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Large-Scale Forest Owner's Information Needs in Operational Planning of Timber Harvesting – Some Practical Views in Metsähallitus, Finnish State-Owned Enterprise

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Metsähallitus in Finland is a state enterprise that manages about 3.5 million hectares of productive commercial state-owned forest land. Metsähallitus has a forest management planning system which uses information stored in a GIS-based forest resource information system. The information on forest resources is currently collected using a standwise inventory system with ocular estimation of stand characteristics. New promising inventory methods based on laser scanning have been introduced. Before taking a new system into use, the information needs of Metsähallitus must be analysed. In this study, information needs in operational harvest planning have been analysed with a qualitative approach. A total of eight team leaders in the forestry business unit were interviewed, six of them representing the process responsible for the operational harvest planning and two representing the process responsible for the harvest and deliveries. Based on the study, two main decision making points with different information needs were confirmed. The first decision making point is related to finding the areas potential for immediate or near future harvesting. Here, geographical information on the need for the treatment as well as rough information on the harvestable volume is needed. In the second decision making point, a final decision of sites to be harvested is made with rather intensive field work. Precise delineations of the treatment are needed as well as good estimates of volumes of different timber assortments. When considering a new inventory system it is justified to consider how much of the information needs in these decision making points can be covered. Two different approaches are proposed for further analysis. The interviews revealed a need for a more structured tactical planning system. Some of the findings of this study – especially the decision making points and information needs in them – may be transferable to other large-scale forest owners.

Keywords forest inventories, harvest planning, information needs
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1 Introduction

1.1 Forests Managed by Metsähallitus

Metsähallitus is a state enterprise that manages practically all state-owned forest lands in Finland. The total land area under Metsähallitus management is about 9 million hectares. The area of commercially managed forests is about 5 million hectares of which 3.5 million hectares have been classified as productive forest land and 1.5 million hectares as poorly productive non-commercial forest lands that are not subject to normal forest activities. Goals related to biodiversity, recreation, reindeer husbandry and Sámi culture restrict the planning and implementation of forest operations. Restricted operations are practised on approximately 0.6 million hectares of the productive commercial forest area. About 5 million cubic meters of raw wood are harvested annually and delivered to customers. (Metsähallitus Annual Report 2007).

Of the total land area of 9 million hectares, about 4 million hectares are conservation areas, wilderness areas and areas assigned to various special uses (Metsähallitus Annual Report 2007).

1.2 Forest Management Planning in Metsähallitus

1.2.1 Regional Natural Resource Planning

According Kangas et al. (2008) forest management planning can be either strategic planning with a time horizon from 20 years upwards, tactical planning with a time horizon from 5–20 years or operational planning where standwise recommendations from tactical planning are carried out. Metsähallitus applies a two-level forest management planning system for commercially managed forests. These two planning levels with a specific planning method are: regional natural resource planning (NRP) and operational planning. NRP can be considered as a strategic level planning system, even though it serves also as a tactical plan in the sense that the plan alternatives are tactically and operationally valid for implementation (Hiltunen et al. 2008). NRP and a Landscape Ecological Planning system were developed to complement traditional forest management planning in the 1990's. Initially they were carried out as separate planning processes but later merged so that landscape ecological planning became a part of NRP (Hiltunen et al. 2008).

The goal of NRP is to work out a balanced management concept for the forests and other natural resources fulfilling all dimensions of sustainability (Hiltunen et al. 2008). All land use categories are included in the planning. Participatory planning is applied with several different approaches (Pykäläinen et al. 1999, Kangas et al. 2001, Wallenius 2001, Pykäläinen et al. 2007, Hiltunen et al. 2008, 2009). Cutting budget calculations and other analyses are used for analysing the production possibilities of the planning area in alternative production programmes. The development of forest resources is simulated and an optimal cutting scheme is defined through optimization with a linear programming algorithm. MELA software (Redsven et al. 2007) is used for the calculations. The key results from NRP for commercial forestry are the land use allocation, cutting budget, targets for silvicultural measures, and some structural targets related to biodiversity for the forests (Metsähallituksen luonnonvarasuunnittelu – Suunnitteluohje 2004). The plans cover a 10-year period. In the middle of the period an intermediate scrutiny of the plan is carried out. This may result in changes for the remainder of the period (Metsähallituksen luonnonvarasuunnittelu – Suunnitteluohje 2004).

1.2.2 Operational Planning

Commercial forests are managed by the Forestry business unit. The unit is divided into two functional departments: the first focuses on the "forest use" process and the other on "delivery to customers" process (Metsähallitus Annual Report 2007). Both of these processes have a distinct organisational and geographical structure. The process "forest use" is responsible for operational planning. The process prepares harvesting plans which are then implemented by the process "delivery to customers". The actual harvesting and wood transport is carried out by contracted private companies. The process "forest use" is geographically divided into 7 regions of which one region (Upper Lapland) has a special status and internal structure. Each of the other 6 regions is divided into forest teams (generally 3, a total of 21 in Metsähallitus) and each forest team is further divided to planning areas (3–10). A forest team is managed by a team leader. Each planning area has a planner who is responsible for producing harvest plans in his area. The planner is supervised by the team leader and assisted by a various number of forest workers (2–10 people). These forest workers have a received special training in conducting standwise inventories.

Silvicultural treatment plans and harvest plans are operational level plans that are to be implemented. Specific instructions have been compiled for the planning of operational harvests. According to the instructions (Korjuun suunnitteluohje 2007) plans must include maps showing the exact location of the harvest (thinnings and regeneration harvests separately) and estimates of the expected volumes by timber assortments. In the planning, the compartments to be thinned during either of the summer or winter seasons are grouped as distinct parcels. Again, the same is done for compartments scheduled for final harvest. This means that each parcel will be harvested in a uniform manner in a specified season. Parcels that are located close to each other and that are expected to be harvested in a sequence constitute a working site. Each parcel should include a maximum harvest volume of 1500 m^3 for thinning and 2000 m^3 for final harvest. On the other hand, the volume to be harvested from a parcel should be no less than 100 m^3. In the instructions, a target of +/–10% accuracy for the estimation of harvestable volume in one working site has been set (Korjuun suunnitteluohje 2007).

Operational planning includes assessing or checking the stand attributes in the field. In addition, the field work includes checking and marking of the valuable nature sites and marking of the main haulage tracks and landings. It generally also includes preliminary planning of some activities related to the harvest, such as planning of soil preparation and planting or planning of drainage.

