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SUSTAINABLE FOREST MANAGEMENT

ECOLOGICALLY SOUND AND SOCIALLY ACCEPTED

Kati Vierikko

ACADEMIC DISSERTATION

To be presented, with permission of the Faculty of Biological and Environmental Sciences of the University of Helsinki, for public criticism in the lecture hall 2 of Viikki Information Centre (Viikinkaari 11) on April 16th at 12 o'clock noon.

Helsinki 2010

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ISBN 978-952-92-6925-9 (paperback)
ISBN 978-952-10-6106-6 (PDF)

Yliopistopaino
Helsinki 2010

This doctoral thesis is based on the following articles, which will be referred to by the Roman numerals I-IV.

I. Vierikko, K., Pellikka, J., Hanski, I. K., Myllyviita, T., Niemelä, J., Vehkamäki, S. and Lindén, H., 2010. Indicators of sustainable forestry: The association between wildlife species and forest structure in Finland. Ecological Indicators 10, 361-369.

II. Vierikko, K., Vehkamäki, S., Niemelä, J., Pellikka, J., Lindén, H., 2008. Meeting ecological, social and economic needs of sustainable forest management at the regional scale. Scandinavian Journal of Forest Research 23, 431-444.

III. Vierikko, K. and Kohl, J., 2009. Improving the ecologically sustainable forest management behaviour – Qualitative frame analyses for argumentation. Annals of Forest Research 52(1), 169-182.

IV. Vierikko, K. and Niemelä, J., 2010. Sustaining biodiversity in commercially managed forests in Finland – putting theory into the practice, 15 pp. (manuscript).

CONTRIBUTIONS

I. Vierikko took the initiative and the paper was jointly planned with the co-authors based on our earlier common research results. Dr Jani Pellikka provided wildlife richness data and Dr Ilpo K. Hanski provided flying squirrel data. Vierikko was responsible for the statistical analysis and writing of most of the paper, particularly the discussion section.

II. The paper was jointly planned with the co-authors based on our earlier published paper in Finnish. Dr Jani Pellikka provided wildlife richness data and Dr Seppo Vehkamäki provided social and economic data, and he was responsible for statistical analysis. Vierikko was responsible for designing the study, and for the introduction, discussion and conclusion sections of the paper.

III. Kati Vierikko prepared the paper together with Dr Johanna Kohl. Vierikko took the initiative, provided linguistic data for analyses and chose the methodological approach. The paper was jointly written, and the co-author was jointly responsible for the theoretical discussion and conclusions.

IV. The paper was written together with Professor Jari Niemelä. Vierikko took the initiative, collected the material, and was responsible for writing most of the paper.

CONTENTS

ABSTRACT

This dissertation explored the ecological dimension of ecologically sustainable forest management in boreal forests, and factors of the socio-cultural dimension that affect how the concept of ecologically sustainable forest management is defined. My approach was problem-oriented and generalistic-holistic.

I examined associations between the abundances of wildlife groups (grouse, large predators, small predators, ungulates) and Siberian flying squirrels, and their co-occurrence with tree structural characteristics at the regional level. The trade-offs between ecological, social and economic sustainability in forestry were explored at the regional scale.

I identified a potential 'shopping basket' of regional indicators for ecologically sustainable forest management, combining the relative abundance of Siberian flying squirrels, a wildlife richness index (WRI) for grouse, diversity indices of saw-timber trees, tree age classes and the proportion of old-growth (> 120 yr) forests. I suggest that the close association between forestry activity, the proportion of young forests (< 40 yr) and a WRI for small predators can be considered as potential 'alarm bells' for regions in which the creation of trade-offs (negative relationships) between economic and ecological components of sustainable forestry is ongoing.

Explorative analyses revealed negative relationships between forestry activity and a WRI of 16 game species, the WRI for grouse and tree age diversity. Socially sustainable communities compete less intensively with ecological components of forests than communities where forestry is important. Interestingly, forest ownership types (farmers, other private forest owners, the forestry industry, the State) correlated significantly with the co-occurrence of flying squirrels, grouse and diverse forest structural characteristics rather than, for instance, with the total number of protection areas, suggesting that private forest ownership can lead to increased ecological sustainability.

I examined forest actors' argumentation to identify characteristics (active forest owning, high working moral, taking responsibility) that affect the interpretation of ecologically sustainable forest management. Frame analyses were performed to identify possible argumentation groups. Four argumentation frame types were constructed: information, work, experience and own position based. These differed in terms of their emphasis on external experts or own experiences. Based on the results obtained, I suggested the most suitable policy instruments adapted to the frame types. The closer ecologically sustainable forest management is to the forest actor's daily life, the more profiled policy tools (counselling, learning through experiences) are needed to guide management behaviour to become more ecologically sound. I illustrated that forest actors interpret, use and understand information through meaningful framing.

I analysed the extent to which ecological research information has been perceived in the Forestry Development Centre TAPIO's recommendations and revised PEFC Finland criteria. It was noted that biodiversity management has been supported, although to a much lower extent that had been suggested by scientists. For example, we noticed that the political value for decaying wood was much lower in PEFC Finland criteria (4 m^3) than could be expected as a socially acceptable level (9 m^3) or ecologically sound (10-20 m^3). I encourage researchers in ecology and society to participate more in the development of the certification system. I consider it important for scientists to join political discourses and become involved in policy making concerning sustainable forest management. By facing the end-users of knowledge in two-directional communication, scientists are more likely to learn to present their results in a way that is reasonable from the user's perspective.

Key words: ecological dimension, forest actor, frame analysis, indicator, policy tool, Siberian flying squirrel, socio-cultural dimension, sustainable forest management, trade-offs, WRI.

To my family

‘Forests are a living dance,
a four-dimensional art form with a variety of rhythm involved.
Do we have the skills to join the dance?’
- Fred L. Bunnell 1998

1. INTRODUCTION

1.1. EXPERIENCED AND MEASURED FORESTS IN FINLAND

When landing at Helsinki-Vantaa or virtually any other airport in Finland, one immediately notices that the Finnish landscape is dominated by forests. However, although the forest landscape is fragmented by human activities (e.g., clear-cuts, roads and other infrastructure), it still looks extremely forested. One might think that Finnish forests have been well managed, and one may be satisfied with the idea that there are enough forests for wood production, protection or recreation. At the same time, one can read news about new conflicts between those in favour of intensive forestry and those concerned with forest protection in Eastern-Northern Finland, and wonder will they ever stop. Another observer sitting on the airplane looking at the forest landscape may notice isolated forest fragments, and wonder whether forest species can survive in this landscape shaped by human-caused disturbances. Yet another may remember reading that a third of the threatened species in Finland live in forests. Each observer on the airplane would probably have his or her own interpretation of the forest scenery. Alongside the socially constructed reality, or tacit knowledge of the forest condition, there are also numerical and measurable facts, explicit knowledge of Finnish forests (Polanyi, 1966; Berger and Luckman, 1994; Hajer, 1995; Hannigan, 1995; Burningham and Cooper, 1999).

Altogether, 75% of the Finnish land surface is covered by forests[1]. The natural (excluding human constructions) forest landscape is characterized by a mixture of closed-canopy forests and semi-open and open mires. Most of Finland and the Fennoscandian region belongs to the boreal coniferous vegetation zone, characterized by a short growing season (Ahti et al., 1968). Finland extends 1 100 km from south to north, and growing conditions differ considerably between the northern and southern parts of the country. The dominant coniferous tree species are Norway spruce (*Picea abies* (L.) H. Karts.) and Scots pine (*Pinus sylvestris* L.) (Esseen et al., 1997).

There are about 900 000 private non-industrial forest owners in Finland (population ca. 5 million), and 60% of productive forest land is owned by them (Finnish Forest Research Institute, 2008). The southern part of the country differs

1 Forests, in this context, are determined by FAO criteria. They comprise productive forest land, where the site productivity is equal to or greater than 1 m^3 per year, and low productive forest land (0.1 - 1 m^3). The latter includes wooded mires. There are ca. 22.9 million hectares of forests in Finland (Ministry of Agriculture and Forestry, 2000; Finnish Forest Research Institute, 2008).

in its forest-owning structure (73% private non-industrial owners). In addition, most of the forests are commercially managed, and the proportion of strictly protected forest land[2] is much lower in the south (2%) than in the north (16%) (Finnish Forest Research Institute, 2008). Approximately 86 000 people worked in the forest sector in 2008, representing 3.5% of the nation's employees (Finnish Forest Research Institute, 2008), and at least 300 scientists are involved in forest-related research in Finland (Hanski et al., 2006). It is estimated that Finns spend over 200 000 person-years[3] annually taking part in outdoor activities (recreation, hunting, collecting) in forests (Vaara and Saastamoinen, 2006). In other words, forests are a significant part of Finnish society that provides economic income, social welfare, and cultural and emotional experiences for its citizens.

1.2. THE PARADIGM OF SUSTAINABLE FOREST MANAGEMENT IN FINLAND

Sustainable forest management (SFM) i.e. sustainable forestry has a long tradition in Finland and in Europe (Palo, 1993; Vehkamäki, 2006). The concept of sustainable forest management has changed over time, and attaching multiple values to forests is a recent trend in forest use (Kangas, 2001). The principle of sustainable forest management emerged during the 18th century in Germany, when the mining industry consumed enormous amounts of wood. J. L. Carlowitz developed the idea of the sustainable use of forests to sustain timber production for future generations (Vehkamäki, 2006). The traditional sustainable forestry, also referred as sustainable yield management, was introduced to Finnish forestry early in the 20th century to safeguard a continuous timber supply (Sample et al., 1993, p. 4; Vehkamäki, 2006).

The modern paradigm of SFM encompasses ecological (environmental), economic and socio-cultural components of management, and was launched in the 'Forest Principles' adopted by the UN Conference on Environment and Development in Rio de Janeiro in 1992 (Kaila and Salpakivi-Salomaa, 2004). *Ecologically sustainable forest management* (ESFM) refers to maintaining forest biodiversity and the ecological capacity of forests, i.e. sustaining the long-term functionality and resiliency of forest ecosystem (e.g. Lindermayer and Franklin, 1997; Frelich and Puettmann, 1999; Svensson et al., 2002; Sverdrup and Svensson, 2002; Wang, 2004).

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2 The term includes both productive and low productive forest land.

3 The regular annual working time of one person, i.e. hours that one person on average works during one year. The average working week is ca. 37.5 hours in Finland, and the average collectively agreed weekly working time in the European Union in 2007 was 38.6 hours (Eurofound, 2008; Statistics Finland, 2009).

Looking back on the short history of Finnish forestry, it can be said that in ten years sustainable forest use has faced an '*ecological revolution'*. Finnish forest politics[4], forest legislation and policy tools4 have undergone 'ecological changes' since the first Forest Principles for SFM adopted (Jokinen, 2001, p. 168; Viitala, 2003a). During the 1990s, national conservation programmes for old-growth forests were conducted to increase the number of strictly and permanently conserved forest areas in Finland (Environmental Administration, 2009). The importance of maintaining biological diversity in commercially managed forest, i.e. the idea of biodiversity management,[5] was incorporated into the forest policy programmes, and also into Finnish legislation (Ministry of Agriculture and Forestry, 1994; Ministry of Agriculture and Forestry, 1999; Finnish Forest Act 1093/1996, Nature Conservation Act 1096/1996).

The first national criteria and indicators for sustainable forest management were established, and these included 26 indicators considering ecological aspects. These criteria were based on the Pan-European Criteria and Indicators for SFM of the Helsinki Resolution (Ministry of Agriculture and Forestry, 1997). Biodiversity management was also included in forest management recommendations for privately owned and state-owned forests (Viitala, 2003a, p. 65-88). The forest certification system was developed for commercially managed forests for the first time during 1996-1999, and the principles of biodiversity management were included in Finnish forest certification systems (FFCS) (Ministry of Agriculture and Forestry, 2000; Viitala, 2003b; Nieminen, 2006). The FFCS has been acknowledged by the PEFC system since 2000 (Ministry of Agriculture and Forestry, 2000).

1.3. ECOLOGICAL SUSTAINABILITY IN FINNISH FORESTS

Moving to a new millennium, everything seemed to be in order in the biodiversity management of Finnish forests, at least in the light of Finnish legislation and the national scale forest and conservation statistics. Today, the principle of equal weight given to the three sustainability elements, i.e. economic, ecological and social elements, has been strongly expressed in the National Forest Programme 2015 (Ministry of Agriculture and Forestry, 1999; 2008). According to the Finnish Forest Act (1093/1996), forests need to be managed in an ecologically, economically and socially sustainable way so that they provide a sustainable yield while their biological diversity is concurrently maintained. In addition, Finland has duties to maintain biological diversity and halt the declining trend in biodiversity (Ministry of the Environment, 2007).

4 See definition in Box 1.

5 See definition in Box 1.

The total number of forests has remained quite constant, and the amount of forest land is not decreasing as might be expected in Central and Southern Europe due to competing land uses such as urbanisation and agriculture (Finnish Forest Research Institute, 2008; Finnish Environment Institute, 2009). In addition, Finland is not struggling with internationally challenging problems such as deforestation and illegal cuttings (Ministry of Agriculture and Forestry, 2000, 2007). Almost 95% of commercially managed forests are certified under the Finnish Forest Certification system (FFCS) endorsed by the PEFC Standards (Anonymous, 2005). The forestry statistics[6] are of high quality, thanks to national forest inventories that have been carried out systematically since the 1920s (Tomppo, 1996). In addition, there are about 60 ongoing biodiversity monitoring programmes in Finland, with an emphasis on the monitoring of species and species groups (Finnish Environment Institute, 2009). Most of them are targeted inventories of threatened species. The proportion of the total land area covered by strictly protected forests is about four times higher than the European average (Environmental Administration, 2009). However, most of the strictly protected areas are concentrated in Northern Finland (Finnish Forest Research Institute, 2008).

