 2). Only one picture was selected for each study stand, resulting in 30 photographs in total.

The questionnaire was designed as a Q-sort test. The respondents were asked to sort 30 photographs into 5 stacks, 6 pictures in each stack. Sorting was in two runs, according to two criteria. The first time the participants had to assess the photographs according to the aesthetic value, the second time – in regard to its ecological assumed value. Pictures with the highest value were put in the first stack and those with the lowest value – in the last stack.

The questionnaire with detailed instructions was sent via internet to three groups of individuals during February – March 2011. The first group was international, representing forestry students and graduates from all over the world (current and former Euroforester students); the second group was formed by forestry students and employees from Ukraine; the third one was a Ukrainian group consisting of people (mainly students) not concerned with forestry. Numbers of sent questionnaires, received responds and respond rate for each group are presented in the Table 4.

Table 4. *Respond rates by the groups of respondents*

| **Group of respondents** | **Number of sent questionnaires** | **Number of responses** | **Respond rate, %** |
|---|---|---|---|
| Group 1 (international) | 63 | 16 | 25,4 |
| Group 2 (Ukraine – forestry educated) | 46 | 17 | 37,0 |
| Group 3 (Ukraine – no forestry education) | 55 | 14 | 25,5 |
| **Total** | **164** | **47** | **29,3** |

### 3.4. Statistical treatment

While respondents made two independent assessments of photos concerning aesthetic and ecological values, each of 30 pictures was given two scores from 1 to 5, depending on the stacks in which it was placed. The five-step scale provided data at ordinal level. However, previous studies have shown that ordinal data can be treated as interval data if the number of categories is more than four and the number of observations is high (Johnson & Creech, 1983 in Lindhagen, 1996). As the current data fit these conditions, it was possible to treat it as ordinal data calculating mean values, standard deviations and correlation coefficients. Differences between mean values were compared using t-tests.

After that the mean scores for every picture were calculated, it became possible to rank photos form 1 to 30 according their aesthetical and ecological values. It gave a possibility to see how qualitative characteristics (species composition, presence of undergrowth and deadwood) affect public judgments of aesthetic and ecological values.

Pearson's correlation coefficients between the mean scores of pictures and quantitative stand characteristics (mean height, mean diameter, standing volume and total volume) were calculated. It was hypothesized that the relationship between aesthetic value and height as well as for aesthetic value and diameter is close to positive linear. The relationship between aesthetic value and volume is unlikely to be linear as both too few and too much of wood would look unattractive for visitors. To exclude a possible negative impact of standing and total volumes on the relationships between the aesthetic value and height and between the aesthetic value and diameter, the partial correlation coefficients were calculated.

Principal component analysis, which allows to convert a set of observations of possibly correlated variables int a set of uncorrelated variables (principal components, or factors), was also used to find the influence of stand qualitative characteristics on people's judgements.

Spearman's correlation coefficient for ranked data was used to compare the assessments of aesthetical and ecological values within each group of respondents and the assessments between the groups. It was hypothesized that the judgments between the groups may differ due to different level of familiarity with forest landscapes. Furthermore, aesthetic and ecological values may to some extent be correlated for the group of respondents who are not familiar with forestry, as scenic beauty was found to be the driving factor of forest perception by the general public.

## *4. RESULTS*

### 4.1. Inquiry in the field (Alnarp LL)

Table 5 shows the result of the evaluation of the 14 study plots according to the characteristics presented in the questionnaire (forest, recreational forest, attractiveness, diversity, naturalness, visibility, passability). The plots in the table are ranked according to their attractiveness.

Table 5. *Mean scores of forest characteristics (forest, recreational forest, attractiveness, diversity, naturalness, visibility, passability) for the study plots (n=14)*

| No of plot | Description | | | Mean scores | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Species composition** | **Undergrowth** | **Deadwood** | **Forest** | **Recreational forest** | **Attractiveness** | **Diversity** | **Naturalness** | **Visibility** | **Passability** |
| 5 | Silver birch, wild cherry | - | + | 5,1 | 2,5 | **3,1** | 2,6 | 2,4 | 5,7 | 3,8 |
| 4 | Aspen | - | + | 5,4 | 3,2 | **3,4** | 2,8 | 2,3 | 5,4 | 5,1 |
| 12 | European ash, hybrid aspen | + | - | 6,0 | 3,1 | **3,5** | 3,0 | 4,0 | 1,8 | 1,2 |
| 2 | Sessil oak, hybrid larch | + | + | 6,7 | 2,7 | **3,9** | 4,8 | 4,7 | 3,9 | 2,9 |
| 8 | Small-leaved lime | - | - | 6,0 | 4,1 | **3,9** | 2,8 | 2,6 | 6 | 6,4 |
| 11 | European beech, hybrid larch | + | + | 6,3 | 3,6 | **4,1** | 3,1 | 2,8 | 3,4 | 3,8 |
| 14 | Pedunculate oak, black alder | + | - | 6,6 | 4,5 | **4,3** | 4,5 | 4,9 | 5,4 | 4,5 |
| 13 | European ash, hybrid larch | - | + | 6,1 | 5,3 | **4,4** | 3,8 | 3,1 | 5,8 | 6,0 |
| 9 | Wych elm, European ash, small-leaved lime, hazel, cranberrybush, goat willow, wild apple, spindle, European beech, Pedunculate oak hawthorn, black alder, hackberry (Alnarps lund) | + | + | 6,0 | 4,5 | **4,7** | 4,2 | 4,2 | 3 | 3,9 |
| 10 | European hornbeam | - | - | 6,1 | 3,9 | **4,7** | 2,5 | 2,8 | 3,3 | 3,1 |
| 1 | Wild cherry | - | - | 4,4 | 3,6 | **4,8** | 1,5 | 1,6 | 4,1 | 5,7 |
| 7 | Norway maple | - | - | 5,6 | 4,8 | **4,8** | 2,3 | 2,6 | 5,6 | 6,1 |
| 3 | Pedunculate oak, silver birch | + | + | 6,4 | 5,1 | **5,9** | 3,7 | 4,0 | 4,9 | 5,1 |
| 6 | Silver birch | - | - | 5,8 | 6,3 | **6,6** | 2,6 | 2,6 | 7,4 | 6,9 |