1.2.3 Linkage Between NRP and Operational Planning, Tactical Planning

Natural resource plans are implemented through silvicultural treatment plans and harvest plans (Hiltunen and Laamanen 2008). The NRP produces a cutting budget and targets for the area of thinning and regeneration for each region. The MELA optimal solution found in the NRP produces a harvest programme which consists of stand-level proposals. The proposals are stored in the GIS. However, they can not be implemented as such as they have been derived without any spatial considerations – the proposals are scattered all over the planning area. In practice, harvests have to be planned by grouping compartments so that e.q. road maintenance costs can be minimized. In order to support the grouping a maximum harvest calculation (maximum MELA) is done with MELA using a 5% interest rate in the calculations (Lehtinen 2008). A high interest rate is used in order to get all silviculturally meaningful harvest proposals into the solution. These proposals are then stored in the GIS, as well, so that they can be utilised in the tactical and operational planning. It has been found out that these maximum MELA solutions are more useful for the operational planning than the NRP proposals. This was found, for example, when Metsähallitus developed a tool for road investment analysis in the road GIS (Tieinvestointien tehokas kohdentaminen 2008). In this tool, costs and revenues for each road investment project can be analysed. In the analysis, the maximum MELA proposals are used to predict the expected revenues in the area of influence of the road in question. With this tool, the profitability of a single road investment can be assessed and alternative investments can be compared.

Operational planning is generally preceded by sketching the working sites on which harvest would be carried out within a time horizon of up to 3–5 years. In Metsähallitus this is understood as tactical planning. However, there is no fixed method or software support for tactical planning. The planning is done with various approaches in different geographical parts of Metsähallitus. A common feature in the approaches is that near future harvests are first predicted using either the GIS stand information or the aforementioned maximum MELA proposals. The harvests can be then visualised on thematic maps and harvestable volumes analysed with a spreadsheet software. Using this information a plan is made that describes how operational planning field work will be scheduled during the coming years. Having no fixed planning system at this level allows flexibility for the operational planning. This facilitates, to some extent, using a market driven approach to scheduling operations.

1.3 Forest Resource Information System

1.3.1 Forest Inventory

Forest resource information used at all levels of forest management planning is collected using a standwise inventory method. In this inventory system stands are delineated on aerial photographs and an ocular estimation of stand characteristics using 2–8 sample plots is carried out in the field (Koivuniemi and Korhonen 2006, Kangas et al. 2004). The estimation includes basal area sweeps with relascope and measurement of average diameter and height of the mean tree for each species. The sweeps can be subjectively located or laid out systematically in the stand. The geographic information system has the following information categories for each stand: land use, forest resources, information on nature characteristics and information on multiple use (Metsähallituksen luonnonvarasuunnittelu – Suunnitteluohje 2004). Up to 1995 the forest resource information was collected for specific forest management planning projects. Since 1995 the information has been updated as a part of the operational forest management planning. In this continuous updating system no specific inventories are carried out. Stands that will be included in a harvest plan or in some other operational forest management plan are visited in the field and the stand dimensions are assessed and updated in the GIS. Neighbouring stands that will not be harvested are inventoried as well so that over a longer period of 10–15 years all stands will have been visited. A harvest proposal is recorded for stands that meet either the thinning criteria or the final harvest criteria. For the stands to be harvested, target values for the stand parameters to be achieved upon completion of the operation are defined and recorded.

Based on the updated forest data a plan is prepared. It is both printed as a document and stored in digital format in the pool of harvest plans. Then later, after the planned operation has been carried out, new data describing the situation after the operation will again be updated in the system. This is done using either the target values or by measuring the stand parameters after the operation has been completed. The stand parameters and stand delineations must be updated immediately after the operation has been completed or, at the latest, by the following February (PATin päivitysperiaatteet 2006). Annual growth of the stands is updated once a year in February with a mass computer run using the growth models produced by the Forest Research Institute (Hynynen et al. 2002, Metsähallituksen luonnonvarasuunnittelu – Suunnitteluohje 2004). Updating with prediction models causes errors to the stand data (e.q. Hyvönen and Korhonen 2003, Haara and Leskinen 2009, Pietilä et al. 2010, Holopainen et al. 2010) which need to be considered when information systems are designed.

1.3.2 Quality of Stand Information

Strict regulations for the maximum acceptable age of stand information in the system have not been given in Metsähallitus. The age of stand parameters (year of field inventory) in the GIS can be seen in Fig. 1. There are some differences between the southern regions, Bothnia and Kainuu regions and Lapland regions. Information that has been collected earlier than 1995 originates from the last district level forest inventories. Old information is more prominent in the north. The reason for this is that the growth of forest in the north is slower than in the south and there is no need for as frequent updating as is in the south. About 50% of the total area has been assessed during the last five years. On the other hand, about 26% of the area has been assessed more than 10 years ago.

A basic requirement for the quality of stand information is that it does not have a significant bias which would cause errors in long term predictions in allowable cut calculations. This is analysed in the NRP projects by comparing the stand information and the information derived from the

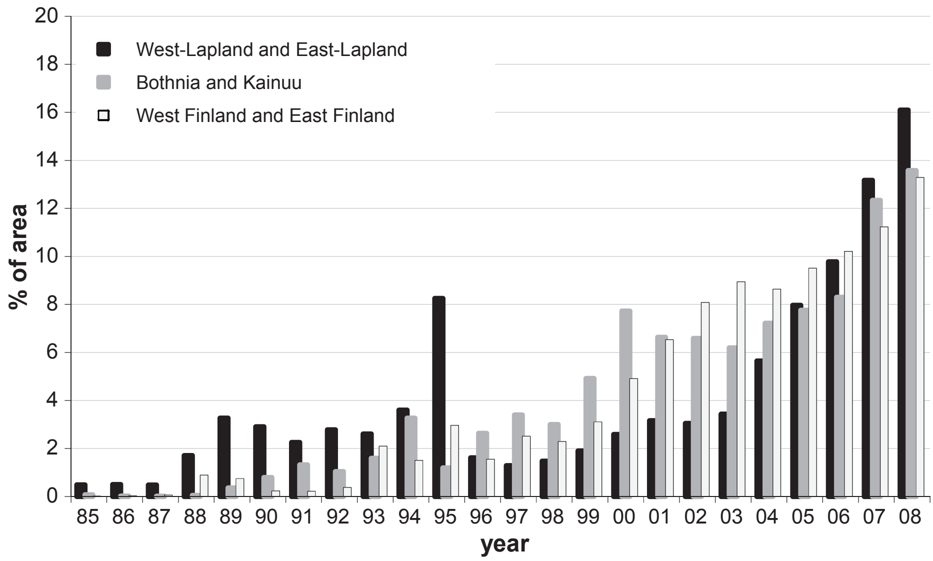

Fig. 1. The share (%) of productive forest land area according to the year of the latest field assessment of stand parameters. (source Metsähallitus SutiGis Geographical Information System 11.12.2008).

National Forest Inventory (NFI) field data. Data from NFI field plots (Tomppo 2006) that fall in Metsähallitus forests are used in these analyses. Comparisons are done either by comparing key statistical figures (Pohjanmaan luonnonvarasuunnitelma 2007) or by making a comparable cutting budget calculation using NFI data (Kainuun alueen luonnonvarasuunnitelma 2004).