1.4. CHALLENGES OF ECOLOGICALLY SUSTAINABLE FOREST MANAGEMENT

Despite the conservation efforts at the national scale and the implementation of new biodiversity management practices into forestry, there is great concern that intensive, industrial forest management, which was widely introduced to Finland in the 1960s, has caused and is still causing a drastic decline in biological diversity, especially in the boreal forest of Southern Finland (e.g. Hanski, 2000; Rassi et al., 2001; Kuuluvainen, 2002). According to the fourth national report to the Convention on Biological Diversity (CBD), biological diversity[7] in forests is still decreasing (Ministry of the Environment, 2009, p. 17). Forest actors[8] taking part in political discourse over the sustainability of forests seem to disagree about whether they are managed in an ecologically sustainable way (Vierikko and Niemelä, 2006). At the national scale, this continuous debate between different forest actor groups can be defined as an intractable dispute (Putnam and Wondolleck, 2003). Forest-related

6 Forestry statistics refer to data that are collected and produced to support sustainable forest management. They include statistics on timber growth and timber removals, which are provided annually by the Finnish Forest Research Institute.

7 Biological diversity is based on indicators that are red-listed forest species, directive forest species, threatened forest habitat types and directive forest habitats (Ministry of the Environment, 2009).

8 See definition in Box 1.

disputes and conflicts have been very common in Finland during the last decades (Vierikko and Niemelä, 2006).

Could we find the solution to conflicting policies and contradictory decision-making situations concerning biodiversity management in commercial forests by increasing ecological research? There have been three national-scale research programmes that have improved our knowledge of Fennoscandian forest biodiversity and disseminated the information to policy makers[8] and decision makers[8] (Markkanen et al., 2002; Horne et al., 2006; Juslén et al., 2008). A major part of the ecological research information[8] concerning the biological diversity of old-growth forests, commercially managed forest and the natural disturbance dynamics of Fennoscandian boreal forests has been produced in the last fifteen years (Kuuluvainen et al., 2004a). Furthermore, many authors have stated that the key factors affecting boreal forest biodiversity are already well documented (see Esseen et al., 1997; Kuuluvainen et al., 2004b; Jalonen et al., 2006). Biologists and forest ecologists have argued that ecologically sustainable forest management should be based on up-to-date scientific information to formulate adaptive forest management practices (e.g. Hansson, 2001; Kuuluvainen et al., 2004a; Hilden, 2005).Despite the fact that information from ecological research has increased, forest actors seem to disagree over which management practices are ecologically sound. With this background, I was not only interested in studying how we can quantify, measure and empirically study ecologically sustainable forest management, but also about what happens to ecological research information in political discourse[9] and decision-making situations. Therefore, I also wanted to examine how ecological sustainability has been interpreted by forest actors, and how research information has been used in policy processes[10] in Finnish society.

9 See definition in Box 1, and in Figure 1.

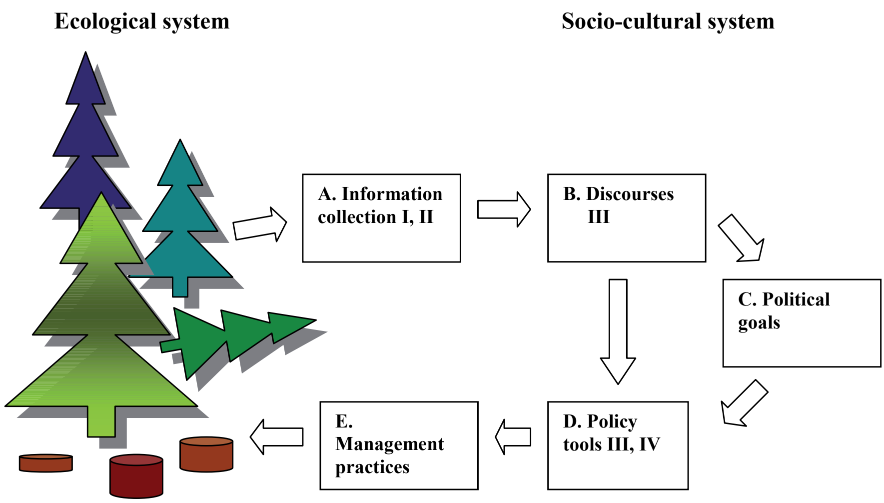
10 See definition in Box 1.

2. THE STUDY FRAMEWORK AND STUDY OBJECTIVES

Sustainable forest management or sustainable forestry concerns ecological issues, e.g. the survival of forest-dwelling species, ecological processes and the resiliency of ecosystem function, but these can also be identified as 'socially constructed phenomena'. Due to the dualistic dimension of the concept of sustainable forest management, I decided to study the subject from the generalist-holistic approach, which aims to understand the 'study problem' from different perspectives and allows a scientist to use methods and analyses from several disciplines (Willamo, 2005; p. 37-38). To illustrate the content of my thesis, and how the papers are linked to the study subject, I present a dualistic model, i.e. a study framework for sustainable forest management, in Figure 1.

I have defined five characters that form the basic framework for my dissertation: A) knowledge and information about forests; B) discourses and debates over forest use; C) goals and purposes of forest politics; D) policy tools to control management, and finally E) sustainable management practises that are directly connected to forest ecosystems (adapted from Jasonoff and Wynne, 1998). The study framework (Fig. 1) is a simplified model of the real world, in which characters are consistently connected to the surrounding physical and social world. In addition, the characters (A-E) refer to the structure of my thesis.

Figure 1. The study framework of my thesis and papers (I-IV) and linkages to the domain characters of sustainable forest management (A-E). The model is a simplified presentation of the real world, and does not illustrate connections to the surrounding socio-cultural and physical world.



In my framework sustainable forest management includes both socio-cultural11 and ecological dimensions (see Haila 2001; Willamo, 2005). The ecological system in Figure 1 represents the nature of forest ecosystems that is determined by biological, physical and chemical factors (see Willamo, 2005, p. 12). Internal forest ecosystem dynamics are affected by abiotic and biotic factors, and can be affected by external factors such as human-caused disturbances resulting from forest management (Fig. 1). The first two papers focused on measuring and quantifying biological diversity, e.g. species abundance and the structural characters of the ecological system.

To interpret and understand the concept of 'sustainable forest management', a social actor[11] needs to gather information from the ecological system (Haila, 2001). One can obtain information about forests directly by 1) systematic monitoring of certain components of the forests, 2) empirical observations for research purposes, and 3) experience-based observation. Systematic monitoring can be divided into large-scale biodiversity or natural resources monitoring, or small-scale specific monitoring of threatened species or habitats (Finnish Environment, 2009). Indirect information has been produced by several actors, e.g., institutional, political and scientific actors, or the media (Janse, 2006). A number of papers have considered sustainable forest management from ecological, economic and social perspectives (e.g. Sverdrup and Stjernquist, 2002; Burton et al., 2003; Jalonen et al., 2006; Reynolds et al., 2007). In the first and the second papers (I, II) I use statistical data that are mainly based on large-scale systematic monitoring.

Besides the empirical and systematic monitoring of components of ecological systems, information about forests is continuously being collected through individual experiences (Leskinen et al., 2008). Environmental experience is formed when an individual observes the environment and creates images based on these observations (Tyrväinen et al., 2005). Experiencing the environment is mainly based on visual observations, but other senses, especially sounds, are also important (Hauru, 2008). My third paper (III) concerns whether experiences have a focal impact when a forest actor12 interprets ecologically sustainable forest management.

Discourse represents diverse places for two-directional communication[12] in which both or all social actors in theory have an equal possibility to discourse (Fig. 1). Discourse in my study framework refers to a socio-cultural agenda, i.e. a place where scientific knowledge meets other knowledge, such as local, traditional and cultural knowledge and experiences (Shannon et al., 2007). This is the place where (dis)agreements have emerged among and between different social actors (environmentalists, decision makers, policy makers, scientists, workers). The place of discourses resembles Kohl's (2008) definition of 'agora', the place where environmental experts communicate and meet. The place of discourses can be

11 See definition in Box 1.

12 See definition in Box 1.

seen as analogous to the policy cultural model (see Jasanoff and Wynne, 1998), in which four different policy cultures interact: academic with science, civic with values, bureaucratic with norms and rules, and finally economic with cost-benefits. My third paper (III) aims to understand the different meanings given to ecologically sustainable forest management by forest actors who are participating in discourses.

Political goals[13] represent shared values of Finnish society that have been considered important to achieve (Fig. 1). I considered National Forest Programmes as representing forest political goals. Policy tools such as criteria, legislation and recommendations put political goals into practice, and regulate the management behaviour of social actors. Management practices refer to the actual world of SFM, in which a social actor becomes another disturbance factor in the ecological system (Kuuluvainen, 2002). In the third paper (III), I consider how policy tools can be used in regulating the management behaviour of forest actors to become more ecologically sound. The fourth paper (IV) compares science-based recommendations with soft law[13] policy tools, to detect the extent to which ecological research information has been applied in policy processes[13].

My dissertation, entitled *Sustainable forest management - ecologically sound and socially accepted*, does not aim to explain or identify the possible causalities between the entities of socio-cultural or ecological systems of the framework; rather, this dissertation examines sustainable forest management in the broader context. By using a generalistic-holistic research approach, my intention is to provide new insights for policy makers, decision makers and scientists to rethink the relationship between science, politics, policy and action. More specifically, my dissertation aims to address the following study objectives:

- To identify potential indicators of ecological sustainability by studying associations between wildlife species and forest structural and additional socio-economic characteristics at the regional scale;

- To investigate the relationships between ecological, social and economic components of sustainable forest management by exploring trade-offs between sustainability components at the regional scale;

- To study the usefulness and acceptability of systematically monitored biodiversity data produced by administrations and research institutions;

- To examine how forest actors who are participating in discourses on sustainable forest management define and give meaning[13] to the concept of sustainable forest management;

13 See definition in Box 1.

- To analyze the argumentation of forest actors in order to identify social characteristics that could determine management behaviour towards ecologically sustainable forest management and allow appropriate policy tools to be set;

- To analyze whether science-base implications have been transferred into forest management practices.

3. MATERIAL AND METHODS

3.1. THE STUDY AREA AND MATERIALS

The study area consisted of 39 or 41 observation units, i.e. LAU-1 (Local Administrative Units 1), ranging in size between 86 000 - 793 200 ha, and located in central Finland (I, II). The advantages of LAU-1 units, also known as regional municipality complexes, is that they are commonly used in recording the economic and social phenomena of regional communities. Additionally, this scale was sufficiently robust to detect relative changes in the richness and abundances of wildlife populations (I). Biogeographically, the study area was located in the southern and middle boreal vegetation zones (Ahti et al., 1968).

The primary data were provided by several administrations and research institutions. A summary of all the used data is presented in Table 2. National Forest Inventories and wildlife species triangle monitoring are examples of large-scale systematic sampling that have been controlled by authorities and have well-defined sampling criteria (Lindén, 1996; Tomppo et al., 1999). The former has been conducted by employed forest experts and uses high technology such as satellite images, while the latter is based on the voluntary work of hunters who have recorded the snow tracks of 30 game animals or made observations of grouse species in the autumn (Tomppo et al., 1999; Pellikka, 2005). The use of volunteers to collect data for conservation projects has been common, and their data can be as valid as that collected by experts (Bell et al., 2008; Lovell et al., 2009). In Finland, the voluntary-based collection of data on forest-dwelling species such as invertebrates has been common among amateur experts, and ca. 70% of biodiversity monitoring has been carried out by volunteers (Juslén et al., 2008, p. 26; Ministry of the Environment, 2008a, p.11). More detailed information on data collection and production can be found in papers I and II, and in the Master’s thesis of Myllyviita (2008).

Table 1. Primary statistical data and determined variables that were used in the papers (I, II, Myllyviita, 2008).

Data	Variable	Indicator	Source	Papers
Relative abundance of the Siberian flying squirrel	Proportion of occupied plots per observation unit	Ecological	The Finnish National History Museum	I
Relative abundance of 16 game animals	Logaritimic value Wildlife richness index for 16 game animals	Ecological	Finnish Game and Fisheries Research Institute (FGRI)	I, II
Relative abundance of five game animal groups	Logaritimic value Wildlife richness index for ungulates, grouse, large predators small predators, and other game animals	Ecological	Finnish Game and Fisheries Research Institute (FGRI)	I, II
Tree and forestry land data	Shannon diversity index for Tree-age classes, tree species, and saw-timber tree species	Ecological	Finnish Forest Research Institute National Forest Inventory NFI 8th and 9th	I, II
	Percentage of saw-timber trees, productive forest land, old-growth forests (>120 y), young forests (< 40 y)	Ecological		I
Protected areas in forestry land	Conservation areas as a proportion of forestry land	Land use	Finnish Environment Institute	I
	Area of old-growth forest reserves as a proportion of forestry land	Land use		I
Agricultural land	Proportion of taxation derived from agricultural land	Land use	Tax authorities	II
Agricultural activity	Gross regional production of agriculture in 2005	Social	Statistics Finland	I
Number of inhabitants	Number of inhabitants in 2005	Social	Statistics Finland	I, II
	Changes in the number of inhabitants during 1995-2001	Social	Statistics Finland	II
Forest ownership groups	Proportion of forestry land owned by farmers, other NIPF, the forest industry and the State	Social	Tax authorities	I
Industry and Service activity	Proportion of total gross value added derived from industry and services	Economic	Statistics Finland	I, II
Forestry production	Gross value of forestry per unit area of forestry land	Economic	Statistics Finland	I, II
Forestry activity	Timber purchases (m^3) of members of the FFIF per unit area of forestry land	Economic	Finnish Forest Industries Federation (FFIF)	II

3.2. STATISTICAL ANALYSIS

The considerations of the realism and constructivism paradigms presented below (3.4) are connected to papers I and II. It was assumed that relationships exist between the studied variables, but due to spatial and temporal inconsistencies in the statistical data, the causalities were not tested. In the first two papers the methodological approach was explorative, and multivariate analyses were used to explore associations in the statistical data.