Almost all study plots received the full range of possible scores within each variable (1 to 10).

The results do not indicate any clear relationship between attractiveness of the forest stands and species composition. In general, monocultures were preferred in front of mixtures.

Presence of undergrowth and deadwood had a negative impact on the overall attractiveness of the forest interiors. However, in the case of the oak-birch stand, understorey and deadwood didn't seem to negatively influence the respondents judgments on forest attractiveness.

Interestingly, the respondents had almost totally different opinions about what is forest and what is recreational forest. Spearman's correlation coefficient for these two characteristics was as small as 0,158.

According to the results presented in the Table 6, naturalness and diversity were highly correlated with the perception of what is a forest, while they didn't correlate with the image of a recreational forest. Attractiveness, visibility and passability were the most important stand characteristics of recreational forest, while unimportant for judgments of stands as a forest.

Table 6. *Spearman's correlation coefficients between forest/recreational forest and other stand characteristics (attractiveness, diversity, naturalness, visibility, passability)*

| | **Attractiveness** | **Diversity** | **Naturalness** | **Visibility** | **Passability** |
|---|---|---|---|---|---|
| **Forest** | 0,042 | 0,751 | 0,856 | -0,269 | -0,360 |
| **Recreational forest** | 0,785 | 0,118 | 0,157 | 0,425 | 0,703 |

Other important points on forest aesthetics were observed during the discussion part of the survey. First, the respondents paid attention to sounds and sense of touch while judging the stands. It contradicts to the general opinion that only visual beauty contributes to the overall aesthetic quality of a forest. Closeness to the road and the railway showed a considerable negative impact on the respondents' judgments of recreational forest and attractiveness. At the same time, rustle of leaves in aspen stand was noticed pleasant and had a positive impact on the assessments. Second, the overall impression of forest seemed not to be the same as the sum of judgments on its single stands. High between-stand diversity and presence of water surfaces in the forest resulted in a very positive impression of the whole area.

### 4.2. Photo assessment of the forest sites (Snogeholm LL)

#### *4.2.1. Relationship between aesthetic value and qualitative stand characteristics (species composition, presence of undergrowth, and presence of deadwood)*

Mean scores, standard deviations and ranking for 30 study plots in the Snogeholm LL according to their aesthetic value are presented in the Table 7.

The results indicate a relatively low variability in the assessment of the aesthetic value of the forest sites between the 47 respondents (Table 7).

From the data it is also possible to make some general conclusions about relationship between aesthetic value and such qualitative stand characteristics as species composition, presence of undergrowth, and presence of deadwood.

From the Table 7 it can be seen that the respondents generally preferred broadleaved-dominated forest stands to coniferous ones. Among the most highly evaluated species were wild cherry, silver birch and black alder (Figure 2, 3, 4,5); two stands dominated by Scots pine were judged as having the lowest aesthetic value (Figure 5, 6). Type of species mix within the stands didn't show any clear relationship with their aesthetic value.

Presence of undergrowth contributed to the reduction of the aesthetic quality of the forest interiors. Presence of deadwood also showed to have an overall negative impact of the aesthetic beauty of the forest stands. However, the conclusions in this case should be made carefully as the public perception of deadwood in the forest depends to large extent on the type of presented deadwood. The current results indicate that lying logs didn't reduce the aesthetic value significantly, or didn't reduce it at all. One example is the beach-poplar plot № 10, where most of poplar has already been cut down and left in the forest. This stand was judged as having a high aesthetic value by 64% of the respondents, and has got a rank of 26,0 (Table 7).