The quality of standwise inventories has been studied e.q. by Haara and Korhonen (2004), Koivuniemi (2003) and Laasasenaho and Päivinen (1986). As the results of these studies depend much of the target area of each study, Metsähallitus has made some own studies as well. Pigg (1994) studied the accuracy of stand parameters inventoried by Metsähallitus in southern Finland. During the late 1990's specific control measurements of stand data were carried out (Kemppi 1998). Vaara (2007) analysed the distribution of deviations between planned and actual volumes in operational harvest plans in West Lapland. In 26% of the logging parcels analysed (total of 178 parcels), the error of the planned volume was less than 10%. In 56% of the logging parcels the error was more than 20%. The quality of the maximum MELA-proposals in West Finland was analysed by Lehtinen (2008). According to him 90.7% of the MELA-proposals matched with the proposals made by the planners in the field.

The stand boundaries in the GIS originate from the last district level inventories done in the 90's. In some areas there are significant alignment problems with data originating from other sources. For example, the stand boundaries in some areas do not match well with new digital real estate boundaries produced by the National Board of Land Survey. Due to the former use of non-orthorectified aerial photographs in the digitization process, the stand boundaries may not match well with those coming from newer orthorectified photographs. Manual fixing of these alignment problems has been very time consuming. To speed this up a software for automatic segmentation of stands using digital aerial photographs has been developed (Kemppainen 2007).

The system of continuous updating of standwise growing stock information has been used since 1995. In a few regions, however, additional subsequent campaigns have been implemented to improve the quality of the information. Some technical improvements (e.q. colour-infrared orthophotos and field computers) have improved the efficiency of the work over the years. However, despite of the development of newer remote sensing techniques, no practical level forest inventory application utilizing these techniques have been used in large scale. For non-commercial purposes a large land area of about 2.6 million hectares of biotope mapping of the conservation and wilderness areas in North Lapland was carried out in 1996–99 using visual interpretation of colour-infrared air photos and limited field work (Sihvo 2001).

1.4 New Inventory Techniques and Analysis of Information Needs

New promising methods for assessing stand parameters with laser scanning techniques have been introduced recently (e.q. Næsset 2002, Næsset et al. 2004, Suvanto et al. 2005, Packalén and Maltamo 2007, 2008). In Finland a method based on airborne laser scanning (ALS) has been tested and shown to be cost-efficient compared with the current standard method of standwise forest inventory (Uuttera et al. 2006). A new forest resource information system based on these techniques for management planning of privately owned forests has been designed and will be implemented (MMM 2008). UPM Kymmene Oyj has analysed the possibility to replace traditional field inventories with laser scanning based inventories (Juntunen 2006).

The ALS-based inventory techniques have proved to be at least as accurate and more cost-efficient than the current inventory method (Haara and Korhonen 2004, Uuttera et al. 2006, Packalén and Maltamo 2007). Therefore, it would seem evident that the new system will replace the current one. However, in order to justify investments in extensive data collection with new technology, special attention should be put on analysing the information needs. There are some significant differences between the inventory results produced by an ALS based technique and the current inventory method. With an ALS based inventory an improved spatial resolution can be achieved. The quality of the information is more uniform than in the current standwise inventory as there is no subjective element related to the ALS-based method. According to the study of Packalén and Maltamo (2007), the stand level total characteristics were estimated with much higher accuracy than with the current inventory system while the species specific accuracies were comparable with the conventional field inventory by compartments.

For rational decision making in forest management, information on what quantities of various resources are present is required (Shiver and Borders 1996). The purpose of the forest inventory must be clearly defined and its planning designed to achieve that purpose (Manual of Forest Inventory 1981). However, "a traditional" analysis of the purpose of the inventory would probably not be comprehensive enough to make satisfactory conclusions about the information needs and about the acceptable costs related to producing that information. "A traditional" approach here is understood as an approach to interview the known and potential users of the information, or to send a questionnaire to them. "A traditional" analysis does not include an analysis of the complex decision making system. This approach risks identifying information needs which may overemphasize information produced by the current inventory system.

According to Duvemo and Lämås (2006), not properly identifying the decisions for which data is being gathered may lead to sub-optimal inventory efforts in practical forestry. To solve this, all (or at least most) uses of the information need to be recognized. Perhaps a more useful approach would be to apply a cost plus loss analysis where the implications of errors in data for forest management decisions are calculated. Effect of errors in inventory data on forest management profitability have been studied eq. by Holmström et al. (2003), Eid et al. (2004), Borders et al. (2008), Islam et al. (2009) and Mäkinen et al. (2010). Eid (2000) analysed – using simulated errors in data – the losses in net present value of the forest due to errors in timing the final harvests. Juntunen (2006) analysed the losses due to sub-optimal forest management decisions caused by inaccuracies in data. He compared two methods: the current inventory method based on ocular estimation and a laser scanning based inventory. According to Duvemo and Lämås (2006) a common feature of research in this field is that it concerns highly simplified planning situations. Duvemo (2009) evaluated, by way of a cost-plus loss analysis, the use of a current practice of using two to somewhat different data sets for tactical and operational planning in a large corporate forest owner's holding in Sweden. Another approach would be to analyse the value of information (VOI). Considerable research has been done in the field of supply chain management and inventory replenishment. Ketzenberg et al. (2007) – based on literature survey – designed a framework of the determinants of the value of information and tested some hypotheses of how the determinants affect the value of information. There is some work done in this respect within forestry as well. Kangas et al. (2010) studied the value of quality information for timber buyers and concluded that investing in quality information was profitable only for the stands of highest volume. Kangas (2010) showed that a VOI analysis can be applied in forestry using Bayesian decision theory and emphasized the need to start analyzing the real data needs of decision makers.

In order to apply "decision oriented inventory planning" (Eid 2000), we first need to define the decision making situations in which the forest information is used. Secondly, as stated by Duvemo and Lämås (2006), to calculate the losses of making decisions on uncertain information, it should be decided how and when losses occur. There are costs that occur with a short time span like costs related to timber harvesting, storing and transportation. From the forest owner's point of view some of these costs may be direct costs that cause immediate production costs or losses in revenues. Again, there are costs due to non-optimal forest management that occur only with a long time span and which may be difficult to recognize. In addition the costs related to the inventory itself must be accounted for.

Barth et al. (2006) studied the needs of input data for preparing national level scenarios for sustainable forestry at a national level. These types of analyses are complex as different types of benefits must be included and multiple stakeholder groups have to be involved in the planning. Barth et al. (2006) claimed that in the end the choice of inventory method in such a situation using cost plus loss approaches will be largely subjective. As a replacement for cost plus loss analyses they proposed a more generic qualitative reasoning for the selection of inventory strategy. In the first step, inventory strategies must be characterised with certain indicators. In the second step, for a set of given indicators, an assessment of the likely consequences of using a certain strategy with a specific quality is determined.