In the first paper we explored associations between forest-dwelling species and forest structural data to describe regional differences in the 'ecological conditions' of sustainable forestry (I). To interpret the results from the multivariate analysis of biological as well as tree structural variables (Table 1), we needed to define *a priori* potential indicators for ecologically sustainable forest management. Based on earlier studies, we selected the following variables as candidate indicators: 1) a wildlife richness index (WRI) for four grouse species (capercaillie (*Tetrao urogallus*), black grouse (*Tetrao tetrix*), hazel grouse (*Bonasa bonasia*) and willow grouse (*Lagopus lagopus*)), and 2) the relative abundance of Siberian flying squirrels. A high abundance of these species has been shown to positively correlate with the species diversity of other taxa, at least in some study cases (Pakkala et al., 2003; Similä et al., 2006; Hurme et al., 2008). We examined the association of biological variables with structural variables that were also considered as potential indicators of ecologically sustainable forestry: 1) the proportion of old-growth forests (< 120 y) and 2) a diversity index of saw-timber tree species (I, Table 1).

In the second paper, we explored the interrelationships and possible trade-offs among ecological, economic and social components of sustainable forestry at the regional scale (LAU-1). We assumed that a high WRI for grouse, a high diversity index for four tree species, and tree age-class diversity[14] would be candidates as indicators of ecological sustainability. Five economic, social and land-use variables were chosen as indicators of economic and social sustainability (see Table 1). We used two different data sets in the factor analyses: data on the mean values of variables, and longitudinal variables from yearly observations collected from 1995-2001 (II).

In using explorative statistical analysis instead of statistical modelling, our aim was to highlight associations between variables and define a suitable 'shopping basket' for regional-scale indicator assessment (I). Multivariate analyses could be useful for pointing out regional (municipality complex) loadings, with variables indicating either good ecological conditions or increased competition between economics and ecology (I,II). However, the analysis does not reveal causal relationships between variables. We performed experimental modelling on causalities between variables

14 The calculation of a diversity index for nine tree-age classes was based on the idea that an equal proportion of different age classes would provide suitable habitats for forest-dwelling species, and would indicate a relatively high proportion of commercially over-mature forests (age classes: 100-120, 120-140, >140 y).

used in papers I and II, and found it relatively unsatisfactory (Vehkamäki et al., 2006; Vehkamäki et al., 2008).

3.3. ANALYSIS OF INTERVIEW DATA

Papers III and IV in this thesis represent the constructivism paradigm, and my methodological approach to the study problem could be anchored to environmental sociology, where the concept 'nature' or 'environmental problems' is seen as socially and culturally constructed (Eder, 1993; Hannigan, 1995). In the third paper, I carried out semi-structured, thematic interviews to examine the argumentation of forest actors and to explore the study objectives (Silverman, 1993; Flick, 2002). The interviews were schematized into three parts (theory, policy, practice) and followed up with an interview protocol, which formed a basis for the questions asked during the interviews. Knowledge-, value- and opinion-based questions were included, allowing the interviewees to express their own perspectives. The original language of the linguistic data was Finnish.

The primary data included 20 face-to-face interviews with forest actors, four of whom were female. The interviewees were categorized according to their relation to forests, and the same person could represent several forest actor groups (Table 2). The analytical approach was based on frame analysis (Goffman, 1974). Elements from the 'grounded approach' were used to classify the data, because different frame types were allowed to emerge from the interview data without any theoretical expectation (Glaser and Strauss, 1967). Further details of the analysis are presented in paper III.

Table 2. The forest ownership, working position, interests and scientific position of 20 interviewees. The interviewees are coded according to their interview order (H01-H20), sex (F = female; M = male), age (1 = less than 35; 2 = 36-45; 3 = 46-55; 4 = 56-65), education (MM = forestry sciences; FM = natural sciences; MI = forestry engineering; MT = forestry worker; MU = other), active working years (a = 1-5 y; b = 6-10 y; c = 11-20 y; d = 21-40 y) and forest ownership (yes = *, no forest = no sign).

Code	Ownership	Position/interest	Scientific position
H01M2MTc*	forest owner		
H02F1MIa*	forest owner		
H03M3MId*	forest owner		
H04M2MMc			
H05F1MIa			
H06M2FMc		conservationist	
H07M4MTd*	forest owner		
H08M3MUc*	forest owner		researcher in the forest institute
H09M3MMc		officer in the administration	
H10M3FMd		conservationist	
H11F4MMd		officer in the administration	
H12M2MIc*	forest owner		
H13F2MU			
H14M3MMc			
H15M3MMd*	forest owner		university researcher
H16M2MMb		conservationist	
H17M2MU*	forest owner	member of Suomen Partiolaiset*’	
H18M1FMa		member of Suomen latu**	
H19M3MMd		tenure in MTK***	
H20M4FMd			researcher in the environment institute
H21F1FMa		conservationist	university researcher

Note *’ The Guides and Scouts of Finland
** Organization for outdoor hobbies and recreation activities
*** Central Union of Agricultural Producers and Forest Owners

In the fourth paper we were interested in assessing the extent to which current ecological research information has been used in the forest management recommendations of the Forestry Development Center TAPIO and in the criteria of Finnish Forest Certification System (FFCS). Because these two instruments were both developed by a working group including different stakeholders, and they are commonly used in commercially managed forests, I considered them to be focal documents when interpreting practical application of sustainable forest management in Finland. We surveyed science-based recommendations particularly concerning coarse woody debris (CWD), because decaying wood has been regarded as one key element in northern boreal forest ecosystems (Esseen et al., 1997).

We compared the science-based recommendations with TAPIO's current forest management recommendations and the revised Finnish Forest Certification (FFCS) criteria, which are referred to in the text as Finnish PEFC (IV; Tapio, 2006; PEFC, 2009). The current FFCS were renamed as the PEFC Finland during the updating work in 2008-2009, and the revised Finnish PEFC Criteria and Standards will be launched in 2011. In addition to examining stakeholders' attitudes towards retention tree cuttings and decaying wood, we surveyed unpublished written comments from 41 stakeholders that had been given during the updating work on the Finnish PEFC Criteria in 2008-09 (IV).

3.4. THE SCIENTIFIC PHILOSOPHY OF THE RESEARCH

My dissertation represents transdisciplinary research that uses theories, models and methodological approaches from disciplines within social and natural sciences (Mikkeli and Pakkasvirta, 2007). The philosophical approach of 'how am I doing science', i.e., the paradigm of this work, is anchored in both constructivism and realism (Huutoniemi, 2003). As I was partly conducting constructivist research, I felt it necessary to place my research in the perspectives of the current philosophy of science approaches (Huutoniemi, 2003, p. 20). I consider the natural world as real and functioning under certain causal physical, chemical and biological processes and being independent of the observer (*ontological realism*). Secondly, I strongly believe that science itself is connected to the social world, and the researcher cannot be an objective 'outsider' observing causalities *from* the natural world (*epistemological relativism*) (Patomäki, 2002, p. 8).

In addition, my intention was not to establish a specific theory or methodology that would have determined the ontological and epistemological perspective of the study object. On the contrary, my approach to the study object was *problem* or *information oriented*, and I have used theoretical and methodological approaches as a 'practical tool' to explore, describe and understand the study object (Clark, 2002; Mikkeli and Pakkasvirta, 2007, p. 89; Willamo, 2005, p. 70).

4. MAIN RESULTS AND DISCUSSION

4.1. PRODUCING ECOLOGICAL RESEARCH INFORMATION ON FORESTS

In this chapter I discuss how we can measure and analyze sustainable forest management by using available statistical data. I also provide potential indicators and consider the usefulness of statistics. To summarize the results of the first paper (I), we found close associations and clear regional patterns between forest species and tree structural variables that were assumed to indicate ecologically sound forest management (Fig. 2). The WRI for grouse, abundance of Siberian flying squirrels, diversity of saw-timber trees and amount of old-growth forests were associated with the western part of the study area. The boreal forests in the western part of the study area supported the survival of four grouse species and flying squirrels more than in regions with indications of intensive forestry (I). We found that forest ownership characteristics correlated with the first principal axes, with associations between the four above-mentioned ecological indicators (I). The private forest ownership of farmers positively correlated with the four ecological indicators, while the degree of other NIPF and forest company ownership correlated negatively. We concluded that the positive correlation could be a consequence of small-scale management activities of farmers in privately owned forests. It has earlier been noted that the forest landscape structure differs between forest owner groups due to differences in the average size of clear-cutting and the density of roads (Uuttera et al., 1998; Löfman, 2006).

The regional patterns of ecological indicators in the western part of the study area indicated good ecological conditions, at least from the perspective of grouse and flying squirrels. However, boreal forests in the west (South Ostrobothnia) are generally poorer than in the central-eastern part of Finland (Savo region) due biogeographical factors (Ahti et al., 1968; Finnish Forest Research Institute, 2008). In addition, the long and intensive land-use history of forests has caused a declining trend in many forest-dwelling species, and many endangered species have become regionally extinct in the western part of the study area (I).

To conclude, our results could support the idea of recovery of the ecological condition of forests in coastal and Southern Ostrobothnia, at least from the perspective of grouse. Miettinen (2009) pointed out that the boreal forest landscape recovers relatively rapidly, in about 30-40 years after clear-cuttings, to become ecologically supportive for capercaillie. Löfman (2006) analysed changes in southern Finnish forests from the 1950s to the 1990s and noticed that closed-canopy forests have increased in certain areas following the large-scale clear-cutting in 1970s. This was partly due to the afforestation of naturally open or semi-open mires after drainage. Drained mires with closed-canopy but relatively young forests (< 60 years) are common, especially in the western part of the study area in the Southern Ostrobothnia (Finnish Forest Research Institute, 2008).

In the second paper (II) we were interested in studying trade-offs between sustainability components at the regional municipality complex scale (LAU-1). Based on our factor analyses we found negative relationships between forestry activity and the wildlife richness of 16 game animals, as well as the WRI for grouse (II). According to these results, forestry activity (cuttings) had been high during 1995-2001 in regions where the quantity of young forests was already high. It is important to note that forestry activity data only include timber cuttings in private forests and exclude state-owned forests. The proportion of state-owned forests is highest in the eastern part (Karelian region). The WRI for 16 game animals and WRI for grouse received low loading values in these regions (Fig. 3b,c). On the contrary, there were no strong competing relations between ecological, social or economic components of sustainable forestry in the western part of the study area (Fig. 3a), while in the central-eastern part of the study area (Savo region) such relations were found (3b,c). In comparing the results of the first and second papers, it is interesting to note that both analyses gave support for a good economic, social and ecological sustainability of forestry and regional society in the western part of the study area.

Figure 2. Regional patterns of closely associated variables: the WRI for grouse, relative abundance of flying squirrels, proportion of old-growth forests (>120 y) and diversity of saw-timber trees. Regions with high loading values for these four variables based on principal component analysis are indicated in dark grey, while regions in pale grey are those where the proportion of saw-timber trees, productive forest land and young forests (< 40 y) received high loading values. (I)

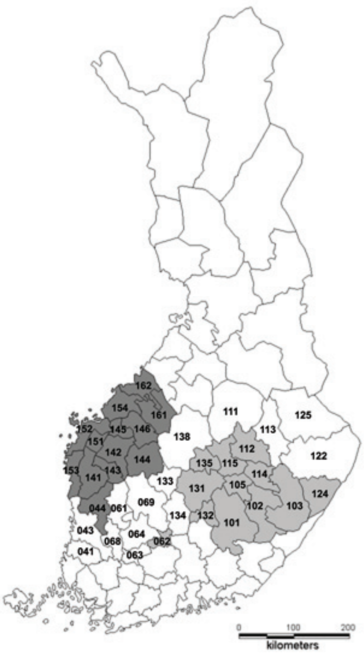
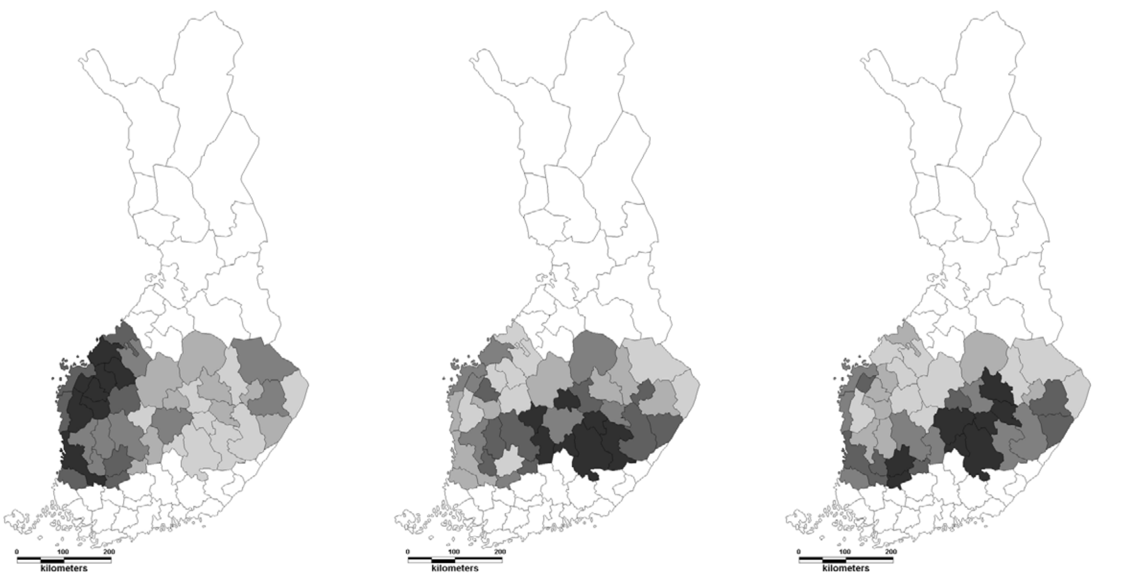


Figure 3. Regional optima (dark grey) for (a) the WRI for grouse, tree age-class diversity, agriculture, industry and service activities, and (b) forestry production, forestry activity and tree species diversity, based on cross-section analysis. (c) The regional optimum for forestry activity (cutting in private forests) using longitudinal analysis. (II)



4.1.1. USING INDICATORS TO MONITOR SUSTAINABLE FORESTRY AT THE REGIONAL SCALE

Criteria and indicators have been developed for assessing and monitoring sustainable forestry worldwide (Vähänen, 2009). They can provide valuable tools in detecting current trends in sustainable forest management (I). In Finland, criteria and indicators have been updated three times (Ministry of Argiculture and Forestry, 1997; 2000; 2007). In addition, the Finnish Environment Institute with other research institutes has developed a biodiversity indicator website that provides information about trends in components related to biological diversity and factors affecting these developments (Auvinen and Toivonen, 2006; Biodiversity, 2009). Biodiversity indicators have been used, for example, in preparing the national CBD reports (Ministry of the Environment, 2009). An important aim in both studies (I, II) was to examine potential regional scale indicators for ecologically sustainable forestry. Especially today, when global climate change is affecting species distribution and ecosystem functions, it is necessary to establish proper and robust 'shopping baskets' for monitoring trends in the ecology of sustainable forest management. Furthermore, assessment and monitoring of regional-scale trends in forestry and forests would provide useful information for the environmental and forestry administrations (e.g. Rosenström, 2009).