Table 7. *Mean scores and ranking of the study plots according to their aesthetic value (n=47)*

| No of plot | Description | | | Mean score | SD | Rank | Significance [a] |
|---|---|---|---|---|---|---|---|
| | Species composition | Under-growth | Dead-wood | | | | |
| 15 | Pine | - | + | 1,57 | 0,80 | 1,0 | a |
| 13 | Scots pine, beech, hazel | + | + | 1,60 | 0,95 | 2,0 | a |
| 19 | Oak | - | + | 1,72 | 0,83 | 3,0 | ab |
| 6 | Ash, cherry, oak, hazel, elm, hornbeam, hawthorn, hackberry, lime, Norway maple, currant, apple, cranberrybush, birch (Artrik lund) | + | + | 1,81 | 1,19 | 4,0 | ab |
| 11 | Hybrid aspen | + | - | 1,85 | 0,93 | 5,0 | abc |
| 21 | Beech, spruce | + | + | 2,21 | 1,08 | 6,0 | abc |
| 2 | Hornbeam, hybrid larch | - | + | 2,23 | 0,98 | 7,0 | abc |
| 26 | Cherry, ash | - | - | 2,34 | 1,39 | 8,0 | bc |
| 30 | Beech, oak, lime | + | + | 2,36 | 1,01 | 9,0 | bc |
| 24 | Oak, ash | - | + | 2,40 | 1,14 | 10,0 | bc |
| 1 | Hornbeam | - | - | 2,68 | 1,12 | 11,0 | cd |
| 23 | Oak, hybrid larch | - | - | 2,72 | 1,42 | 12,0 | cd |
| 4 | Beech, alder | - | + | 2,81 | 1,30 | 13,0 | cde |
| 29 | Spruce, oak, hornbeam, hazel, birch, lime, ash, beech (“Sillesasmodellen”) | + | + | 2,85 | 1,16 | 14,0 | cde |
| 28 | Spruce, oak, hornbeam, hazel, birch, lime (“Bubbetorpmodellen”) | + | - | 2,87 | 1,03 | 15,0 | cde |
| 12 | Aspen, birch, alder, goat willow | + | + | 2,94 | 1,34 | 16,5 | cdef |
| 22 | Alder | - | - | 2,94 | 1,36 | 16,5 | cdef |
| 27 | Alder, lime, hackberry, rowan | + | - | 3,34 | 1,49 | 18,0 | defg |
| 20 | Lime, oak | - | + | 3,45 | 1,14 | 19,0 | efg |
| 25 | Oak, aspen | - | - | 3,57 | 1,28 | 20,0 | fg |
| 3 | Beech, birch | - | + | 3,60 | 1,38 | 21,5 | fg |
| 5 | Oak, maple | - | + | 3,60 | 1,19 | 21,5 | fg |
| 18 | Lime, birch | - | + | 3,68 | 1,18 | 23,0 | gh |
| 8 | Cherry, birch | - | - | 3,70 | 0,98 | 24,0 | gh |
| 14 | Hybrid larch | - | + | 3,77 | 1,05 | 25,0 | ghi |
| 9 | Beech, hybrid aspen | - | + | 3,85 | 1,25 | 26,0 | ghi |
| 17 | Birch, alder | - | - | 4,00 | 1,00 | 27,0 | ghi |
| 16 | Birch | - | - | 4,34 | 0,96 | 28,0 | ij |
| 10 | Cherry, hybrid larch | - | - | 4,40 | 0,92 | 29,0 | ij |
| 7 | Cherry, alder | - | - | 4,70 | 0,55 | 30,0 | j |

[a] Mean values with a letter in common do not differ significantly (p=0,05).

Figure 2. Cherry-alder stand (rank 30,0)

Figure 3. Cherry- hybrid larch stand (rank 29,0)

Figure 4. Birch stand (rank 28,0)

Figure 5. Birch-alder stand (rank 27,0)

Figure 6. Pine stand (rank 1,0)

Figure 7. Pine-beech-hazel stand (rank 2,0)

*2*

*4.2.2 Correlation between aesthetic value and quantitative stand characteristics (mean diameter, standing volume and total volume)*

The Pearson's correlation coefficients between the mean aesthetic value of the stands and their quantitative characteristics were calculated.

The results showed a significant (at the 5% level) but low positive correlation between the aesthetic value and the mean height (Figure 8, 9). The mean diameter was also positively correlated with the mean aesthetic value. However, the correlation was significant only for the max mean diameter (Figure 10, 11).

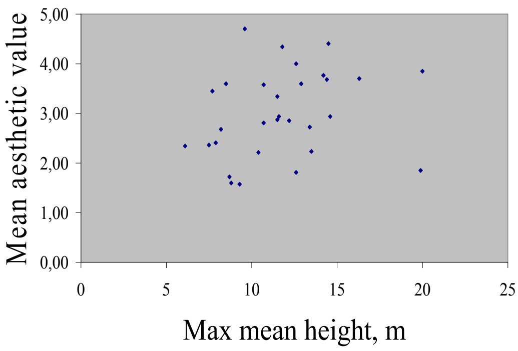


Figure 8. Correlation between the mean aesthetic value and the max mean height (R=0,2510)

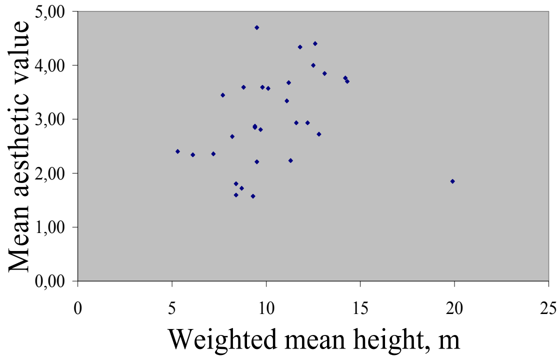


Figure 9. Correlation between the mean aesthetic value and the weighted mean height (R=0,2447)