1.5 Objective of the Study

Metsähallitus is looking for more cost efficient methods for producing and managing forest resource information. The current system is labour intensive and, with the continuously rising costs of manpower, becoming more and more expensive. In order to achieve the "decision oriented inventory planning", the current practices and the use of information in forest management planning in Metsähallitus must be analysed. Duvemo and Lämås (2006) recommend that the development of new data acquisition methods should be carried out in close co-operation with the developers of planning and decision support systems, as well as with its final users in practical forestry. The planning system in Metsähallitus is a complicated one with several planning levels. Planning is supported with a number of different computer software systems. With respect to the accuracy of forest resource information, perhaps the most demanding process is the operational harvest planning. Therefore it is justified to start analysing the decision making situations and information needs at the operational planning level. This study aims at recognizing and analysing the information needs related to forest stocking experienced by the personnel in charge of planning of the operational timber harvesting. Before implementing a new inventory technique, it is worthwhile to examine how well it supports the targeted decision making. In this study, the main features of current practices in operational timber harvest planning and in updating of forest resource information will be looked at. Different decision making situations will be analysed and the information needs in these situations will be examined. Differences in the practices between different geographical locations within Metsähallitus will be included. Problems related to current practices and to the use of current information will be studied. Based on this analysis, recommendations for development and needs for further research will be derived.

2 Material and Methods

A qualitative method using semi-structured interviews (Eskola and Suoranta 1998) was applied in this study. Forest team leaders from the process "forest use" were identified as the key group representing the data user views. They are the supervisors of the actual planners. They can also be considered representatives of mid-level management. According to Hyötyläinen and Kalliokoski (2001) mid-level management has a clear enough picture of the every-day operations of the organisation and its problems in development. In addition, mid-level management can give information to the management of the organisation of the realistic possibilities and constraints related to operations. A total of six interviewees from the regions of the process "forest use" were selected by the respective regional directors. The region Upper-Lapland was left out of the study because of its unique status and relatively low cutting budget (less than 3% of the total of Metsähallitus). Even though the actual users of the harvest plans are employed in the process "delivery to customers" the main target group was chosen from the process "forest use". Two team leaders from the process "deliveries to customers" were selected as representatives of the actual data users. This was done to get supplementary information directly from the actual data users on some of the themes. Interviewees from process "deliveries to customers" were selected by the director of the process.

A set of questions was designed and sent to the interviewees before the interviews. The following themes were covered by the questions in the interviews of "forest use" team leaders: 1) current sources of information for locating harvest operation sites, 2) method applied in tactical planning and need for developing an established system, 3) applied practices in updating stand information, 4) accuracy requirements for volume estimates on a logging site, 5) cost implications of high errors in timber volume estimates and 6) current problems related quality of stand information and 7) need for data by tree species. In the interviews of the team leaders of the process "delivery to customers" only themes 4) and 5) were discussed. However, some views related to theme 2) were also expressed in these two interviews. The themes were selected and questions were designed using prior expert information on the operational planning process and decision making in it. In addition, problems earlier raised by some individual planners were used in defining the themes. In setting the questions, the main strengths and weaknesses of the new laser based inventory techniques were considered too.

Additional questions were asked during the interviews in order to achieve a relatively uniform level of details in the answers and to clarify some concepts. The two team leaders from the process "delivery to customers" were interviewed using a different set of questions which were not provided to them beforehand. The interviews were carried out between 12.12.2006 and 6.3.2007. Two of the interviews were done at the headquarters of Metsähallitus and the rest of them at the local office of each interviewee. The shortest interview took 52 minutes and the longest one took 1 hour and 40 minutes. The average duration of the interviews was 1 hour and 4 minutes. All interviews were digitally recorded. In the analysis, a traditional method of itemizing the contents was used (Eskola and Suoranta 1998). The recordings were decoded by typing the key facts given by the interviewees into a table (from the six "forest use" team leaders and on to a list from the two team leaders of the process "delivery to customers") for further analysis. Only facts that were clearly linked to the chosen themes or to the phases of the planning process in question were recorded in the table. Due to the semi-structured nature of the interviews facts describing a certain matter did not appear in the same order. From the table, similarities in the facts were searched and the facts grouped according to the theme and to the phase of planning process. No transcribing of the recordings was deemed necessary as only reasonably clear facts were gleaned from the interviews. The data acquisition might have been possible to carry out through a questionnaire as well. However, as some of the questions included technical terms that might require explanation, it was considered more reliable to carry out interviews with a possibility to give explanations or additional supporting questions.

The specific questions are listed in the appendix. In the interviews some additional questions were asked. They were, to some extent, different in each interview and are not listed in the appendix. Also, some questions which were finally considered irrelevant to the topic of the study have not been listed and the answers to them were not analysed. The six interviewees from the process "forest use" have been designated as FU1 to FU6 and the two interviewees from the process "delivery to customers" have been coded as DC1 and DC2. The corresponding regions of the interviewees have been given in the appendix.

3 Results

3.1 Current Sources of Information for Locating of Harvest Operation Sites

In all regions the two most common sources of information for locating harvest planning sites are the GIS (stand database) and aerial photographs. These were listed by all interviewees of the process "forest use". Local knowledge was mentioned by 4 interviewees (FU1,FU2,FU4,FU5). Harvest proposals generated in the previous field assessment were mentioned by one team leader (FU5). Maximum MELA harvest proposals were mentioned in 4 interviews (FU1, FU2, FU4, FU6). There are big differences how much value is given to the maximum MELA proposals. Two interviewees (FU2, FU6) think that they are important especially for young planners without very much local knowledge. According to these two replies the reliability of the proposal is not always considered good, but nevertheless they give good information on where harvest possibilities can be found. In two teams (FU5, FU3) they are considered to be too unreliable and therefore they are not being used. The other of these teams has a practise to order a specific MELA-calculation for planning of future harvests. This calculation is very much like the maximum MELA-calculation although it has some specifications defined differently than in the "standard" calculations.

Five interviewees told the NRP cutting budget proposals are not used in locating harvesting sites. One interviewee did not know about these proposals and suspected that they had not been brought to the GIS at all (FU4).

The above mentioned sources of information are used for directing field work for operational level planning. The actual harvesting decisions in all teams are made on the basis of field visits. Two team leaders emphasize the need of extensive field work to locate harvesting possibilities and to prepare the harvest plans (FU3, FU4). Very much time in the field is used for delineating the actual harvest locations in heterogenous natural forests as the actual harvest areas can be much smaller than the stand delineations (FU1). In one team, all harvest sites are delineated with a GPS (FU6).

3.2 Method Applied in Tactical Planning (Planning of Harvest Location) and Need for Developing an Established System for Tactical Planning

Four interviewees (FU2, FU3, FU4, FU5) described how the tactical planning (planning of harvest location) is carried out. In one team (FU4) this type of planning is understood as a base plan which directs the field work resources to certain areas to search or to confirm the harvesting possibilities and to update the stand information. In one team (FU3) planning is based on analysing potential harvesting volumes by groups of stands using the maximum MELA proposals and selecting a number these groups for field planning. In one team (FU2) this type of planning means that during winter time the short-term planning sites are selected, and each planner has his own way doing this. In one team (FU5) systematic planning is applied each year: a spreadsheet software is used to analyse areas and volumes of stands to be harvested in the coming year. One interviewee indicated that no "true" tactical planning is done (FU6) and another said that they don't do tactical planning in their region (FU2). However, it is unlikely that there would be no such tactical planning at all in these two teams. It may be that their planning is very flexible and the interviewees did not recognise it as tactical planning.