Based on our analyses, I suggest that the co-occurrence of five variables, the WRI for grouse, abundance of flying squirrels, diversity index of saw-timber trees, diversity index of tree age classes and proportion of old-growth forests, could be considered as forming a 'shopping basket' for ecologically sustainable forestry at the regional scale in the Fennoscandian region (Table 3). The WRI for grouse and abundance of flying squirrels together seem to indicate a good ecological condition of forests, which are all considered to suffer from intensive forest management practices that cause degradation of the environment[15] (e.g. Saari et al., 1998; Kurki et al., 2000; Hanski, 2006; Pellikka et al., 2006). The four grouse species (capercaillie, black grouse, hazel grouse and willow grouse) differ in their primary habitat requirements, indicating diversity in forest landscape patterns (Saari et al., 1998; Pakkala et al., 2003; Åberg et al., 2003). The Siberian flying squirrel requires mature spruce forests with a mixture of broadleaved trees, especially aspen (*Populus tremula* L.) (Selonen et al., 2001).

On the contrary, the WRI for small predators, WRI for ungulates, forestry activity and the proportion of young forests could be considered as potential indicators of the negative cumulative effects of human-caused disturbances. Earlier studies have reported that especially ungulates and small mammals either benefit from or are indifferent to fragmented forest landscapes (Kurki et al., 1998, 2000). The

15 Degradation of the environment refers to management practices that make the environment unsuitable for species (such as removals of deciduous trees, clear-cuttings and ditching).

future research challenge is to determine whether a high wildlife richness index for grouse and a high abundance of flying squirrels can support the survival of other forest-dwelling species at the regional municipality complex scale (LAU-1). It is also important to point out that the 'shopping basket' protocol for indicating sustainable forest use does not replace the need for species-specific monitoring (Pellikka, 2005).

Table 3. Potential indicators for monitoring ecologically sustainable forest management at the regional (LAU-1) scale in the terms of biological diversity.

	Shopping basket of indicators of ecologically sustainable forestry		Indicators of the negative cumulative effect of human-caused disturbances
1	Wildlife richness index for grouse	1	Forestry activity (timber sales m^3/year)
2	Relative abundance of Siberian flying squirrels	2	Proportion of young forests (<40 y)
3	Diversity index for saw-timber trees	3	Wildlife richness index for small predators
4	Diversity index for tree age classes	4	Wildlife richness index for ungulates
5	Proportion of old-growth forests (> 120 y)		

4.1.2. THE USEFULNESS OF THE STATISTICAL DATA

Research institutions[16] have widely used systematically collected data in research concerning topics that have emerged from political goals, interests and purposes (I, IV). Changes in social values have also affected the protocols of systematic sampling (Leskinen et al., 2008). For instance, forest structural and biological variables connected to biodiversity have been included in forest inventories since 1995 (Tomppo, 1996). In our studies we used systematically collected statistical data that were produced by other research institutions (I, II). The primary use of the data varied greatly, and they had been produced by governmental authorities for economic, social and ecological needs (Table 1).

The statistical data used in papers I and II were collected at different spatial scales. It would, however, benefit both data producers and users if the spatial scale was the same for presenting the information. The LAU-1 level, i.e. regional municipality complex (seutukunta), was found to be a useful scale in studying associations between variables in economic, ecological and social data. The administrations of the forest and environment sectors mainly work at the forest centre (13 centres in Finland) and regional environment centre (13) scales, respectively. These administrations differ in their sphere of operation, and in addition, regional environment centres faced structural changes at the beginning of 2010. I encourage administrations and other institutions to take regional scale indicators seriously into consideration when developing biodiversity indicators, or criteria and indicators for sustainable forestry.

16 See definition in Box 1.

I was also interested in testing the accessibility of the statistical data. Hundreds of statistical data sets are freely available concerning economic, social and environmental characteristics in Finland, especially at the national scale. These are provided by various authorities such as Statistics Finland and the Finnish Forest Research Institute. Today, the Internet and media have a central role as information sources for different forest actors (Janse, 2007, p. 39). However, not all statistical data were freely available. The costs of statistical data varied greatly among administrations. Research Institutions (not included as co-authors in publications) provided data for scientific purposes at no cost after short negotiations. However, the regional scale administration in the forest sector charged for providing statistic data on Kemera-based[17] subsidies, although the practice varied between authorities.

4.2. EXPERIENCING AND FRAMING FORESTS

In this dissertation my aim was not only to measure or quantify the ecological dimension of SFM but also to understand what happens to ecological research information after it is produced, and how different forest actors construct ecologically sustainable forest management based on both ecological knowledge produced by research institutions and direct observation based on their own experiences, i.e. local ecological knowledge[18].

In my study framework (Fig. 1), discourse represented the place in which forest actors gave a meaning to, i.e. framed the concept of 'ecologically sustainable forest management'. To understand the socio-cultural construction of sustainable forest management, I analyzed the argumentation of forest actors who had taken part in discourses over forests. The first finding was that forest actors framed the concept from different perspectives (III, Vierikko and Niemelä, 2006). Based on this observation, I developed four argumentation groups based on the perspectives from which forest actors framed the concept. These argumentation groups were: information, working, experience, and own position based (III).

The first group was divided into two subgroups according to whether their argumentation was based on scientific knowledge or was an institutional-based18 definition (Table 4). Individuals in the working-based argumentation group 'followed orders' from employers. The experience-based group was also divided into two subgroups according to whether their argumentation emerged from practical management experiences or from their own forest policy experiences. Persons in the own position based argumentation group avoided making interpretations of

17 Kemera-based subsidies refer to forestry or biodiversity management that has been financially supported by the government. Kemera subsidies are determined by the Act on the Financing of Sustainable Forestry (1094/1996).

18 See definition in Box 1.

any kind because of their working position or considering the subject to be 'value-laden' (III). It is worth mentioning that the definition of ecologically-sustainable forest management varied between individuals, but not consistently between argumentation groups. The SFM definition included such characteristics as species and their habitat protection, ecosystem function, forest vitality and biodiversity (III).

Table 4. Argumentation frame types, description of the groups, and domain characteristics that can be identified beyond the argumentation frame types. The expressions of the argumentations groups are presented concerning the role of society and of scientific knowledge in determining ecologically sustainable forest management. Further details are provided in article III.

Frame type	Description	Domain characteristics	Role of society	Role of scientific knowledge
Information-scientific based	Emphasising the role of natural science and its authorities	Academically educated Trusts scientific experts	Society's preferences control the practice of ESFM	Best available information, guided by political interests
Information-expert based	Taking ES as a given definition by an external expert or institution	Heterogeneous group Trust external experts	Legislation and institutions control the practice of ESFM	Usable knowledge, controls decision making
Work based	Taking his/her own working position into consideration and expressing that as a worker he/she has serious responsibilities and duties to enhance ESFM	Working in forestry Organizational position Local knowledge Strong work ethic	Norms and rules control the practice of ESFM, responsibilities compete with each other	Base for management planning
Experience-practice based	Expressing ES from his/her own practical perspective, and being personally responsible for enhancing ES	Forest owner Local knowledge Takes personal responsibility	Construct their own practice Society's values determine the practice of ESFM	Base for management planning
Experience-expertise based	Highlighting his/her own experiences, while at the same time expressing that he/she is not responsible for enhancing ES	Academically educated Working in office Strong own opinions	Construct their own practice, Society's values determine the practice of ESFM	Controlled by policy interests
Own position based	Avoiding a clear definition of ES, or a definition for ES has emerged from a stakeholder or working position	Stakeholder position Organizational position	Public opinion and society's values control the practice of ESFM	Not expressed precisely

Note: ESFM = ecologically sustainable forest management, ES = ecological sustainability

4.2.1. SOCIO-CULTURAL CONTEXTS OF ECOLOGICAL SUSTAINABILITY

Based on results of the third paper and our earlier Finnish publication (Vierikko and Niemelä, 2006), I constructed a model of ecologically sustainable forest management to demonstrate differences among argumentation frame types in the role of knowledge and meaning of the concerned subject (Fig. 4). With the model I wanted to emphasize not only that subcomponents of sustainable forest management can be competing with each other and that there are trade-offs between them, but also that the ecological component itself holds competing and complementary elements that determine the concept. The two axes of the model illustrate changes in the type of knowledge (theoretical-practical) and in the meaning (objectivity-subjectivity) of the concept of 'ecologically sustainable forest management'.

When practical knowledge receives more emphasis in argumentation, theoretical knowledge diminishes (Fig. 4). The practicality in this statement refers to knowledge gained from experience (Hannigan, 1995, p. 97). It is a mixture of own experiences, absorbed external knowledge (science, institutional), learned cultural habits and traditions (local ecological knowledge). Theoretical knowledge refers to natural scientific knowledge that has been produced by research institutions and published in (inter)national research journals (Yli-Pelkonen and Niemelä, 2005).

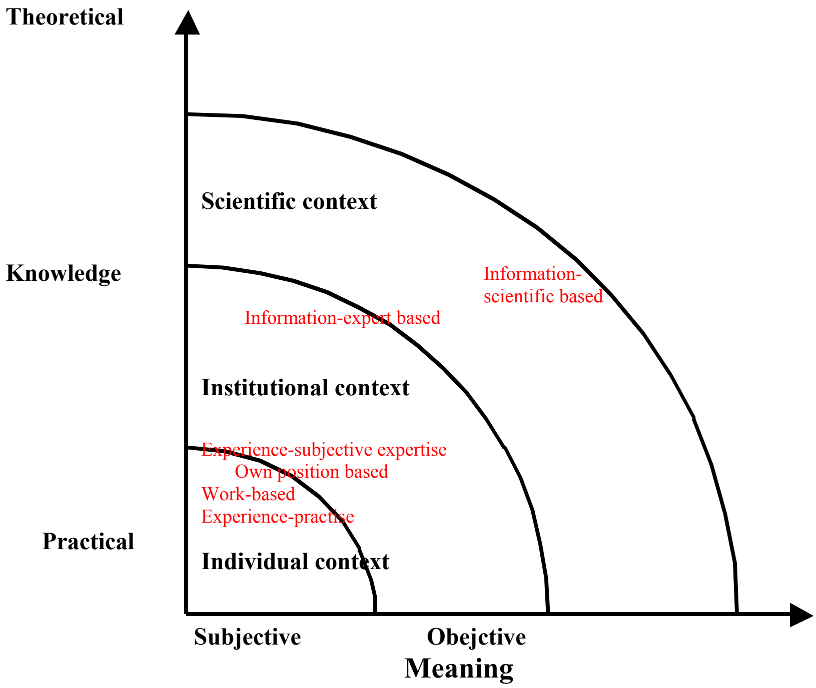
The same phenomenon concerns the meaning of ecologically sustainable forest management (Fig. 4). When entities in daily life such as working experience, life history and adopted habits receive more weight in the argumentation, the objective meaning to the concerned subject decreases. Meaning refers to socio-cultural processes of how the concept of 'ecologically sustainable forest management' has been constructed. If the construction is strongly based an individual's daily routines, I consider it as subjective meaning, and when the concept is constructed by society or the scientific community the meaning is objective to the subject (Berger and Luckmann 1994, p. 72-73).

I defined three socio-cultural contexts[19] that could be identified beyond every argumentation group but with different weightings: scientific, institutional and individual (Fig. 4). The three zones between the axes represent socio-cultural contexts. The outer zone is the scientific context that I consider as theoretical knowledge of the concept of 'ecologically sustainable forest management'. The second zone represents institutional contexts with political programmes, legislation, and with administrative norms. The inner zone represents the individual context that emphasises entities in daily life. Elements such as benefits, costs, effectiveness, experiences and preferences have a dominating role in this context. The role of identity is strong, which means that a social actor usually defends rather than gives up his or her own perspectives or opinions about ecologically sustainable forest management (Gray, 2003, p. 21).

All four argumentation frame types and their sub-types were fitted into the model (Fig. 4) based on the descriptions, dominating characteristics and social structures in their argumentations (Table 4). Relationships between the contexts can be seen as overlapping with each other, so that the individual context comprises elements from both institutional and scientific contexts. However, these contexts can also be competing or trading-off with each other.

19 See definition in Box 1.

Figure 4. Theoretical model of socio-cultural contexts that had greatest effect on the interpretation of forest actors of the concept of 'ecologically sustainable forest management'. When practical knowledge receives more weight in the argumentation, the weight of theoretical knowledge decreases. The same phenomenon occurs with subjective and objective meaning. See the text for more detail.