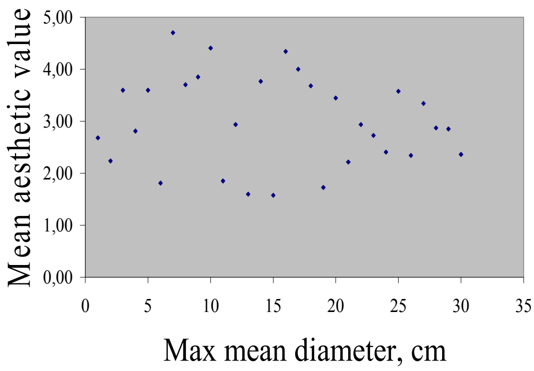


Figure 10. Correlation between the mean aesthetic value and the max mean diameter (R=0,2557)

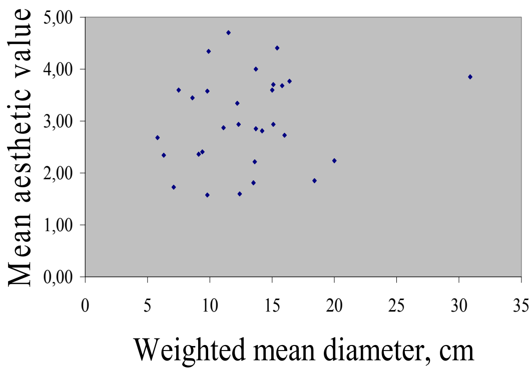


Figure 11. Correlation between the mean aesthetic value and the weighted mean diameter (R=0,1851)

The results showed a small negative correlation between the mean aesthetic value and standing volume as well as between the mean aesthetic value and total volume (Figure 12, 13). However, the results indicate only absence of a linear relationship between these characteristics.

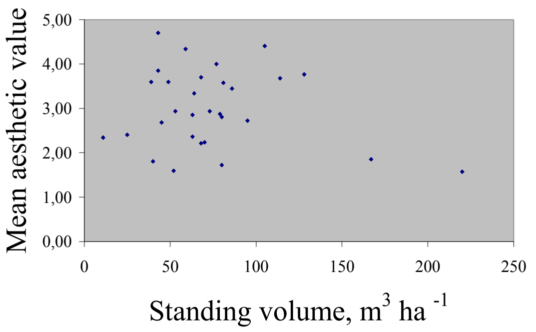


Figure 12. Correlation between the mean aesthetic value and standing volume (R= -0,1696)

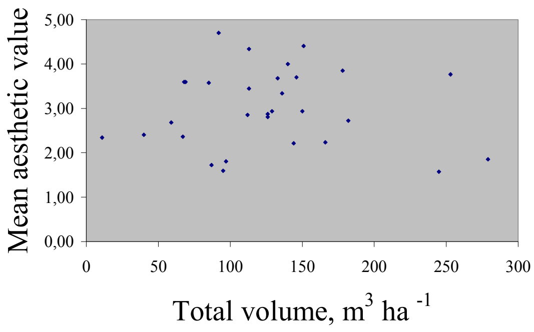


Figure 13. Correlation between the mean aesthetic value and total volume (R= -0,0337)

The partial correlation coefficients for both the mean height and the mean diameter are higher than overall correlation coefficients for these characteristics (Table 8). This indicates a higher strength of relationship between the mean height of trees and the aesthetic value and between the mean diameter of trees and the aesthetic value.

Table 8. *Partial correlation coefficients*

| **Included variable** | **Excluded variable** | |
|---|---|---|
| | **Standing volume** | **Total volume** |
| Max mean height | 0,3223 | 0,3758 |
| Weighted mean height | 0,3838 | 0,4494 |
| Max mean diameter | 0,2506 | 0,2124 |
| Weighted mean diameter | 0,4383 | 0,3455 |

The results received from the principal component analysis confirm the previous findings. Two uncorrelated factors which comprised 71,7% of all variables (mean height, mean diameter, etc.) in total, were used for the analysis. Contribution of the variables to both factors is presented in the Table 9.

Table 9. *Contribution of the variables to the factors and their coefficients*

| Variable | | Factor 1 | | Factor 2 | |
|---|---|---|---|---|---|
| No. | Description | % | r | % | r |
| 1 | Mean weighed height | 24,7 | 0,8493 | 1,2 | -0,1166 |
| 2 | Mean weighed diameter | 27,2 | 0,8915 | 2,7 | -0,1769 |
| 3 | Standing volume | 16,7 | 0,6990 | 4,7 | 0,2342 |
| 4 | Total volume | 31,0 | 0,9523 | 1,6 | 0,1382 |
| 5 | Undergrowth | 0,1 | 0,0586 | 36,5 | 0,6522 |
| 6 | Deadwood | 0,3 | -0,0973 | 53,4 | 0,7890 |

The stands with the highest astethic value got positive scores on the Factor 1 axes, and negative scores on the Factor 2 axes (Figure 14). Thus, the mean height and mean diameter have a positive but rather small impact on the aesthetic value. Total and standing volumes, as well as deadwood and undergrowth, influence negatively on the aesthetic beauty. While the impact of volume is not very strong, understorey and deadwood seem to be the main factors contributing to diminish the scenic beauty.

