SILVA FENNICA

Silva Fennica 46(4) research articles

www.metla.fi/silvafennica · ISSN 0037-5330
The Finnish Society of Forest Science · The Finnish Forest Research Institute

Strengthening Top-Level Guidance in Geographically Hierarchical Large Scale Forest Planning: Experiences from the Finnish State Forests

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Hiltunen, V., Kurttila, M. & Pykäläinen, J. 2012. Strengthening top-level guidance in geographically hierarchical large scale forest planning: experiences from the Finnish state forests. Silva Fennica 46(4): 539–554.

Different planning approaches conclude to different results. The top-down approach allocates resources efficiently from the top-level perspective, while the bottom-up approach provides optimal results for the lower levels. Integrated approach that combines the elements of these two basic approaches provides compromise solutions for decision makers. The aim of this study was to examine potential efficiency improvements in hierarchically structured large scale forest management through increased top-level guidance. The resulting effects on the acceptability of the plans on the lower level were also studied. Large scale planning typically considers forests owned by states, companies and municipalities. In the case study of the Finnish state forests, alternative country level solutions were generated by combining regional forest plans in different ways. The results showed that the currently applied bottom-up approach, which produces regionally optimal management strategies, did not result in the most efficient use of resources on the country level. However, the new country level solutions did not produce huge improvements in the country level objective values compared to the results of the current approach. Furthermore, if country level efficiency improvements were emphasized more, together with wide approval by regional stakeholders and local residents, new kind of interaction and participation between the planning levels and also between the regions would be needed.

Keywords acceptability, efficiency, hierarchical planning, strategic forest planning
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Received 14 February 2012 **Revised** 3 September 2012 **Accepted** 5 September 2012
Available at http://www.metla.fi/silvafennica/full/sf46/sf464539.pdf

1 Introduction

Forestry must respond to many requirements related to ecological, economic, social and cultural sustainability. When striving for sustainable forestry, management decisions and operations should be feasible within all affected geographical locations and planning levels, which in this way form a hierarchical system. The demands for achieving comprehensive sustainability are particularly strong in the management of "commonly owned" forests, like state forests and those owned by municipalities. Integration of national and regional forest programmes can also be seen as a task of hierarchical forest planning where sustainability is strived for on the both planning levels. In order to fulfill the sustainability requirements, these forest planning processes are generally participatory and multi-objective (e.g. Nordström et al. 2010). In addition, different planning approaches are applied to meet these objectives (e.g. Hoganson and Rose 1984, Hoen et al. 2006, Hiltunen et al. 2008). Depending on the interaction and the general direction of the information between the planning levels, the hierarchical planning approaches are commonly categorized into the top-down, the bottom-up and the integrated approaches (Weintraub and Cholaky 1991, Kurttila et al. 2001, Hujala and Kurttila 2010).

The concept of hierarchical planning systems was developed by Anthony (1965). In his framework, objectives and policies of the organization are set in the strategic planning. The task of tactical control (planning) is to assure the most effective use of the available resources, and operational control takes care that special tasks are meaningfully implemented. The decisions made at one hierarchical level act as constraints on the lower level decisions. The lower levels, in their turn, provide information for the upper level decisions (Gunn 1991). Later, Shneeweiss (1998) introduced a general framework to study various hierarchical structures of an organization from management and leadership point of view. In a hierarchical structure one system may, for example, have more power or information than another, or issues within one system may have to be resolved earlier than issues within another system.

The hierarchical approach has been used also to analyze complex ecological systems, like forests. For example, Wu and David (2002) identified that complex systems have both a vertical structure that is composed of levels, and a horizontal structure that is composed of holons (nested geographical units of different sizes at the same level). Hierarchical levels are separated by different process characteristics. Higher levels are characterized by larger units and slower processes, and lower levels are characterized by smaller units and faster processes. In a forestry context this means, for example, that changes in a complete forest structure in a large forest area take decades or more, although at the level of one stand the structure may change rapidly e.g. due to forest fires or cutting operations. Hierarchical structures prevail in forest planning also in the management perspective. For example, there has to be interplay and coherence between the national level and the regional level forestry programs in order to make the national forest policy targets realistic and implementable (Prager and Freese 2009, Hujala and Kurttila 2010).

The basic idea in hierarchical planning is to decompose a problem into smaller entities, which are easier to manage both in relation to the issues themselves and to the data (e.g. Bare 1996, Wu and David 2002). The other goal of decomposition is specialization. Problems to be solved are different on different levels, which require specialized tools and different data (e.g. Gunn 1991, Church et al. 1998). A key challenge in hierarchical planning is to ensure consistency between the planning levels (Weintraub and Cholaky 1991).

In the bottom-up approach of hierarchical forest planning, the bottom level processes and planning are emphasized first. A limited number of efficient and approved plan alternatives can be first created for the bottom levels. The top-level plan is then composed as an aggregate of these plan alternatives (e.g. Kurttila et al. 2001). If several plans are truly accepted from the lower levels, the aggregation can be carried out by utilizing, for example, integer optimization, where the top level goals are included in the objective function. Treating the regional plans as indivisible guarantees acceptance at the regional level. Consequently, the solution is feasible at the bottom level and optimal at the top level; subject to the set restrictions that have been included in the bottom level alternatives. If only one plan is initially accepted at the lower levels, the sum of these plans is then the only possible plan for the upper level. A weakness of the bottom-up approach is that the aggregate solution may appear not-acceptable at the top level if the combinations of the lower-level alternatives are not in line with the top level goals.