The model aims to illustrate that although different forest actors agree that forests need to be managed in an ecologically sustainable way, they conceptualize the purposes from different contexts. Practice-based and work-based argumentations are closely connected to the role of forests in a person's daily life, and individual life history, former experiences and images of forests therefore have a strong impact on what kind of meaning a person gives to the concept of ecologically sustainable forest management (III; Leskinen et al., 2008). The common argument is that science has a crucial role in defining ecological sustainability, but according to our frame analysis, an individual's operational life, i.e. experiences have a stronger impact on the definition of ecological sustainability than ecological research information (III; Vierikko and Niemelä, 2006). The closer the forest is to an individual's daily life, the more important are own experiences (III). Experiences can differ depending on whether an individual observes the forest as forest worker, researcher, recreationist or forest owner. In addition, images and valuations can affect experiences. For example, depending on how the observer values 'naturalness' or 'safeness', a fallen or dead tree can be experienced either positively or negatively (Tyrväinen et al., 2005; Karjalainen and Sievänen, 2006).

4.3. POLICY PROCESSES OF ECOLOGICAL RESEARCH INFORMATION AND DISCOURSES

Finally, I examined how sustainable forest policy[20] has been evaluated in practice, i.e. how we can understand the management behaviour of forest actors and guide their behaviour with policy tools (III). In addition, I surveyed how scientific knowledge has been put into practice based on the results on my qualitative analyses (IV). First, before discussing the results from the policy context, I need to present the focal values in forest politics.[20] National forest programmes have had a strong role in Finnish forest politics compared to other European countries (Palo, 1993). Therefore, I considered that National Forest Programmes reflect current social values20 in forest politics (see the study framework in Fig. 1, p. 14).

4.3.1. POLITICAL GOALS FOR MANAGING BIODIVERSITY

The aim of the National Forest Programme 2015 is to achieve '*More welfare from Diverse Forests*', i.e. to increase the multiple use of forests based on the principles of sustainable development without giving more weight to any one of the sustainability components over the others (Ministry of Agriculture and Forestry, 2008). The National Forest Programme 2015 highlights the social benefits (biodiversity, carbon sink, recreation, timber) of forests. However, there is strong political pressure to increase the annual use of domestic wood from the current level of ca. 55 million m^3 to 70 million m^3 (Ministry of Agriculture and Forestry, 2008).

The goal of maintaining the biological diversity of forests is expressed in the National Forest Programme as '*the deterioration of forest biotopes and species ceases and a stable positive trend of biodiversity is established*' (Ministry of Agriculture and Forestry, 2008). In addition, the programme highlights the importance of maintaining the genetic diversity of tree species. One important political meaning that has been given to the forest ecosystem is its function as a carbon sink (Ministry of Agriculture and Forestry, 2008). The programme states that genetically diverse tree populations can better adapt to future climate changes. The policy tools for achieving the goal of '*the deterioration of forest biotopes and species ceases and a stable positive trend of biodiversity is established*' are excluded from the Forest Biodiversity Programme METSO 2008-2016 (Ministry of the Environment, 2008b). Voluntary actions and temporality are currently emphasized when developing socially acceptable policy tools to maintain the biological diversity of Finnish forests (Ministry of the Environment, 2008b; Horne, 2006; Paloniemi and Tikka, 2008).

20 See definition in Box 1.

4.3.2. USING AND DEVELOPING POLICY TOOLS

Here, I first discuss whether the characteristics of different argumentation groups (Table 4) have an impact on individual decision making, and to what extent we can use different policy tools to possibly guide the management behaviour of different forest actor groups to become more ecologically sound (III). I then discuss the extent to which ecological research information has been taken into consideration when developing TAPIO's management recommendations and when revising the Finnish PEFC Criteria (IV).

To summarise the main results, I categorized current Finnish forest policy instruments, which aim to maintain the biological diversity and ecological sustainability of boreal forests, into five groups based on Schneider and Ingram's (1990) behavioural assumptions of policy tools, i.e. (1) authority, (2) incentive, (3) capacity, (4) symbolic and hortatory, and (5) learning (Table 5). These groups differ in their operational characteristics and how an agent or targeted group is assumed to behave.

Based on the descriptions and domain characteristics of the four argumentation groups presented in Table 4, I made suggestions about which policy tools would be appropriate in guiding management behaviour to become more ecologically sound (Table 6). The most challenging and important from the pragmatic context of goals would be non-industrial private forest owners (NIPF) belonging to the experience-practise based argumentation group, and forest workers belonging to either the work- or experience-practice based argumentation groups. In these groups, life or working history and experiences had a strong impact on how the concept of 'ecologically sustainable forest management' was interpreted (III, see also Fig. 4). Personal advice and learning together with others having similar experiences were found to be suitable policy tools to guide management behaviour.

Primmer and Karppinen (2009) studied attitudes and social norms of foresters concerning the conservation of valuable habitats. They noticed that life history, traditions and past behaviour can have an important role in defining the biodiversity management actions of foresters at the operational level. Paloniemi and Tikka (2008) reported that NIPF owners who had earlier taken the value of nature into account were also interested in protecting the biological diversity of the forests in the future. Hysing and Olsson (2005) examined the behaviour of private forest owners and also noticed that personal advisory and counselling services were effective in guiding the biodiversity management behaviour of forest owners. However, they noted that information provided by capacity tools (the informative instrument of Vedung, 1998) did not change the values or preferences of forest owners (Hysing and Olsson, 2005). If there is a strong tradition in the commercial use of forests among NIPF and forest workers (Paloniemi and Tikka, 2008) belonging to experience-practice or work-based argumentation groups, socio-cultural boundaries for biodiversity management and conservation actions will mainly be determined by the individual contexts (see Fig. 4).

Table 5. Behavioural assumptions of policy tools (Schneider and Ingram 1990) and Finnish forest policy instruments for ecologically sustainable forest management.

Policy tool	Main assumptions	Characteristics	Finnish forest policy instruments
Authority	Leader-fellowship relation-ships; the forest actor follows the rules and is faithful to his/her duties, even without incentives	Hierarchical system; commonly used together with other tools	Regulations, norms and duties based on Finnish legislation; nature conservation programmes
Financial incentives	The forest actor maximizes his/her utilization; will not change management action without incentives; capable of recognizing different opportunities	Positive and negative financial payments	Kemera-based* subsidies as compensation payments for timber loss in safeguarding local nature values
Capacity	The forest actor is a free agent and able to make his/her own decisions; open-minded to new information and assistance	Providing information; training and education; providing skill and advice; support for handling different situations	Biodiversity-based forest plans; forest management recommendations; training and education; counselling and advising
Symbolic and hortatory	The forest actor is motivated when his/her beliefs and values are taken into consideration; preferences are culturally defined; intangible values	Convincing and offering images, labels and symbols	Voluntary-based biodiversity markets by the Metso II**; certification system
Learning	There are no *a priori* assumptions	Varies among the situation's and actors' values and preferences	Exchanging experiences with other forest actors; learning through experiences; defining the most suitable solution

Note: * Kemera refers to the Act on the Financing of Sustainable Forestry (1094/1996)
** Metso II refers to a reference from the Ministry of the Environment (2008b)

Table 6. Policy tools to guide the management behaviour of private forest owners and forest workers, and possible strengths and weaknesses of the group that must be taken into consideration when choosing the appropriate policy tools.

Argumentation group	**Strength**	**Weakness**	**Policy tool**
Information - expert NIPF owners	Easily accept and search for new information	Vulnerable o competing information sources	Authority with capacity
Experience - Practice NIPF owners	Take personal responsibility Self-educating and active	Negative attitude towards diversity protection; blind for own mistakes	Symbolic and learning with other owners, in some cases authority
Work - Forest workers	Have a strong impact on other decision making	Low motivation and competing duties towards economy	Capacity Symbolic Learning with other workers

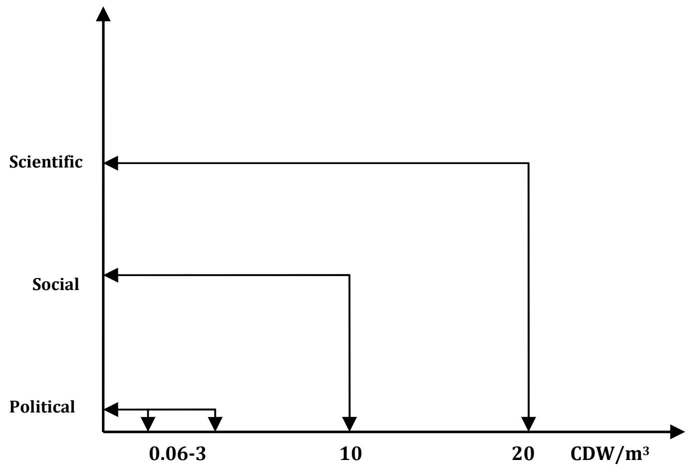
Note NIPF Non-industrial Private Forest owner

In the fourth paper we compared science-based recommendations for biodiversity management in commercial forests to current policy tools (Forestry Development Center TAPIO's management recommendations and Finnish forest certification systems, i.e. Finnish PEFC Criteria). To summarise our findings, TAPIO's management recommendations and Finnish PEFC Criteria, in principal, were based on ecological research information (IV). However, the science-based recommendations concerning, for instance, the number of trees left in retention tree cuttings[20] have not been evaluated to the same extent as into TAPIO's management recommendations or the revised Finnish PEFC Criteria (IV). Despite the cumulative trend in ecological research information and recommendations made by researchers, other needs such as social acceptability and economic efficiency received more weight in the updating of Finnish forest certification standards (IV).

The revised Finnish PEFC criterion recommend leaving an average of 5-10 living trees with a minimum dbh of 10 cm, or dead trees with a minimum dbh of 20 cm per hectare after clear-cuttings. This is comparable to 0.06-4 m^3/ha decaying wood (Hänninen, 2001; Kotiharju et al., 2006). There is empirical evidence that the survival of many rare and threatened wood-inhabiting species improves after the threshold value for decaying wood of 20 m^3/ha is exceeded. (IV). Koskela et al. (2004) assessed public attitudes towards the optimal number of retention trees. They found that public opinion supported leaving ca. 20 large trees/ha, which was comparable to 9 m^3/ha of decaying wood.

I argue that there is a potential to increase the current number of retention trees (5-10 trees per hectare) closer to what the public prefers and what science-based recommendations have suggested. The relationship between science-based, socially acceptable (public attitudes) and politically supported (Finnish PEFC Criteria) values for retention trees (decaying wood) is illustrated in Figure 5.

Figure 5. Scientific, social and political values for the amount of decaying wood (CWD) per hectare. Theoretical refers to the scientifically defined threshold value (20 m^3/ha) to increase the survival of wood-inhabiting species. Social refers to public attitudes concerning the optimal number of retention trees. Political refers to the recommended number of retention trees and amount of dead wood in clear-cuttings in the PEFC Criteria. See paper IV for further details.



The working group for the Finnish PEFC Criteria and Standards actually represented the forum for discourse in which participants (forest actors) framed the concept of 'ecologically sustainable forest management' from their own perspectives. Because of the differing views, the participants disagreed to a great extent in setting the criteria for ecologically sound forest management (IV). The criterion for retention trees and decaying wood in the revised Finnish PEFC Criteria were determined by socio-cultural boundaries of different argumentations groups (see Fig. 4). I argue that it is important for scientists to participate in the policy process so that ecological research information (as with other research information) can be brought up to the practical level of knowledge required by end-users. In addition, scientists needs to recognize changes in social values and understand the contradictory needs and interests emerging from different socio-cultural contexts.

5. CONCLUSIONS – PERHAPS ECOLOGICALLY SOUND BUT ALSO SOCIALLY ACCEPTABLE

To bring up the results of multivariate analyses in measuring and monitoring the ecological dimension of forests, and to understand which factors in the socio-cultural dimension affect how the concept of 'ecologically sustainable forest management' is constructed, I here make some final conclusions. My intention was to understand why, despite the cumulative trend in ecological research information, there are still contradictory views among forest actors on how to sustain boreal forests in an ecologically sound way. Another interest was in what happens to ecological research information when it is interpreted by different forest actors and when ecologically sustainable forest management is socially accepted among these actors.

A regional-scale indicator 'shopping basket' can provide valuable information for policy and decision makers

Based on our analyses (I, II), I suggested potential biological and structural indicators for ecologically sustainable forestry and for the negative cumulative effect of human-caused disturbances (p. 28). Analysis of the co-occurrence of certain ecological variables considered as potential indicators for sustainable forest management would improve the reliability of the indicators as compared to using them separately (Niemelä and Baur, 1998). The analyses and the use of regional-scale indicators should be interpreted with the aid of experts, because end-users can interpret indicators for their own purposes (Silvasti, 1994). Policy and decision makers are interested in using indicators of high political relevance from their own context (Rosenström et al., 2006). The use of a regional municipality complex (seutukunta) would supply information on whether economic, ecological and social targets and goals for sustainable forestry have been achieved (Larsson, 2001; Gough et al., 2008). Multivariate analyses together with ecological, economic and social indicators of SFM could increase the political relevance of the shopping basket approach.

The use of ecological research information is guided by the socio-cultural dimension

Despite the cumulative trend in ecological knowledge production, the individual context, i.e. experiences, preferences and interests of daily life, defines how the results are interpreted and used in policy making (III, IV). Kyllönen (2004) separated two resolution problem types for democratic decision making: information-based and interpretation-based framing. In the latter case, parties disagree about the facts concerning the debated issue, while the information-based problem can be resolved, at least in theory, by carrying out more research on the contradictory issue. The interpretation-based case is a more challenging problem to resolve, because forest actors can interpret facts, i.e. ecological research information, according to their own experiences and interests (III).

The interpretation of information takes place through meaningful framing

According to our results, forest actors interpret, use and understand information through meaningful framing (III). Based on the model of socio-cultural boundaries for ecological sustainability, and the results of our frame analyses, I argue that even if natural science is needed to identify, measure and visualise phenomena, elements and changes in the environment for actors (e.g. Hannigan, 1995, p. 41; Haila, 2001), its role in interpreting ecological sustainability is not focal (III). Elements in daily life and characteristics beyond the argumentation such as forest ownership, working position or educational background can have a central impact on meaningful framing (III). To understand and guide policy making in sustainable forest management, we need to identify those factors that determine meaningful framing.

