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Non-Industrial Private Forest Landowners' Choices of Timber Management Strategies and Potential Allowable Cut: Case of Pohjois-Savo

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In the study, the potential allowable cut in the district of Pohjois-Savo – based on the non-industrial private forest landowners' (NIPF) landowners' choices of timber management strategies – was clarified. Alternative timber management strategies were generated, and the choices and factors affecting the choices of timber management strategies by NIPF landowners were studied. The choices of timber management strategies were solved by maximizing the utility functions of the NIPF landowners. The parameters of the utility functions were estimated using the Analytic Hierarchy Process (AHP).

The level of the potential allowable cut was compared to the cutting budgets based on the 7th and 8th National Forest Inventories (NFI7 and NFI8), to the combining of private forestry plans, and to the realized drain from non-industrial private forests. The potential allowable cut was calculated using the same MELA system as has been used in the calculation of the national cutting budget.

The data consisted of the NIPF holdings (from the TASO planning system) that had been inventoried compartmentwise and had forestry plans made during the years 1984–1992. The NIPF landowners' choices of timber management strategies were clarified by a two-phase mail inquiry.

The most preferred strategy obtained was "sustainability" (chosen by 62 % of landowners). The second in order of preference was "finance" (17 %) and the third was "saving" (11 %). "No cuttings", and "maximum cuttings" were the least preferred (9 % and 1 %, resp.). The factors promoting the choices of strategies with intensive cuttings were a) "farmer as forest owner" and "owning fields", b) "increase in the size of the forest holding", c) agriculture and forestry orientation in production , d) "decreasing short term stumpage earning expectations", e) "increasing intensity of future cuttings", and f) "choice of forest taxation system based on site productivity".

The potential allowable cut defined in the study was 20 % higher than the average of the realized drain during the years 1988–1993, which in turn, was at the same level as the cutting budget based on the combining of forestry plans in eastern Finland. Respectively, the potential allowable cut defined in the study was 12 % lower than the NFI8-based greatest sustained allowable cut for the 1990s. Using the method presented in this study, timber management strategies can be clarified for non-industrial private forest landowners in different parts of Finland. Based on the choices of timber managemet strategies, regular cutting budgets can be calculated more realistically than before.

Keywords Analytic Hierarchy Process, non-industrial private forest landowner, potential allowable cut, timber management strategy, utility function.
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Preface

This study is part of the project 'Optimization of Regional Cutting Budgets' in the Finnish Forest Research Institute. The main objective of the project is to develop a new system of calculation for determining regional cutting budgets. Special thanks are due to the following partners of the project for their help and advice during the research process: The Finnish Forest Industries Federation, The Central Union of Agricultural Producers and Forest Owners, The Forest Center Tapio, The Forestry District of Pohjois-Savo, The University of Joensuu and The National Board of Taxation.

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1 Introduction

1.1 Sustained Allowable Cut in Finland

The commercial cuttings from non-industrial private forests (NIPF) in Finland have been 50–70 % of the total amount of timber used by the country's forest industries (Aarne 1993). Thus, the timber supply from NIPF lands is important for Finland's forest-based industries. Following the economic recession, new decisions for investments are again being considered by forest companies.

The sufficiency of the wood raw material does not limit plans for new mill investments – at the national level, the sustained allowable cut (Revised Forest... 1992) has been clearly higher than the realized cuttings during last few years. However, as a possible hindrance to future investments, forest industries have been concerned about NIPF landowners' willingness to sell timber.

Generally, the regional allowable cut has been viewed on the basis of the inventory data provided by National Forest Inventories (NFI) and the cutting budgets derived by combining private forestry plans. Two major weaknesses that relate to the cutting budgets based on NFI data, are:

1 Both regional and national cutting budgets have been calculated assuming that all the country's forests are treated as a single forestry unit.
2 The variability with goals of NIPF landowners has been ignored.

Thus, considering the forest resources simply as one entity leads to an overestimation of NFI-based cutting budgets. In fact, the cutting budgets derived by combining private forestry plans can be more than 30 % lower than those based on NFI data (FOREST 2000... 1985). On the other hand, forestry plans made for NIPF holdings are often deliberate underestimations of the actual cutting potential; the cutting budgets presented in private forestry plans can be nearly 20 % smaller than the actual allowable cut based on sustained forestry (Pesonen and Räsänen 1993).