In the top-down approach, the use of forest resources is planned and decided first at the top-level. Technically this approach allocates resources optimally from the point of view of organizations' top-level goals, subject to the production possibilities of the whole planning area (Kurttila et al. 2001, Hujala and Kurttila 2010). After the top level allocation the problem can be decomposed into tactical planning tasks and/or sub-area level planning problems (Weintraub and Cholaky 1991, Sessions and Bettinger 2001). Aggregated data is often used in the top-down calculations because large planning areas mean massive amounts of basic data and thus demanding planning calculations (Rose et al. 1992).

The top-down approach is widely used in practice in forestry. For example, Hoganson and Rose (1984) basically applied the top-down approach in their simulation approach for optimal timber management scheduling, and Rose et al. (1992) used it in impact assessment of forestry programs in Minnesota state. Connected to the top-down approach, LP-based forest planning tools, like FORPLAN in the United States (US) (Church et al. 1998), FMPP in Sweden (Jonsson et al. 1993) or MELA (Redsven et al. 2009) in Finland have gained wide use in estimation of cutting possibilities at country and regional levels.

However, the top-down approach may include some weaknesses regarding e.g. the acceptability at the lower levels. For example, the cutting proposals may be unrealistic on the lower level (e.g. Weintraub and Davis 1996), which may make the implementation of the operations difficult. It may also happen that local people do not accept activities derived in the strategic top-level plan if its effects are distributed unevenly between the sub-areas, and so the plan may not be feasible to implement. In other words, a strict resource allocation from the top level can restrict too strongly the decision making processes at lower levels, leading to problems with sustainability on smaller scales. The aggregation and disaggregation of the data back to the basic levels may also cause differences and problems in implementation (e.g. Bare 1996), because e.g. spatial relationships of the data are difficult to tackle in the aggregation. These phenomena illustrate the importance of structured feedback mechanisms and negotiations between the planning levels. For example, more accurate operational and tactical constraints from the lower levels may be needed to act as feedback methods to the strategic level. To tackle these issues, Bettinger et al. (2005), for example, developed a model for large scale landscape planning that included both top-down and bottom-up approaches.

In the integrated approach, both the upper level and the lower level are considered simultaneously. Some targets can be set at the upper level; others may be set on the lower level (Kurttila et al. 2001, Kurttila and Pukkala 2003, Pykäläinen et al. 2000). The planning process is iterative and interactive between the planning levels. The emphasis of the upper level goals and restrictions can be adjusted, along with the emphasis of the lower level goals (Colberg 1996). These kinds of interactive planning procedures provide diverse information relating to the results on different planning levels, and on trade-offs between different outputs in different scales (see e.g. Bettinger et al. 2005). The provided information promotes negotiation and supports decision making inside and between the planning levels. The integrated approach often responds well to the need to match different and often contradictory management objectives on regional or strategic levels (e.g. Castelletti and Soncini-Sessa 2006, Hoen et al 2006). For example, Dudek and Stadtler (2005) suggest that a negotiation-based planning process integrated with mathematical optimization meets the needs of interaction between different planning levels. In practical forest planning, it is hard to find studies where integrated planning had been applied, although research examples of adapting this approach exist (e.g. Pykäläinen et al. 1999, Hoen et al. 2006).

In practical large scale applications of hierarchical planning, upper level guidance has not always been very strong. For example in Finland, the national forestry program gives main guidelines to the regional forestry programs, but it does not set strict goals for the regions. Also in the regional strategic planning of the Finnish state forests, the country level guidance exists, but it has given some freedom to adopt the forest use to the regional conditions and goals. In each regional planning process the regionally optimal resource allocation has been searched within the country level instructions, and the country level plan is then constructed as their sum. Thus, the process resembles more the bottom-up approach.

The applied bottom-up approach in the Finnish state forest planning may cause inefficient use of the forest resources on the country level. In other words, it is possible that the current sum of the regionally selected plans does not correspond to the country level goals and production possibilities in the best way. In this situation, there may exist possibilities to find pareto improvements from the current solution, i.e. new country level solutions in which it is possible to increase the value of certain goal without decreasing the value of any other goal. In the latter case, the forest use could be changed to better meet the country level demands.

The aim of this study is to examine whether increased country-level guidance in the regional planning processes would result in efficiency improvements in forest management of the Finnish state forests. Improved efficiency of the alternative country level plans is evaluated by comparisons between the reference bottom-up solution and the new efficient country level top-down solutions. In addition, the acceptability of the new country level solutions at the regional level is assessed by analyzing the changes needed within the regions to get the new plans implemented.

In the next section the materials and methods used to compose and evaluate different country level solutions for the Finnish state forests are presented. Thereafter the results are presented in chapter 3. Finally, in the discussion section, practical possibilities to improve the efficiency of the use of the state forests are assessed, and general development recommendations for hierarchical large scale planning processes are given.

2 Materials and Methods

2.1 Natural Resources Planning in the Finnish Forest and Park Service

The Finnish Forest and Park Service (FFPS) manages forests owned by the state of Finland. In FFPS participatory strategic forest planning is carried out by a process called natural resources planning (NRP). The main goal of NRP is to work out optimal resource allocation for the region for the next ten year period. Planning projections cover 40 years in order to secure long term sustainability. In addition to being regionally optimal and operationally feasible, the outcomes of the regional NRPs should fulfill FFPS' country-wide strategic goals (Asunta et al. 2004). Thus the planning levels and geographically distinct forest areas depend on each other both ecologically and from managerial perspective.