Science-based recommendations and ecological advice need to be transferred to practice

Forest actors mostly believed that ecological research information represents reliable facts about forests (III). However, research results do not necessarily reach decision makers, because they may see research as irrelevant or uninteresting (e.g. Rosenström, 2009). Improvement in communication between science and policy is important (Pregernig, 2000; Janse, 2008). Also, researchers must be sensitive to recognizing the changes in values and preferences of society so that they can perform timely research that is relevant to the public or decision makers. Value changes such as 'how to protect biodiversity' are a great challenge for conservation biology and forest ecological research (Edwards and Abivardi 1998, Suter 1998).

Scientists should participate in policy processes

It is said that science represents the place of knowledge production, while policy refers to actions, i.e., the place of knowledge use (Jasanoff and Wynne, 1998). Scientists can be seen as producers of reliable and objective 'facts' about ecological systems, but scientists should avoid advocacy in order to maintain credibility (for more, see Nelson and Vucetich, 2009). Scientists seem to disagree about whether they can guide decision making or take part in political discourses. To conclude, I consider it important that scientists are interested in joining political discourses and policy processes concerning sustainable forest management to bring research information closer to the decision makers. When facing the end-users of information in two-directional communications, scientists are more likely to learn to present their results in a way that makes sense to policy or decision makers.

ACKNOWLEDGEMENTS

This research forms part of a multidisciplinary research project in Finland called ‘Forests and Good Life’. The project was supported financially by the Metsämiesten Säätiö. The Finnish Cultural Foundation also gave a financial support for finishing my dissertation work.

I warmly thank members of our research group: Katja Tervo, Riku Rinnekangas and Matti Vaara, and their supervisors Pertti Rannikko, Veikko Anttonen and Olli Saastamoinen for changes ideas and opinions about sustainability. I want to thank Risto Hyvärinen about interesting discussions concerning sustainability.

I am grateful for my supervisor Jari Niemelä who had always time for quick comments, and allowed me my develop my own inspirations, and I warmly thank my other supervisor Seppo Vehkamäki who shared his ideas of sustainability with me. I am happy that I could join meetings of the Urban ecology group. Thank you all Susanna Lehvävirta, Katja Matveinen-Huju, Vesa Yli-Pelkonen, and Kaisa Hauru. Special thanks Johan Kotze and Stephen Venn for checking the language of manuscripts many times. I thank Roy Siddall for checking language of the summary.

I want to thank Prof. John Innes and Dr. Päivi Tikka for reviewing my thesis. I also thank Prof. Mikael Hilden for accepting the proposal to act as an opponent. I thank the custos for being there.

I want thank all co-authors of the papers: Ilpo Hanski, Harto Lindén and Tanja Myllyviita. Special thanks to Jani Pellikka for sharing thoughts about the reality of existing world.

Special thanks to my friends back from the very beginning and from high school: Mari, Sanna K, Sonja, Mirka, Sanna S and Tuula. I also thank many biology friends but especially Tea and Sara with whom I have shared many experiences and thought with me last ten years. Thanks to Heli, Heikki and Thea. Thank god I found you via Vesa. Thanks to Rea and Pekka for opening your home for this loud family, and to Milka and Matti for helping with children time to time.

During my scientific journey my social life has gone through huge changes – the loss of my dear father, Pertti, who supported me to continue with my studies, marriage to my loving Vesa, and having three wonderful children: Vihtori, Artturi and Onerva. Warm thanks Vesa for being patient with my absentminded soul and unordered habits. I am very happy to have a great family and I want to thank my mother Raija who have helped me lot with everything, and my sister Nina with being supportive. I thank my husband’s adult children: Antti, Ville, Hellu and Lassi. Without my family effort, this work would have been impossible to produce. Ja kiitos myös sukulaisilleni – Talluskalle ja muille tädeilleni ja sedälleni sekä serkuilleni.

Box 1. The terms used in the summary, their definitions and meanings in the context of my dissertation.

Biodiversity management refers to practices that aim at maintaining the species diversity and improving the surveillance of forest-dwelling species. It includes management actions such as retention tree cuttings and set aside habitats in cuttings. Management actions are determined by political interests and controlled by legislation, or guided by 'soft law systems' such as management recommendations and forest certification systems.

Contexts in this study are understood as all the interconnected physical and societal realities that actors are faced with daily, and which are relevant to the environmental beliefs and commitment of an actor (adapted from Burningham and O'Brien, 1994). Local contexts can be societal structures (e.g. institutions, economic situation, norms), cultural elements (e.g. life history, traditions, rules) or environmental objectives (e.g. living place, working place).

Decision maker refers generally to politicians at the local, regional and national scales, employees in public administrative bodies, private companies and non-governmental organizations, and members in decision-making bodies of the same agents.

Ecological research information is used to describe forest-related *scientific knowledge* that includes the study topics of forest-dwelling species or ecosystem function (Yli-Pelkonen and Niemelä, 2005).

Forest actor refers to a social actor who is actively or closely connected to forests or forest-related decision making through work, a stakeholder position, ownership or recreation.

Forest politics can be broadly understood as a decision-making situations or forums in which different organizations, stakeholders or actors with their varying interests take part and their purpose is to control, promote or guide the substance of a policy (Koskinen and Jokinen, 1997; Valkeapää et al., 2009). In my dissertation, national and regional forest programmes are considered to represent forest politics and its focal goals.

Forestry refers administrations and all kinds of management actions that either aim to improve wood production (such as harvesting, ditch cleaning and supplementary ditching, forest road building) or all cuttings in which timber volume is removed from a forest area (e.g. thinning, harvesting, clear-cuttings, shelter-wood cutting, energy wood cutting).

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Institutional refers departments, authorities and public sector entities and their formal constraints (e.g. laws, political programmes, research results and strategic papers) (North, 1990).

Meaning is understood as the way in which a person understands, explains, feels about and reacts towards a given phenomenon (Rosengren, 2000). Meaning can also be considered as how a person creates meaning psychologically, socially and culturally (Janse, 2007, p. 22). In our study we have assumed that meaning creation happens through socio-cultural framing (Vierikko and Niemelä, 2006).

Local ecological knowledge (LEK) refers to knowledge held by individual social actors about their local ecological systems, in my thesis forests (see LEK in Olsson and Folke, 2001; Yli-Pelkonen and Kohl, 2005).

Policy refers in my thesis to the dynamic and complex process of putting political goals into action (see more Janse, 2007, p. 15-19). National forest programmes, regional forest programmes, PEFC Criteria, Criteria and Indicators for sustainable forest management are examples o*f policy processes* in which several social actors are joined.

Policy maker refers to a social actor who participates in policy processes (e.g. Janse, 2008).

Policy tools refers to the techniques and instruments that the government, administrations and other agencies use to achieve *a priori* defined political goals (Schneider and Ingram 1990, Hajer 1995).

Politics is a field in which social actors with differing interests, state representatives, different economic sectors and various organizations, as well as members of the public, seek to control the concerned issue.

Political discourse in my dissertation is understood as public discussion of certain issues or phenomena that social actors with different interests take part in, and their purpose is to control, promote or guide the substance of a policy (Koskinen and Jokinen, 1997).

Political goals refer to purposes and aims that have been established for strategic and operational, national and regional programmes of forestry or environment administrations.

Public opinion is the aggregate of individual attitudes or beliefs held by the adult population. Opinion is considered supportive when the majority of the population (> 50%) agrees with or supports the concerned subject based on questionnaire surveys.

Research institutions represent universities and other governmental research institutions such as the Finnish Game and Fisheries Research Institution, Finnish Forest Research Institution and National History Museum.

Retention tree cutting, i.e. green tree retention (GTR), has become a widely used management method in the traditional final felling system in Finland. The number of trees that are permanently left in the clear-cut area varies between 5-15/ha. Retention trees are either dispersed around the clear-cut area, or they are clustered in patches (Vanha-Majamaa and Jalonen, 2001).

Scientific knowledge refers to 'explicit knowledge' that has been produced by public research institutions or organizations, submitted to peer-reviewed critique, and published in (inter)national research journals.

Social actors in my thesis refer to individuals, administrations, media, private companies, research institutions or any other group or organization that is acting in society. A *forest actor* refers to an individual social actor who is actively connected to Finnish forests through work, a stakeholder position, ownership or recreation.

Social values are understood as shared components of individuals, communities and societies that are experienced to be important to achieve or maintain certain goals, such as a high standard of living or global biodiversity (Levonmäki, 2004).

Socio-cultural. Culture represents knowledge, models and strategies beyond our daily life, which guide and determine our actions and interpretation (Jokinen and Saaristo, 2002, p. 148). Social represents societal and community entities that surround our daily life (Vierikko and Niemelä, 2006). Habermas (1987, p. 85) defined a society as a community with shared rules and sanctions. The society in my dissertation represents Finnish society, the culturally and socially shared factors and characteristics of our community that separate us from other societies (Jokinen and Saaristo, 2002, p. 12-13).

Soft law systems in my dissertation refer to policy instruments that are not obligatory in terms of Finnish legislation. The social actor is not perceived and no sanctions are set if the actor does not follow the orders of soft law systems (for more, see e.g. Shaffer and Pollack, 2009).

Sustainable forest policy refers to policy processes that put political goals for sustainable forest management into action.

Two-directional social communication refers to social interaction between at least two persons that compromises both an action and a reaction (Janse, 2007 and references cited on p. 20-21).

5. REFERENCES

Act on the Financing of Sustainable Forestry (1094/1996). Ministry of Agriculture and Forestry. Available at: http://www.finlex.fi/en/laki/kaannokset/1996/en19961094.pdf.

Anonymous, 2005. Forest Certification in Finland - What is it? Finnish Forest Foundation. 23 pp. Available at: http://www.pefc.fi/media/Asiakirjat/Esitteet/KT_englanti.pdf

Ahti, T., Hämet-Ahti, L. and Jalas, J. 1968. Vegetation zones and their sections in northwestern Europe. Annales Botanici Fennici 5, 169-211.

Auvinen, A-P. and Toivonen, H., 2006. Biodiversiteetin seuranta ja indikaattorit – katsaus kansainvälisiin hankkeisiin ja ehdotuksia Suomen biodiversiteettiseurannan kehittämiseksi. Suomen ympäristö 33/2006. 77 pp. (in Finnish with English summary)

Bell, S., Marzano, M., Cent, J., Kobierska, H., Podjed, D., Vandzinskaite, D., Reinert, H., Armaitiene, A., Grodzińska-Jurczak, M. and Muršič, R., 2008. What counts? Volunteers and their organisations in the recording and monitoring of biodiversity. Biodiversity and Conservation 17, 3443-3454.

Berger, P. and Luckman, N. 1994. Todellisuuden sosiaalinen rakentuminen. (The Social Construction of Reality, 1966). Helsinki, Kirjapaino-Oy Like. (Translation into Finnish by Raiskila, V.). 255 pp.

Biodiversity, 2009. Available at: http://www.biodiversity.fi/en/home.

Burningham, K. and O'Brien, M., 1994. Global environmental values and local contexts of action. Sociology 28(4), 913-932.

Burninghman, K. and Cooper, G. 1999. Being Constructive: Social Constructionism and the Environment. Sociology 33(2), 297-316.

Burton, P. J., Messier, C., Smith, D. W. and Adamowicz, W. L., 2003. Towards Sustainable Management of the Boreal Forests. NRC Research Press, Ottawa.1039 pp.

Clark, T. W., 2002. The Policy Process. A Practical Guide for Natural Resources Professionals. Yale University Press, New haven and London. 215 pp.

Eder, K., 1993. The New Politics of Class: Social Movements and Cultural Dynamics in Advanced Societies. Wiltshire, Sage publications (GB, Cromwell Press Ltd.). 223 pp.

Edwards, P. J. and Abivardi, C., 1998. The value of biodiversity: where ecology and economy blend. Biological Conservation 83, 239-246.

Environmental Administration, 2009. Protecting forests. Available at: http://www.environment.fi/default.asp?node=17268&lan=en.

Esseen, P-A., Ehnström, B., Ericson, L. and Sjöberg, K. 1997. Boreal forests. Ecological Bulletins 46,16-47.

Eurofound, 2008. Working time developments – 2007. European Foundation for the Improvement of Living and Working Conditions. Available at: http://www.eurofound.europa.eu/docs/eiro/tn0804029s/tn0804029s.pdf (cited 7.10.2009).

Finnish Environment Institute, 2009. Monitoring biodiversity. Available at: http://www.environment.fi/default.asp?contentid=184409&lan=en.

Finnish Forest Act, 1093/1996. Metsälaki perusteluineen. Lakikokoelma, Edita, Helsinki. 53 pp. (in Finnish)

Finnish Forest Research Institute, 2008. Finnish Statistical Yearbook of Forestry. 424 pp. Available at: http://www.metla.fi/julkaisut/metsatilastollinenvsk/tilastovsk-sisalto.htm.

Flick, U., 2002. An Introduction to Qualitative Research. Great Britain, Cromwell Press Ltd. 310 pp.

Frelich, L. E. and Puettmann, K. J., 1999. Restoration ecology. In: Hunter, M. L. J. (Eds.), Maintaining Biodiversity in Forest Ecosystems. Cambridge University Press, Cambridge. p. 499-524.

Glaser, B.G. and Strauss, A.L., 1967. The discovery of grounded theory: strategies for qualitative research. New York, Aldine de Guyter. 271 pp.

Goffman, E., 1974. Frame analysis. An essay on the organization of experience. Cambridge, Massachusetts, USA. 586 pp.

Gough, A.D., Innes, J.L. and Allen, D.S., 2008. Development of common indicators of sustainable forest management. Ecological Indicators 8, 425-430.

