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Developing decision support in participatory strategic forest planning in Metsähallitus

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Academic dissertation

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ABSTRACT

The aim of this thesis was to develop new decision support for strategic forest planning in Metsähallitus, called natural resources planning (NRP), especially for supporting the participatory stakeholder group work. Until now the group's work has been based mainly on discussions and negotiations in the group on the subjects to be processed. Cardinal decision support methods, such as analytic hierarchy process (AHP) or interactive decision analysis (IDA) have also been applied to support the group's decision making.

Direct holistic evaluation of alternative plans and use of voting methods were studied in sub-study I, combined use of voting methods and IDA in sub-study II, and use of MESTA decision-support tool in sub-study III. Sub-studies I–III were integrated into ongoing NRP processes. Effects of the top-down planning approach to the efficiency of forest use on the whole Metsähallitus level were examined in sub-study IV, as well as acceptability of its results on the regional level. In these analyses the results of the top-down approach were compared to the results of the currently applied bottom-up approach. In sub-study IV, data of earlier NRP processes were utilized.

The results show that decision support should be applied in adaptive way in NRP. For the participation it is also important that the applied methods and tools are transparent, easy to understand and easy to use. In NRP, the solution can often be found with help of voting methods, which operate on ordinal scale and are easy to understand and use. Approval voting (AV) proved suitable for selecting decision criteria, Borda Count in eliciting preferences and Multicriteria approval (MA) in evaluation of the alternatives. When necessary, deeper analysis can be carried out by cardinal methods like IDA. Applied after the use of voting methods, IDA was felt rather easy to understand and use by the participants. MESTA tool proved also to be applicable in supporting the group decision making. Results of the direct holistic evaluation, in turn, showed that it does not provide any additional support for the stakeholder group work. Hierarchical analyses indicated that there are possibilities for deeper integration of the whole Metsähallitus level goals into the regional NRPs. To be implemented, participation at the Metsähallitus level needs to be introduced, NRP process revised and planning tools further developed.

Keywords: decision support, forest planning, hierarchical analyses, participation, voting methods

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My supervisors, Prof. Mikko Kurttila and Dr. Jouni Pykäläinen, advised and encouraged me during the whole project, which was crucial in completing the work. Prof. Timo Pukkala gave me valuable guidance at the beginning of the process, and his comments improved the manuscript remarkably during the finalization stage. Prof. Jyrki Kangas made an essential contribution to sub-study I, and Prof. Pekka Leskinen and MSc. Karri Pasanen brought their special expertise to sub-studies II and III. The comments and suggestions of the pre-examiners of the thesis, Prof. Gillermo Mendoza and Prof. Karin Öhman, motivated me to finalize and improve the work. I want to express my warmest thanks to all the aforementioned for their contribution to the work. Discussions with Prof. Annika Kangas, Dr. Teppo Hujala, Dr. Pauli Wallenius and many other researchers have also promoted this work, for which I would like to thank them.

Sub-studies I-III were integrated into ongoing regional natural resources planning processes in Metsähallitus, which were conducted by their own project teams. I thank the project teams for their readiness to provide research material and for their good co-operation in the projects.

I want to express my special thanks to Dr. Pentti Roiko-Jokela, my former manager and colleague, who encouraged me to continue the project in its early phases when it seemed difficult to integrate the project into my everyday work. Finally, the role of my family: Marja-Liisa, Sari and Saara, has been of the uppermost significance. Without their support and endurance this interminable project would have been a mission impossible.

Kajaani, March 2012
Veikko Hiltunen

LIST OF ORIGINAL ARTICLES

This thesis is a summary of the following articles and manuscripts, which are referred to in the text by their Roman numerals. The articles **I-III** are reprinted here with kind permision of the publishers while the study **IV** is the author version of the submitted manuscript.

I Hiltunen, V., Kangas, J., Pykäläinen, J., 2008. Voting methods in strategic forest planning - experiences from Metsähallitus. Forest Policy and Economics 10: 117–127.

II Pykäläinen, J., Hiltunen, V., Leskinen, P., 2007. Complementary use of voting methods and interactive utility analysis in participatory strategic forest planning: experiences gained from western Finland. Canadian Journal of Forest Research 37: 853–865.

III Hiltunen, V., Kurttila, M., Leskinen, P., Pasanen, K., Pykäläinen, J. 2009. Mesta: An internet-based decision-support application for participatory strategic-level natural resources planning. Forest Policy and Economics 11 (2009): 1–9.

IV Hiltunen, V., Kurttila, M., Pykäläinen, J. 2011. Strengthening country level guidance in natural resources planning of Metsähallitus: impacts on efficiency and acceptability of the forest use. Manuscript. 33 p.

The author was responsible in data collection in all sub-studies. He participated in designing the sub-studies and the analyses of the data in all sub-studies. In sub-studies I–III he was responsible of the questionnaires, and he carried out the analyses connected to voting methods. In sub-study IV the author was responsible for defining the alternative planning approaches in the Metsähallitus context. He also made the analysis of the results of different approaches, where calculations connected to the top-down approach were conducted by Kurttila. The author was the main writer in sub-studies I, III and IV.

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1. INTRODUCTION

1.1. Decision support

Decision making process

Decision making process is commonly understood to comprehend the whole chain from problem identification to the final choice: structuring a decision problem, defining the consequences of decision alternatives, eliciting the preferences of the decision makers, and evaluating and comparing the decision alternatives (e.g. Keeney 1982, Kangas 1992). The process can be described also in more detail (e.g. Pukkala 2007). All steps that precede decision are called decision analysis. They provide information and support to make the decision. The role of planning is to generate decision alternatives and predict their consequences. Decision is a selection among the alternatives; the result of decision analysis should be that the decision maker is able to evaluate the alternatives and choose the one best with respect to her / his goals (Pukkala 2007).

Decision making can be analysed from descriptive viewpoint (how people actually make decisions), or from prescriptive viewpoint, i.e. how decisions should be made to obtain the best result (e.g. von Winterfeld and Edwards 1986). Decision support is based on prescriptive approach and it aims at helping decision makers to improve their decisions (Kangas et al. 2008). Decision support relies on the idea of people's rational behaviour, where the decision maker tries to find the solution most favourable to her / him among the decision alternatives.

The role of decision support is sometimes emphasised in the literature. For example, Belton and Steward (2002) divide the process into three phases: problem structuring, model building and using the model to inform and challenge thinking. Keeney (1992) stresses decision makers to focus on values (goals, preferences) and on creating new alternatives based on their values. Both these approaches point the role of the process and decision support as boosters of "new thinking"; search of new solutions instead of evaluating existing ones. According to Keeney (1992), creating the alternatives is the most crucial phase of the decision making process. Basically the role of decision support is to help the decision makers to identify their fundamental values, which direct their selections.

Classifications of decision problems

Decision problems can be classified to one-dimensional and multidimensional (Kangas et al. 2008). In one-dimensional situation just one goal is considered, whereas multidimensional analyses assess many goals simultaneously. The problems may also be discrete or continuous. In discrete cases the number of possible alternatives is limited, while in the continuous cases it is infinite. Decisions can be made under certainty or uncertainty, and the number of decision makers can range from one to very many. From the decision making and support point of view, one-dimensional problem under certainty with one decision maker is the simplest situation. Consequently, a multidimensional problem including uncertainty and having a lot of decision makers is the most challenging.

In addition to the above classes, forest planning problems are conventionally divided into three categories: strategic, tactical and operational planning (e.g. Pukkala 2009). The direction of the management (what is wanted from the forests) is decided on the basis of strategic planning. In practise, the long term management goals and principles are set for the forest area. The goals are set e.g. for the forest owner's whole forest property, or on regional or country levels for forest policy purposes. Tactical planning defines how the goals are achieved in smaller areas (e.g. on district level), and operational planning shows how the operations are carried out on the basic management units level (mostly on the stand level). In operational planning situations, there may be only a few decision alternatives, making the problem obviously discrete. In tactical and strategic planning situations the number of different combinations of possible actions may be huge, practically infinite. In most problem formulations, the planning problem is still discrete, because stands are indivisible and each stand has a finite number of alternative treatments. In strategic planning, the number of evaluated alternatives may be reduced to a few although their potential number would be very high. Generally forest planning and decision making situations include also uncertainty. Decisions can be made by a single decision maker (the forest owner) or the process may include many decision makers, stakeholders and participants.

Optimization

Different tools have been developed to aid decision making in different situations. Mathematical optimization methods provide exact optimal solutions to decision problems. Applications based on linear programming (LP) (e.g. Dantzig 1963) are widely used. In LP, normally one goal is maximized or minimized, the other goals being formulated as strict constraints. LP applications suit best to one-dimensional continuous problems not involving uncertainty, although techniques to handle uncertainty in LP have also been developed (e.g. Hof and Pickens 1999). Integer programming is a LP modification, which allows the handling of planning units as indivisible, as often reguired in forestry practice. In the LP-modification called goal programming all objectives may be flexible and optimized simultaneously.

Simulation and optimization methods were adapted into forest planning in late 1960s and early 1970s. The U.S. Forest Service took the LP-based FORPLAN model (Iverson and Alston 1986) as the main tool of its strategic forest planning during the 1970s. It provided the basic practical tools to tackle multi-goal planning problems. FORPLAN was widely applied also outside U.S., and it has had a great impact on forest management throughout the world (Church et al. 1998). FORPLAN was substituted in U.S. in the 1990s by SPECTRUM that offered a more diverse set of optimization tools, like goal programming in addition of LP.

Simulation and optimization methods entered the Finnish forest research and planning in the early 1970s (Kilkki 1968). The first practical LP planning applications were developed at the Finnish Forest Research Institute (Metla) for strategic forest planning on regional and country levels (Siitonen 1983). Gradually the model has been developed into the current Mela software (Redsven et al. 2009), which utilises an optimization algorithm called JLP (Lappi 1992). Commercial delivery of Mela began in the 1990s, and now it is widely applied in strategic forest planning in Finland by the Finnish forestry actors, and also abroad. The use of integer and goal programming in forestry has been studied in Finland to some degree (Kangas & Pukkala 1992), but widely applied commercial planning tools have not appeared.

Practical planning cases are often so complicated that it is hard to tackle them by the exact optimization methods. The planning problem has to be simplified or it has to be solved by other tools. Heuristic optimization methods provide a set of techniques by which complicated problems can be described and handled more realistically than with LP (e.g. Reeves 1993, Pukkala 2007, Pukkala 2009). Heuristic methods can produce a good solution with fairly simple calculations, but they cannot guarantee an optimal solution. Heuristic optimization was introduced in the Finnish forestry in the early 1990s (Pukkala & Kangas 1993). MONSU

(Pukkala 2006) is an example of planning tools for practical forestry purposes, which applies many different optimization techniques and includes several heuristic techniques.

Multiple criteria decision support

Multiple criteria decision support (MCDS) methods have been developed for the analysis of multiple-criteria decision situations, and they are generally applied to situations where decision alternatives need to be evaluated holistically. Criteria are measures or standards, relevant and significant to the problem at hand, which can be used to judge if one alternative is more desirable than another (Belton and Steward 2002). The idea is to enlighten the problem from all interesting aspects by the applied criteria. The multiple criteria decision situation often includes conflicting interests, and a set of criteria that are difficult to compare with each other in equal terms. The key principle in the MCDS methods is to evaluate each alternative in relation to each individual criterion and then aggregate the results by using the aggregation rules of the applied decision model. The decision model combines the criteria measurements with decision makers' preferences in order to evaluate the alternatives (Lahdelma & Salminen 2010). Multi criteria decision support methods entered into the arena in the 1970's (see e.g. Korhonen et al.1992).

In multiple-use management forests are used to produce simultaneously several products and services, like income, biodiversity, recreation, etc., within the frame of the production possibilities of the forest (Kangas et al 2008). Multiple-use management was included in the principles of sustainable forest management (SFM) at the United Nations Conference on Environment and Development, in Rio, Brazil (1992). Sustainable forestry has to meet the criteria of biological, economic, social and cultural sustainability. In planning, ecological and economic issues can usually be tackled by experts, but participation of stakeholders and citizens is needed to fulfil the social and cultural dimensions of sustainability (e.g. Davis and Johnson 1986, Pykäläinen et al 1999). The first MCDS decision support applications in Finnish forestry were introduced in early 1990s (Kangas 1992). Then, MCDM methods have been frequently applied in forestry (e.g. Myllyviita et al 2011).