In the Finnish state forests, stands are the basic operational management units. Tactical planning of cuttings takes place on team-area and landscape levels, and strategic planning is carried out on regional and country levels. Stand wise data are used in the NRP planning calculations in order to make sure that the regional plans can be implemented in practice. The NRP process has been carried out by rotating yearly from region to region, for all seven regions for which FFPS is responsible. Some regional processes may also be simultaneous. The plans cover a 10-year period, but every plan is revised every five years. Because the aim of every NRP process is to determine the best management strategy for the region's forest resources for the planning period, participation on regional (county) and local (community) levels is an essential part of every NRP. The NRP process consists of

(i) problem structuring (analyzing the planning task in detail) and involvement of the stakeholders
(ii) eliciting preferences of the participants, and selecting the decision criteria
(iii) producing alternative plans for the region (typically less than 10 plans), and estimating the values of their decision criteria
(iv) participatory multi-criteria evaluation of the alternative plans and
(v) selecting the best plan for the region.

As described above, the creation and evaluation of relevant regional alternatives through a participatory process is the core of NRP processes. At the end of the process, there is one approved plan alternative in every region, the other alternatives being rejected. The country level solution of FFPS is simply the sum of the approved regional strategies. However, in order to sustain consistency between the country and regional levels, the frames and guidelines for every NRP are set by the Chief Executive Officer (CEO) of FFPS at the beginning of the process in a meeting of FFPS' board of directors. These guidelines concern, for example, the magnitude of possible land-use reallocation. These frames are based mainly on former activity levels of the region and, e.g., on revised management emphasis in FFPS. Later in the process, when the outcomes of the plan alternatives have been worked out, they are assessed by the CEO and the board of directors, and the guidelines are specified in more details.

The specification may pertain, for example, to land use allocation or the range of allowable cut in the region during the next period. The above method of supervision of the planning process brings elements of the integrated approach into the planning; while the plans are actually compiled at the regional level, key regional targets are framed at the country level by FFPS. At the final stage of the process FFPS still approves the plan, and is therefore the formal and actual decision maker. The stakeholder group participates during whole the process, giving its views to all essential planning questions and finally proposing to FFPS a strategy that should be applied in the region over the next 10 years.

2.2 Alternative Plans from NRP Processes

As stated in the earlier section, generation of relevant strategy alternatives for the region and evaluation of them from ecological, economic, social and cultural viewpoints is the key element in NRP. Among the created alternatives, the basic alternative represents the strategy "business as usual". Other alternatives respond to different expectations concerning the future development of the society, and to the wishes of the stakeholder group's participants. They may emphasize issues like nature conservation, recreation or some other forest uses and their combinations. Most of the alternatives can be implemented in practice. Some informative plan alternatives (outside the decision making power of the planning process) have also been included in order to highlight the extreme points of the alternative space, although they were considered not to be directly implementable in practice. Technically, the alternatives are created by allocating land use and changing forest management practices according to the principles of each alternative. The key purpose of the set of alternatives is that they illustrate the production possibilities of the region and trade-offs between different management objectives.

In order to secure long term sustainability, the length of planning period in NRP is 40 years, which is divided into four 10-years sub-periods. In the estimation of the values of the decision criteria for each alternative, the future development of forests is predicted with MELA-software. MELA utilizes computerized rule-based simulation of treatment schedules for stands and JLP optimization algorithm (Lappi 1992, Redsven et al. 2009). After simulating the treatment schedules for stands, the optimization problem (maximizing the net present value, subject to constraints that secure sustainability) is created and solved at the regional level. Consequently, the created alternatives are regionally optimal, and operatively feasible (from the perspective of the production possibilities of the region).

The research material of this study consists of data from six regional NRPs. The regions are Western Lapland (WLapland), Eastern Lapland (ELapland), Bothnia Region (Bothnia), Kainuu Region (Kainuu), Western Finland (WFinland) and Eastern Finland (EFinland). They cover about 80% of FFPS' land area and produce more than 95% of FFPS' economy. The planning processes within these regions have been carried out during 2004–2008 and the plans are quite commensurable with each other. The NRP of Upper Lapland was excluded from the research material because of its special circumstances, with heavy emphasis on reindeer herding and the rights of native people.

In the data of this study the number of alternatives in different regions varied originally from five to eight. Some of the alternatives corresponded closely to some other alternative, and thus they were left out of the analysis. As a result, there remained five alternatives in all the regions with similar compositions. In the "basic alternative" (Alt 1), the current land use allocation and forest management practices are continued in each region. In Alt 2 cuttings are increased, in Alt 3 protected area is increased, in Alt 4, more areas are reserved for recreation, and Alt 5 shows the effects of "the maximum biodiversity protection". Alternatives 2–5 have been created by changing land-use allocation and forest management practices in the data. Alt 2 and Alt 5 were partly out of regional decision making power (some elements could not have been implemented with regional decisions), but they were included in the calculations to better illustrate the alternative space.

2.3 Evaluation Criteria and Indicators

In order to make the evaluation of ecological, economic, social and cultural sustainability tangible, respective criteria and indicators have to be defined and operationalized in the planning context. Four main criteria have made a breakthrough in the participatory planning processes of FFPS during the last 15 years. They are called as "ecological viewpoints", "economy of FFPS", "recrea-

Table 1. The NRP outcome matrices with five alternatives and five indicators. The alternatives that were selected in the regional NRP processes are marked in bold.