Five out six interviewees indicated that a specific system for tactical planning is needed. Having an established system would strengthen the planning. The system should allow a longer planning period and should support comparisons between potential harvesting sites (FU1, FU2, FU6). One interviewee (FU4) suggested that the new road investment analysis option in the road GIS will be enough to satisfy the tactical planning needs.

The team leaders of the process "delivery to customers" were asked about development needs in the planning of harvest sites. Both interviewees (DC1 and DC2) see that the planning should include a better analysis of the harvest cycle and the concentration of harvests, and that planning should avoid producing very fragmented harvesting sites.

3.3 Applied Practices in Updating Stand Information

Forest workers specialised in planning usually assist in carrying out stand assessments, except in one team (FU3). Furthermore, in two teams (FU2, FU5) the forest workers prepare actual harvest plans as well. Generally, however, only the planner prepares the actual harvest plans. The stand parameters are, in most cases, re-assessed for preparing the harvest plan in three of the teams (FU1, FU5, FU6). In one team, if the previous assessment is very recent, it is not done again (FU4). In the case of thinning a control type of assessment is sufficient (FU3). There are two approaches among the planners in updating the stand information. One is to update a certain geographical area and measure all stands in it systematically. One is to measure the stands to be included in the harvest plan and stands only in immediate vicinity. In one team stands outside harvest sites are measured with fewer sample plots (relascope sweeps) or are not measured at all (FU5).

According to 4 interviewees (FU1, FU3, FU5, FU6), the stand characteristics are not generally measured after the harvest has been carried out. This means that after the cutting, the target stand characteristics stored in the stand database are changed to those of the new assessment. However, if there is any indication from the process "delivery to customers" staff that the actual harvesting has not followed the plan, a new assessment is done (FU1, FU4). In two teams (FU2, FU4) some measurements after the harvest are done, but more from the point of view of quality control.

In two teams (FU2, FU3) specific campaigns on updating old stand information were carried some years ago. These campaigns have been completed and no new ones have been planned. However, one interviewee (FU3) expects that there may arise a need for such campaigns again.

3.4 Accuracy Requirements Set for Volume Estimates on a Working Site

The interviewees were asked what should be the acceptable error for the total volume estimate at a working site. According to 4 interviewees (FU1, FU4, FU5,FU6), an error at the level of 20% for total volume is considered to be the limit for an acceptable estimate. One interviewee (FU3) puts the limit at 10% and one (FU2) at 25%. The acceptable error in sawlog volume is considered to be at the same level (FU1, FU4). In one team, special emphasis in the field planning is put on assessing the volumes by timber assortments as small amounts of specific assortments are delivered to many mill sites (FU4). On the other hand, in one team (FU6), the issue of timber assortments is somewhat less important as not so many different special assortments are delivered. However, in this team (FU6), assessment of defects in expected sawlogs is considered important.

Especially in the case of questions related to accuracy it must be kept in mind that the interpretation of a question may be different between the interviewer and the interviewee. E.q. the interviewee may have understood that the area in question is larger than what the interviewer has meant. This could explain the exceptionally high accuracy requirement given by one of the interviewees.

One interviewee from the process "delivery to customers" puts more emphasis on the estimates of timber assortments than in the total volume (DC1). According to him, an error of 20% in the total volume is not a problem, especially if the actual volume is higher than expected. Errors in the relative proportion of assortments within a certain tree species is considered more problematic. The 10% accuracy target was considered reasonable by the other interviewee in the process "delivery to customers" (DC2). The other one thinks it is tight but can be achieved in normal conditions (DC2).

The team leaders of the process “delivery to customers” were asked how feedback is given to the planners on the achieved accuracy. A follow-up table is compiled where totals over a longer time period are being monitored (DC1). Feedback is given directly to the planner working at the same office and the table is given to the “forest use” process (DC1). The actual volumes harvested are written on the harvest plans so that the planners can see in writing how accurate the estimates have been (DC2). Verbal feedback to the planners is given as well (DC2).

3.5 Cost Implications of High Errors in Timber Volume Estimates

Three types of direct cost implications due to high errors in volumes were mentioned. First, higher than expected volumes of spruce assortments may result in storing wood at the roadside for a longer time than usually. If this takes place in spring or summer it may cause quality losses (FU3, DC1). Secondly, low actual harvest volumes may mean that new winter roads will have to be prepared late in spring time (FU1). On the other hand, high actual harvest volumes may cause that some winter roads that have already been prepared will be unnecessary (FU5). On peatlands the harvests are linked with other works like ditch maintenance and fertilizing. Changes in the implementation of harvests will then cause changes in the plans and implementation of these works (FU5). The third direct cost implication mentioned (DC2) is related to the sudden closing of work sites or opening of new work sites due to errors in volume estimates. This is a direct cost to the contracted private logging companies but will indirectly affect the harvesting costs of Metsähallitus as well. These direct costs due to errors in volume estimates are not a very big issue (FU3, DC2). Many of the errors in volume estimates can be managed through rescheduling of the harvest programme (FU6). However, high errors in volume estimates may sometimes lead to serious difficulties in the scheduling and may cause a hurried search for a new harvesting site (FU2, FU4, DC2). Today, a major problem with the structure of the reserve of harvesting sites is the shortage of sites suitable for summer harvesting (DC2).

3.6 Current Problems Related Quality of Stand Information

Four out six interviewees (FU1, FU3, FU4, FU5) mentioned that there are problems related to the geometry or the alignment of the stand boundaries in the GIS. Maintenance of the geometry is laborious and it is expensive to maintain the current quality (FU3). Two teams (FU2, FU4) mentioned that there still exists some unreliable information in the stand database. In one team (FU6) the stands have enormous internal variation and decision making based only on current stand information is not possible. In general, the current quality of the stand information is considered to be reasonably good in four teams (FU2, FU3, FU4, FU5). Two teams (FU1, FU6) do not consider the quality to be very good. In the coming years there will be large areas of young stands reaching thinning dimensions. With the current stand data quality a lot of time has to be spent on finding and delineating the actual parcels for harvesting (FU1).

3.7 Need for Data by Species

The stand information currently includes a description of the dimensions (basal area, mean height and diameter and age) of each species and crown layer. As an option, instead of parameters for all species, only relative proportions of stand volume or basal area of the main species would be presented. Three teams (FU2, FU3, FU4) felt that dimensions by species and data concerning timber assortments will be important in the future. Three teams (FU1, FU5, FU6) considered that having information by species might not be necessary in the basic structure of the stand data, since decision making on where to start the planning of operational harvests does not require that level of detail. Only standwise volumes categorized by thinning and by final cutting are required at this stage (FU5). Operational planning, in any case, includes field work and the species information as well as information on timber assortments can be added to the data of the stands actually to be harvested at that time (FU5, FU6).