1.2. Need to develop decision support in strategic forest planning in Metsähallitus

1.2.1. History of forest management and planning in Metsähallitus

Forest management

Metsähallitus (the Finnish Forest and Park Service) was established in 1859 to manage the forests owned by the state of Finland. In the early days the most important task was to organise the forest administration and management. It was also important to protect the state forest from being utilised without permission for cultivation, tar burning, construction material or fire wood collection by new-settlers. Gradually the situation normalized in regard to illegal utilisation and the work of Metsähallitus started to emphasise forest management; i.e. cuttings and silviculture (Parpola and Åberg 2009).

In the course of time the Finnish state used its land, forest and water resources for the actual needs of the Finnish society. After the World War II, about 400 000 Finnish people (about 10 % of the population) had to be re-settled. Also state land was used for this purpose from the middle of 1940s to late 1960s. As a result, the area of state lands decreased from about

9.9 million hectares in 1950 to about 8.3 million hectares in 1970. Saw-logs and other wood material delivered from the state forests played an important role in the reconstruction of the post-war country. Cuttings in the state forests amounted to 6 million m^3 / year in 1950s and 1960s (rising even to 7.5 million m^3 in 1958), when they had been about 4 million m^3 / year before the war-time, and about 2 million m^3 / year in the beginning of the 20th century. From 1970s to 2000s the drain has been about 4.5 million m^3 / year.

Parallel with the growth of economic welfare, and partly as an international trend, the nature protection paradigm entered permanently into the central values of the Finnish society. It affected also to the stewardship of Metsähallitus. Several nature conservation areas, mainly national parks, were established in 1957. In the second wave of protection, peatland protection and supplementary national parks programmes were accomplished in the late 1970s. They were followed by protection programmes for old-growth forests in the 1990s, separately for South and North Finland. Most protection areas were established on the state land, and mainly in northern Finland. As a result, nature conservation and wilderness areas cover today about 45 % of the total land area of Metsähallitus. When the millennium turned to 2000s, programmes for enhancing biodiversity, like the forest biodiversity programme for southern Finland (Etelä-Suomen,.. 2002, Governmental… 2008) and the National strategy and action plan for conservation and sustainable use of biodiversity in Finland 2006–2016 (Heikkinen 2007), entered in. They cover all forest ownership categories, and their focus area is southern Finland. Consequently, in these programmes the role of state areas is not as crucial as in the earlier programmes, but still important.

Hunting, fishing and picking berries are the oldest forms of recreation uses, and earlier they were important also for livelihood. From those times dates the right of local citizens of northern Finland to hunt without charge on the state land within their living community. Construction of hiking and cross country skiing routes on special recreation areas made its breakthrough in 1960s and 1970s. Active fishing management in Metsähallitus was also often concentrated on the special recreation areas to serve leisure time fishers. Free cattling on state forests and peat lands was economically important for local farmers until early 1950s in northern Finland, and reindeer hurdling is still important on the northern reindeer management area. Today, many hills under Metsähallitus' governance are under the pressure of the expanding downhill skiing tourism, or the wind power industry as the newest incomer. Wind power mills are also planned in the sea areas.

The history demonstrates that the natural resources under Metsähallitus governance have all the time been used for multiple purposes, the mutual importance of different uses varying in time and space. In some cases there may have existed a single major use, like the post-war re-settlement, or the establishment of new protection areas, that overruled the other uses in the decision making (compare Berck 1999). However, it can be recognised that a central goal in the management has been an intention to find out an appropriate balance between different uses among different goals and disputes (Parpola and Åberg 2009). In history, the decisions were based on the actual needs and prospects, and on the political and human judgement that was supported by economic and other calculations.

Forest planning

Forest planning in Metsähallitus started with the mapping of the forest resources, in late 1800s. The first forest inventory was carried out in 1883–1905, when all log-sized trees of Metsähallitus were inventoried. Comprehensive inventories with long-term cutting budget calculations were started in1922 (Sandström et al. 2009). Thus, the tradition of inventories and strategic forest planning in Metsähallitus is about 100 years old.

The early long term cutting budgets were based on forest data received by systematic line inventory. The cutting amount was decided based on the area to be regenerated during next 20-year period in order to achieve a balanced age structure in a very long term (about rotation length), or applying the Austrian formula (see e.g. Pukkala 2007). When stand-wise inventories proceeded gradually from district to district and their information became reliable enough, the stand-wise data were approved also as the data base for long term forest planning during the 1950s. A cutting budget method called "Yield Cutting Budget" (Lihtonen 1959) was adopted in 1940s, and it was followed by a method named "Goal Cutting Budget" in 1960s (Kuusela and Nyyssönen 1962). The emphasis in the traditional strategic forest planning applied in Metsähallitus until the early 1990s was on assessing the sustainable yield in terms of the allowable annual cut, in the frame of tightly pre-decided resource allocation for different purposes.

Since early 1990s, management planning in Metsähallitus has been multi-objective. In addition to several different objectives it involves different geographical and temporal scales, many decision making levels, many stakeholders, and public participation. Partly driven by the paradigm of sustainable forest management, SFM (Rio declaration 1992), participation was introduced into the Finnish state forestry in the early 1990's in order to enhance the role of citizens and stakeholders in forest management decisions (Loikkanen et al. 1999). Simultaneously, natural resource planning (NRP) and landscape ecological planning (LEP) methods were developed to replace the traditional strategic forest planning (Roiko-Jokela 1995, Hallman 1998, Heinonen 1997, Karvonen 2000).

Natural resource plans are strategic long-term plans in terms of land-use, allowable cut, and other guidelines on a regional scale. The area of the regional plans ranged from about 0.5 million hectares to about 2.5 million hectares. In the landscape ecological planning the focus was set on analysing and sustaining biodiversity at the landscape level within the framework of NRP (Korhonen et al. 1998). Their area ranged from some thousands of hectares in South Finland to tens of thousands of hectares in North Finland, being in average about 35 000 hectares. Both NRP and LEP planning processes were based on stand-wise data, GIS analyses and the use of simulation and optimization methods in the Mela-software (Redsven et al. 2009). Participation played an essential role in both processes. Especially local and regional stakeholder groups were involved in the processes, and they gave their decision proposals to Metsähallitus. Altogether seven NRP plans and 112 LEP plans were developed during 1996–2000 covering practically all Metsähallitus' estates (Karvonen et al. 2001).

1.2.2. Metsähallitus today

Resources and management

The total area of the state–owned public lands is about 9 million hectares, located mainly in the northern and eastern parts of Finland (Figure 1). The key principle in forest management is the multiple-use approach. It is implemented by means of land-use allocation for different main uses, and using the same areas simultaneously for several purposes. About 3.6 million hectares are under commercial forestry, and in addition there are about 1.5 million hectares of poorly-productive commercial forests outside forestry activities. All commercial forests are open for recreational uses, and maintenance of biodiversity is emphasised in their management.

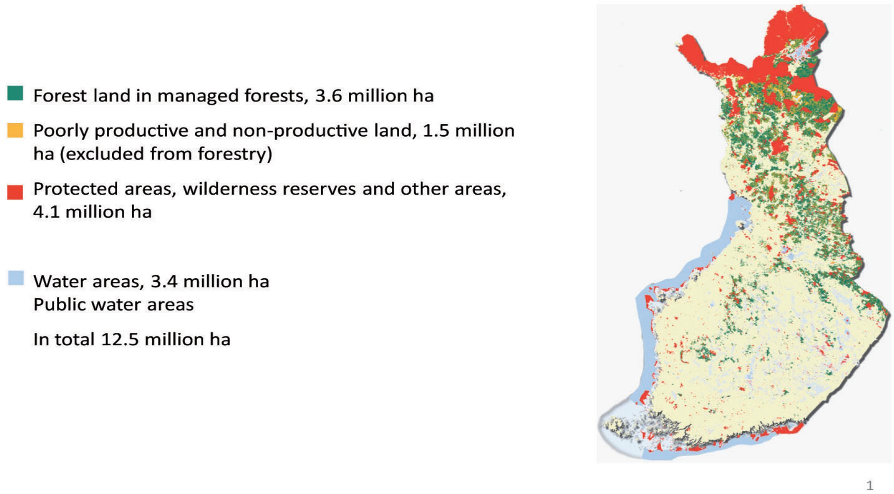


Figure 1. Metsähallitus' land and waters

The rest, about 4 million hectares, consists mainly of nature conservation areas and wilderness areas outside any forestry operations, but recreational uses are allowed in most places. Those 4 million hectares include also some minor areas assigned to some special use, like roads, for example. The area of public waters is about 3.4 million hectares, mainly sea waters. (Metsähallitus' Annual Reports 2010).

As a whole, Metsähallitus contributes to the welfare of the Finnish society by its forestry activities, by enhancing nature conservation and biodiversity, and by recreational services linked with forests and waters (including zoning of shores and hill-sides for leisure time housing and activities). The share of Metsähallitus of the total forest area of Finland is about 25 % and the share of the annual cut is nearly 10 %. Metsähallitus' annual cut is around 5 million m^3. More than 90 % of the nature protection areas in Finland are located in the state areas, and a major part of the recreational areas, too.

Organisation and decision making

Metsähallitus was a state department until the year 1994. Then it was transformed into a state-owned enterprise, which provides also public services in nature conservation and recreation. Today, Metsähallitus is internally organised into three main units: Metsätalous (forestry), Portfolio (the other business activities), and Luontopalvelut (public services). Forestry and the other businesses earn their money from their customers, while the public services are financed via the state budget. In 2010, the total turnover of Metsähallitus was about 365 million euro (€), producing a net income of about € 110 million (Metsähallitus' Annual Reports… 2010). About € 105 million was paid to the owner and the rest, about € 5 million, Metsähallitus invested in developing the enterprise. Public services were financed by about € 50 million. The total staff (salaried staff and workers, entrepreneurs) is nearly 3000 people.

Regarding to the decision making, the Finnish Parliament sets the general goals and guidelines of management through acts and decrees. The foremost acts concern the position and tasks of Metsähallitus, which also provides public services (Laki Metsähallituksesta 2004) and establishment of nature protection areas. Also the annual goals and budgets are confirmed by the parliament. More detailed supervision is carried out by the Ministry of Agriculture and Forestry and in biodiversity issues by the Ministry of the Environment. Metsähallitus is the practical manager of the state's property, actually fitting together the different political, customer and citizen level needs. Internally Metsähallitus is led by the chief executive officer (CEO).

Strategic forest planning

From the early 2000s the main strategic management planning tool has been the renewed natural resource planning (NRP) that combines the former NRP and LEP. The ecological issues are assessed and planned mainly on the landscape level, the other issues on the regional level. All results are then combined, analysed and reported on the regional level. The NRP plans are formulated for regions, whose areas range from about 0.5 million hectares to about 3 million hectares. The goal of a NRP process is to work out a balanced management concept for the region's resources for the next period. The strategy is officially decided and fixed for the first 10 years, but projections are done over time spans of 30–40 years in order to secure sustainability also in the long run. The NRP plans are renewed at intervals of ten years and reviewed midway through the period (Asunta et al. 2004).

The core of the NRP planning process is in generating a number of alternative strategies, and in analysing and evaluating them with respect of different aspects of sustainability. In determining the regional strategy, a holistic comparison and evaluation of the alternatives, from all dimensions of sustainability, is crucial. Basically, the NRP process produces information and support for this evaluation, assisting participants (stakeholders and citizens) and the staff of Metsähallitus to clarify what kind of outcomes the area's natural resources can produce and what they really want from the resources in the planning case. Thus, NRP is a typical strategic planning process, in discrete planning space, in which the direction and the general goals of the management are worked out (see eg. Pukkala 2007, Nordström et al 2010). In the participatory context of NRP, normally 5–8 interesting relevant alternatives are created (from the huge number of the alternatives) to illustrate the production possibilities of the planning area, and the results of different choices.