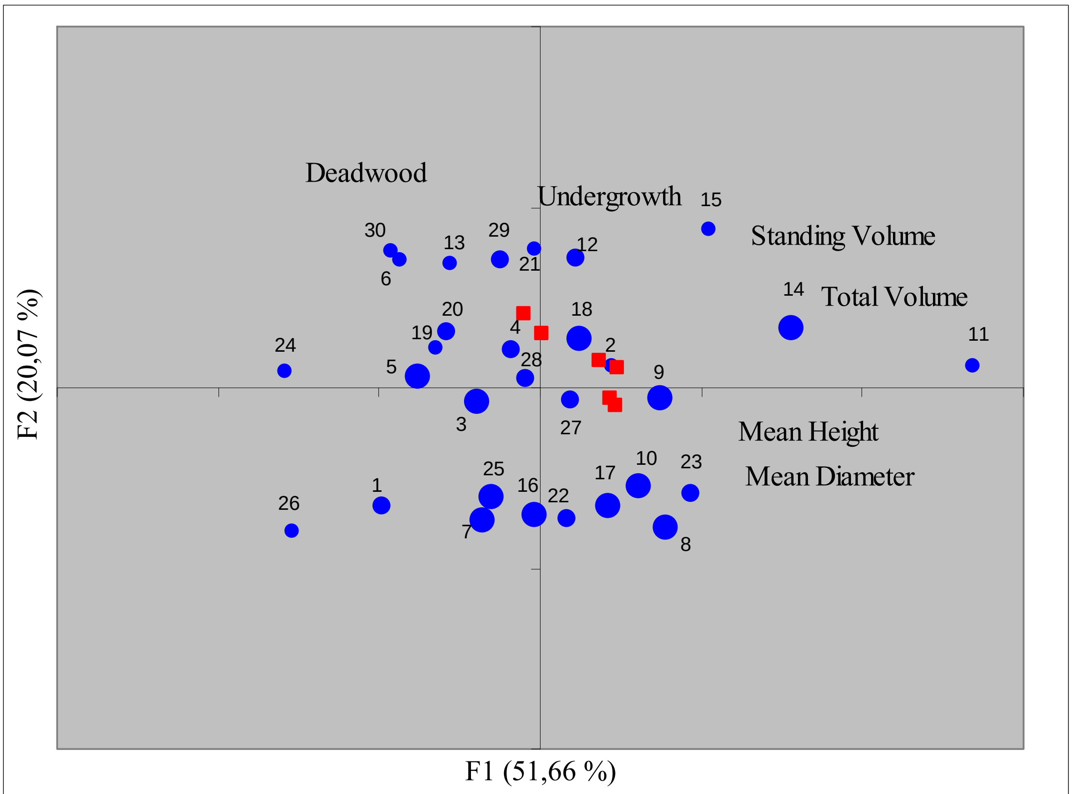


Figure 14. Factor scores and aesthetic value of the observed forest stands

*4.2.3. Relationship between ecological value and qualitative stand characteristics (species composition, presence of undergrowth, and presence of deadwood)*

Table 10. *Mean scores and ranking of the study plots according to the ecological value (n=47)*

| No of plot | Description | | | Mean score | SD | Rank | Significance [a] |
|---|---|---|---|---|---|---|---|
| | Species composition | Under-growth | Dead-wood | | | | |
| 26 | Cherry, ash | - | - | 1,57 | 1,10 | 1,0 | a |
| 15 | Pine | - | + | 2,38 | 1,44 | 2,5 | ab |
| 14 | Hybrid larch | - | + | 2,38 | 1,45 | 2,5 | ab |
| 19 | Oak | - | + | 2,49 | 1,27 | 4,0 | bcd |
| 20 | Lime, oak | - | + | 2,62 | 1,07 | 5,0 | bcd |
| 5 | Oak, maple | - | + | 2,64 | 1,22 | 6,0 | bcd |
| 13 | Scots pine, beech, hazel | - | - | 2,70 | 1,60 | 7,5 | bcd |
| 10 | Cherry, hybrid larch | + | + | 2,70 | 1,50 | 7,5 | bcd |
| 24 | Oak, ash | - | + | 2,74 | 1,15 | 9,0 | bcd |
| 25 | Oak, aspen | - | - | 2,77 | 1,54 | 10,5 | bcd |
| 16 | Birch | - | - | 2,77 | 1,22 | 10,5 | bcd |
| 21 | Beech, spruce | + | + | 2,83 | 1,27 | 12,0 | bcde |
| 11 | Hybrid aspen | + | - | 2,87 | 1,41 | 13,0 | bcdef |
| 7 | Cherry, alder | - | - | 2,91 | 1,61 | 14,0 | bcdef |
| 29 | Spruce, oak, hornbeam, hazel, birch, lime, ash, beech ("Sillesasmodellen") | + | + | 2,96 | 1,30 | 15,0 | bcdef |
| 28 | Spruce, oak, hornbeam, hazel, birch, lime ("Bubbetorpmodellen") | + | - | 2,98 | 1,09 | 16,0 | bcdef |
| 4 | Beech, alder | - | + | 3,00 | 1,12 | 17,0 | bcdef |
| 1 | Hornbeam | - | - | 3,04 | 1,32 | 18,0 | bcdef |
| 8 | Cherry, birch | - | - | 3,11 | 1,43 | 19,0 | bcdef |
| 9 | Beech, hybrid aspen | - | + | 3,15 | 1,25 | 20,0 | bcdef |
| 3 | Beech, birch | - | + | 3,23 | 1,25 | 21,0 | bcdef |
| 30 | Beech, oak, lime | + | + | 3,30 | 1,23 | 22,0 | bcdef |
| 2 | Hornbeam, hybrid larch | - | + | 3,32 | 1,25 | 23,0 | bcdef |
| 18 | Lime, birch | - | + | 3,38 | 1,36 | 24,0 | bcdef |
| 12 | Aspen, birch, alder, goat willow | + | + | 3,40 | 1,39 | 25,0 | bcdef |
| 17 | Birch, alder | - | - | 3,57 | 1,41 | 26,0 | cdef |
| 22 | Alder | - | - | 3,60 | 1,45 | 27,0 | cdef |
| 6 | Ash, cherry, oak, hazel, elm, hornbeam, hawthorn, hackberry, lime, Norway maple, currant, apple, cranberrybush, birch (Artrik lund) | + | + | 3,72 | 1,65 | 28,0 | def |
| 23 | Oak, hybrid larch | - | - | 3,91 | 1,23 | 29,0 | ef |