4 Discussion

4.1 Decision Making Points

Based on the study, the planning of harvest operations can be confirmed to have two distinct work phases and decision making points: 1) search and analysis of harvest possibilities and 2) actual planning of the harvest. These two decision making points have different information needs.

4.1.1 Work Phase 1 / Decision Making Point 1

In the first work phase the decision making question is whether to implement actual operational harvest planning on a certain area or not. This can be understood to be the question of decision making at the tactical planning. For this decision making, information on the maturity (for regeneration) and density (for thinning) of the stands is required as well as a rough estimate of volumes to be harvested. On the other hand, detailed information on volumes by timber assortments is not needed at this stage. Information in this work phase is currently acquired from several data sources such as GIS, aerial photos, local knowledge and field work. There is big variance on the spatial structure and reliability of the stand information (GIS) within different parts of Metsähallitus. The quality seems to be lowest in the northern regions, perhaps due to the large areas and somewhat more extensive type of forestry practiced there over the past decades. The team leaders representing the northern regions felt that the current stand data is not good enough for locating the harvest possibilities. This means that a lot of field work is needed. In the southern regions, the situation is different and the quality of the data is considered better.

4.1.2 Work Phase 2 / Decision Making Point 2

During the second work phase in operational harvest planning, decisions are made about which parts of a certain area are actually going to be harvested. This work phase is based on rather intensive field work. During the field work the dimensions of the stands to be harvested are assessed and the actual harvest area is delineated. The assessed stand dimensions are used to confirm the decision to harvest. As a result of this planning phase, the actual harvest site is delineated both in the GIS and in the field with necessary field markings. Finally, up-to-date estimates of volume information of different timber assortments are assessed. Stands to be harvested and to be included in the harvest plans are practically always re-inventoried or at least the validity of the stand parameters are checked. This practice resembles the two-level inventory in the tactical and operational planning system analysed in the study of Duvemo (2009).

The acceptable maximum error of the total volume estimate at one harvest working site is considered to be 20%. The team leaders interviewed felt that an error higher than this would be too large. On the other hand, the target of 10% error which is set by the planning instructions is generally considered to be too tight for practical work. Therefore, the 10% figure given in the instructions is seen more as "a target only". The interviewees' opinion was that the sawlog volume should be estimated with at least a similar accuracy as the total volume. According to Haara and Korhonen (2004), using the traditional standwise inventory, an RMSE of 25% for volume can be achieved which means that in two cases out of three an accuracy better than this can be achieved. According to the study, an RMSE of 40% can be achieved for timber volume. There seems to be a need for improvement in this respect.

Direct costs incurred as a result of large errors in volume estimates are related to the deterioration in the quality of timber when stored too long at the roadside, or to forced and unplanned changes in the implementation of the harvests. Losses related to the quality occur occasionally but they are not seen as a significant problem. Errors in volume estimates are managed by the "delivery to customer" process by modifying and rescheduling the harvest programme. This may sometimes be a serious problem especially in years of mild winter when harvesting is not possible at all sites. Flexibility due to both the scale of operations in general and the large pool of harvest sites alleviates these problems. There is some need for improvement in the estimates of sawlog volumes in particular, however, the problem seems not to be very serious. Large errors are related to the method of standwise inventory and especially the subjective element in it. Improving accuracy with the current system leads to an increased amount of field work and higher costs.

4.2 Tactical Planning

The forest management planning system of Metsähallitus does not include an established and structured method for tactical planning. Tactical planning is done, but with various methods without any rigid formalities. According to this study the team leaders in the process "forest use" feel that there is a need for a better organized planning method.

The cutting proposals from the maximum MELA-calculations (5% interest) are in some areas seen as very useful and in some areas less useful due to the high rate of unrealistic proposals. Lehtinen (2008), based on a study carried out in West Finland region, proposed that the quality of the MELA-proposals can easily be improved by setting the calculation parameters to better match the practical guidelines of forest management in each region. The quality of the stand data is rather good in West Finland region. Particularly in the northern regions, it is very likely that the unrealistic proposals produced by MELA are mainly caused by the great heterogeneity of the stands.

4.3 Considerations on New Approaches

When considering the future development of the forest resource information system in Metsähallitus and taking into account the new promising features in ALS-based inventory techniques, two different approaches could be designed and studied further. The first option would be to clearly separate the data used in the decision making point 1 from the data used in the decision making point 2. That could, for example, mean that the decision making at point 1 would be based on ALS inventory data with good spatial resolution and reliability for the purpose. The decision making at point 2 would be based on traditional field work. The second option would be that the remote sensing material to be acquired would be accurate enough to fulfil the information needs at both decision making points. The two options – or three options if the current practice is included – could be compared for example to the cost-plus loss approach used by Duvemo (2009).

In analysing the value of any new information to assist in the decision making at point 1, the following aspects must be especially kept in mind: the spatial resolution of the information and the reliability of the stand parameters with respect to the correct timing of the next treatment. The value of information at point 2 is affected by the same qualities but, in addition, requires reliable estimates of volumes of different timber assortments. The main expected gain in using any new data lies in the reduced need for field work. If this is so, some might ask why not aim directly at producing data that would fulfil information needs at both decision making points? There are at least two reasons why this might not be appropriate. First, the information needs concerning volumes of timber assortments at decision making point 2 seem to be fairly stringent and it may be very expensive to produce such information reliably with remote sensing methods. Secondly, field work in operational planning is currently needed for other purposes, as well. These include, for example, assessing nature types that need to be preserved, assessing logging conditions, planning of forest haulage routes and making field markings for harvest machines. These are tasks that need to be done in the field regardless of the source and quality of the actual stand information. According to recent studies (Uuttera et al. 2006, Packalén and Maltamo 2007) laser scanning inventories are promising and could possibly possibly even satisfy the information needs at the decision making point 2. This needs to be verified through further studies and tests in the field. The findings of this study – decision making points and information needs in them – could perhaps be useful for other large forest owners as well when planning their inventory and information systems.

This study revealed opinions of the staff working with practical level forest management planning and staff working with harvest operations concerning their information needs. It is very likely that their views do reflect the true information needs. On the other hand it is very difficult to quantify these needs with the approach used in this study. A proposed next step would be to analyse which of the above outlined approaches would be the most profitable.

The analysis of the value of new information brought to the planning system must include the possible gains through improved decisions through level planning. A remote sensing based inventory could produce up-to-date information on a large area over a large area in a short time period. If the quality of the remote sensing data would be uniform over the inventory area and if it would be at a level that has been achieved in the recent studies, it would create new possibilities to analyse the profitability of different harvest schemes and to use optimization in decision making. The development of a structured tactical planning system in Metsähallitus should be initiated. Perhaps this should first aim at designing a simple basic system which would make it possible to analyse harvest possibilities both spatially and numerically, and to make preliminary harvest programmes with a 3–5 year time horizon. Then, the next step would be to introduce optimization features in the system.