1.2 Strategic Decisions in the Management of Non-Industrial Private Forests

Strategic planning operates on the future production possibilities; the starting point of which is the convertability of the factors of production and their allocation (e.g. Kast and Rosenzweig 1974). When applied to NIPF management planning, the strategic view includes the production of alternative, strategic-level programmes for timber production and silviculture. Timber management covers a range of strategies from no cuttings at all to maximum cuttings within the limits of timber production possibilities. For instance, timber management strategies can be described by the intensity and the recurrence of cuttings.

Non-industrial private forest landowners are a heterogenous group with different objectives and intentions. Due to the overall changes in society, the structure of non-industrial private forest (NIPF) ownership of Finland is constantly changing. The average size of forest holdings is decreasing, while the number of non-farmer forest owners is constantly growing due to the inheritance mechanism (Ripatti 1992). People are less dependent on their forest property as a source of income and their attitudes toward the environmental aspects of forestry have become more positive. It has also been stated that the non-economic benefits of forestry will gain increasing importantance among NIPF landowners (Karppinen 1992).

Most NIPF landowners have long term perspectives and strategic views concerning forest management (Lönnsted 1989). It is important to understand the strategic decisions of NIPF landowners for several reasons: e.g. 1) when predicting of the timber supply from private forests for future investments by forest industries (Lönnstedt and

Roos 1993), and 2) when planning the governmental forest policy in general.

In Finland, present-day NIPF management planning is basically tactical. Landowners lack information about the actual, strategic-level decision alternatives and their consequences. Furthermore, decision analysis; that is, giving recommendations about decisions and making decisions are often separated in planning. The importance of planning in the production of decision alternatives, and in defining landowners' preferences, is often ignored. Sometimes the presentation of even a single timber production program has been called planning (Kangas and Pukkala 1992). Due in part to the growing interest shown in the non-economic uses of forest property, there is an apparent need to include strategic aspects in NIPF management planning.

While strategic forest management planning is lacking in private forestry of Finland, landowners tend to underestimate their allowable cut. Furthermore, forestry plans are usually underestimates compared to the sustained allowable cut of forest holdings (Pesonen and Räsänen 1993). Moreover, 60 % of the landowners have actually harvested even less than the cutting budget presented in forestry plans (Pesonen et al. 1994a).

Many studies on strategic forest management planning (e.g Wardle 1965, Kilkki 1968, Ware and Clutter 1971, Kangas and Pukkala 1992) have been done and several tools (Siitonen 1983, Johnson et al. 1986, Jonsson et al. 1993, Pukkala and Kangas 1993) have been developed for strategic forest management planning. However, few studies have been made concerning the regional cutting budgets derived from the strategic goals of NIPF landowners. Lönnstedt and Roos (1993) concluded that the cutting potential based on the objectives of NIPF landowners ensures an adequate supply of wood raw material for future investments by Sweden's forest-based industries.

1.3 Modelling the Strategic Decision Making of NIPF Landowners

Modelling the strategic decision making of NIPF landowners, like any other attempt at modelling human behaviour, is a complex and multidimensional task. Few studies have been made on the strategic decisions of NIPF management (Lönnstedt and Törnqvist 1990, Hansson et al. 1990, Pukkala and Kangas 1993) and the factors affecting these decisions have received little attention.

One of the methods used in decision analysis is the Analytic Hierarchy Process (AHP). Recently, the AHP has been applied to several kinds of decision situations. Moreover, there have been studies on the applications of the AHP to forest management planning (Mendoza and Sprouse 1989, Kangas 1992, Kangas and Pukkala 1992).

The Analytic Hierarchy Process is a mathematical method for analysing complex decision problems with multiple criteria (Saaty 1977, 1980). Basically, the AHP is a general theory based on certain mathematical and psychological foundations. In the AHP, a hierarchial decision schema is constructed by decomposing the decision problem in question into decisions elements: goals, objectives, attributes and decision alternatives. The importances or preferences of the decision elements are compared in a pairwise manner with regard to the element preceding them in the hierarchy (Kangas 1992). In this study, the AHP was used to determine the NIPF landowners' choices of preferred timber management strategies.