		Indicator				
		Econet 1000 ha	AllCut 1000 m³	Jobs man year	Recr 1000 ha	TurnO mill. €
WLapland	Alt 1	181	794	428	62	41.5
	Alt 2	150	1027	527	50	51.3
	Alt 3	181	669	374	62	36.2
	Alt 4	**181**	**788**	**431**	**84**	**41.5**
	Alt 5	186	774	421	62	40.7
ELapland	Alt 1	309	749	350	125	33.5
	Alt 2	263	984	440	121	42.7
	Alt 3	309	535	269	125	25.0
	Alt 4	**309**	**747**	**357**	**135**	**33.7**
	Alt 5	312	741	347	125	33.2
Bothnia	**Alt 1**	**126**	**882**	**536**	**39**	**57.2**
	Alt 2	120	937	560	32	59.8
	Alt 3	137	860	526	44	56.2
	Alt 4	126	867	529	44	56.8
	Alt 5	142	846	519	44	55.6
Kainuu	Alt 1	110	1000	480	16	55.0
	Alt 2	104	1057	493	15	56.7
	Alt 3	118	934	459	17	52.7
	Alt 4	**110**	**992**	**484**	**17**	**55.5**
	Alt 5	136	866	431	18	49.9
WFinland	Alt1	190	500	425	36	41.9
	Alt 2	164	588	465	32	46.0
	Alt 3	201	462	408	40	40.4
	Alt 4	**199**	**481**	**416**	**44**	**41.3**
	Alt 5	218	434	395	48	39.4
EFinland	**Alt 1**	**157**	**1048**	**486**	**18**	**66.1**
	Alt 2	109	1140	519	14	71.2
	Alt 3	166	1010	475	19	64.5
	Alt 4	157	1017	478	19	64.8
	Alt 5	206	892	434	22	59.4

tional use of forests" and "social impacts of FFPS on (local and) regional level" (e.g. Pykäläinen et al. 2007, Hiltunen et al. 2009). Aspects connected with reindeer herding were the fifth criterion that was applied in Northern Finland. Every criterion was still specified more accurately by indicators. In the previous NRP processes, every criterion was specified with two indicators so that one indicator expressed the amount and the other indicator measured the quality of the item. In the selection of the indicators it had to be ensured that their values can be calculated at the end of the planning period from the data for each alternative.

Altogether 19 different indicators were used in the six NRP processes, and the number of used indicators in different NRP processes varied from eight to ten. However, there occurred five indicators that were similar in all NRP processes, the rest being at least partly case specific. The common indicators were: "the area of ecological network" (EcoNet), "allowable cut" (AllCut), "jobs" (Jobs), "areas for recreation" (Recr) and "turnover of FFPS" (TurnO). There was, however, some regional variation in the determinations of these indicators, especially in the indicator Recr. For this reason, indicator Recr was harmonized in four areas so that it corresponds to the definitions used in Eastern and Western Lapland. "Turnover of FFPS" described the economic contribution of FFPS to the regional economy. As a result, the data that were used for creating country level alternatives in this study are shown in Table 1.

2.4 Methods for Composing and Evaluating Country Level Plans

2.4.1 Creation of Top-down Alternatives

The principal solution for the top-down approach would have been to use the whole stand database of FFPS, simulate alternative treatments for stands and formulate and solve a country level LP problem (Weintraub and Cholaky 1991). The number of planning units (stands) however exceeded 1 million, and the size problem of LP (Rose et al. 1992) was met; the problem was unmanageable. Therefore, in this study, the creation of country level alternatives was based on the utilization of regional alternatives. The country level plans were generated from them by applying total enumeration. Total enumeration of the country level plans means that all possible combinations of the regional plans were created. The values of the decision criteria in each country level plan were calculated by adding the values of the individual decision variables from those region level plans that are included in the solution. In this case, the total enumeration was possible due to manageable amount of alternatives ($5^6 = 15\,625$ plans).

2.4.2 Evaluation of the Alternatives

The evaluation of the alternative plans in the regional NRP processes is carried out both from the perspectives of the participants' goals and values, and from the perspective of the goals of FFPS. Different techniques have been utilized in the participatory multi-criteria evaluation of the alternative plans. For example, direct holistic evaluation, voting methods (Hiltunen et al. 2008), definition of the acceptance thresholds of the criteria by MESTA tool (Hiltunen et al. 2009) and utility analysis (Pykäläinen et al. 1999, Pykäläinen et al. 2007) have been used in regional NRP processes.

In this study, the main part of the evaluations concerned the following indicators: ecological network (EcoNet), allowable cut (AllCut) and recreation (Recr). This is because it was observed that indicators jobs (Jobs) and turnover (TurnO) were highly correlated with allowable cut (AllCut), with correlation coefficients more than 0.99. The reason for this is that both of the above indicator values are derived directly from (and, in practice, they depend on) the cutting activity level. As a result, those two indicators were omitted in further analyses.

The created country level plans provided information concerning country level production possibilities and trade-offs (substitution rates) between the indicators. In the evaluation of the alternatives, the bottom-up solution is considered as a reference, to which the other solutions are compared. The comparisons of the country level solutions were performed from three perspectives, which were: (i) finding out if there are possibilities for pareto improvements (i.e. is it possible to increase the value of one or more indicators without decreasing the value of other(s)) compared to reference solution; (ii) how much certain indicator value increases if it is maximized so that the value of some other indicator was constrained to the level of the reference solution and what happens to the third indicator value; and (iii) what kind of solutions result if each indicator value is maximized separately. In total, 15 different solutions were selected to be compared to the reference solutions.