This study has looked at the information needs at operational planning level, and to some extent at tactical planning. The study has focused on the information on the growing stock only. When analyzing the value of the information, other information needs – like the needs in NRP – have to be taken into account as well. Finally, it must be kept in mind that Metsähallitus aims at maximizing multiple benefits from the forests. There are many data users with specific data needs. Therefore, the design of information structures and systems is a complex task. The qualitative approach chosen for this study helps to build a picture of the decision making points and information needs in the target planning process. The picture is important but it does not allow making a cost plus loss analysis. Some reasonably good quantitative assumptions regarding short term losses could be made on the basis of this study. Actual quantitative studies are still needed to complement information on the costs and losses for the design of the system. However, as Barth et al. (2006) have stated, in a complex situation the choice of inventory method may, irrespective of such analyses, remain largely subjective.

References

Barth, A., Lind, T., Peteresson H. & Ståhl, G. 2006. A framework for evaluating data acquisition strategies for analyses of sustainable forestry at national level. Scandianvian Journal of Forest Research 21(1): 94–105.

Borders, B.E., Harrison, W.M., Clutter, M.L., Shiver, B.D. & Souter, R.A. 2008. The value of timber inventory information for management planning. Canadian Journal of Forest Research 38: 2287–2294.

Duvemo, K. 2009. The Influence of data uncertainty on planning and decision planning and decision processes in forest management. Doctoral dissertation. Department of Forest Resource Management, SLU. Acta Universitatis Sueciae 2009:6.

— & Lämås, T. 2006. The influence of forest data quality on planning processes in forestry. Scandinavian Journal of Forest Research 21: 327–339.

Eid, T. 2000. Use of uncertain inventory data in forestry scenario models and consequential incorrect harvest decisions. Silva Fennica 34(2): 89–100.

— , Gobakken, T. & Næsset E. 2004. Comparing stand inventories for large areas based on photo-interpretation and laser scanning by means of cost-plus-loss analysis. Scandinavian Journal of Forest research 19: 512–523.

Eskola, J. & Suoranta, J. 1998. Johdatus laadulliseen tutkimukseen. Osuuskunta Vastapaino. (In Finnish).

Haara A. & Korhonen, K.T. 2004. Kuvioittaisen arvioinnin luotettavuus. Metsätieteen aikakauskirja 4: 489–508. (In Finnish).

— & Leskinen, P. 2009. The assessment of the uncertainty of updated stand-level inventory data. Silva Fennica 43(1): 87–112.

Hiltunen, V. & Laamanen, R. 2008. Suurten alueiden suunnittelu – Metsähallituksen suunnittelujärjestelmä. Tapion taskukirja. (In Finnish).

— , Kangas, J. & Pykäläinen, J. 2008. Voting methods in strategic forest planning – Experiences from Metsähallitus. Forest Policy and Economics 10: 117–127.

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

Holmström, H., Kallur, H. & Ståhl, G. 2003. Cost-Plus-Loss analyses of forest inventory strategies based on kNN-assigned reference sample plot data. Silva Fennica 37(3): 381–298.

Holopainen, M., Mäkinen, A., Rasinmäki, J., Hyytiäinen, K., Bayazidi, S. & Pietilä, I. 2010. Comparison of various sources of uncertainty in stand-level net present value estimates. Forest Policy and Economics 12: 377–386.

Hynynen, J., Ojansuu, R., Hökkä, H., Siipilehto, J., Salminen, H. & Haapala, P. 2002. Models for predicting stand development in MELA system. Finnish Forest Research Institute Research Papers 835.

Hyötyläinen, R. & Kalliokoski, P. 2001. Tietojärjestelmien käyttöönottoprosessi. In: Toiminnanohjausjärjestelmän käyttöönotto pk-yrityksessä. VTT julkaisuja 854. Espoo. (In Finnish).

Hyvönen, P. & Korhonen, K.T. 2003. Metsävaratiedon jatkuva ajantasaistus yksityismetsissä. Metsätieteen aikakauskirja 2/2003: 83–96. (In Finnish).

Islam, N., Kurttila, M., Mehtätalo, L. & Haara, A. 2009. Analyzing the effects of inventory errors on holding-level forest plans: the case of measurement error in the basal area of the dominated tree species. Silva Fennica 43(1): 71–85.

Juntunen, R. 2006. Puustotiedon laadun vaikutus metsänkäsittelyn optimoinnin tuloksiin – UPM Metsän laserkeilausaineiston ja kuviotiedon vertailu. Pro gradu -tutkielma. Helsingin yliopisto. Metsäekonomian laitos. (In Finnish).

Kainuun alueen luonnonvarasuunnitelma 2004. Kausi 2002–2011. Metsähallituksen metsätalouden julkaisuja 50. (In Finnish).

Kangas, A. 2010. Value of forest information. European Journal of Forest Research 129: 863–874.

— , Kangas, J. & Pykäläinen, J. 2001. Outranking methods as tools in strategic natural resources planning. Silva Fennica 35(2):215–227.

— , Heikkinen, E. & Maltamo, M. 2004. Accuracy of partially visually assessed stand characteristics – a case study of Finnish inventory by compartments. Canadian Journal of Forest Research 34: 916–930.

— , Kangas, J. & Kurttila M. 2008. Decision support for forest management. Managing Forest Ecosystems 16. 224 p.

— , Lyhykäinen, H. & Mäkinen, H. 2010. Value of quality information in timber bidding. Canadian Journal of Forest Research 40:1781–1790.

Kemppainen, T. 2007. Kuvioverkon oikaisu. Loppuraportti. Moniste. Metsähallitus. (In Finnish).

Kemppi, E. 1998. Raportti Lieksan kuviotietojen laadun mittauksesta. Moniste. Metsähallitus. (In Finnish).

Ketzenberg, M., Rosenweig, E., Marucheck, A. and Metters, R. 2007. A framework for the value of information in inventory replenishment. European Journal of Operational Research 182: 1230–1250.

Koivuniemi, J. 2003. Metsiköihin ja paikannettuihin koealoihin perustuvan kuvioittaisen arvioinnin tarkkuus. The accuracy of the compartmentwise forest inventory based on stands and located sample plots. Helsingin yliopiston metsävarojen käytön laitoksen julkaisuja 36. Dissertation. 160 p.

— & Korhonen, K.T. 2006. Inventory by compartments. In: Kangas, A. & Maltamo, M. (eds.). Forest inventory – methodology and applications. Managing Forest Ecosystems Vol 10. Springer. 362 p.

Korjuun suunnitteluohje 2007. Metsähallituksen metsätalouden ympäristöjärjestelmä. Moniste. (In Finnish).

Laasasenaho, J. & Päivinen, R. 1986. Kuvioittaisen arvioinnin tarkistamisesta. Folia Forestalia 664. 19 p. (In Finnish).

Lehtinen, J. 2008. Metsäsuunnittelun järjestelmien ehdottamien toimenpiteiden laatu. Pro gradu -tutkielma. Helsingin yliopisto, Metsävarojen käytön laitos. (In Finnish).