1.4 Aims of the Study

The aims of this study are to 1) produce alternative timber management strategies for the NIPF landowners, 2) find out their choices of alternative timber management strategies, 3) clarify the factors affecting these choices, and finally, 4) based on landowners' choices of timber management strategies, calculate the potential allowable cut from non-industrial private forests in the district of Pohjois-Savo. The potential allowable cut is calculated with TASO- and NFI-data to show, how reliable is to generate regional allowable cut with TASO-data.

In this study, *timber management strategy* is defined as an alternative for a NIPF landowner in the utilisation of his/her forest property and *potential allowable cut* means the regional cutting budget calculated for particular forestry area, and derived from the landowner's choices of timber management strategies.

The choices of timber management strategies

are solved by maximizing the utility functions of NIPF landowners. The parameters of the utility function are estimated with the AHP. The potential allowable cut is derived from the NIPF landowners' choices of timber management strategies, and it is compared a) to the cutting budgets based on NFI7 and NFI8, b) to the combining of NIPF management plans, and c) to the realized cuttings from NIPF lands. The potential allowable cut is calculated using the same MELA system (Siitonen 1983) as has been used in the calculation of national cutting budgets. The frame of reference of this study is presented in Fig. 1.

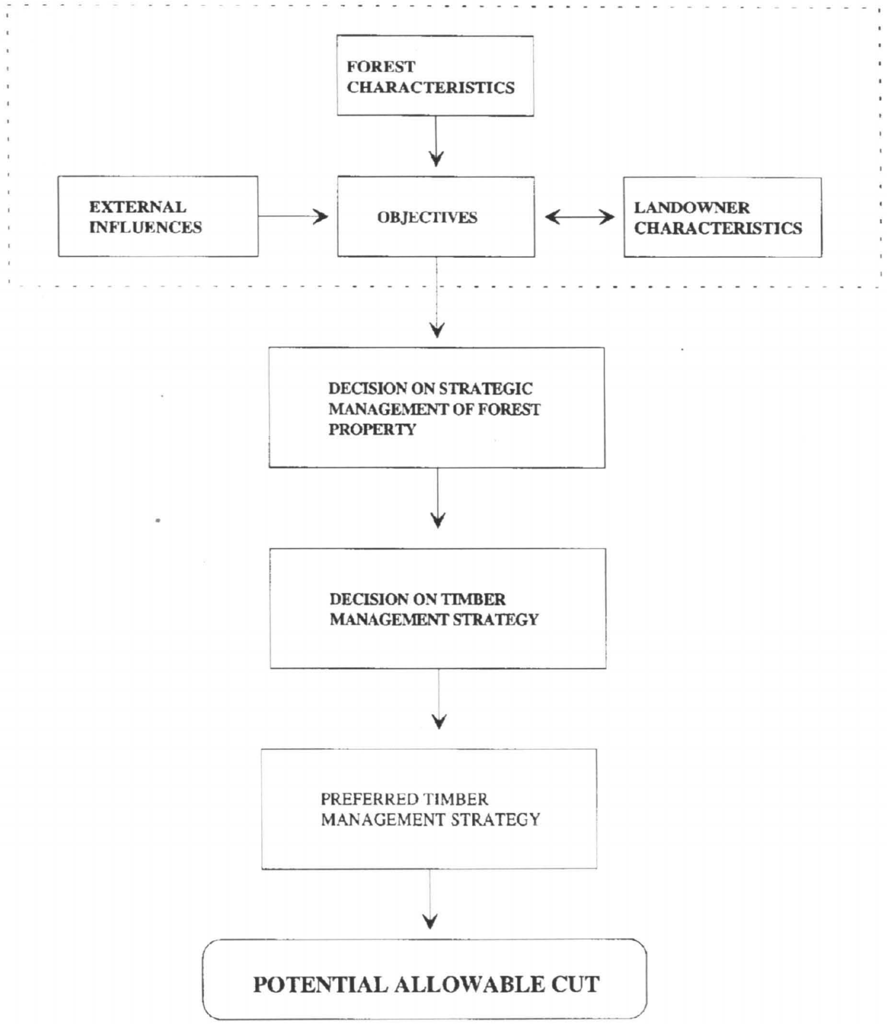

Fig. 1. Theoretical frame of the study.