The general framework for NRP is set by the associated legislation and the supervision imposed on Metsähallitus by the state. NRP is then the company's own planning process to integrate the wishes of the operational environment to the frame set by the owner. The wishes are expressed in general level in the beginning of the process, and in details in the proposal of the stakeholder group to Metsähallitus near the end of the NRP process. Partly due to the emphasized role of participation, the NRP and LEP plans in 1990s were composed basically by the bottom-up approach, but within the frames and guidelines set for the management by Metsähallitus. The same holds true also for the current NRP planning. As a result, the NRP of the whole Metsähallitus level is in practice the sum of the regional NRP plans.

1.2.3. Experiences of decision support in Metsähallitus

Experiences from participation and MCDS methods

Participation in both NRP and LEP processes has produced much information about the attitudes and values of the local people and other stakeholders. In addition, new valuable knowledge concerning the specialities in the local nature was also achieved during these processes. Thus, for Metsähallitus, participation produced direct decision support, already as such. Participation brought more interaction and negotiation with stakeholders and citizens, and this way it contributed to the acceptability of the plans and activities in the operational environment. From the general perspective, participation proved to be a step towards more sustainable forestry in social terms (Loikkanen and Wallenius 1997, Niemelä et al. 2001, Wallenius 2001).

A basic lesson learned already in the early NRP processes was that planning problems related to NRP are quite complicated, and that it is hard to tackle the several and often contradictory goals and interests included without using any decision support tools (Pykäläinen and Loikkanen 1997). In order to respond to the planning challenges, different MCDS methods were tested. The very first tests of MCDS methods in Metsähallitus were applications of the analytical hierarchy process, AHP (Kangas and Matero 1993) and the heuristic optimization, HERO (Kangas et al. 1996). Later, Interactive Decision Analyses (IDA) has been utilised in some processes (Heinonen 1997, Pykäläinen et al. 1999, Kangas et al. 2001b). Also, the A'WOT method was tested (Kurttila et al. 2000, Pesonen et al. 2001) and outranking methods such as ELECTRE and PROMETHEE (e.g. Brans et al. 1986, Roy 1991, Laukkanen et al. 2001) were tested to some extent (Kangas et al. 2001).

Most NRP processes until early 2000s (and all LEP plans) were, however, carried out without using any MCDS methods, just participation was adapted. When the planning cases where MCDS was used were compared to the other cases, the experiences encouraged using MCDS decision support more systematically, and to test and apply also new methods in future NRP processes.

Need for versatile set of support methods

The role of decision support in the NRP planning is to help the participants to take over the planning situation, to focus on the key issues, to support the participants' own goal setting, and to facilitate the stakeholder group's decision making. On the other hand, the use of decision support tools should be simple, not making the planning too "technical" and steeling the focus. Thus, the need for adaptive application of decision support in participation can be recognised; in "easy cases" none or very simple support is enough, while in the "difficult cases" versatile and profound support may be necessary.

In the participatory context of Metsähallitus, the applied decision support methods should be transparent and easy to understand, explain and use. Handling both ordinal and cardinal information is also necessary, because different participating people prefer different styles of communication and interaction (e.g. Kolb 1984). The MCDS methods tested in Metsähallitus (AHP, HERO, SMART, IDA, A'WOT) have proved to be transparent and easy enough to use, providing "exact" cardinal priorities of the alternatives. However, their drawback is that cardinal data are needed. For example, expressing priorities in cardinal scale may be challenging for some people (e.g. Turban 1988, Pykäläinen et al. 1999).

1.3. The goal of the study

The general goal of this doctoral thesis was to develop the strategic forest planning of Metsähallitus, especially the participative and multi-goal approaches. The main objective was to develop and test the use of new decision support methods (not earlier tested in Metsähallitus) in the NRP planning, especially in order to improve the work of the NRP stakeholder groups. Development of the structure and contents of the whole NRP planning process (data, steps of the process, results and presentation of them, what (steps) should be emphasised, etc,) was also an objective of this study. In addition, possibilities to a deeper integration of the regional and the whole Metsähallitus planning levels were examined. The thesis was consciously focused on developing strategic forest planning in Metsähallitus because of the actual needs of Metsähallitus and the relevant test material provided by the organisation. However, the results of the thesis can be applicable also in other comparable organisations.

Three out of four sub-studies were carried out in the frame of the practical NRP processes. In this frame every research issue was included in a real, ongoing standard NRP process. Based on the consideration and the experiences from earlier NRP processes of Metsähallitus, different interesting new methods and analyses on their applicability were included in sub-studies I–III. In sub-study IV analyses of different planning approaches were carried out.

The specific objective in sub-study I was to study direct holistic evaluation and voting methods in NPR planning. The main research questions were, whether direct holistic evaluation can provide decision support that is enough in the NRP context, and how much the support that voting methods provide on ordinal scale promotes learning and assists decision making in the NRP context.

In sub-study II, combined use of voting methods and interactive utility analysis (IUA) were examined. The aim was to compare the easiness of use of voting methods (ordinal methods) and utility analyses (a cardinal method) for the participants. The other main research issue was to analyse the value added of cardinal decision support information, compared to that of ordinal information.

In sub-study III, use of voting methods and the Mesta decision-support tool (Pasanen et al. 2005) were analysed. Integration of the individual evaluation phase to the group evaluation phase, properties and functioning of Mesta, and the decision support it provides in the group work were the specific objectives of the study.

The specific objective in sub-study IV was to analyse the results of the top-down approach to efficiency of resource use and acceptability of the plans both on regional and Metsähallitus level, compared to the bottom-up approach. The hierarchical analyses in sub-study IV were not a part of any ongoing NRP process, but data of existing NRP plans were utilised in the work.

2. DATA AND METHODS

2.1. Data

The data for sub-studies I–III were collected in the NRP processes of Metsähallitus. The NRP processes took place in 2003 for Kainuu region, in 2004 for western Finland, and in 2005–2006 for eastern and western Lapland. The author was engaged in every process. The planning area in Kainuu covers about 1 million hectares, in western Finland about 0.5 million hectares, and nearly 4 million hectares in eastern and western Lapland. Analyses and evaluations were based on the outcomes of eight (8) alternative strategies in Kainuu, and on the outcomes of seven (7) alternatives in western Finland and in Lapland. The outcomes were described by eight (8) indicators in Kainuu and western Finland, and by ten (10) indicators in Lapland. The outcome matrixes of sub-studies I–III are presented in appendix A, as well as descriptions of the applied alternatives, criteria and indicators.

In sub-study IV, data of Bothnia region and eastern Finland were adopted in addition to the data used in sub-studies I–III. For the calculations and analyses, five alternatives were selected from every region, representing basic alternative ("business as usual"), two "extreme" alternatives (one emphasising biodiversity, the other emphasising wood production), and two alternatives in-between the basic and the extremes. Alternative plans were first produced at the bottom level (regional level). Thereafter, top level (Metsähallitus level) plans were generated from them by adopting principles of bottom-up or top-down approach.

In sub-studies I–III, altogether five stakeholder groups with nearly 80 members were involved. In Kainuu a group of 18 members was involved, in western-Finland 3 groups with totally 44 members, and in Lapland a group of 16 members. The participants' experiences of the processes were elicited by questionnaires in each sub-study. The questionnaires included about 60 questions in Kainuu, about 70 questions in western Finland, and about 40 questions in eastern and western Lapland. Free oral feedback was also received from the participants. About 100 people participated in public meetings of the planning processes. In addition, altogether about 70 statements on the plans were received from local communities and other stakeholders. About 350 people participated via internet.

2. 2. Creation of alternatives

The NRP planning process includes the following phases: evaluation of the current state of the planning area and operational environment, goal analysis, creation of alternatives, their evaluation and selection of one alternative as well as its further specification, implementation and follow-up (Asunta et al 2004). In goal analysis the stakeholder group selects relevant objective variables (criteria and indicators) for the analysis. In general they cover the following four perspectives: economy, social aspects, ecological and multiple use goals. The process is often iterative so that especially the goal analysis, creation of alternatives and evaluation can be repeated. For example, new alternatives may be added to the analysis. In the planning calculations, compartment data from the Metsähallitus databases are utilized. Calculations result in spatially explicit solution, i.e. treatment recommendation for each stand. Planning utilizes exogenous spatial approach (e.g. Kurttila 2001), where e.g. the constraints for important areas, such as capercaillie lekking sites are defined through GIS operations.

The creation and multi-criteria evaluation of alternative strategies is in the core of the NRP process. In the creation of alternatives, forest management principles and land use allocations are varied and the effects of these variations are found out. The main tool for these impact analyses is the MELA system, supported by GIS analyses. Typically, the process that was applied also in sub-studies I–III can be outlined as follows (e.g. Hujala & Kurttila 2010):

(i) Updating and / or acquiring forest inventory data from the planning area.

(ii) Defining treatment classes for planning area's stands (i.e. selecting stands that are under restricted use, or totally outside forestry operations) according to the principles of the alternative strategy in question by utilizing GIS operations etc.

(iii) Alternative treatments are created for the area's forest stands with computer simulations. In simulations, treatments (i.e. cuttings and necessary post-harvesting operations) are simulated

for stands that belong to the category "commercial forests" when thinning and regeneration criteria are met. In addition, also delayed thinnings and final cuttings are simulated for these stands. For stands that have been included e.g. in a treatment class "recreation", the first possible regeneration can be delayed e.g. by 40 years. Several treatment alternatives are simulated for all stands where commercial cuttings may be carried out.
(iv) Alternative forest plans are composed by allocating the treatment classes in every alternative according to the principles of that alternative. The relevance of the alternatives (e.g. how well they span the decision space) is secured by discussions in the stakeholder group.
(v) LP problems maximising the net present value (NPV) subject to constraints that secure long term sustainability are formulated and solved by the MELA system.
(vi) Multi-criteria comparisons of the alternative plans with MCDM techniques are carried out.

In the hierarchical analyses of sub-study IV, the current Metsähallitus level (top level) NRP plan (the sum of the regional NRP plans), corresponds to the alternative of the bottom-up planning approach. Creation of alternatives for the top-down approach was started by an effort to use the whole stand wise data of Metsähallitus. However, the Metsähallitus' Mela software application was not able to process this large data, and therefore a different top-down approach was adopted, in which all possible Metsähallitus level combinations of the regional plan alternatives were created (about 15600 combinations) and utilized in further analyses.

2.3. Evaluation of alternatives

In the core of the evaluation of the alternatives is the NRP stakeholder group that participates in all phases of the process. The final aim of their work is to create, with the help of different decision support tools and group negotiations, a commonly accepted proposition for Metsähallitus, in which they define which kind of forest management (which alternative) they recommend for the region. The decision support methods and tools applied in this thesis are presented in the following paragraphs.

2.3.1. Direct holistic evaluation

In direct holistic evaluation the alternatives are evaluated based on their results as a whole, without more specified analyses. The method was used in sub-study I to rank the plan alternatives. The production possibilities of the planning area and the trade-offs between different outcomes were learned and analysed first by utilizing the outcome matrix. Thereafter, alternative plans were evaluated holistically, considering simultaneously their results as a whole. Every stakeholder group member made her/his own evaluation independently, and thereafter the group's view was developed by discussion and negotiation.

2.3.2. Voting methods

Voting methods have been widely used in different kinds of social decision processes in order to combine individual preferences into a collective choice. They can be classified into approval voting and preferential voting categories (Pukkala 2007). Plurality voting is the most common voting method, and it is "the standard method" in elections etc. Approval voting (AV) is another common method in the category of approval voting. The Borda count method, cumulative voting and multi-criteria approval (MA) are also widely applied preferential votings, and there exist many other voting methods, too (see e.g. Kangas et al. 2006).

In plurality voting, every voter has one vote that he/she casts in favour of the most preferred candidate, and the candidate receiving most votes is the winner (Cranor 1996).