The new country level plans were examined also from the regional perspective. This was done by comparing what changes would be needed in regions to get the country level plans implemented. The analyses were carried out as a posterior difference-analysis, because any actual participatory planning process was not going on in FFPS.

3 Results

3.1 Evaluation of the Solutions from the Country Level Perspective

All country level solutions are shown graphically in Figs. 1a–c. The efficient alternatives are located at the north-eastern border of the alternative "clouds" in Figs. 1a and 1c. Fig. 1a shows the relationship between ecological network and allowable cut. The efficient frontier is convex, showing that, at the extremes, the substitution rates increase. In Fig. 1c, the relationship between recreation and allowable cut is shown. The production possibility frontier is again typical of competing products. The shape of the cloud in Fig. 1b differs from others, showing the relationship between ecological network and recreation. Evidently, these two indicators complement each other, at least within the decision space that is based on the original NRP alternatives. The location of the reference solution is also shown. It is located rather close to the efficient frontiers. However, the results show that the regionally selected management strategies from the bottom-up approach do not result in the most efficient solution at the country level.

The created country level plans provided information concerning the country level production possibilities (Table 2) and trade-offs (substitution rates) between the indicators (Table 3). These results also show how the values of the indicators change compared to the reference value.

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 $m^3 a^{-1}$ and at the same time avoid decreasing the values of the other two indicators from the reference solution. However, these improvement possibilities are minor since increases are generally less than 1% of the indicator values of the reference solution.

Increasing ecological network so that the allowable cut stays at least on the reference level would decrease recreation areas. As Figure 1c shows, there are small possibilities to increase recreation areas so that the allowable cut stays at least on the reference level. In addition, those changes would slightly increase ecological network. An increase in allowable cut, so that ecological network stays at least on the reference level, would decrease recreation areas. Generally, the conclusion of the above trade-off analysis is that by maximizing ecological network or allowable cut would cause an approximate 10% loss in the other indicators; whereas maximizing recreation areas would cause losses only in the allowable cut, but would cause a surplus in ecological network.

Maximizing ecological network at the country level would mean a heavy decrease in allowable cut and a slight change in recreation areas. Maximizing cuttings would, in turn, shrink remarkably both ecological network and recreation areas, compared to the regionally selected strategies. Maximizing recreation areas would increase ecological network and drop cuttings.

3.2 Evaluation of the Solutions from the Regional Perspective

The analyses of this section describe what kind of changes would be needed regionally, if the aim was to implement the new country level solutions presented in Tables 2 and 3. This analysis gives an insight as to whether the new country level