2 Utility Function and Timber Management Strategies

2.1 Estimation of the Utility Function's Parameters Using the Analytic Hierarchy Process

According to a generally accepted economic theory, rational decision-makers (such as forest owners) are supposed to maximize their utility when they make decisions (eg. Hirshcleifer 1984). In the theoretical utility approach, the preferences of a decision-maker are often modelled as a function called the utility function. Utility theory has been further developed to solve decision problems with multiple objectives in complex decision situations, i.e. the Multi-Attribute Utility Theory (e.g. von Winterfeldt and Edwards 1988, Kangas 1992, Mykkänen 1994).

The linear and additive utility function applied in this study, has been the one most commonly used. It is also considered to be the easiest to interpret (Pukkala and Kangas 1993). In the formulation of the utility function for determining the choice of timber management strategy, the overall utility obtained from the use of forest property consisted of the utility obtained from the economic and the non-economic benefits of the forest property. In this study, the *economic benefits* consisted of the utility of timber production and the *non-economic benefits* of other benefits. Therefore, the form of the additive utility function was (1)

$$\max U = a_1 u_{econ}(S_j) + a_2 u_{non}(S_j) \qquad (1)$$

where

U is the total utility obtained from the use of the forest property (i.e. the utility from the preferred timber management strategy)

$u_{econ}(S_j)$ is the utility obtained from the economic benefits of the preferred timber management strategy

$u_{non}(S_j)$ is the utility obtained from the non-economic benefits of the preferred timber management strategy

S_j is the preferred timber management strategy

j is the number of timber management strategy

a_1, a_2 are parameters describing the importance of the respective criterion

The parameters a_1, and a_2 of the utility function (1) were solved using the AHP. The use of the AHP to solve decision problems may be divided into four steps (Kangas 1992):

1. The decision hierarchy is constructed by decomposing the original decision problem into a hierarchy of interrelated decision elements (Zahedi 1986).
2. Pairwise comparisions are made at each level of the hierarchy. In making the comparisons, the question concerns, which of the two factors has the greater weight in decision-making, and how much greater, or which of the two decision alternatives is more preferred with regard to a certain decision attribute.
3. Using the pairwise comparisons as the input, the relative weights (importance/preference) of the elements at each level are computed by using the eigenvalue method. The resulting weights, or priorities, represent the decision-maker's perception of the relative importance or preference of the elements at each level of the hierarchy.
4. The ratings for the decision alternatives are calculated based on the priorities of the decision elements.

In pairwise comparisons, landowners had to decide which one of the two timber management strategies they preferred, both with respect to the economic and non-economic benefits of the use of their forest property. Landowners had the option of expressing the priority ratio as (a) equal priority of both timber management strategies, (b) weak priority of one timber management strategy when compared to another, (c) strong priority of one timber management strategy when compared to another, (d) demonstrated priority of one timber management strategy over another, or (e) absolute priority of one timber management strategy over another. The respective priority ratios were translated into numerical values of 1:1, 3:1, 5:1, 7:1 and 9:1, or 2:1, 4:1, 6:1 and 8:1, as intermediate values.

Following the pairwise comparisons, a reciprocal matrix A (2) was constructed. In the matrix the element $a_{mn} = 1/a_{nm}$. Thus, when $i = j$, $a_{mn} = 1$.

$$A = (a_{mn}) = \begin{bmatrix} 1 & s_1/s_2 & \dots & s_1/s_j \\ s_2/s_1 & 1 & \dots & s_2/s_j \\ . & . & \dots & . \\ . & . & \dots & . \\ s_j/s_1 & s_j/s_2 & \dots & 1 \end{bmatrix} \qquad (2)$$

where

s_m/s_n is the priority ratio between the timber management strategies m and n

j is the number of timber management strategies compared

Using the matrix as the input, the relative priorities of the timber management strategies being compared, with respect to the economic and non-economic benefits of the use of the forest property, were computed using the eigenvalue technique. The right eigenvector of the largest eigenvalue of matrix A constituted the estimation of the relative priorities. The relative priorities were calculated by solving the eigenvector equation (3)

$$(A - \lambda_{max} I)q = 0 \qquad (3)$$

where

λ_{max} is the largest eigenvalue of A

q is its right eigenvector

I is the unity matrix

Saaty (1977) has shown that λ_{max} of a reciprocal matrix A is always greater or equal to j. If the pairwise comparisons do not include any inconsistencies, $\lambda_{max} = j$. The more consistent the comparisons are, the closer the value of computed λ_{max} is to j. Based on this property, a consistency index, CI, was constructed (4).