Approval voting is a voting system where each voter gives a vote for every candidate he/she approves (Brams and Fisburn 1983). Every voter can vote for as many candidates as he/she "approves". The candidate receiving the greatest number of votes is declared the winner.

The Borda count method was originally introduced in 1781 (de Borda 1781). The method takes into account the voters' preference rankings of the candidates. In the case of n candidates, each voter gives n votes for the most preferred candidate, n−1 for the second preferred candidate, and finally one vote for the least preferred candidate (e.g. Saari 1994). The candidate getting the most votes is the winner.

In cumulative voting, every voter is given as many votes as there are candidates in the election and the voter can cast them freely to the candidates according to his/her preferences (Blair 1973). In a commonly used modification of cumulative voting, each voter distributes 100 points among the candidates in a way relevant to his/her preferences. All points can be given to a single candidate, they can be distributed evenly among all the candidates, and all combinations in-between are also possible.

Multi-criteria approval (MA) is an extension of approval voting that was developed for multi-criteria decision support (Fraser and Hauge 1998). MA is used for holistic evaluation of decision alternatives. The key information needed in order to rank the alternatives is the importance order of the evaluation criteria, and the border of approval for each criterion. Every alternative is first evaluated to be either approved or disapproved in relation to each criterion. Thereafter, the alternatives are ranked holistically in relation to the importance order of the criteria. The standard version of MA has been developed for one decision maker, but it is also suitable for group decision making if the decision makers can agree on the importance order of the criteria and on the border of approval for each criterion (Kangas et al. 2008).

In this study, plurality voting and approval voting were used to select the indicators of decision criteria in sub-studies I–III. Plurality voting was applied also in public participation (in "open house meetings") to rank the alternatives. Borda count method was used in sub-studies I–III and cumulative voting in sub-studies I and II to elicit preferences of the stakeholder groups by ranking the criteria in their importance order. Multicriteria approval was adopted in ranking of the alternatives in sub-studies I and II, using criteria specific averages as approval borders.

Advantages of voting methods include that they are familiar to many people from other contexts, like elections. Their principles are also easy to understand, and they operate with low-scale information. This means e.g. that it is enough to elicit preferences in ordinal scale. On the other hand, if the preference information is elicited in cardinal scale it stays partially unutilised by voting methods.

2.3.3. Complementary use of voting methods and interactive utility analyses

Combined use of voting methods and utility analysis was tested in sub-study II. Voting methods were first used in selecting the indicators of the decision criteria, in eliciting preferences, and then in the ranking of the alternatives. Thereafter, utility analysis was carried out within the most interesting alternatives in order to provide cardinal priority information between them.

Interactive decision analyses (IDA) combines SMART (e.g. von Winterfeld and Edwards 1986) and AHP (e.g. Saaty 1990) techniques. In an IDA process, partial utility functions are first defined by experts for each decision criterion. The functions are then presented, discussed and agreed (or changed) in the group of participants. The weights of the criteria are decided in an interactive process by the participants. Weights can be defined either by the direct rating techniques of SMART or by the pair wise comparison techniques of AHP. Lately, an additive utility model is applied to rank the solutions (Pykäläinen et al. 1999).

In sub-study II, principles of IDA were applied complementarily with voting methods, calling the application as interactive utility analyses (IUA). The IUA process was launched by illustrating the planning problem to the group members graphically in a form of a decision hierarchy (the decision model). After that, the expertise based sub-utility functions and weights for the criteria were presented and thoroughly discussed in the group. As a result, the expertise based sub-utility functions and the criteria weights were selected for the starting point for a participatory IUA process. Later in the IUA process, the participants defined the final criteria weights, and after that the total utilities of the alternative strategies were calculated by summing up their scaled sub-utilities.

2.3.4. MESTA

MESTA is an internet-based decision support tool for discrete choice problems. Theoretically it dates back to the functional idea of feasible region reduction methods (Steuer 1986). When applying feasible region reduction methods, the constraints of the problem are iteratively reformulated until the decision maker is satisfied with the result. Parallel with the reformulation, the decision maker progressively defines her/his preferences.

In participatory forest planning Mesta provides an illustrative internet-based user interface for carrying out the interactive reduction of the feasible set of plan alternatives. Reduction is done by adjusting the thresholds (the acceptance borders) of the criteria. These correspond to the constraints of the feasible reduction methods. The basic idea in the acceptance threshold definition in a case of only one decision maker is that the decision maker assesses and adjusts the acceptance thresholds until one and only one of the decision alternatives exceeds all thresholds (Pasanen et al. 2005). A further aim is to adjust the acceptance thresholds as long as the decision maker understands the potential trade-offs behind the decision criteria. In particular, the decision maker should ensure that he/she is not willing to make any further adjustments to the thresholds, i.e. the decision maker is sure that he/she has found the alternative that best meets his/her objectives. In a participatory planning process the individual adjustments produce preference data for the forthcoming group work supported by the MESTA tool.

In sub-study III, the stakeholder group used Mesta tool both individually and as a group, when they had first become familiar with the production possibilities of the planning area. First, the stakeholder group members adjusted their individual approval borders of the criteria. These results were integrated to the group negotiation phase so that the average indicator-specific values of the individual phase were used as the initial values for the group adjusting process. A facilitator used the MESTA tool in the group adjustment. The adjustment was carried out in the descending order of importance of the criteria. The importance of the criteria had been elicited earlier by the Borda count method.

2.3.5. Hierarchical analyses

In hierarchical analyses results of different planning approaches are analysed from different points of view (e.g. Kurttila et al. 2001, Hujala & Kurttila 2010). Impacts of different planning approaches on the efficiency and acceptability of forest resource use on Metsähallitus and regional levels were analysed in sub-study IV.

The results of the current bottom-up approach were used as a reference in the analyses. In the top-down approach, it was analysed especially whether the Metsähallitus' forest resources can be used more efficiently than currently from the whole Metsähallitus point of view. The results of the top-down approach were compared to those of the current bottom-up approach. Acceptability of the top-down approach on the regional level was analysed by comparing what changes would be needed in the regional strategies if the top-down approach was applied. Based on the results of those analyses, possibilities for a better integration of the Metsähallitus and regional levels in the NRP process were assessed.

3. RESULTS

3.1. Use of new decision support methods in the NRP process

Direct holistic evaluation

In sub-study I, eight decision alternatives were evaluated (see appendix A): 1. Basic alternative (business as usual), 2. Basic alternative with a more scattered ecological network, 3. More emphasis on nature conservation compared to Basic alternative, 4. Emphasis on wood production, 5. More emphasis on recreation and tourism compared to Basic alternative, 6. Combination of alternatives #3 and #5, 7. Combination of alternatives #4 and #5, 8. Great emphasis on nature conservation.

The outcomes of the alternatives were described with eight indicators: A. Area of the ecological network, B. Quality of the network (school grade by specialists), C. Total net income from forestry and other commercial activities, D. Sustainable (allowable) annual cut, E. Area of forests older than 80 years (suitable for recreation like hiking etc.), F. Area of forests younger than 20 years (suitable for game such as moose and hares), G. Metsähallitus employment (person years), H. Gross turnover.

In direct holistic evaluation every group member evaluated the plan alternatives first individually, and thereafter they were evaluated in the group by discussions. Future changes in markets and in the values and needs of people were analysed to some degree in the discussions. In the group evaluation the basic alternative (business as usual) and alternative 5 (more emphasis on recreation and tourism) become preferred over the others. These two alternatives were assessed both providing a balanced set of outcomes. The conclusion of the group's chairman was that the basic alternative would do well also in the coming period, but alternative 5 might also meet well the future demands. An explicit common agreement on, which one of those two would be better, was attempted to reach but could not be worked out. This direct holistic evaluation result differs slightly from the group's evaluation result by the MA voting, which named alternative 5 the best. At the end of the process, the group proposed for Metsähallitus alternative 5 as the basis for the future strategy.

In sub-study III, it was also noticed that in a direct holistic evaluation which is based on just the outcome matrix, there is the risk that the participants may rely more on their feelings than on profound analysis of the decision alternatives. As a whole, direct holistic evaluation was found to be an easy and straightforward way to evaluate alternatives, resembling people's everyday, "ad hoc" decision making (Steuer 1986), but it did not promote the participants' learning. Neither did it help the stakeholder group in problem structuring and systemizing the decision making process.

Voting methods

Easiness to understand and use voting methods

In sub-studies I and II, the stakeholder group members elicited whether the applied voting methods are easy to understand and use. The principles of approval voting (AV), Borda count, cumulative voting and multi-criteria approval (MA) were found easy to understand in both sub-studies, although the principles of MA were not felt as easy as the others (Table 1). About two thirds (2/3) of participants agreed with the statement that the principles of voting methods are easy to understand, except MA for which only about 50 % agreed. AV, Borda count and cumulative voting methods were also felt easy to use, but MA was felt to be more difficult in both sub-studies (Table 2). In sub-study III, AV and Borda count were felt easy and useful (oral feedback, not asked in the questionnaire). To conclude, all the applied voting methods in this research were felt quite easy to understand and use, but MA was felt less easy as the others.

Table 1. Participants' responses to a statement: "voting methods are easy to understand".

Method	sub-study	agree	slightly agree	disagree
AV	I	67	33	-
	II	77	23	-
Borda Count	I	67	33	-
	II	55	39	6
Cumulative voting	I	75	25	-
	II	66	22	17
MA	I	50	50	-
	II	48	41	11

Table 2. Participants' responses to a statement: "voting methods are easy to use".

Method	sub-study	agree	slightly agree	disagree
AV	I	59	33	8
	II	66	28	6
Borda Count	I	59	33	8
	II	56	33	11
Cumulative voting	I	50	42	8
	II	61	22	17
MA	I	42	41	17
	II	18	71	12

Support in learning

In the NRP processes of sub-studies I–III, the current state was assessed in two parts: evaluation of the performance of the past plan, and analyses of the present situation (compare Asunta et al. 2004). Correspondingly, the planning phases of the NRP process were named in the questionnaires as: a. success of the past plan, b. analyses of the present situation, c. analyses of objectives, d. analyses of the production possibilities, and e. choice of the future plan. In the responses of all sub-studies I–III, all the phases of the process were experienced to be valuable for learning. However, the analyses of the present situation, and the analysis of the production possibilities were ranked as having the highest value in supporting learning, both in the responses given to the questionnaires (Table 3) and especially in free-form oral feedback. In sub-study I, goal analyses were felt important, too.

In the analyses of the present situation, presentation, explanation and illustration of the existing resources, and discussions in that context were felt valuable for learning. In the analysis of production possibilities, the outcome matrix of the alternatives was felt to expose in a concrete way the production possibilities of the area. When trade-offs between different outcomes were still analysed and illustrated (by experts) in more detail, the analysis of production possibilities was recognised having high importance in grasping the planning situation.

Voting methods were assessed helpful in keeping the process easy, concrete and transparent. In sub-study I, about half of participants responded in the questionnaire that the use of voting methods and the related discussions and argumentations were of very high or high value for learning. In sub-studies II and III, voting methods and the related discussions were not felt as important in learning as in sub-study I.

As a conclusion, the applied voting methods promoted the participants’ personal and collaborative learning in the selection of the criteria (“what are the essential issues in this planning case and how they should be described and measured?”), in considering objectives and preferences (“what is important to me /us, and how important the objectives are in relation to each others?”), and in the evaluation of the alternatives (“how the plan alternatives fulfil my / the group’s preferences?”).

Table 3. The most important planning phase for learning of the participants.

			Phase		
Sub-study	**a**	**b**	**c**	**d**	**e**
I	-	9	36	55	-
II	-	21	16	47	16
III	-	26	15	48	11

Support to decision making

Plurality voting and approval voting were used in sub-studies I-III to support the selection of the indicators of the criteria in the group work. Their use in this step proved to be simple and transparent, and they promoted the groups to specify the relevant common indicators. Plurality voting was used also in public meetings to pinpoint the best strategy, and the method worked well.