Gray, B., 2003. Framing of environmental disputes. In: Lewicki, R.J., Gray, B., Elliott, M. (Eds.), Making Sense of Intractable Environmental Conflicts. Concepts and cases. Island Press. p. 11-34.

Habermas, J., 1987, Järki ja kommunikaatio, tekstejä 1981-1985. Hakapaino Oy, Helsinki. 210 pp. (Translated into Finnish by Kotkavirta, J.)

Haila, Y., 2001. Ympäristöherätys. In: Haila, Y. and Jokinen, P. (Eds.), Ympäristöpolitiikka. Tampere, Vastapaino. p. 21-46.

Hajer, M. A. 1995. The Politics of Environmental Discourse. Ecological Modernization and the Policy Process. Clarendon Press, Oxford. 332 pp.

Hanski, I. 2000. Extinction debt and species credit in boreal forests: modeling the consequences of different approaches to biodiversity conservation. – Annales Zoologici Fennici 37, 271-280.

Hanski, I. K., 2006. Liito-oravan *Pteromys volans* Suomen kannan koon arviointi. Ministry of the Environment. 66 pp. (in Finnish)

Hanski, I., Jalonen, R., Kuuluvainen, T., Nikinmaa, E. and Tahvonen, O., 2006. Johdanto. Jalonen, R., Hanski, I., Kuuluvainen, T., Nikinmaa, E., Pelkonen, P., Puttonen, P., Raitio, K. and Tahvonen, O. (Eds.), 2006. Uusi metsäkirja. Gaudeamus, Helsinki. p. 11-21. (In Finnish)

Hannigan, J. A. 1995. Environmental Sociology. A Social Constructionist Perspective. Routledge, London and New York. 236 pp.

Hansson, L. 2001. Key habitats in Swedish managed forests. Scandinavian Journal of Forest Research Suppl. 3, 52-61.

Hauru, K. 2008. Metsänreunan vaikutus virkistyskokemuksiin kaupunkimetsissä. Unpublished Master Thesis. Department of Biological and Environmental Sciences, University of Helsinki. 58 pp. (In Finnish)

Hilden, M., Auvinen, A-P. and Primmer, E. 2005. Suomen biodiversiteettiohjelman arviointi. Suomen ympäristö 770, Suomen ympäristökeskus, Helsinki. 251 pp. (In Finnish)

Horne, P., 2006. Forest Owners' acceptance of incentive based policy instruments in forest biodiversity conservation - a choice experiment based approach. Silva Fennica 40, 169-178.

Horne, P., Koskela, T., Kuusinen, M., Otsamo, A. and Syrjänen, K. (Eds.) 2006. Metson jäljillä: Etelä-Suomen metsien monimuotoisuusohjelman tutkimusraportti. Ministry of Agriculture and Forestry, Ministry of the Environment, Finnish Forest Research Institute, Finnish Environment Institute, Vammalan Kirjapaino Oy, Vammala. 387 pp. (In Finnish)

Hurme, E., Mönkkönen, M., Sippola, A-L., Ylinen, H. and Pentinsaari, M., 2008. Role of the Siberian flying squirrel as an umbrella species for biodiversity in northern boreal forests. Ecological Indicators 8, 246-255.

Huutoniemi, K., 2003. Realismi ja konstruktivismi tieteidenvälisessä ympäristötutkimuksessa – yhteismitattomuus, yhteensovittaminen vai dialogi. Unpublished Master Thesis. Department of Biological and Environmental Sciences, University of Helsinki. 78 pp. (In Finnish)

Hysing, E. and Olsson, J., 2005. Sustainability through Good Advice? Assessing the Governance of Swedish Forest Biodiversity. Environmental Politics 14(4), 510-526.

Hänninen, H., 2001. Luontokohteet ja säästöpuusto talousmetsien hakkuissa – seurantatulokset vuosilta 1996-99. In: Siitonen, J. (Eds.), Monimuotoinen metsä. Metsäluonnon monimuotoisuuden tutkimusohjelman loppuraportti. Metsäntutkimuslaitoksen tiedonantoja 812, 81-95. (In Finnish)

Jalonen, R., Hanski, I., Kuuluvainen, T., Nikinmaa, E., Pelkonen, P., Puttonen, P., Raitio, K. and Tahvonen, O. (Eds.), 2006. Uusi metsäkirja. Gaudeamus, Helsinki. 382 pp. (In Finnish)

Janse, G., 2006. Information search behaviour of European forest policy decision-makers. Forest Policy and Economics 8, 579-592.

Janse, G., 2007. Communication in forest policy decision-making in Europe: a study on communication processes between policy, science and the public. Academic Dissertation. Dissertationes Forestales 48. 72 pp.

Janse, G., 2008. Communication between forest scientists and forest-policy-makers in Europe – A survey on both sides of the science/policy interface. Forest Policy and Management 10, 183-194.

Jasanoff, S. and Wynne, B., 1998. Science and decision making. In: Rayner, S. and Malone, E. L. (Eds.), Human choice & Climate change. Battelle Press. p. 1-87.

Jokinen, A., 2001. Metsäammattilaisten dilemma: toiminta vahvistaa toimintaa vahvistavia instituutioita. In: Haila, Y. and Jokinen, P. (Eds.), Ympäristöpolitiikka. Gummerus, Jyväskylä. p. 168-182.

Jokinen, K. and Saaristo, K., 2002. Suomalainen yhteiskunta. WSOY, Helsinki. 356 pp.

Juslén, A., Kuusinen, M., Muona, J., Siitonen, J. and Toivonen, H. (Eds.), 2008. Puutteellisesti tunnettujen ja uhanalaisten metsälajien tutkimusohjelma (PUTTE). Loppuraportti. Suomen Ympäristö 1/2008. Ministry of the Environment. 146 pp. Available at http://www.ymparisto.fi/download.asp?contentid=78890&lan=fi (cited 8.10.2009). (In Finnish)

Kaila, S. and Salpakivi-Salomaa, P., 2004. Metsätalouden toimija ja kestävän kehityksen periaate. In: Kuuluvainen, T., Saaristo, L., Keto-Tokoi, P., Kostamo, J., Kuuluvainen, J., Kuusinen, M., Ollikainen, M., Salpakivi-Salomaa, P. (Eds.). Metsän kätköissä. Suomen metsäluonnon monimuotoisuus. Edita, Helsinki. pp. 210-214.

Kangas, J. 2001. Kansalaismielipide Suomen metsistä. In: Kangas, J. and Kokko, A. (Eds.). Metsän eri käyttömuotojen arvottaminen ja yhteensovittaminen. Metsäntutkimuslaitoksen tiedonantoja 800, 37-39. (in Finnish)

Karjalainen, E. and Sievänen, T. 2006. Metsä elvyttää ja virkistää – mutta millainen metsä? In: Jalonen, R., Hanski, I., Kuuluvainen, T., Nikinmaa, E., Pelkonen, P., Puttonen, P., Raitio, K. & Tahvonen, O. (Eds.). Uusi metsäkirja. Gaudeamus. Helsinki. p. 247-251.

Kohl, J. 2008. Agoralla – avauksia ympäristöasiantuntijoiden vuorovaikutusprosesseista. Academic Dissertation. Faculty of Social Sciences, University of Helsinki. Yliopistopaino, Helsinki.

Koskela, E., Ollikainen, M. and Pukkala, T., 2004. Biodiversity Conservation in Boreal Forests: Optimal Rotation Age and Volume of Retention Trees. Helsinki Center of Economic Research, Discussion Paper no. 2. 30 pp. Available at: http://ethesis.helsinki.fi/julkaisut/eri/hecer/disc/2/biodiver.pdf

Koskinen, K. and Jokinen, P., 1997. Environmental Discourse Coalitions. A Case Study of the Finnish National Commission on Sustainable Development. In: Suoninen, M. and Toivonen, T. (Eds.), Perspectives in Sociological Research. Sociological Research Reports, Series A 22. University of Turku, Department of Saociology. p. 15-39.

Kotiharju, J. S., Kouki, J. and Punttila, P., 2006. Ongelmakohtia kuolleen puun ylläpidossa nykyisissä metsäekosysteemeissä. In: Horne, P., Koskela, T., Kuusinen, M., Otsamo, A., Syrjänen, K. (Eds.), Metson jäljillä: Etelä-Suomen metsien monimuotoisuusohjelman tutkimusraportti. Ministry of Agriculture and Forestry, Ministry of the Environment, Finnish Forest Research Institute, Finnish Environment Institute, Vammalan Kirjapaino Oy, Vammala. p. 212-216. (In Finnish)

Kurki, S., Nikula, A., Helle, P. and Lindén, H., 1998. Abundances of red fox and pine marten in relation to the composition of boreal forest landscapes. Journal of Animal Ecology 67, 874-886.

Kurki, S., Nikula, A., Helle, P. and Lindén, H., 2000. Landscape fragmentation and forest composition effect on grouse breeding success in boreal forests. Ecology 81, 1985-1997.

Kuuluvainen, T., 2002. Disturbance dynamics in boreal forests: Defining the ecological basis of restoration and management of biodiversity (introduction). In: Korpilahti, E., Kuuluvainen, T. (Eds.), Disturbance Dynamics in Boreal Forests: Defining the Ecological Basis of Restoration and Management of Biodiversity. Silva Fennica 36, 5-11.

Kuuluvainen, T., Mönkkönen, M., Keto-Tokoi, P., Kuusinen, M., Aapala, K. and Tukia, H., 2004a. Metsien monimuotoisuuden turvaamisen perusteet. In:

Kuuluvainen, T., Saaristo, L., Keto-Tokoi, P., Kostamo, J., Kuuluvainen, J., Kuusinen, m., Ollikainen, T. and Salpakivi-Salomaa, J-P. (Eds.), Metsän kätköissä – Suomen metsäluonnon monimutoisuus. Edita Publishing, Helsinki. p. 142-191.

Kuuluvainen, T., Saaristo, L., Keto-Tokoi, P., Kostamo, J., Kuuluvainen, J., Kuusinen, M., Ollikainen, T. and Salpakivi-Salomaa, J-P. (Eds.), 2004b. Metsän kätköissä – Suomen metsäluonnon monimutoisuus. Edita Publishing, Helsinki. 381 pp.

Kyllönen, S., 2004. Julkisen päätöksenteon haasteet kestävän kehityksen toteuttamisessa. In: Loukola, O. and Tervo, M. (Eds.), Metsien kestävä käyttö – periaatteita ja tavoitteita. Department of Forest Economics, University of Helsinki, Publications 14. p. 43–57.

Larsson, T-B., 2001. Biodiversity Evaluation Tools for European Forests. Ecological Bulletins 50. 237 pp.

Leskinen, L.A., Laurén, K., Järvinen, S., Sairinen, R. and Leskinen, P. 2008. Sosiaalisten ja kulttuuristen vaikutusten ja kestävyyden arvioiminen metsätaloudessa ja metsien monimuotoisuuden turvaamisessa. Metlan työraportteja 99. 24 pp. Available at: http://www.metla.fi/julkaisut/workingpapers/2008/mwp099.htm.

Levonmäki, I. 2004. Metsäpoliittinen päätöksenteko haasteiden edessä: toimintaympäristön muutoksia, uusia arvoja ja prosesseja. In: Loukola, O. and Tervo, M. (Eds.), Metsien kestävä käyttö – periaatteita ja tavoitteita. Department of Forest Economics, Publications 14. University of Helsinki. p. 9-29. (in Finnish)

Lindén, H., Helle, E., Helle, P. and Wikman, M., 1996. Wildlife triangle scheme in Finland: methods and aims for monitoring wildlife populations. Finnish Game Research 49, 4-11.

Lindermayer, B. D. and Franklin, J. F., 1997. Managing stand structure as a part of ecologically sustainable forest management in Australian mountain ash forests. Conservation Biology 11, 1053-68.

Lovell, S., Hamer, M., Slotow, R. and Herbert, D., 2009. An assessment of the use of volunteers for terrestrial invertebrate biodiversity surveys. Biodiversity Conservation 18: 3295-3307.

Löfman, S., 2006. Changes in forest landscape structure in southern Finland in the late 1900's. Academic Dissertation. Dissertationes Forestales 32. Faculty of Forestry, University of Joensuu.

Markkanen, S., Vieno, M. and Walls, M. 2002. Finnish Biodiversity Research Programme FIBRE 1997-2002. Summary report. Paino-Raisio Oy, Raisio. 154 pp.

Miettinen, J., 2009. Capercaillie (*Tetrao urogallus* L.) habitats in managed Finnish forests - the current status, threats and possibilities. Academic Dissertation. Dissertationes Forestales 90. Faculty of Forest Sciences, University of Joensuu.

Mikkeli, H. And Pakkasvirta, T., 2007. Tieteiden välissä. Johdatus monitieteisyyteen, tieteidenvälisyyteen ja poikkitieteisyyteen. Wsoy Oy, Helsinki. 211 pp.

Ministry of Agriculture and Forestry, 1994. Metsätalous ja ympäristö. Metsätalouden ympäristöohjelmatyöryhmän mietintö 1994:3. (In Finnish)

Ministry of Agriculture and Forestry, 1997. Suomen kestävän metsätalouden kriteerit ja indikaattorit metsätalouden tilan kuvaajina. Paintek Pihlajamäki Oy, Helsinki. 72 pp. (In Finnish)

Ministry of Agriculture and Forestry, 1999. Finland's National Forest Programme 2010. Publications 2/1999, Helsinki. 37 pp.

Ministry of Agriculture and Forestry, 2000. The state of Forestry in Finland 2000. Criteria and Indicators for sustainable forest management in Finland. Publications 5a/2000, 102 pp.