[a] Mean values with a letter in common do not differ significantly (p=0,05).

In contrast to aesthetic value, calculated standard deviations and significance of differences between mean values indicate a high variability in individual judgments on ecological value (Table 10).

Type of species mixture had the most significant influence on the respondents' judgments of forest stands according to their ecological value. Monocultures were evaluated as having the lowest ecological value, while simple and complex mixtures were among the most valuable from the ecological point of view. Among the woody species, represented in the study stands, black alder was found to have the highest ecological value.

The results didn't show any clear relationship between ecological value and presence of deadwood and undergrowth (Figure 15).

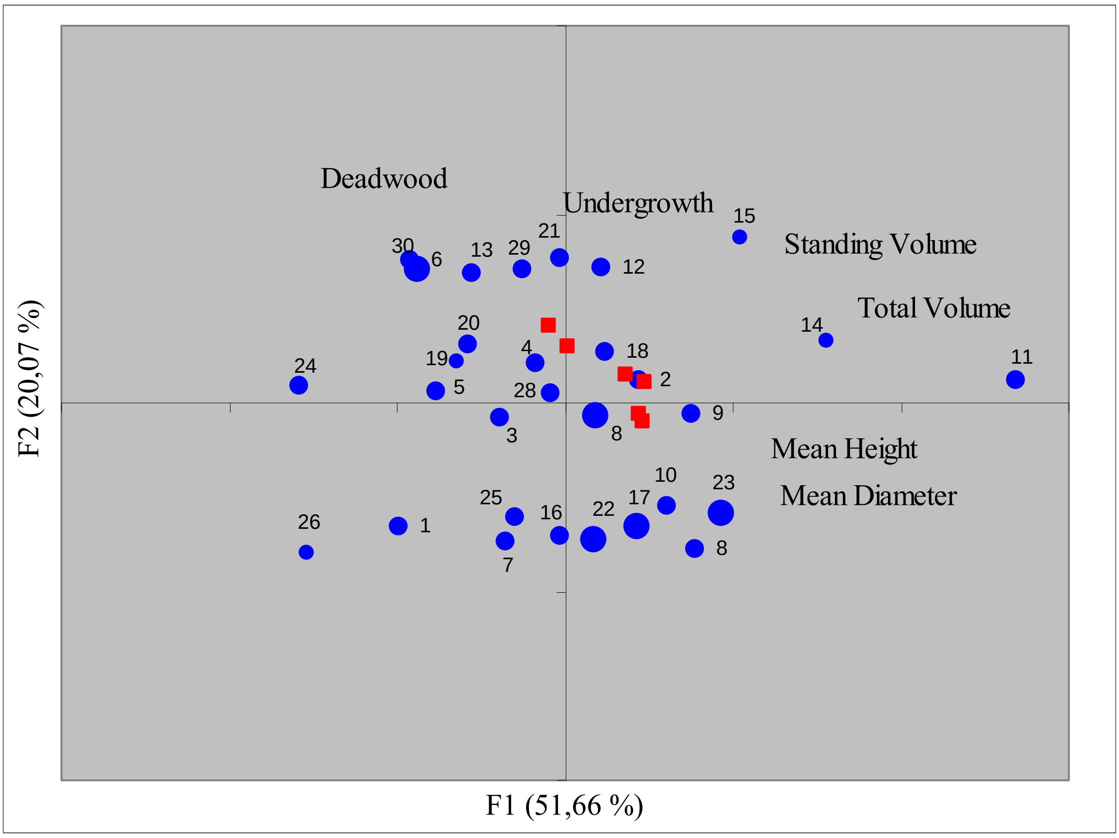


Figure 15. Factor scores and ecological value of the observed forest stands

*4.2.4. Comparison of judgments between and within different groups of respondents*

High correlation coefficients (>0,8) between different groups of respondents assessments of aesthetic value once again indicate the high level of the similarity of opinions between the respondents. On the other hand opinions on ecological value differed to a large extent between the groups. (Table 11).