Borda count method and cumulative voting were used in order to elicit the participants' preferences, by setting the indicators into importance order in sub-studies I and II. The results of the methods differed from each other in both sub-studies. The main reason for the differences may be that cumulative voting allows a more value-based order of importance definition than Borda count voting, because in cumulative voting one can omit some criteria (irrelevant to him/her) in the ranking process.

In sub-study I, importance order votings were completed both before and after the alternatives' outcomes were known. The information received on the production possibilities influenced on the group's preferences, and, correspondingly, the voting results differed a lot (Table 4). The conclusion of the stakeholder group was that the posterior Borda count voting result is the most relevant preference base for evaluating the alternatives. The Borda count method provided, in a way, a more holistic picture of the goals than does cumulative voting, which is also easier to manipulate (e.g. Kangas et al. 2006). The results suggest that it seems preferable to elicit the preferences by Borda count voting after knowing about the production possibilities and mutual dependences of the outcomes.

Multicriteria approval (MA) was applied in sub-studies I and II for holistic evaluation of the alternatives. In sub-study I, MA clearly pointed a winner candidate among the strategy alternatives (Alternative 5 in Table 5). For the participants, the alternatives were easier to rank by MA than by direct holistic evaluation. At the end phase of the process the group proposed to Metsähallitus the candidate selected in MA for the next period's strategy. In sub-study II, no winner could be found by MA, but four alternatives appeared equal good (Alternatives 4–7 in Table 6).

Table 4. Importance order of the criteria in the stakeholder groups by different votings in sub-study I.

Cumulative voting, a priori	Borda count, a priori	Borda count, posterior
D	A	G
B	E	D
E	D	E
G	G	B
A	B	A
H	F	H
F	C	F
C	H	C

Table 5. The approval of the alternatives in relation to the criteria in sub-study I.

Alternatives	G	D	E	B	A	H	F	C
1	+	+	-	+	-	+	+	+
2	-	+	-	-	-	+	+	+
3	-	-	+	+	+	-	-	-
4	+	+	-	-	-	+	+	+
5	+	+	+	+	-	+	+	+
6	-	-	+	+	+	-	-	-
7	+	+	-	-	-	+	+	+
8	-	-	+	+	+	-	-	-

Criteria columns G–C. The criteria are in their importance order

Table 6. The approval of the alternatives in relation to the criteria in sub-study II (in one of three stakeholder groups of the sub-study). The criteria are the same as in sub-study I, but alternatives are partly different from those of sub-study I.

Alternatives	A	E	G	B	C	F	D	H
1	-	-	+	-	+	-	+	+
2	-	-	+	-	+	-	+	+
3	-	-	+	+	+	-	+	-
4	+	+	-	+	-	+	-	-
5	+	+	-	+	-	+	-	-
6	+	+	-	+	-	+	-	-
7	+	+	-	+	-	+	-	-

The criteria are in their importance order

They were approved in relation to the foremost, second, fourth and sixth criterion in order of preference, whereas the remaining three alternatives were not. However, the four alternatives were deadlocked with one another, because they were approved and disapproved in relation to the same criteria. It was hard to judge their mutual preferences based only on this analysis, and therefore cardinal analyses were needed. Tables 5 and 6 show that preferences of the stakeholders in sub-studies I and II differ quite a lot.

The participants concluded that the use of voting methods contributed especially to negotiation and consensus within the group as compared by direct holistic evaluation of only the outcomes of the alternatives. In sub-study I, most participants shared the opinion that the process influenced their goal setting much or moderately. From the goal setting perspective, the discussions and argumentations within the group during presentation of the outcomes and in context of voting were experienced equally useful as the analyses of production possibilities. About 40% of the participants saw that these discussions influenced their goal setting much or very much. The rest assessed that they had a moderate influence. Two thirds of the participants estimated that the process succeeded in fitting together the participants' goals well or very well. The rest saw that the success was moderate.

As a summary on use of voting methods, the results of this study show that voting can be used in selecting and specifying the evaluation criteria (and /or indicators) and alternative plans, in eliciting and ranking preferences, and for the holistic evaluation of the alternatives. Voting methods are easy to learn and explain, and they promote keeping the process simple and transparent. Although the methods need and provide only ordinal information, they may often find the solution and in cases they do not, the result can be used as a basis for further analysis.

Complementary use of voting methods and interactive utility analysis

Voting and interactive utility analyses (IUA) were used in a complementary way in sub-study II, without knowing beforehand the results of voting methods. The idea was to analyse the most interesting alternatives more specifically on cardinal scale, and to assess the value added they provide after the ordinal analyses by voting methods. When voting ended in deadlock within four candidates (Table 6), the cardinal analyses of IUA were needed to support the practical choices in the planning case. The IUA process found a quite clear winner among the candidates (Figure 2), and sensitivity analysis proved the solution also stable. At the end of the process, the group proposed for Metsähallitus the same strategy alternative (alternative REC in Figure 2) to be selected as the final strategy.

From the decision support perspective, the IUA session made it easier for the majority of the participants to define their own goals for the strategy. In general, the results of voting and IUA supported each other in this sub-study. This made it easier for the participants to write down their final statements for the decision proposal. In the NRP process of sub-study II, the decision support offered by IUA was more versatile than that of voting methods. Experiences from this case support combined use of voting and IUA. Applying both of them in the same process enables better possibilities for evaluating the alternatives and the planning process as a whole.

Most of the working group members learned new and essential matters during the IUA process. Especially they experienced better understanding of the decision problem through getting familiar with the decision hierarchy, and they learned a lot by doing the interactive weighting of the criteria. Sensitivity analyses proved also valuable for learning. Taking into account that the IUA was carried out last in the process, its contribution to participants' learning has to be considered remarkable. The participants also assessed the easiness of the applied methods, and according to their feedback there was no difference in the easiness of understanding the voting and the IUA methods. However, it has to be noticed that if the methods had been applied in the opposite order, IUA first and votings thereafter, the responses might have been different. As a conclusion of this study, adaptive use of ordinal voting methods and cardinal IUA method is recommendable in actual NRP processes.

Use of Mesta tool

In sub-study III, the stakeholder group used Mesta tool (Figure 3) both individually and as a group, when they had first become familiar with the production possibilities of the planning area. Most group members used Mesta in the individual evaluation phase of the alternatives, and decided their acceptance threshold values by it. However, only one group member carried out the acceptance threshold definitions so far that only one alternative was accepted with respect to all indicators. All the others stopped too early, i.e. they defined the thresholds so high that none of the alternatives met the acceptance thresholds for all of the indicators. In the group evaluation phase, the average indicator-specific values of the individual phase were used as the initial values for the group adjusting process.

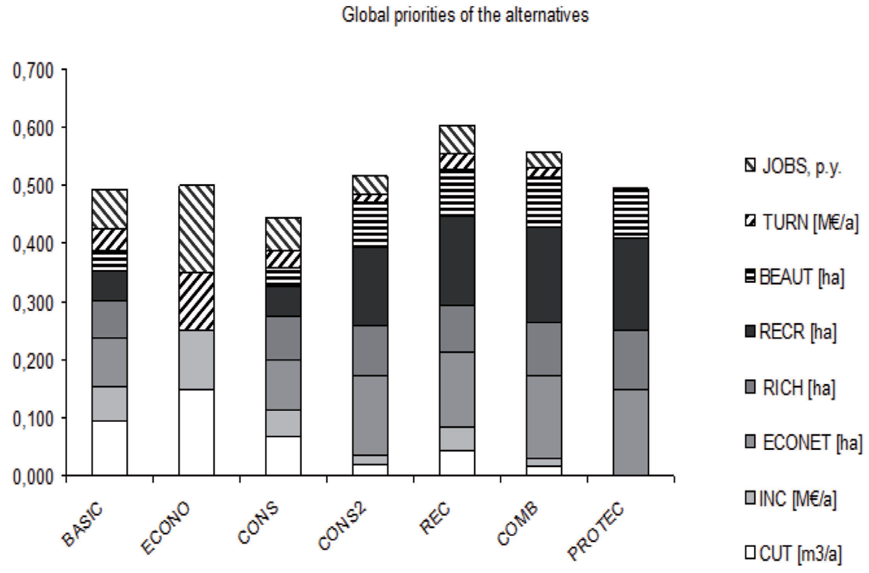


Figure 2. Cardinal priorities of the alternatives in sub-study II.

In the beginning, Alternative 2 fulfilled the largest number of acceptance borders, but not all. The adjusting was started from the least important indicator, and the end result of the iterative adjusting procedure was that Alternatives 2 (more emphasis on recreation, compared to basic alternative), 4 (more emphasis on reindeer hurdling, compared to basic alternative) and 5 (slight enlargement of ecological network, compared to basic alternative), and Basic alternative could be accepted out of seven alternatives. This result satisfied the group, and they did not want to proceed further in the Mesta analysis, e.g. to continue adjusting the indicator-specific acceptance thresholds in order to decrease the number of feasible alternatives. After the Mesta analyses the stakeholder group held a meeting, and as their final result, the group recommended the implementation of Alternative 2.

Most participants responded that they were able to use Mesta by themselves and that they understood the principle of the method. However, only one participant used Mesta to a point where only one alternative became accepted. One explanation for this result may be that the participants did not, after all, understand the Mesta principle and for that reason they did not continue with fitting their goals into the production possibilities long enough. Another possibility is that the participants consciously emphasized the goals that were important to them, in order to secure their positions in the forthcoming group negotiation phase.

The use of Mesta at individual level was not felt to be very educational for the participants. Instead, the Mesta-supported negotiation process proved to be important for learning in the group. The use of Mesta, with all the indicator-specific threshold values on the interface at the same time, promoted the participants' learning about the trade-offs between the indicators. It also boosted negotiations within the group. During this negotiation process, the participants discussed and analyzed the contents of the alternatives in more details than earlier. They also arrived at the common conclusion that the acceptance levels of certain criteria may not be reduced at all, due to reasons they all agreed upon.

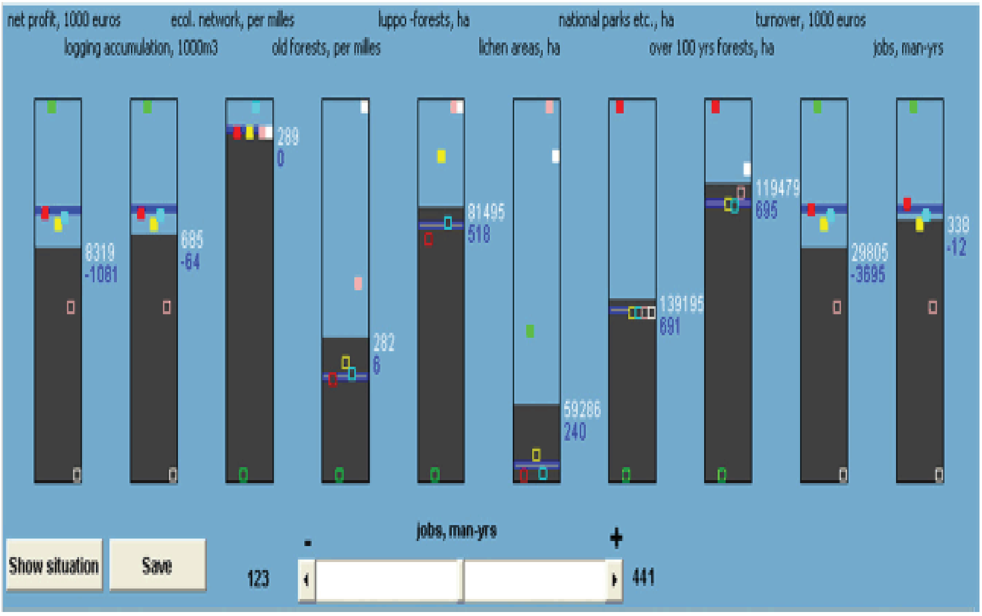


Figure 3. Acceptance borders and acceptability of alternatives described through the Mesta interface at the beginning of the group adjusting process. The acceptance borders for each criterion are marked with blue color in each bar (i.e. the acceptance border is at the level where black color changes to blue color, the black color pointing the not- acceptable value area). The criteria values of Basic alternative (reference values) are marked with blue lines, and the criteria values of the other alternatives with dots and rectangles in different colours. The numbers aside the bars refer to the current acceptance border value (white), and to the positive or negative difference of the reference value from it (blue).