$$CI = (\lambda_{max} - j)/(j - 1) \qquad (4)$$

CI estimates the level of consistency with respect to the entire comparison process. A consistency ratio, CR, also measures the coherence of the pairwise comparisons. To estimate the value of CR, the average consistency index of randomly generated comparisons, the value of ACI, has to be calculated (5). The ACI varies functionally according to the size of the matrix (e.g., Saaty 1980).

$$CR = 100(CI / ACI) \qquad (5)$$

In human evaluation processes, some inconsistencies can be expected and also tolerated. As a rule of thumb, a CR value of 10 % or less is considered acceptable.

2.2 Definition of Timber Management Strategies

In order to solve the parameters of the utility function (1), five alternative timber management strategies were computed using the MELA system. MELA is a Finnish LP-based system for long-term timber management planning (Kilkki and Siitonen 1976, Siitonen 1983, 1993). The strategies were described for each landowner with the objective and constraint variables derived from the MELA parameters (Fig. 2). The planning period was 20 years, divided into four 5-year intervals. In the calculations, the forest-holding level development of several forest characteristics was described and illustrated for the landowners.

Each landowner was provided with five alternative timber management strategies covering a planning period of 20 years. In principle, the main differences between the strategies can be described in terms of intensity and the recurrence of removals. The objective variable used in optimisations was the maximisation of the stumpage earnings for the first planning period (the constraints for each strategy are presented below). The applied timber management strategies were as follows:

S_1 "NO CUTTINGS"
– removals set to zero

S_2 "SAVING"
– removals set to half of the removals under condition "SUSTAINABILITY"

S_3 "SUSTAINABILITY"
– even flow of removals over the planning period
– even flow of stumpage earnings over the planning period
– even amount of regeneration areas over the planning period
– volume of sawtimber at the end of planning period equal to, or greater, than at the beginning of period
– market value of growing stock at the end of planning period at least the same as at the beginning

S_4 "FINANCE"
– even flow of removals during the first two planning periods
– market value of the growing stock at the end of planning period at least the same as at the beginning

S_5 "MAX CUTTINGS"
– even flow of removals during the last three planning periods

The NIPF landowners were asked to prioritise the timber management strategies according to their personal goals and preferences for forest use. First, the NIPF landowners were asked to compare the importance of the economic and non-economic benefits of the use of their forest holdings. Second, pairwise comparisons were made between the management strategies, considering the economic and the non-economic benefits separately (Fig. 3). The AHP process resulted in the relative priorities for each strategy being scaled 0–1. For each landowner, the strategy with the highest global priority (i.e., one that maximises the overall benefit) thus represented the most preferred alternative.

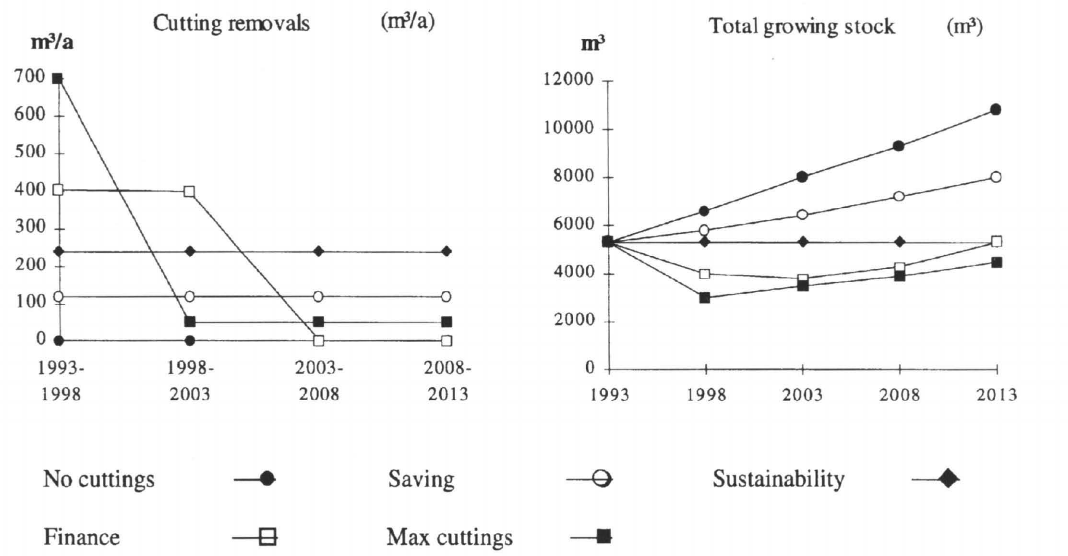

Fig. 2. Alternative timber management strategies described as the development of the removals and the total growing stock during the planning period (an example of calculations for each NIPF landowner, representing a sample case of the forest holdings).