Ministry of Agriculture and Forestry, 2007. Suomen metsät 2007. Kestävän metsätalouden kriteereihin ja indikaattoreihin perustuen. Publications 7/2007. 99 pp. (In Finnish)

Ministry of Agriculture and Forestry, 2008. Finland's National Forest Programme 2015. Government Resolution. Publications 3b/2008. Available at: http://www.mmm.fi/attachments/metsat/kmo/5Ad5R83tH/KMO2015engl.pdf

Ministry of the Environment, 2007. Saving nature for people. National strategy and action plan for conservation and sustainable use of biodiversity in Finland

2006-2016. The Finnish Environment 35/2007. Edita Oy, Helsinki. 162 pp. (In Finnish with English summary)

Ministry of the Environment, 2008a. Development of Environment Monitoring. The environmental administration's productivity project. Reports of the Ministry of the Environment 18/2008. Available at: http://www.ymparisto.fi/download.asp?contentid=85583&lan=fi. (In Finnish)

Ministry of the Environment, 2008b. Etelä-Suomen metsien monimuotoisuuden toimintaohjelma 2008-2016 (Metso II). Publications 5/2008. 46 pp.

Ministry of the Environment, 2009. Fourth National Report on the Implementation of the Convention on Biological Diversity in Finland. 158 pp. Available at: http://www.environment.fi/download.asp?contentid=105207&lan=EN.

Myllyviita, T., 2008. Ecological and social sustainability of boreal forest ecosystems at the regional scale. Unpublished Master Thesis. University of Helsinki, Finland, 56 pp.

Nature Conservation Act (1096/1996). Ministry of Environment. Available at: http://www.finlex.fi/en/laki/kaannokset/1996/en19961096.pdf

Nelson, M.P. and Vucetich, J.A., 2009. On Advocacy by Environmental Scientists: What, Whether, Why, and How? Conservation Biology 23, 1090-1101.

Niemelä, J. and Baur, B., 1998. Threatened species in a vanishing habitat: plants and invertebrates in calcareous grasslands in the Swiss Jura mountains. Biodiversity and Conservation 7, 1407-1416.

Nieminen, A., 2006. Metsäsertifioinnin ekotehokkuus. Working Papers of the Finnish Forest Research Institute 39. 85 pp. Available at: http://www.metla.fi/julkaisut/workingpapers/2006/mwp039.htm.

North, D. C., 1990, Institutions, institutional change, and ecological performance. Cambridge, UK, Cambridge University Press.

Olsson, P. and Folke, C., 2001. Local Ecological Knowledge and Institutional Dynamics for Ecosystem Management: A Study of Lake Racken Watershed, Sweden. Ecosystems 4, 85-104.

Pakkala, T., Pellikka, J. and Lindén, H. 2003. Capercaillie *Tetrao urogallus* - a good candidate for an umbrella species in taiga forest. Wildlife Biology 9, 309-316.

Palo, M., 1993, Ympäristötietoisen metsäpolitiikan strategia. In: Matti, P. and Hellström, E. (Eds.). Metsäpolitiikka valinkauhassa. Metsäntutkimuksen tiedonantoja 471. p. 307-448. (In Finnish)

Paloniemi, R. and Tikka, P., 2008. Ecological and social aspetcs of biodiversity conservation on private lands. Environmental Science & Policy 11, 336-346.

Patomäki. H., 2002. After international relations. Critical realism and the (re) constrction of world politics. Routledge, London and New York. 267 pp.

PEFC 2009. PEFC Suomi. Available at: http://www.pefc.fi/pages/fi/etusivu.php.

Pellikka, J., 2005. Management of wildlife richness in Finnish forests – interplay between game-related actors and actions. Academic dissertation. Department of Applied Biology, publications 25. University of Helsinki, Finland.

Pellikka. J, Lindén, H. and Nikula, A., 2006. Onko riistanrikkaus yhteydessä maankäyttöön? Suomen riista 52, 62-75. (In Finnish)

Polanyi, M., 1966. The Tacit Dimension. Reprinted in 1983. Doubleday & Company, New York. 108 pp.

Pregernig, M., 2000. Putting science into practice: the diffusion of scientific knowledge exemplified by the Austrian 'Research Initiative Against Forest Decline'. Forest Policy and Economics 1, 165-176.

Primmer, E. and Karppinen, H., 2010. Professional judgement in non-industrial private forestry: Foresters attitude and social norms influencing biodiversity conservation. Forest Policy and Economics 12(2), 136-146.

Putnam, L. and Wondolleck, J.M., 2003. Intractability: Definitions, Dimensions, and Distinctions. In: Lewicki, R. J., Gray, B. and Elliott, M. (Eds.), Making Sense of Intractable Environmental Conflicts. Concepts and Cases. Island Press. pp. 35-59.

Rassi, P., Alanen, A., Kanerva, T. and Mannerkoski, I. (Eds.), 2001. Suomen lajien uhanalaisuus 2000. Ministry of the Environment and Finnish Environment Institute, Helsinki. 432 pp. (in Finnish)

Reynolds, K. M., Thomson, A. J., Köhl, M., Shannon, M. A. and Rennolls, K. (Eds.), 2007. Sustainable Forestry from Monitoring and Modelling to Knowledge Management & Policy Science. Kings Lynn, UK. 527 pp.

Rosengren, K. E. 2000. Communication, an introduction. Sage, London.

Rosenström, U., 2009. Sustainable development indicators: Much wanted, less used? Academic Dissertation. Department of Biological and Environmental Sciences. University of Helsinki. Edita Prima Ltd. 74 pp.

Rosenström, U., Mickwitz, P. and Melanen, M., 2006. Participation and enpowerment-based development of socio-cultural indicator supporting regional decision-making for eco-efficiency. Local Environment 11(2), 182-200.

Saari, L., Åberg, J. and Swenson, J. E., 1998. Factors influencing the dynamics of occurrence of the Haxe Grouse in a fine-grained managed landscape. Conservation Biology 12, 586-592.

Sample, A., V., Johnson, N., Aplet, G., H. and Olson, J. T., 1993. Introduction. Defining Sustainable Forestry. In: Johnson, N., Olson, J. T. and Sample, A. V. (Eds.). Defining Sustainable Forestry. Island Press. 318 pp.

Schannon, M.A., Buttoud, G. and Päivinen, R., 2007. In: Reynolds, K. M., Thomson, A. J., Köhl, M., Shannon, M. A. and Rennolls, K. (Eds.), Sustainable Forestry from Monitoring and Modelling to Knowledge Management & Policy Science. Kings Lynn, UK. p. 1-13.

Schneider, A. and Ingram, H., 1990. The behavioral assumptions of policy tools. Journal of Politics 52, 511-529.

Selonen, V., Hanski, I. K. and Stevens, P., 2001. Space use of the Siberian flying squirrel *Pteromys volans* in fragmented landscapes. Ecography 24, 588-600.

Shaffer, G. C. and Pollack, M. A., 2009. Hard vs. Soft Law: Alternatives, Complements and Antagonists in International Governance. Minnesota Law Review, 2010;

Minnesota Legal Studies Research Paper No. 09-23. 88 pp. Available at SSRN: http://ssrn.com/abstract=1426123.

Silvasti, E. 1994. Intressi ohjaa informaatiota. Kanava 22(4), 205-208.

Silverman, D., 1993. Interpreting Qualitative Data. Methods for Analysing Talk, Text and Interaction. Great Britain, Cromwell Press Ltd.

Similä, M., Kouki, J., Mönkkönen, M., Sippola, A-L. and Huhta, E., 2006. Co-variation and indicators of species diversity: Can richness of forest-dwelling species be predicted in northern boreal forests? Ecological Indicators 6, 686-700.

Statistics Finland, 2009. Henkilötyövuosi. Available at: http://www.stat.fi/meta/kas/henkilotyovuosi.html.

Suter, W., 1998. Involving conservation biology in biodiversity strategy and action planning. Biological Conservation 83, 235-237

Sverdrup, H. and Svensson, G. E., 2002. Defining sustainability. In: Sverdrup, H., Stjernquist, I. (Eds.), Developing Principles and Models for Sustainable Forestry in Sweden. Kluwer Academic Publishers, Netherlands, p. 21-32.

Svensson, M. G. E., Stjernquist, I., Schlyter, P. and Sverdrup, H. 2002. Biodiversity in sustainable forest. In: Sverdrup, H. and Stjernquist, I. (Eds.), Developing Principles and Models for Sustainable Forestry in Sweden. Kluwer Academic Publishers, Netherlands. p. 273-296.

Sverdrup, H. and Stjernquist, I. (Eds.), Developing Principles and Models for Sustainable Forestry in Sweden. Kluwer Academic Publishers, Netherlands. 480 pp.

Tapio, metsätalouden kehittämiskeskus, 2006. Hyvän metsänhoidon suositukset. Metsäkustannus Oy. 100 pp. (in Finnish)

Tomppo, E., 1996. Biodiversity monitoring in Finnish forest inventories. Assessment of biodiversity for improved forest management. Proceedings of the international workshop 12-17 June, 1995. European Forest Institute. EFI Proceedings No. 6. 8 pp.

Tomppo, E., Katila, M., Moilanen, J., Mäkelä, H. and Peräsaari, J.,1999. Kunnittaiset metsävaratiedot 1990-94. Metsätieteen aikakauskirja, 4B/1999, 619-839. (In Finnish)

Tyrväinen, L., Pauleit, S., Seeland, K. and Vries, S. 2005. Benefits and uses of urban forests and trees. In: Konjonjendjik, C. (Eds.), Urban Forests and Trees. Springer.

Uuttera, J., Maltamo, M., Kurki, S. and Mykrä, S., 1998. Differences in forest structure and landscape patterns between ownership groups in Central Finland. Boreal Enviroment Research 3, 191-200.

Vaara, M. and Saastamoinen, O., 2006. Metsät ja puut arjen ajankäytössä – Kuvakulmia suomalaiseen elämäntapaan. In: Vehkamäki, S. (Eds.), Metsät ja hyvä elämä monitieteinen tutkimusraportti. Metsäkustannus Oy, Helsinki. p. 345-403. (In Finnish)

Valkeapää, A., Paloniemi, R., Vainio, A., Vehkalahti, K., Helkama, K., Karppinen, H., Kuuluvainen, J., Ojala, A., Rantala, T. and Rekola, M., 2009. Metsät ja metsäpolitiikka – kansalaisten näkemyksiä. Tutkimusraportteja – report 55. Department of Forest Economic, University of Helsinki. 36 pp. Available at: http://www.mm.helsinki.fi/MMEKN/tutkimus/julkaisut/Report55.pdf. (In Finnish)

Vanha-Majamaa, I. and Jalonen, J., 2001. Green tree retention in Fennoscandian forestry. Scandinavian Journal of Forest Research Suppl. 3, 79-90.

Vedung, E. 1998. Policy instruments: typologies and theories. In: Bemelmans-Videc, M-L., Rist, R. C. and Vedung, E. (Eds.), Carrots, sticks and sermons: policy instruments and their evaluation. Transaction Publishers, New Brunswick, p. 103-128.

Vehkamäki, S. 2006. Metsien käytön ja hyvän elämän murrosten vuorovaikutus - Kestävyyden näkökulma. In: Vehkamäki, S. (Eds.), Metsät ja hyvä elämä: monitieteinen tutkimusraportti. Metsäkustannus Oy, Helsinki. p. 33-167. (In Finnish)

Vehkamäki, S., Vierikko, K., Niemelä, J., Pellikka, J. and Lindén, H., 2006. Kestävää metsätaloutta: Sosiaalis-taloudellisten ja ekologisten kestävyysmuuttujien vaihtosuhteista. In: Vehkamäki, S. (Eds.), Metsät ja hyvä elämä: monitieteinen tutkimusraportti. Metsäkustannus Oy, Helsinki. p. 405-447. (In Finnish)

Vehkamäki, S., Hanski, I. K. and Vierikko, K., 2008. Trade-offs between different types of sustainability in the Finnish forestry. In: Stirn, Z. L. (Eds.), Emergin needs of society from forest ecosystems: towards the opportunities and dilemmas in the forest mangerial economics and accounting. Collection of presented scientific papers at the International Symposium. Biotechnical Faculty, University of Ljubljana. Available at: http://www.iufro404-08.si/.

Vierikko, K. and Niemelä, J., 2006. Arvojen ja arjen ekologinen kestävyys – metsätoimijoiden tulkinta ja ekologisen kestävyyden merkityssisällöt. In Vehkamäki, S. (Eds.), Metsät ja hyvä elämä: monitieteinen tutkimusraportti. Metsäkustannus Oy, Helsinki. p. 221-271. (In Finnish)

Viitala, J., 2003a. Metsätalouden vihreä muutos. Tietosanoma, Helsinki. 320 pp. (in Finnish)

Viitala, J., 2003b. Metsäsertifiointimme koko kuva. Tietosanoma, Helsinki. 251 pp. (in Finnish)

Vähänen, T. 2009. Criteria and Indicators for Sustainable Forest Management and Trade in Forest Products and Services. A Background paper for the Global project: Impact Assessment of Forest Products Trade in Promotion of Sustainable Forest Management. GCP/INT/775/JPN. Available at: http://www.fao.org/forestry/foris/data/trade/pdf/vahanen.pdf.

Wang, S. 2004. One hundred faces of sustainable forest management. Forest Policy and Economics 6, 205-213.

Willamo, R., 2005. Kokonaisvaltainen lähestymistapa ympäristönsuojelutieteessä. Sisällön moniulotteisuus ympäristönsuojelijan haasteena. Academic Dissertation. Environmentalica Fennica 23. University of Helsinki.

Yli-Pelkonen, V. and Niemelä, J., 2005. Linking ecological and social systems in cities: urban planning in Finland as a case study. Biodiversity and Conservation 14, 1947-1967.

Yli-Pelkonen, V. and Kohl, J., 2005. The role of local ecological knowledge in sustainable urban planning: perspectives from Finland. Sustainability; Science, Practice & Policy, 3-14.

Åberg, J., Swenson, J. E. and Angelstam, P., 2003. The habitat requirements of hazel grouse (*Bonasa bonasia*) in managed boreal forest and applicability of forest stand descriptions as a tool to identify suitable patches. Forest Ecology and Management 175, 437-444.