Thus, the group's preferences became clearer during the Mesta-supported negotiation process and this encouraged the group to find a jointly accepted solution.

Almost all the participants had identified their favourite alternative already when analysing the production possibilities, before using Mesta. Thus, the use of Mesta at the individual evaluation phase had not been necessary. The results from the individual Mesta phase however facilitated the group negotiation process because the acceptance thresholds of the individual participants were utilized in it in different ways. The Mesta group evaluation phase was ended when four alternatives out of seven became accepted. Therefore the group's recommendation to Metsähallitus was not identified directly through the use of the decision support tool. However, the process was significantly facilitated by the use of Mesta, when the common acceptance thresholds for the criteria were found. In the questionnaire, six of ten participants responded that the use of Mesta was very useful or useful in the group negotiation phase.

As a summary, Mesta supported learning and negotiations in the stakeholder group and in this way contributed to the group decision making, although the final solution was not directly found by the tool. At the individual level, the role of the tool in learning and decision support was not felt as significant.

3.2. Development of the structure and contents of the NRP process

The NRP process of Metsähallitus follows the conventional structure of a participatory planning process. It is divided into steps of structuring the decision problem, defining decision alternatives and assessing the impacts of each alternative, determining the preferences of the decision makers and participants, and comparing and evaluating the decision alternatives (e.g. Kangas 1992). The actual decision is then made based on the information and decision support produced in the planning process (e.g. Pukkala 2007).

The responses by the participants show that the NRP planning process is clear as a whole, and it is divided into rational phases. However, the responses stressed the key role of the alternative plans, which were experienced as the most important part of the process. Plan alternatives helped the participants to structure the problem and to view it from all dimensions according to the multi-goal approach. The alternatives provided valuable information for learning and understanding the production possibilities of the area and the trade-offs between different objectives. This information helped the participants in analysing their fundamental values and mutual trade-offs between the values, which form the basis for the evaluation of the alternatives. The lesson learned in this study is that much consideration has to be put on generating the alternatives, their number and contents, and on expressing, visualising and explaining their outcomes. In the participatory NRP context the outcomes of the alternatives need to be expressed in simple, tangible and transparent terms.

From the learning point of view, a larger number of alternatives (7–9 alternatives) seems preferable. In the planning cases of this study also the “extreme” alternatives, outside the allowed decisions, provided valuable information on the production possibilities and trade-offs. From decision support point of view, the “extreme” alternatives may be a bit problematic. The use of the values of the extreme alternatives can bias the calculation of the arithmetic means that are used as approval borders of the decision criteria e.g. in MA. Experiences of public meetings suggest preferring in the group evaluation a few main alternatives that considerably differ from each others, instead of a large number of alternatives with minor differences. In hierarchical analyses (paragraph 3.3.), it seems to be useful to illustrate the production possibilities by alternatives including a lot variation, while the real evaluations need to be restricted to alternatives that can be implemented in practise.

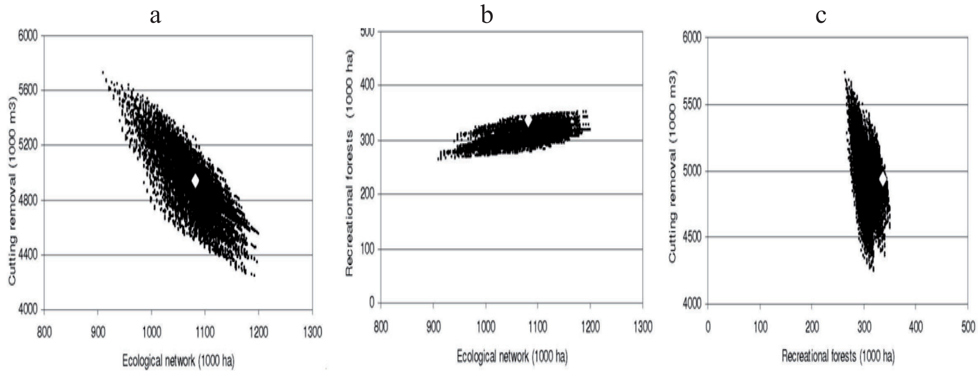
As a conclusion of this study, the NRP planning process is functional as a whole. In Metsähallitus’ planning context, five to seven “real“ plan alternatives seem to be suitable, and some of them should be created adaptively in the course of the process. The alternatives have to be able to illustrate the interesting, relevant decision space within the production possibilities. In public meetings just a few (3–5) alternatives should be included in the evaluation. Regarding the number of evaluation criteria (indicators), the experiences from the sub-studies support using five to eight criteria in the evaluation of alternative plans. Especially criteria with high correlation could be avoided. In the learning phase, using more criteria (8 applied in general) proved to be useful.

3.3. Integration of regional and national planning levels in Metsähallitus

Results of the bottom-up and top-down approaches

Currently the Metsähallitus level (top level) NRP plan can be achieved by summing the regional (bottom level) NRP plans. This corresponds to a typical bottom-up planning approach.

Figure 4 a, b, c. Interrelationships between ecological network and cuttings, ecological network and recreational forests, and recreational forests and cuttings on the Metsähallitus level in the top-down approach.



In sub-study IV, the top-down approach was started by an effort to run the Mela-simulation and optimization programme using the whole stand wise data of Metsähallitus. The number of calculation units increased from about 0.2 million units in the regional calculations to more than 1 million units in this calculation, and the size problem of LP (Rose et al. 1992) was met; the problem was unmanageable. Thus the common top-down results, where all the basic management units are organised optimally from the top-level point of view (Weintraub and Cholaky 1991), were not achieved in the study. Therefore, another top-down approach was adopted, in which all possible Metsähallitus level combinations of the above regional plan alternatives, 15 625 combinations were calculated. The results of this total enumeration are presented in Figure 4 a, b, c. The results of the current approach are marked with a white rectangles in the figure.

Evaluation of the solutions from the whole Metsähallitus level perspective

Among the created 15 625 country level solutions, there were seven solutions that provide pareto improvements from the reference solution. In these solutions, it is technically possible to increase the ecological network at maximum by 13 000 hectares, recreation forests by 7 000 hectares or cuttings by 43 000 m^3 /year and at the same time avoid decreasing the values of the other two indicators from the reference solution. However, the pareto improvement possibilities are minor since generally the increase is less than 1% from the indicator values of the reference solution.

Maximizing ecological network on the Metsähallitus level (+118 000 ha) would mean a heavy decrease in allowable cut (-385 000 m^3 /year) and decrease also in recreation areas (-18 000 ha) on the country level. Maximizing cuttings (+795 000 m^3 /year) would, in turn, shrink remarkably both ecological network (-172 000 ha) and recreation areas (-73 000 ha), compared to the reference solution. Maximizing recreation areas (+14 000 ha) would increase ecological network (+94 000 ha) and drop cuttings (-344 000 m^3 /year). The above results show that there are possibilities to change Metsähallitus level forest policy targets (mutual emphasis of different forest uses) and adapt forest use according to them.

Evaluation of the solutions from the regional perspective

The seven solutions that provide pareto improvements from the reference solution are well in line with the strategy selection in Eastern and Western Lapland. Elsewhere, some changes in the strategies would be needed. In Kainuu the solutions suggest heavy emphasis on timber production. Based on the preference information of the Kainuu NRP this would not be acceptable on the regional level. In the other regions, there is also some variation between the reference and suggested strategies, but they might be approved on those regions.

In order to maximize the ecological network on the Metsähallitus level, the selected strategies should be substituted by some other alternative in every region. The same holds as regards maximizing allowable cut. Based on the preference information gathered in the NRP processes in question, all the changes would probably not to be accepted in the regions. In order to maximize recreation areas in the frame of selected cuttings, changes would be needed in the regions of Bothnia, Kainuu and WFinland. Based on available preference information, it is hard to judge whether the changes would be accepted or not in the regions.

Because no ongoing NRP process was included in sub-study IV, it was not possible to observe how much the regional preferences could be adjusted in an actual negotiation process, i.e. how much the regions would give up from their optimal strategies. Similarly, there was no information available how big changes the Metsähallitus level stakeholders and decision makers would really demand from the regions in an actual negotiation processes.

The key result of the analysis was that there are possibilities to deeper integration of the Metsähallitus level and regional level goals. The top-down approach would allocate resources more optimally on the Metsähallitus level. Some regions could emphasize more biodiversity aspects, some recreation and some wood production. However, it is hard to predict “the right level of specialization”, because e.g. biodiversity issues are a lot space-connected, and possibilities for recreation are also needed in every region. On the other hand, the main advantages of currently applied bottom-up approach include the regional level sustainability and wide acceptability of the regional plans, due the participation. The results strongly indicate that when developing NRP process more towards the integrated approach, a real negotiation and adjusting process needs to be developed between the Metsähallitus and regional levels, before the integrated approach can be applied in practice.

4. DISCUSSION

4.1. Introduction of new tools and approaches into strategic forest planning of Metsähallitus

This thesis concentrated on developing strategic forest planning in Metsähallitus, for actual needs and practical reasons. However, the results of the thesis may be adapted also in other organisations where strategic planning of forests and/or other natural resources is fundamental, and the operating context is considered favourable for using them. Hopefully the thesis also motivates new research in the topics.

The use of voting methods in actual strategic forest planning processes in Metsähallitus was the most important new element introduced by this study. Voting methods have gained acceptance as decision support tools in dealing with natural resources problems (e.g. d’Angelo et al. 1998, McDaniels and Thomas 1999), but in forestry they have not yet had much practical use. In Finland, Laukkanen et al. (2002) introduced multicriteria approval

(MA) into tactical forest management planning. Later on, MA was applied in deciding sustained harvesting in group decision context (Palander & Laukkanen 2003, Laukkanen et al. 2004). However, this thesis may be the first time when voting methods have been used extensively in practical forest planning processes.

The main result of the thesis is that voting methods are applicable in the practical NRP processes. They can be used instead or together with the MCDS methods tested earlier in Metsähallitus (Heinonen 1997, Pykäläinen et al.1999, Kangas et al 2001a, Pesonen et al. 2001). By experiences gained in the sub-studies I–III the use of voting methods improves the work of the NRP participatory groups and makes it more efficient, transparent and fair (see e.g. Mendoza and Martens 2005). When cardinal decision support is necessary, voting analyses can be complemented by e.g. interactive utility analyses (IUA).

In addition of introducing new planning tools the thesis showed also that the current resource allocation is not optimal on the whole Metsähallitus level. The natural resources of Metsähallitus could be used more efficiently by applying management strategies based on top-down or integrated approaches (see e.g. Hoen et al. 2006). However, due to large participation and the bottom-up approach, the current plans are regionally optimal and widely accepted. This is important from the point of view of acceptability of Metsähallitus' operations, and it maintains good reputation of Metsähallitus among local people. A bit surprising was the observation that the calculation capacity of the current planning tools (of Metsähallitus) has to be developed before all Metsähallitus data can be handled. Use of the whole data set is requisite for realistic analyses in the top-down and integrated approaches.

4.2. Development of NRP

4.2.1. Development of the multi-goal approach in NRP

The primary goal of strategic forest planning is ensuring sustainable forest management. Achieving sustainability requires the exploration and articulation of society's and people's fundamental values, and there are tradeoffs to be made e.g. between economic development and environmental quality, and between the well-being of future generations and the present (Cohon 2011). Therefore, multi-goal approach is the basic methodology also in the NRP process in Metsähallitus. Multi-goal approach challenges the participants to take into account all relevant aspects of the planning case, and to consider trade-offs between the preferences. The experiences gained in this thesis about the multi-goal approach adopted in Metsähallitus and the practical way it is carried out in the NRP processes, suggests that it works, and needs no major revisions (compare Niemelä et al. 2001, Raitio 2008).