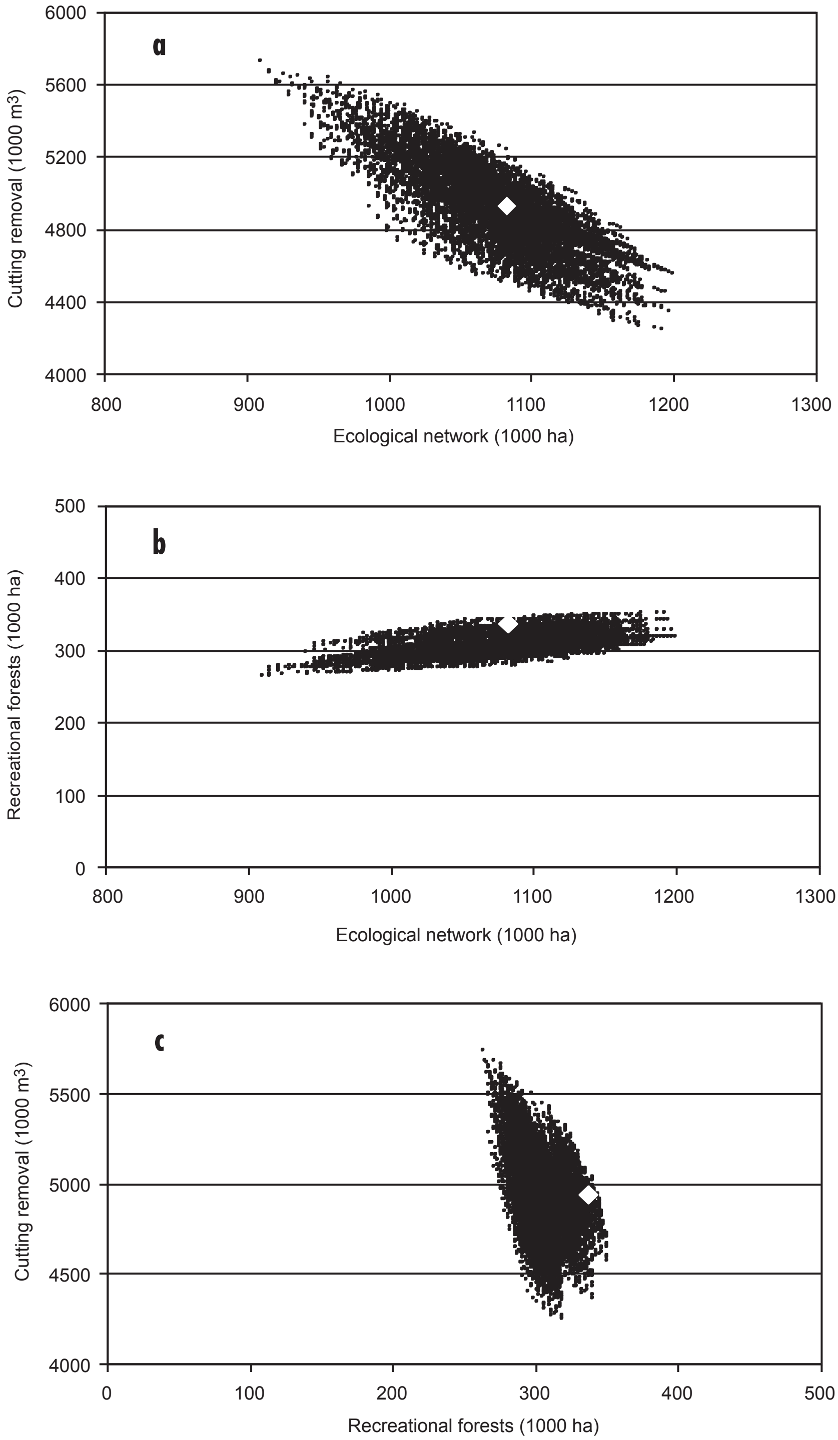

Fig. 1a-c. The graphical presentation of all Metsähallitus level solutions with respect to ecological network and allowable cut (Fig. 1a); ecological network and recreation (Fig. 1b); and recreation and allowable cut (Fig. 1c).

Table 2. The whole Metsähallitus level outcomes in different solutions. The first row shows the reference indicator values from the bottom-up approach. The following six rows show the solutions that provide pareto improvements (the seventh pareto optimal solution is the same as "Max Recr *s.t.Ref AllCut*"). In the following rows, s.t. refers to a constraint set to the solution, e.g. s.t. *Ref AllCut* means that the solution's indicator value has to be at the level of the reference plan. The last three rows show the indicator specific maximums.

	Indicator				
	EcoNet 1000 ha	AllCut 1000 m^3	Jobs man years	Recr 1000 ha mill.	TurnO €
Reference	**1082**	**4938**	**2710**	**337**	**295**
Pareto 1	1096	4943	2968	341	294
Pareto 2	1085	4950	2701	341	294
Pareto 3	1087	4950	2701	341	294
Pareto 4	1095	4956	2698	339	295
Pareto 5	1092	4967	2702	340	295
Pareto 6	1087	4981	2709	340	296
Max EcoNet *s.t.Ref AllCut*	1138	4940	2702	305	294
Max Recr *s.t.Ref AllCut* [a)]	1095	4941	2691	344	294
Max AllCut *s.t.Ref EcoNet*	1083	5240	2808	300	305
Max Recr *s.t.Ref EcoNet*	1176	4594	2577	351	281
Max AllCut *s.t.Ref Recr*	1047	5033	2724	340	299
Max EcoNet *s.t.Ref Recr*	1195	4567	2557	341	279
Max EcoNet	**1200**	4553	2547	319	278
Max AllCut	910	**5733**	**3004**	264	**328**
Max Recr	1176	4594	2577	**351**	281

[a)] Solution is also one of the seven solutions that provide pareto improvement.

Table 3. Differences in the three indicator values between the country level solutions and the reference solution. The actual values of the reference solution are show in the first row.

	Indicator		
	EcoNet 1000 ha	AllCut 1000 m^3	Recr 1000 ha
Reference	**1082**	**4938**	**337**
Pareto 1	+14	+5	+4
Pareto 2	+3	+12	+4
Pareto 3	+5	+12	+4
Pareto 4	+13	+18	+2
Pareto 5	+10	+29	+3
Pareto 6	+5	+43	+3
Max EcoNet *s.t.Ref AllCut*	+56	+2	–32
Max Recr *s.t.Ref AllCut* [a)]	+13	+3	+7
Max AllCut *s.t.Ref EcoNet*	+1	+302	–37
Max Recr *s.t.Ref EcoNet*	+94	–344	+14
Max AllCut *s.t. Ref Recr*	–35	+95	+3
Max Econet *s.t. Ref Recr*	+113	–371	+4
Max EcoNet	+118	–385	–18
Max AllCut	–172	+795	–73
Max Recr	+94	–344	+14

[a)] Solution is also one of the seven solutions that provide pareto improvements.

Table 4. Alternatives selected for regions in different Metsähallitus level solutions. Pareto refers to seven solutions that offer Pareto improvements at Metsähallitus level.

	WLapland	ELapland	Bothnia	Kainuu	WFinland	EFinland
Reference	**4**	**4**	**1**	**4**	**4**	**1**
Pareto 1	4	4	3	2	3	4
Pareto 2	4	4	4	2	3	4
Pareto 3	4	4	3	2	4	4
Pareto 4	4	4	1	2	1	5
Pareto 5	4	4	5	2	1	4
Pareto 6	4	4	3	2	1	4
Max EcoNet *s.t. Ref AllCut*	2	5	5	1	5	5
Max Recr *s.t. Ref AllCut* [a)]	4	4	4	2	5	1
Max AllCut *s.t. Ref EcoNet*	2	2	5	2	5	5
Max Recr *s.t. Ref EcoNet*	4	4	4	5	5	5
Max AllCut *s.t. Ref Recr*	4	4	4	2	2	5
Max EcoNet *st. Ref Recr*	4	5	5	5	5	5
Max EcoNet	5	5	5	5	5	5
Max AllCut	2	2	2	2	2	2
Max Recr	4	4	4	5	5	5

[a)] Solution is also one of the seven solutions that provide pareto improvement.

combinations could become regionally accepted.

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 strategies would be needed. In Kainuu the solutions suggest heavy emphasis on timber production. In the other regions, there is some variation between the suggested strategies.