Mäkinen, A., Kangas, A. & Mehtätalo, L. 2010. Correlations, distributions and trends of forest inventory errors and their effects on forest planning. Canadian Journal of Forest Research 40: 1386–1396.

Manual of forest inventory 1981. Food and agriculture organization of the United Nations. Rome.

Metsähallituksen luonnonvarasuunnittelu – Suunnitteluohje 2004. Metsähallituksen metsätalouden julkaisuja 47. (In Finnish).

Metsähallitus, Annual Report. 2007. Finland.

Metsähallitus SutiGis Geographical Information System 11.12.2008. http://www.metsa.fi/sivustot/metsa/en/NaturalResources/Informationsystems/Geographicinformationsystem/Sivut/GeographicInformationSystem.aspx

MMM 2008. Maa- ja metsätalousministeriön metsävaratiedon ja metsäsuunnittelun strategia 2008–2015. (In Finnish).

Næsset, E. 2002. Predicting forest stand characteristics with airborne scanning laser using a practical two-stage procedure and field data. Remote Sensing of Environment 80: 88–99.

— , Gobakken, T., Holmgren, J., Hyyppä, H., Hyyppä, J., Maltamo, M., Nilsson, M., Olsson, H., Persson, Å & Söderman, U. 2004. Laser scanning of forest resources: the Nordic experience. Scandinavian Journal of Forest Research 19: 482–499.

Packalén, P. & Maltamo, M. 2007. The k-MSN method for the prediction of species-specific stand attributes using airborne laser scanning and aerial photographs. Remote Sensing of Environment 109: 328–341.

— & Maltamo, M. 2008. Estimation of species-specific diameter distributions using airborne laser scanning and aerial photographs. Canadian Journal of Forest Research 38: 1750–1760.

PATin päivitysperiaatteet 2006. Metsähallituksen metsätalouden ympäristöjärjestelmä. Mimeograp. (In Finnish).

Pietilä, I., Kangas, A., Mäkinen, A. & Mehtätalo, L. 2010. Influence of growth prediction errors on the expected losses from forest decisions. Silva Fennica 44: 829–843.

Pigg, J. 1994. Keskiläpimitan ja puutavaralajijakauman sekä muiden puustotunnusten tarkkuus Metsähallituksen kuvioittaisessa arvioinnissa. Metsänarvioimistieteen Pro gradu -työ. Helsingin yliopisto, metsävarojen käytön laitos. 92 p. (In Finnish).

Pohjanmaan luonnonvarasuunnitelma 2007, Kausi 2007–2017. Metsähallituksen metsätalouden julkaisuja 59. (In Finnish).

Pykäläinen, J., Kangas, J. & Loikkanen, T. 1999. Interactive decision analysis in participatory strategic forest planning: experiences from State owned boreal forests. Journal of Forest Economics 5: 341–364.

— , 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.

Redsven, V., Hirvelä, H., Härkönen, K., Salminen, O. & Siitonen, M. 2007. MELA2007 Reference Manual. The Finnish Forest Research Institute. 642 p.

Shiver, B. & Borders, B. 1996. Sampling techniques for forest resource inventory. John Wiley & Sons, Inc.

Sihvo, J. 2001. Ylä-Lapin luonnonhoitoalueen ja Urho Kekkosen kansallispuiston luontokartoitus. Loppuraportti osa 1: Projektikuvaus. Metsähallituksen luonnonsuojelujulkaisuja. Sarja A, 130. (In Finnish).

Suvanto, A., Maltamo, M., Packalén, P. & Kangas, J. 2005. Kuviokohtaisten puustotunnusten ennustaminen laserkeilauksella. Metsätieteen aikakauskirja 4: 413–428. (In Finnish).

Tieinvestointien tehokas kohdentaminen, 2008. Loppuraportti. Metsähallitus. (In Finnish).

Tomppo, E. 2006. The Finnish national forest inventory. Chapter 11. p. 179–194. In: Kangas, A. & Maltamo, M. (eds.). Forest inventory – methodology and applications. Managing Forest Ecosystems Vol 10. Springer. 362 p.

Uuttera, J., Anttila, P., Suvanto, A. & Maltamo, M. 2006. Yksityismetsien metsävaratiedon keruuseen soveltuvilla kaukokartoitusmenetelmillä estimoitujen puustotunnusten luotettavuus. Metsätieteen aikakauskirja 4: 507–519. (In Finnish).

Vaara, P. 2007. The quality of a stand marked for cutting in the Metsähallitus Lapland delivery to customer-process. Thesis. Rovaniemen ammattikorkeakoulu.

Wallenius, P. 2001. Osallistava strateginen suunnittelu julkisten luonnonvarojen hoidossa. Metsähallituksen metsätalouden julkaisuja 41. (In Finnish).

Total of 58 references

Appendix 1. Questions presented to interviewees working in process "forest use".

1) Current sources of information in tactical planning or in locating of harvest sites
   a) Describe how potential harvest sites are located by your team
   b) What are the roles of following materials and methods in defining the need for treatment?
      i) Stand database (GIS) with up to date stand information
      ii) Aerial photo interpretation
      iii) Maximum MELA harvest proposals (calculated with 5% interest rate)
      iv) Other sources – please specify material and method
2) What kind of experiences have you had of the maximum MELA harvest proposals?
3) What kind of role do the harvest proposals created with the Natural Resources Planning process have?
4) Do you think that a uniform and established planning method should be developed for tactical planning? Do you think that tactical planning should be supported with a specific computer software?
5) Quality requirements for stand data
   a) How big is the acceptable error between a tree volume estimate and a harvested volume in a working site (in per cent)? (Can be understood as a kind of a limit. If the error is expected to be higher the volume estimation should updated.)
      i) Considering total volume estimate (all tree species)?
      ii) Considering volume estimates by tree species (or by timber assortments)?
   b) What kind of problems or additional costs will be encountered if the error is higher?
   c) How important is it to have stand parameters described by tree species in the information system?
6) Current problems related to the quality of stand information
   a) What are the biggest problems related to stand information in the GIS when used for operational planning of treatment?
   b) How would you describe the quality of the stand information used by your team?

Interviews of the team leaders of the process "forest use" by regions:
FU1 = West Lapland; FU2 = Kainuu; FU3 = West Finland; FU4 = East Finland; FU5 = Bothnia;
FU6 = East Lapland

Appendix 2. Questions presented to interviewees working in process "delivery to customers".

1) How big is the acceptable error between a tree volume estimate and a harvested volume in a working site (in per cent)?
   i) Considering total volume estimate (all tree species)?
   ii) Considering volume estimates by tree species (or by timber assortments)?
2) What kind of problems or additional costs (losses) will be encountered if the error is higher?
3) What kind of development needs do you see in the current operational harvest planning system?
4) How do you give feedback to the planners regarding the accuracy of their estimation?

Interviews of the team leaders of the process "delivery to customers" by regions:
DC1 = West Finland; DC2 = Lapland