Table 11. *Correlation between different categories of respondents assessments of forest stands according to their aesthetical and ecological values (Spearman's correlation coefficients)*

| Comparison | | Aesthetic value | Ecological value |
|---|---|---|---|
| **No** | **Description** | | |
| 1 | Group 1/ Group 2 | 0,884 | 0,319 |
| 2 | Group 2/ Group 3 | 0,866 | 0,344 |
| 3 | Group 3/ Group 1 | 0,844 | 0,066 |
| 4 | Males/ Females | 0,840 | 0,443 |

Spearman's correlation coefficients between judgments on aesthetic value and judgments on ecological value within each group of respondents were -0,259 for the Group 1, 0,340 for the Group 2, and 0,560 for the Group 3. As it was hypothesized the level of forestry education influences the correlation between aesthetic and ecological value.

## *5. DISCUSSION*

### 5.1. Impact of stand characteristics on the aesthetic value

#### *5.1.1. Size of trees*

The correlation analysis and principal component analysis both showed that the priority of forest stands increased with increasing mean tree height and mean diameter.

However, the correlations between tree size and aesthetic quality were quite weak within this study. The possible explanations are:

- the early stage of development of trees represented in the study forest stands, which resulted in a narrow range of height and diameter meanings;
- perceived forest landscape, as any other landscape, is more than the sum of its physical attributes, i.e. all the attributes of forest landscape interact with each other in different ways. Thus, it is hard to determine the impact of a single factor on the overall attitude towards the forest landscape.

#### *5.1.2. Standing volume and total volume*

Standing and total volumes had a negative relationship with overall scenic beauty and a negative impact on correlations between height/diameter and the aesthetic quality according to the partial correlation analysis. However, it should be considered that volume variables have a non-linear relationship with aesthetic beauty of forest on the stand level. Both small and great volumes have a negative impact on people's preferences.

Similar findings are presented in many studies (Gundersen & Frivold, 2008; Ribe, 1989; Silvennoinen, 2001). In the study by Silvennoinen (2001) the scenic beauty of forests was found to be positively correlated with mean height and volume of large trees, and negatively correlated with number trees per hectare.

#### *5.1.3. Presence of understorey and deadwood*

The results of the principal component analysis indicated that presence of understorey and deadwood in the forest had a strong negative impact on the scenic beauty. This is due to limited visibility and penetrability, which were among the most important attributes of aesthetically attractive forests according to the results of the inquiry in the Alnarp LL and eralire sitedstudies (Ode & Fry, 2002; Nielsen & Jensen, 2007).

In contrast to small woody debris, large logs didn't reduce the aesthetic quality of the forest stands considerably. Both aesthetics and ecology benefits from this finding, and is seen as a good way of combining the two values within one forest stand. Similar suggestions can be also found in Sheppard (2001) and Velarde et al. (2006).

### *5.1.4. Species and structural diversity*

Tree species composition didn't influence the respondents' judgments of forest stands to a large extent. However, preferences of broadleaves to conifers, and light stands to dark ones were clearly observed in the current study. Furthermore, monocultures with a row-wise structure were highly appreciated in both outdoor and photo assessments. Jensen & Skovsgaard (2009) got the similar results while investigating the preferences of Danes towards precommercial thinning practices in young oak stands.

Young dense hornbeam and beech stands with openings after felling of fast growing larch and hybrid aspen were judged as having a higher aesthetic value compared to hornbeam and beach monocultures of the same age. Thus, it is suggested that mixtures of species with different growing patterns may be beneficial not only from the silvicultural point of view, but from aesthetic point as well.

The above stated results suggest that in the young forests the impression of easy access is the major influential factor of public preferences. Thus, large amounts of deadwood, dense understorey, and high standing volume, all contribute to a negative attitude towards forest interiors, while row-wise structure and homogeneous ground cover are highly appreciated. Single tree characteristics are not of great importance at the early stage of development. However, they would probably become the main factors of the public perception further on.

## 5.2. Aesthetics vs. Ecology

There is a continuing discussion among scientists about whether human landscape preferences are based on immediate, affective perceptions of the landscapes or if landscape aesthetics is a cognitive, knowledge-based process. According to the last approach, which is recognized as ecological aesthetics among scientists, specific knowledge on forestry and ecology should have a great impact on individual landscape aesthetic preferences towards more ecologically sustainable landscapes (Gobster, 1996). However, some recent studies (Parsons & Daniel, 2002), as well as the current study disprove this hypothesis.

The results of this study showed that aesthetic preferences had a close link to emotion-related psychological responses and didn't have any relationship with specific knowledge. Both foresters and people unfamiliar with forest had very similar opinions on what type of forest is aesthetically attractive and what is not. This supports the theory that the aesthetic perception is genetically predetermined (Appleton, 1975; Ulrich et al., 1991, Kaplan, 1982).