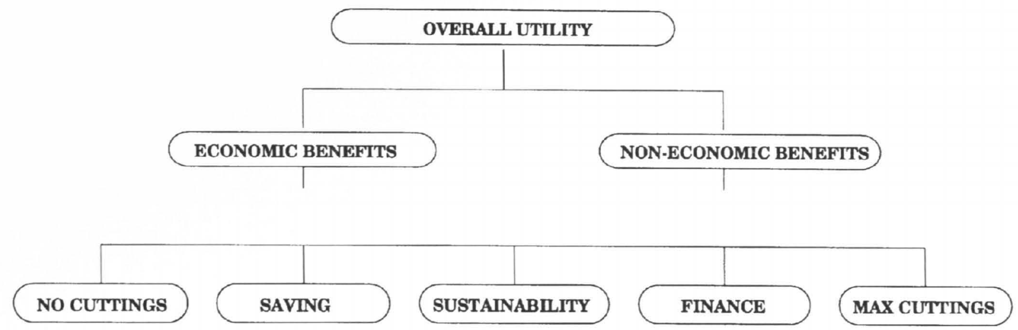

Fig. 3. Decision hierarchy for selecting the preferred timber management strategy.

3 Material

3.1 Data Sets Based on NFI and TASO

The basic data consisted of non-industrial private forest holdings in the Pohjois-Savo district that had a forestry plan made during the years 1984–1992. The data were collected from the TASO planning system, which has been the system of forest management planning for non-industrial private forestry since 1987 (Ranta 1991). The basic material consisted of 7365 forest holdings with a total forest area of 404 489 ha and an average holding size of 54.9 ha (Table 1). The coverage of the total forest area of Pohjois-Savo was 42.3 %. The difference when compared to the total coverage of the private forestry plans (73 % of total NIPF area in 1992) was due to the oldest plans not being in a usable form, and the fact that not all of the forest holdings had a forestry plan (Table 2).

Table 1. Distribution of the basic data according to the area of the forest holding.

Size of holding, ha	Forest area	%	Count	%	Average size
5–19.9	25058	6.2	1781	24.2	14.1
20–49.9	110322	27.3	3370	45.8	32.7
50–99.9	104942	25.9	1534	20.8	68.4
100–	164167	40.6	680	9.2	241.4
Total	404489	100.0	7365	100.0	54.9

Table 2. Forest area distribution of the official register on Finnish farm holdings.

Size of holding, ha	Forest area	%	Count	%	Average size
5–19.9	153502	16.8	9908	41.4	15.5
20–49.9	307742	33.8	9196	38.4	33.5
50–99.9	254132	27.9	3586	15.0	70.9
100–	196430	21.5	1252	5.2	156.9
Total	911806	100.0	23942	100.0	38.1

One of the aims of this study was to test the effect of the sampling method on the calculation of timber management strategies. Therefore, two sampling methods were used: 378 landowners were chosen by random sampling based on the NFI sample plot network and 379 landowners were chosen by systematic stratified sampling. Thus, the total sample consisted of 757 forest holdings (Table 3).

The forest holdings were divided into four groups according to their forest area: 5–19.9, 20–49.9, 50–99.9 and over 100 hectares. Stratified sampling was made according to the sizes of the forest holdings, so that the number of holdings in each sample group was determined by assigning a 4 % maximum standard error in the initial volume (m3/ha) within the groups. In the NFI-based sampling, a forest holding was included in the sample if an NFI sample plot was located on the holding and if a forestry plan had been made for the holding since 1984.

In order to obtain results as reliable as possible, the two samples were finally combined. This was done because comparison between the two samples revealed no significant differences in regard what comes to the average stand characteristics and the landowners' choices of timber management strategies.

After sampling, background information on NIPF landowners, their forest property and for-

Table 3. Distribution of the sampling according to the area of the forest holding.