In order to maximize the ecological network on the country level, the selected plan alternatives should be substituted by some other alternative in every region (Table 4). The same holds for maximizing allowable cut.

In order to maximize recreation areas in the frame of selected cuttings, changes would be needed in the regions of Bothnia, Kainuu and WFinland. In the Bothnia region, the change would increase recreation areas by about 10%, and decrease cuttings by about 2%; the ecological network would remain unchanged. In the Bothnia region, the social impacts of FFPS (through cuttings and jobs) were ranked as the most important goal in the regional NRP process, so it is hard to say if the substitute alternative could become accepted by the area's stakeholder group. In the Kainuu region, the recreation areas would shrink by about 10%, cuttings would increase by about 5% and the ecological network would decrease by about 5%. During the initial NRP process of Kainuu, the stakeholder group did not accept any decrease in the ecological network. In WFinland, both recreation area and the ecological network would be enlarged by about 10%, and cuttings would decrease by about 10%. In WFinland, a strategy emphasizing biodiversity and recreation was adopted and thus, the suggested changes are in line and strengthen the adopted strategy. However, cuttings were also considered quite important, and it is hard to say if a drop of 10% in cuttings could become accepted in the stakeholder group of the WFinland region.

4 Discussion

Different planning approaches conclude to different outcomes in regard of effectiveness of forest resource use and acceptability of the plans in different planning levels. The top-down approach allocates resources efficiently from the top-level perspective, the bottom-up approach provides optimal results for the low-level, and the integrated approach combines the elements of these two and provides compromise solutions.

The developments in strategic forest planning have been based mainly on the top-down approach during the last decades (e.g., Hoganson and Rose 1984, Jonsson et al. 1993, Redsven et al. 2009). The approach provides appropriate results for long term forest policy decisions on large areas. In the top-down approach, aggregated data are generally applied, and the planning is subtracted to the main criteria. Thus, e.g. locally important issues and spatial relationships of the data may be difficult to take into account, which may cause problems in the implementation (e.g. Weintraub and Davis 1996). More recently, the introduction of participatory approaches has enhanced the use of the bottom-up in practical planning processes (e.g. Pykäläinen 1999, Hiltunen et al. 2008). The bottom-up approach provides feasible and optimal plans on the lower level, but the outcome may not be optimal on the upper level (e.g. Hoen et al. 2006, Pykäläinen et al. 2007).

Often hierarchical planning processes include some interaction between the planning levels and thus some characteristics of integrated approach. It is, however, hard to find a profound integrated approach from forest planning practice. In the integrated planning approach, the important issue is the consistency between different planning levels which is searched by structured interaction between the planning levels, combined with iterative planning loops (Castelletti and Soncini-Sessa 2006). This aspect has not received much attention e.g. in the Finnish state forest planning, partly due to sequential nature of the regional planning processes.

Due to increasing demands towards different uses of natural resources, it seems evident that more diverse assessments of the production possibilities of forest resources are needed in various different large scale hierarchical forest planning processes (e.g. Raitio 2008). This calls for the provision of versatile information in the planning processes. The calculations carried out in this study illustrated how differently FFPS's forest resources could be managed and what kind of effects certain selections would result both on the country level and on the regional level. In addition, the calculations illustrate the potential impacts on the acceptability of the forest use when country level guidance is strengthened.

There exist different solutions for hierarchical planning processes (e.g. Nousiainen et al. 1998, Kurttila et al. 2001). In FFPS, the plans based on local preconditions are first generated for regions, and the country level plan is then composed of the selections made at the regions. The regional plan alternatives provide versatile information for regional participation and decision making. The planning procedure provides regionally optimal plans with respect to the regional goals, and the plans on both levels are consistent with each other and implementable in practice (e.g. Weintraub and Davis 1996). All information from the regional processes is available at the whole FFPS level, and it could be used in setting frames for the regional processes. Still, in the end, the aggregate country level result is primarily decided in the regional processes, and the country level efficiency cannot be secured. For example, the calculations of this study showed that the cutting amount of FFPS was not located at the efficient frontier. In addition, we do not know whether the ecological network or recreational areas are optimal in size and location on the country level (see e.g. Weintraub and Davis 1996, Bragg et al. 2004). However, it seems that big efficiency improvements on the country level are not possible, if regional acceptability is also striven for.

Although questions about the country level optimum have been raised, creation of country level top-down alternatives for e.g. comparison purposes has not been a common approach in FFPS. This study was started by an effort to carry out the principal top-down planning calculations at country level by using the whole stand database of FFPS (Weintraub and Cholaky 1991). However, the size problem of LP was met and the task was unmanageable; despite of the progress in development of optimization techniques and computational power during last decades (e.g. Atamtürk and Savelsbergh 2005). The top-down solutions of this article were combinations of regional alternatives that were created in regional processes. The alternatives were based on regional views and their variation was restricted to some degree. The pareto improvements on the country level could have been greater, if the top-down solutions were based on country level LP-problems that utilize whole country level variation. On the other hand, the NRP regions are very large, which probably limits the possibilities to increase the country level efficiency due to increased planning scale. Hence, it is not clear that genuine top-down optimization or specialization of forest use among the regions would considerably improve the country level efficiency.