Ecological, economic and social dimensions of sustainable forest management were met in all sub-studies I–III, while the cultural dimension entered in just sub-study III. When specifying and concretizing the dimensions into criteria, economic and ecological dimensions were assessed to fit as evaluation criteria as such (calling the criteria as economy and ecology) but the social dimension was characterised by two criteria; contribution to recreation and contribution to the welfare of local communities (see appendix A). In every sub-study I–III, alternative candidates for the dimensions and criteria were suggested in the early steps of the processes, but eventually the above criteria were accepted in consensus in all groups. In other words, the selected, same four criteria were assessed important and relevant in all planning regions, despite different nature conditions and distinct operative environment of the regions. The four criteria can therefore be considered as having become standards in the Metsähallitus

NRP planning context.

In the NRPs of eastern and western Lapland the cultural dimension actually meant reindeer husbandry. Criteria for this dimension were hard to define, because reindeer husbandry is tightly interconnected with the contribution on welfare of local communities (working opportunities of reindeer managers). At the end, the cultural dimension was described by criteria that tell more about the reindeer husbandry conditions than about the cultural elements of reindeer husbandry. In planning cases I and II, no special cultural aspects to be included in the planning were identified. The ongoing inventory of cultural heritage in Metsähallitus, started in 2010, can bring practical cultural elements into future NRP processes.

Every criterion was described more specifically by two indicators. Due to the evaluation method applied in the NRP process, indicators are the actual basic evaluation factors (see e.g. Malczewski 1999, Maness and Farrell 2004). Candidates for indicators were proposed both by the project teams and the participants. Most of the indicators were selected in consensus, but some voting was used in all NRP processes of sub-studies I–III. Approval voting proved to be the most suitable method to aid the selection. Net profit and allowable cut were selected as indicators of economy in all cases. Biodiversity was described by the area of ecological network, in all cases, while the other indicator varied case by case. Recreation was described by the area of forests reserved mainly for recreation, in all areas, the other indicator varying case by case. Contribution to the welfare of local communities was described in all cases by the number of Metsähallitus' working places, and by the amount of money Metsähallitus uses in the region. In the aggregation and mutual comparisons of regional plans, for example in the country-level hierarchical analyses of sub-study IV, homogeneous indicators are needed.

The applied number of evaluation indicators, 8 in general, seems appropriate in the NRP context, especially in the learning phase. The interesting issues are sufficiently addressed by this number of indicators. In sub-study III, with 10 indicators, most participants felt even so many indicators still suitable. However, also in this study in the ranking of the alternatives, fewer indicators proved to be easier to handle (Miller 1956). In hierarchical analysis five, perhaps even three, main indicators may be enough. A small number of indicators helps to concentrate on the main issues on all planning levels, makes interpretation of the (criteria and) indicators more coherent at all levels, and simplifies planning calculations and illustration of their results.

Alternative plans have also a central role in implementing the multi-goal approach in reality. In this study, five to seven plan alternatives were used in the start of the processes. In sub-studies I and II, one additional alternative ("extreme biodiversity" in both processes) was created in the course of the processes. In sub-study III, two additional alternatives (for reindeer husbandry) were needed to give more information on production possibilities and trade-offs. In all cases, also the "extreme" alternatives, outside the allowed decision space, proved to be important for learning and analysing the production possibilities multiobjectively.

4.2.2 Development of the steps of NRP

The NRP process follows the conventional steps of a forest planning process (e.g. Pukkala 2007), emphasising the actual selection (decision) as an independent phase in the process. Based on the responses of questionnaires in sub-studies I–III, the NRP planning process appeared well structured as a whole (e.g. Rauschmauyer and Wittmer 2006), while special emphasis has to be put on the creation of the alternatives (e.g. Keeney 1992).

A stakeholder analysis (mapping of stakeholders and their goals) is a crucial phase in a participatory process, sometimes it is nominated as the first step in the process (Nordström et al.

2010). In NRP, stakeholder mapping is a part of the state-of-art analyses. In the actual NRP processes of sub-studies I and II, the stakeholder groups were settled in meetings where “all possible stakeholders” were invited, and they selected the members of the group. In the process of sub-study III, the group was directly invited and named by Metsähallitus, and it was supplemented by one member in the group’s first meeting. The experiences suggest that the selection method applied in sub-study III is preferable. It is convenient also from the stakeholders’ point of view, and the statements received from different stakeholders indicate that representative participation was secured (see e.g. Beierle and Cayford 2002).

Goal analysis in the NRP process is carried out iteratively. In the beginning of the process the participants describe their objectives at a general level, verbally and also in terms of criteria. When the production possibilities have been analysed, the participants specify their own objectives more accurately by setting the preferences of the indicators. In this study, the Borda count method proved to be suitable to aid this phase. Later, the stakeholder group’s common preferences are worked out in a group negotiation that is aided by MA voting or by other decision support tools. By this procedure, all the provided planning information and the undergone individual and group learning processes can be utilised in the goal setting of the group.

By experiences gained in the sub-studies of this thesis, the use of voting methods helps to make preference eliciting quite simple, while MCDS methods in general are considered a bit complicated for this purpose (Nordström et al. 2010). However, it is important that in different preference eliciting steps there is a possibility for discussions and clarifications beyond the results of the outcome matrix and the criteria and indicators, as was noticed especially when applying the Mesta tool in the group work. No major changes in the NRP preference eliciting seem necessary on the basis of the conducted sub-studies.

In the analyses of the production possibilities the basic plan alternative (“business as usual”) is important, giving all participants a projection on what will happen in the future if everything continues similarly as in the past. “Extreme” alternatives illustrate maximums and minimums of the production possibilities, and trade-offs between different products and services. All above alternatives have proved important for learning the production possibilities, which is a prerequisite for realistic goal setting. In generating the other alternatives to be included in the analyses, it is important to secure that the set of alternatives span the interesting decision space sufficiently and that the alternatives are not directed towards any single stakeholder’s interests (Nordström 2010). The adaptively created alternatives in the course of the planning process support learning and judgements especially in the interesting decision space (Castelletti et al. 2006). In that sense the practise applied in the NRP processes is recommendable also in the future, although it takes some extra time, money and effort. In practical hierarchical analyses it is reasonable to restrict the process on, for example, from four to five main alternatives. It helps keeping the process simple and coherent.

From decision support point of view, the “extreme” alternatives may be problematic because they cannot be implemented. In addition, e.g. in cases where the arithmetic means are used as approval borders of the decision criteria, like in “standard MA”, they may become biased. Therefore, when applying MA, it is recommendable to specify the approval borders instead of using arithmetic means. In that phase of the planning process the group is already well educated in the problem, and it is capable to specify the approval borders.

According to Saaty (1990), seven is the maximum number of objects that a person can compare and still be consistent. Also in this study in preference eliciting by cumulative voting most participants omitted some of the eight indicators, perhaps due to the above reason. Another reason may be the correlation between the indicators, e.g. net income, working places and the money spent by Metsähallitus in the region, are nearly directly dependent on the proposed harvest. Although the above indicators describe different criteria, some participants may have felt that it is enough to vote just one (most important) of them. Participants may also give their points consciously just to some indicators (Kangas et al. 2006). In preference eliciting by the Borda count method eight indicators could be handled properly, and in the responses of the participants of this study Borda count entered as the recommended method in preference eliciting.

In public meetings the number of indicators was decreased from eight to five when ranking the alternatives (the number of which was also decreased to four or five), and this seems justified when plurality voting or approval voting are applied to pinpoint the best candidate (see also Juutinen et al. 2011).

4.2.3. Development of decision support in NRP

Participation has an important role in NRP. The stakeholder group is in the core of decision making in a NRP process, taking part in every phase of the process and eventually giving its proposal to Metsähallitus. The role and empowerment of the stakeholder group in the decision making of NRP can be classified on level 4 (Collaborate) of the five level scale of the International Association of Public Participation (2007) (Table 8). This level gives the participants real possibilities to affect the natural resource use decisions, which still are eventually made by Metsähallitus. By this study, there is no need to change the role of participation.

The main objective of this thesis was to develop decision support in NRP. Experiences of the use of decision support methods applied in sub-studies I–III are summarised in Table 9 by key characteristics assessed in the study.

Table 8. Spectrum of public participation by International Association of Public Participation (2007).

Level	Public participation goal
5 Empower	To place final decision-making in the hands of the public
4 Collaborate	To partner with the public in each aspect of the decision including the development of alternatives and identification of the preferred solution
3 Involve	To work directly with the public throughout the process to ensure public issues and concerns are consistently understood and considered
2 Consult	To obtain public feedback on analysis, alternatives, and/or decisions
1 Inform	To provide the public with balanced and objective information to assist them in understanding problems, alternatives, and/or solutions

Table 9. Comparison of the applied decision support methods in terms of the preference input needs and by characteristic of the results they provide, easiness of the principles and use of the methods, and the support they provide for learning and decisions (partially adopted (marked with *) from Kangas and Kangas (2002).

Method	**Information from decision maker**	**Result**	**Understanding of principles of the method**	**Ease of use of the method**	**Support for learning**	**Support on selections**
Direct holistic evaluation	Holistic assessment of the alternatives	Ordinal ranking for the alternatives	easy	easy	low	low
Plurality voting	Choice of favourite indicator	Selection of indicators	easy	easy	low	medium
Approval voting	Choice of approved indicators	Selection of indicators	easy	easy	low	medium
Cumulative voting	Distribution of votes to indicators	Ordinal ranking of preferences	easy	easy	medium	medium
Borda count voting	Importance order of indicators	Ordinal ranking of preferences	easy	easy	medium	rather high
Multicriteria approval	Importance order of criteria *	Dominant alternative(s) *	medium	rather easy	medium	rather high
Mesta	Acceptance thresholds of indicators	Approved alternatives / the best alternative	rather difficult	medium	medium	medium
Interactive utility analyses	Criteria weights	Cardinal priorities for the alternatives	rather difficult	medium	high	high

The basic lesson learned in this thesis about decision support was that decision support methods and tools should be used in an adaptive way in the actual NRP processes. They should be used in when needed in different steps of the process, and starting with simple methods (see e.g. Myllyviita et al. 2011). Common solution can often be found by ordinal voting methods (Hiltunen et al. 2008), and if cardinal support is needed, the results of ordinal methods serve a natural basis for deeper analysis (Pykäläinen et al. 2007).

By the use of decision support methods and tools, the concepts used in the planning became more consistent and mutually agreed, which decreases pointless arguing and focus can be directed on elements to be decided, like fundamental values that are the basis for the evaluation, goals and criteria. The process becomes also more transparent, when the outcomes can be traced back to the inputs, and influence of every participant can be specified (e.g. Rauschmayer and Wittmer 2006). The process also becomes fairer, when the "shy and silent" participants get their voices more equally heard by the use of support methods. All this improves understanding of the other participants' sights and helps finding the group's common decision.

The study pointed out that behavioural aspects are important when selecting decision support methods. It seems that many people more easily accept a satisfactory solution the rationale of which they can understand than results of sophisticated methods which are too complex for them (e.g. Kangas and Kangas 2005). This was the message especially in the oral feedback of the participants. In general, participants seem to favour "easy" decision support methods, such as voting instead of numerical methods involving many calculations. This observation points to keeping the support as simple as possible. It was noticed, for example, that the (preference) inquiries needed should not be too difficult. The role of an outsider facilitator is important, too. She / he should be a specialist in participatory processes getting it going fluently, transparently and efficiently. Outsider decision support specialist brings more knowledge to the process increasing the trust on the process and on the results.

Regarding the nature of NRP planning, the adaptively created alternatives suggest that NRP is not a strict MCDS aggregation process that evaluates certain discrete alternatives created in advance, of which the best is selected (Nordström et al. 2010). Instead, at the end, the group's proposal to Metsähallitus is based on group discussions and negotiations within the group, partly beyond the results shown by the outcome matrix and the applied support methods. Actually the NRP aggregation process (Belton and Pictet 1997) ends to the group decision as near to consensus as possible, which is well in line with the basic ideas of the NRP participation.