Quite the contrary situation was with the judgments of forest sites according to their ecological value. In contrast to the aesthetic value, which comprises a high level of subjectivity and is related to emotional experience, the ecological value is an objective characteristic, and its assessment accuracy depends only on the knowledge of the assessor. Judgments between groups varied considerably, and it can be explained by different levels of education on forest ecology, and partially by difficulties in assessing the ecological value through the photographs. Interestingly, the stands including black alder got the highest scores. Probably, this is due to the species' ability to fix nitrogen in available form which results in rich ground vegetation and enhances the overall 'greenness' of the landscape.

Absence of relationship between the assessments of aesthetical value and ecological value within two groups of foresters one more time goes against the approach of ecological aesthetics. On the other hand, there was a positive correlation between the two individual assessments in the group representing the general Ukrainian population. In this case, scenic beauty of forest sites seemed to influence people's judgments on its ecological value. However, because of the small number of respondents from the general population, this result is unreliable so far and should be investigated further on.

The variability of results from the field inquiry in the Alnarp LL was high. This probably happened due to the small number of respondents (n=14) and the high level of cultural diversity among the respondents. Even though the results of correlation analysis were quite significant. The results showed that the image of recreational forest differed to a great extent from the image of forest in general. The respondents were able to recognize more valuable stands from an ecological point of view, i.e. those which comprised a relatively high level of species and structural diversity, and looked more naturally. However, such forest interiors were disliked by the respondents, and they didn't wish to set up their recreational activities there. Insteatd cleaned-up stands with good visibility and ease of movement were found to be the most attractive. Again, the respondents' knowledge on ecology didn't contribute to the higher appreciation of natural-looking forests and its attributes like understorey and deadwood, from the aesthetic point of view.

To avoid misunderstandings, it should be pointed out that knowledge on ecosystem management and forestry practices definitely affect public perception of forest's appearance. However, if people percept forest with too dense understorey, or clear-cut, it means they understand that 'It should look like this' (as this position is supported by some logical explanation), but it doesn't necessarily mean 'I enjoy it'.

The main suggestion for forest managers is that it is very hard to maintain both high aesthetic and ecological value within one forest stand, and an appropriate practice would be to compensate the lack of aesthetic/ecological value in one stand by its prevalence in another.

### 5.3. Shortcomings of the study

The major shortcoming of this study is the small number of the respondents in the surveys (and the the low response frequency). Due to this, the results on correlation analysis show only general trends in relationships between people's preferences and physical attributes of forest, however, correlation coefficients are not reliable in their absolute meanings and can not be used for simulating public preferences in further research.

Although photo assessment method was found to be reliable by many researches (Karjalainen, 2006), it comprises some disadvantages as well. First of all, on the photographs forest is perceived as static environment, while in real it is dynamic and its perception involves all senses. Second, the sense of scale, which is important factor of landscape perception according to Ode & Fry (2002), is almost absent on the photographs. And the last point is that the similarity of young forest stands on the photographs is even higher than in the real. This is due to low distinctiveness of many tree species in the young age (at least for the general public). Spatial structure is also badly seen on the photographs because of small tree sizes.

It should be also kept in mind that the variables which were used in the analysis do not fully represent the situation in the forest. Regardless of their importance, grounds cover vegetation as well as number trees per hectare were not included in the analysis.

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## *APPENDIX 1.* Questionnaire on forest aesthetics (Alnarp LL)

*In the following seven questions you should give a rate from 1 to 10, where 1 is the lowest and 10 is highest.*

1. Do you consider this to be a forest?

2. Does this stand fit your view of a recreational forest?

3. How attractive (from the aesthetical point of view) do you find this stand?

4. How diverse (from the biological point of view) do you find this stand?

5. How «natural» do you find the stand?

6. Rate the visibility of the stand?

7. Rate the passability of the stand?

*In the next questions you will need to express your opinion in your own word. Please try to give a full answer.*

8. What is your general impression of this stand?

9.How much time would you prefer to spend in this stand?

10. Please name the most unpleasant and most pleasant features of this stand?

11. What kind of psychological effects does this stand have on you?

12. Do you prefer this stand to previous stand (from the recreational point of view)?

*APPENDIX 2*. **Photographs of forest stands (Snogeholm LL)**

1. Hornbeam

2. Hornbeam, hybrid larch

3. Beech, birch

4. Beech, alder

5. Oak, maple

6. Ash, cherry, oak, hazel, elm, hornbeam, hackberry, lime, cranberrybush, birch (Artrik lund)

7. Cherry, alder

8. Cherry, birch

9. Beech, hybrid aspen

10. Cherry, hybrid larch

11. Hybrid aspen

12. Aspen, birch, alder, goat willow

13. Scots pine, beech, hazel

14. Hybrid larch

15. Pine

16. Birch

17. Birch, alder

18. Lime, birch

19. Oak

20. Lime, oak

21. Beech, spruce

22. Alder

23. Oak, hybrid larch

24. Oak, ash

25. Oak, aspen

26. Cherry, ash

27. Alder, lime, hackberry, rowan

28. Spruce, oak, hornbeam, hazel, birch, lime (“Bubbetorpmodellen”)

29. Spruce, oak, hornbeam, hazel, birch, lime, ash, beech (“Sillesasmodellen”)

30. Beech, oak, lime