In the current bottom-up NRP processes, the local sustainability issues have generally been profoundly considered with stakeholders, and consequently the regional plans and the connected operations have been rather widely accepted (Pykäläinen et al. 2007, Hiltunen et al. 2008, 2009). In FFPS, the approach has probably been able to prevent conflicts that could have resulted in deadlocked situations where e.g. the cuttings need to be restricted remarkably. Regarding the interchange between different planning levels, it has been difficult for the participants in some NRP processes to accept pressures coming from the upper levels of the operational environment, e.g. pressures of national and international non-governmental organizations to protect more old-growth forests in Lapland (Itä- ja Länsi-Lapin luonnonvarasuunnitelma 2006). In addition to the risk of inefficiency at the country level, a drawback of the current approach is limited coordination between regions. However, until now the outcomes of the NRP plans have fulfilled the country level goals set for FFPS by the parliament.

The results of this study indicate that increased specialization and different allocation of responsibilities among regions might allow more efficient use of the resources on the top-level. In this situation, some regions could emphasize biodiversity aspects, some recreation and some wood production. Specialization would be based on the natural conditions of the regions, and on the needs emerging either from country level or from the region or local level. However, it is hard to predict "the right level of specialization", because e.g. biodiversity issues are highly spatially dependent, and mutual trade-offs between biodiversity areas or subjects in different regions are often hard to decide (e.g. Moilanen et al. 2010). Possibilities for recreation are also needed in every region.

The acceptability of the country level top-down solutions was evaluated in this study by posterior analysis. The utilized preference information and experiences from the earlier NRP processes suggest that major changes in the regional strategies would not be acceptable. In a real planning situation, the results could have been different. The new information provided by the top-down solutions could have promoted iterative negotiations between the planning levels about the needs and possibilities to adjust the goals on both levels (Castelletti and Soncini-Sessa 2006, Sessions and Bettinger 2001). This kind of interaction might have turned the participation results on the regional level more favorable towards the top-down approach.

When comparing the bottom-up and the top-down approach, a basic question is the number and nature of evaluation criteria or indicators to be included. Altogether 19 indicators were applied in the original NRP processes. Five of them were basically common, the rest were more or less case-specific by their definitions. In the current bottom-up planning approach, each regional optimum included all relevant indicators of that planning case. In the top-down approach the indicators were substrated to five common indicators, and finally to three to allow more illustrative comparisons of the results. It is evident that a lot of information stayed unused in the top-down approach. On the other hand, when planning a top-down survey "from an empty table", it is natural to restrict to the main indicators in order to keep the data manageable and the analysis coherent. Thus, decisions have to be made based on more rough data in the top-down approach compared to that of bottom-up, which emphasizes the importance of criteria and indicator selection.

In general, the criteria used on the top-level may well differ from the criteria used on the lower level. However, regionally important issues that are not included in the calculations as criteria or indicators have to be analyzed and discussed between the planning levels before making final decisions. In the case study, an example of these kinds of issues was the question about the quality of the ecological network. In one region it was described by "area of herb-rich sites", in another by "the area of old-growth forests". These questions should be taken into account in the hierarchical planning processes.

As a summation, in order to be successful in the interaction and in order to develop the NRP process towards the integrated approach, new feedback and negotiation procedures need to be developed for NRP. As there has been no country level participation at FFPS, the country level goals of different stakeholders are not well known. Therefore, the acceptability of the existing or new country level solutions is not known either. In the future, organizing country level participation process should be considered. The important country level stakeholders should be involved, including forest and environmental state organizations, forest industry, recreational users, NGOs, country level land-use planners, research organizations etc..

Introduction of integrated planning process would enable the adoption of a country level participatory process. In this kind of process, both vertical (between NRP areas and country level stakeholder group) and horizontal (between NRP areas) interaction would be needed. One possible solution for integrated country and regional level participation in NRP could be to let the country level stakeholder group to define their preferences before regional processes. These preferences could be used to figure the interesting decision space on the country level, and to roughly frame the regional alternative spaces. Then, the regional groups could comment the frame and suggest possible adjustments from their own perspective. The common sight on the country level frame and on the regional alternative spaces would be found by discussions and negotiations between the country level and regional groups. It is important to notice that acknowledging country level goals calls for interaction also between the regions. After creation of the feasible regional plan alternatives, the country level solution would be conducted based on the country level preferences. The country level solution would then be divided to the regions according to the regional plan alternatives included in the solution. In the finalizing phase of the regional plans, the regional characteristics could be taken into account in more detail.

The rotating style of the NRP processes within regions and the long duration of the seven NRP processes might cause problems when applying the top-down or integrated approaches. Some problems might be avoided by simultaneous planning processes, as described above. In this situation, organizing the required planning expertise and management capabilities of these parallel sub-processes may create new challenges.

If the goal of NRP also in the future is regional optimality and wide acceptability of the regional plans and local forest management, the bottom-up approach works rather well and it has provided reasonable resource use also on the country level. If the aim is to make the resource use still more efficient, the planning approach should be further developed. This means that attention should be given also to the participatory evaluation of the alternatives at the country level. According to the results of this study, it is proposed that the NRP planning is developed towards integrated approach in future planning cases. This approach would provide the most versatile information for decision making on both levels, and support both vertical and horizontal interaction in the planning process.

The general approaches of this study as well as the principles of the calculations can be useful when formulating processes and selecting methods for many different participatory geographically hierarchical natural resources planning situations. These kinds of situations are common also in forest policy processes. For example, all European countries should develop and start to implement national forest programs by 2020 (FOREST EUROPE Work Programme 2012). In the creation of these programs, it is important to consider the efficiency, acceptability and geographical allocation of different forest related actions. In addition, similar situation also occur, for example, in forest companies and municipalities, where the management of forest resources is geographically organized.

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