4.3. Success of the NRP processes in the study

Success of a participatory process can be assessed from the outcome-focused point of view, the actual management plan provided, and from the process-focused point of view, against the goals of the participation. Beierle and Cayford (2002) have formulated five social goals for participatory processes: 1. incorporating public values into decisions, 2. improving the substantive quality of decisions, 3. building trust in institutions, 4. resolving conflict among competing interests, and 5. educating and informing the public. The following judgements about success of the NRP processes of the sub-studies are based on the author's observations and interpretations.

A successful NRP process provides an optimal management plan for Metsähallitus' regional resources, with respect to the (revealed) priorities of the operative surroundings (goals 2, 1 and 4). The NRP plan meets the preferences well, because the alternative plans are efficient (Pareto-optimal), new efficient alternatives are created adaptively, and the actual management plan is still described in detail beyond the criteria and indicators. There were no conflicts in any of the sub-studies I–III. Strongly competing interests occurred in sub-study II between nature conservation and cuttings, and in sub-study III between reindeer husbandry and other uses, especially cuttings. However, they could all be resolved in the processes to a satisfactory endresult.

Results of sub-study IV show that different planning approaches (bottom-up, top-down) allocate the resource utilization differently on different scales (goals 2 and 4). The acceptability of the results also varies. The top-down approach provides optimal and most acceptable results from the Metsähallitus level standpoints, but the results are hardly acceptable in the regions. The current, regionally optimal results, in turn, are not the best at the Metsähallitus level. If more interaction between Metsähallitus and the regions is wanted, a new interaction and negotiation process between the planning levels is needed. One possibility is that the regions provide some alternative plans that they accept, and the Metsähallitus level optimum is combined from them (Kurttila et al. 2001). Also sub-studies I–III suggests that the planning process needs to be reorganised if interaction between the planning levels is wanted to enhance.

From the participatory point of view, the NRP processes builds trust towards Metsähallitus (goal 3). A limited number of stakeholder or institution have a possibility to participate in the work as a stakeholder group member, others can participate so that they communicate with these members. When the representativeness still is commonly verified in the group, accumulation of trust towards Metsähallitus and between the participating institutions is evident. The most important in trust building is the interaction of the group members within the group work and with the staff of Metsähallitus, which paves way to continuing interaction also after the NRP process.

Public values are incorporated in the NRP decisions (goal 1) through the stakeholder group work, public meetings and by contacts of citizens via internet. In public meetings alternative plans are ranked by voting, and people use internet to answer questionnaires and to give free feedback. All this information is analysed in the stakeholder group before it gives the proposals to Metsähallitus. It is also taken into account in Metsähallitus' decisions. Although there is always uncertainty on how well the participation reflects public values (Buchy and Hoverman 2000), the author's conclusion is that by the applied method, public values are well incorporated into the NRP decisions.

The feedback given by the stakeholder group members suggests that they learned a lot about Metsähallitus in general, and about planning of the use of the region's natural resources during the processes (goal 5). Informing the public took place via public meetings, internet, radio and some advertisements in newspapers. Since in sub-studies I–III only about 100 people attended the public meetings, and about 350 people participated via internet, it has to be judged that informing the public has stayed on low level.

4.4. Proposals for future processes and studies

Based on the experiences from the practical NRP processes of this thesis, the author would adopt mainly the current NRP process also in forthcoming processes, with some changes in different steps. In addition, same kind of planning approach could be applied also in other forest planning processes outside Metsähallitus, e.g. in regional forestry programmes. In the future NPR processes, participants to the stakeholder group would be invited by Metsähallitus, and the group would be complemented later if necessary. Voting methods should be applied systematically in the work of the stakeholder groups when decision support is needed. Plurality voting and approval voting should be used in the selection of indicators and plan alternatives. Borda count (posterior) should be applied in preference eliciting and MA in the evaluation of alternatives. When necessary, IUA or Mesta tools could also be used to support group negotiations in the evaluation. Applications of new planning and decision support methods and tools and planning approaches would be studied actively.

In order to develop decision support in the NRP processes, use of SMAA (Lahdelma & Salminen 2010) and outranking methods needs to be researched. The families of ELECTRE and PROMETHEE are the most commonly known outranking methods (e.g. Roy 1991). The strengths of SMAA and outranking methods include that also ordinal and even qualitative data can be utilised in versatile forms. They are also easy to use for decision makers, when the numerous calculations that they include are carried out automatically by computers. However, their drawback in participatory context may be limited transparency. To be trusted, the support methods have to presented and explained in an understandable way to the participants (Kangas and Kangas 2005). The principles of the above methods may be too complicated to be explained and to learn for the participants.

Goal programming (GP) could also be introduced and studied in future NRP processes (Eyvindson et al. 2010). In GP, all goals can be optimized simultaneously (Pukkala 2007), which resembles people's every day decision making situations. By utilizing goal programming, one can check if the selected objective levels of the criteria can be fulfilled simultaneously with respect to the multi-dimensional production possibilities. In NRP all goals actually are under optimization, within the limits of the decision empowerment of the process. The optimization process of GP might be illustrative for the participants, probably providing good support for selections. It is possible to handle GP problems in Mela software, but until now it has not been utilised in Metsähallitus.

In future processes the analysis of production possibilities in a NPR process should be started with about five alternative plans, around the basic alternative. They should be differentiated so that they enlighten the relevant decision space comprehensively and evenly with respect to each criterion and / or indicator in the decision empowerment of the process. Minimum acceptance borders for every criterion or indicator could also be used as a starting point in the analyses of production possibilities. The need for "extreme" alternatives, outside the decision empowerment, has to be considered carefully. Probably they are not necessary in future processes. Some new alternatives can be created in the course of the process to specify the most interesting parts of the decision space. After the first preference elicitings, the planning team could use e.g. the SMAA method to pinpoint the need for new alternatives, and alternatives that can possibly be dropped out from the process. In the evaluation of the alternatives, the number of indicators should be reduced to about five, and they should be used as the selection criteria.

When starting the NRP processes in the middle of the 1990s the bottom-up planning approach was a natural selection, due to the conscious emphasis set to the local/regional participation. Partly it was also due to technical reasons like problems in organising many simultaneous NRP processes, lacking expertise and planning capacity, etc. The bottom-up approach has several process advantages, including a wide approval of the plans by regional stakeholders and local residents. This study shows, however, that there are possibilities for improving the interaction between the strategic Metsähallitus level goals and the regional NRP processes by applying different planning approaches. In the future, studies should be conducted on the organization of participation at the Metsähallitus level, and interaction in participation between regional and Metsähallitus levels.

A basic matter for useful top-down and integrated analyses is to develop planning tools that are capable to use the whole Metsähallitus level data. Especially, spatial relationships of the data and different forest functions should be taken into account better than today (Heinonen 2007, Pukkala et al. 2009, Moilanen et al. 2010). This limits possibilities to use sample data, because spatial relationships are then difficult to take realistically into account. Further studies are needed also on the possibilities of specialisation of the regions in order to make resource allocation more efficient at the whole Metsähallitus level. There are, however, many limits to specialisation, e.g. biodiversity issues are tightly space-connected, and possibilities for different recreation uses are needed almost everywhere.

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Appendix A

Description of the plan alternatives in sub-study I:

1. Basic alternative (business as usual)
2. Basic alternative with a more scattered ecological network
3. Alternative with more emphasis on nature conservation, compared to Basic alternative
4. Alternative with emphasis on wood production
5. Alternative with more emphasis on recreation and tourism, compared to Basic alternative
6. Combination of alternatives #3 and #5
7. Combination of alternatives #4 and #5
8. Alternative with great emphasis on nature conservation

Description of the plan alternatives in sub-study II:

1. Basic alternative (business as usual)
2. Alternative with emphasis on wood production
3. Alternative including nature conservation activities proposed in Metso-programme
4. Alternative with more emphasis on nature conservation, compared to Basic alternative
5. Alternative with more emphasis on recreation and tourism, compared to Basic alternative,
6. Combination of alternatives #4 and #5
7. Alternative with great emphasis on nature conservation

Description of the plan alternatives in sub-study III:

1. Basic alternative (business as usual)
2. Alternative with more emphasis on recreation and tourism, compared to Basic alternative
3. Alternative with emphasis on wood production
4. Alternative with more emphasis on reindeer husbandry, compared to Basic alternative
5. Alternative with more emphasis on nature conservation, compared to Basic alternative
6. Alternative with heavy emphasis on reindeer husbandry
7. Alternative where just thinning cuttings (no regeneration cuttings) are applied in forestry

Description of the evaluation criteria and indicators in sub-study I:

Ecology
A. Area of the ecological network, 1000 ha
B. Quality of the ecological network, school grade by specialists
Economy
C. Total net income from forestry and other commercial activities, mill. € per year
D. Sustainable (allowable) annual cut, 1000 m^3 per year
Recreation
E. Area of forests older than 80 years (suitable for recreation like hiking etc.), 1000 ha
F. Area of forests younger than 20 years (suitable for game such as moose and hares), 1000 ha
Social impacts on regional level
G. Metsähallitus employment, person years
H. Gross turnover, € mill.

Description of the evaluation criteria and indicators in sub-study II:

Ecology
A. Area of the ecological network, ha
B. Total area of the forests over 100 years and herb-rich forests included in the ecological network, ha
Economy
C. Sustainable (allowable) annual cut, m^3 per year
D. Total net income from forestry and other commercial activities, mill. € per year
Recreation
E. Area of forests suitable for recreation like hiking etc., ha
F. Area of forests older than 60 years in recreation forests (scenically beautiful forests), ha
Social impacts on regional level
G. Metsähallitus employment, person years
H. Gross turnover, € mill.

Description of the evaluation criteria and indicators in sub-study III:

Economy
A. Total net income from forestry and other commercial activities, mill. € per year
B. Sustainable (allowable) annual cut, 1000 m^3 per year
Ecology
C. Area of the ecological network, % of productive forest land area
D. Area of forests older than 160 years, % of productive forest land area
Reindeer husbandry
E. Area of forests characterized by beard lichen, ha
F. Lichen areas, ha
Recreation
G. Scenic areas and recreation forests and national parks, ha
H. Forests older than 100 years included in above forests, ha
Social impacts on regional level
I. Gross turnover of Metsähallitus, € million / year
J. Employment opportunities offered by Metsähallitus, man-years

The outcome matrix in sub-study I

Indicator	Alternative 1	2	3	4	5	6	7	8
A	110	111	118	104	110	118	104	136
B	8	7	9	6	8	9	6	10
C	11,6	12,2	10,1	13,2	11,2	9,7	12,4	8,9
D	1000	998	934	1057	992	927	1047	866
E	173	173	177	170	176	180	172	182
F	71	71	68	75	69	65	72	63
G	480	469	459	493	484	463	501	431
H	55,0	54,3	52,7	56,7	55,5	53,2	57,4	49,9

The outcome matrix in sub-study II

Indicator	Alternative 1	2	3	4	5	6	7
A	189749	164328	190672	200745	199078	207456	217538
B	52329	43796	53642	55575	54725	56442	57615
C	500000	587604	487743	462120	481489	457232	433705
D	12.2	15.2	11.9	11.1	11.7	11.0	10.3
E	74952	63622	74952	88410	103195	113025	111616
F	28348	24925	28348	31393	32961	35247	38328
G	425	465	419	408	416	406	395
H	41.9	46	41.4	40.4	41.3	40.5	39.4

The outcome matrix in sub-study III

Indicator	Alternative 1	2	3	4	5	6	7
A	9.4	9.4	12.2	9.1	9.3	6.9	2.4
B	749	747	944	721	741	535	156
C	28.9	28.9	24.6	28.9	29.2	28.9	28.9
D	27.6	27.6	25.9	27.9	27.7	29.3	32.4
E	80 977	80 572	72 094	83 522	81 131	85 279	85 279
F	59 046	59 007	59 633	59 097	59 022	60 593	60 382
G	138 504	158 995	122 213	138 506	138 508	138 509	138 510
H	118 784	122 768	107 977	118 916	118 825	119 309	120 297
I	33.5	33.7	42.7	32.4	33.2	25.0	10.1
J	350	357	440	339	347	269	124