Size of holding, ha	Forest area	%	Count	%	Average size
5–19.9	2388	5.1	169	22.3	14.1
20–49.9	8850	18.9	263	34.7	33.7
50–99.9	14423	30.8	205	27.1	70.4
100–	21122	45.1	120	15.9	176.0
Total	46783	100.0	757	100.0	61.8

Table 4. Distribution of the sampling after mail inquiries according to area of the forest holding.

Size of holding, ha	Forest area	%	Count	%	Average size
5–19.9	815	4.1	54	17.6	15.1
20–49.9	3442	17.2	104	34.0	33.1
50–99.9	6462	32.3	90	29.4	71.8
100–	9274	46.4	58	19.0	159.9
Total	19993	100.0	306	100.0	65.3

Table 5. Subsample of 213 records according to area of forest holding.

Size of holding, ha	Forest area	%	Count	%	Average size
5–19.9	629	4.6	41	19.2	15.3
20–49.9	2451	18.0	73	34.3	33.6
50–99.9	4038	29.6	57	26.8	70.8
100–	6532	47.9	42	19.7	155.5
Total	13650	100.0	213	100.0	64.1

estry goals were collected in a two-phase mail inquiry. The two-phase inquiry was necessary because the landowners had to be asked in advance for their permission to use the data from their forestry plans. In the first inquiry, the landowners were asked some questions about their ownership characteristics, economy and educational background. In addition, the inquiry asked about landowners' preferences for the economic vs. non-economic benefits of their forest property. The total number of accepted answers was 455 representing an average holding size of 59.1 ha. Furthermore, both inquiries included some questions about the landowners' conceptions as to the choice between two alternative forest taxation bases for the 13-year transition period*.

For the second inquiry, calculations were made and presented for each landowner about their timber management strategies and their choices of forest taxation basis. In the second inquiry, 306 acceptable answers were received representing an average holding size of 62.1 ha (Table 4).

The total area of the final sample was 13 650 ha, covering 1.4 % of the area of NIPF lands in the Pohjois-Savo district. The average size of the forest holdings presented was 64.1 ha, which was larger than the average of the entire population. The selection of material during the different phases of the study resulted in a situation where small holdings (under 20 ha and 20–50 ha) were underrepresented and large holdings (over 100 ha) overrepresented when compared to the corresponding proportions in the Official Register of Finnish Farms (Table 2, Pihljerta 1994). There are least three reasons causing this bias: 1) the forest holdings with forestry plan were generally above-average in size, 2) NFI-sampling (one of the two sampling methods) favoured large holdings, and 3) presumably, landowners with large forest holdings were more interested in participating the study. Due to this bias, all the results (distribution of choices of timber management strategies, potential allowable cut) were weighted with the area group distribution of the Official Record of Finnish Farms (Pihljerta 1994).

In order to calculate the regional cutting budgets, a subsample of 213 forest holdings (Table 5) was picked for further analyses (hereafter referred to as the TASO data). In order to obtain reliable and regionally representative results, the selection of these holdings was based on the date of the forest inventory. Thus, only holdings with inventory data not older than from 1988 were included in the subsample.

The reference material for the calculations consisted of the cutting budgets calculated on the basis of sample plot data provided by NFI8 (hereafter referred as the NFI data). The same timber management strategies were calculated for the NFI data, and the results were then compared to those of the TASO data. In the calculations of the potential allowable cut from NIPF lands, it was as-

* The Finnish forest taxation system was changed in 1993 when a site productivity taxation was replaced by a realized income taxation. Site productivity taxation has been based on estimated taxable income, i.e. mean annual increment according to the soil productivity. The realized income taxation is based on individual landowner's annual revenues from timber sales. In spring 1994, landowners had to choose the taxation basis according to which to be taxed for the next 13-year transition period. After the transition period, all landowners will be taxed by realized income from timber sales. By choosing the site productivity taxation for the transition period, the landowners with plenty of allowable cut are able to realize the cumulated increment which has already been taxed once. The choice between the alternative taxation bases is affected mainly by the amount of cuttings during the transition period, the estimated value of annual increment in site productivity taxation and landowner's marginal tax rate (Pesonen et al. 1994b).

Table 6. Main characteristics of the sample, based on owners' responds.

	Mean	SD
Owner, %		
Farmer	58.6	
Non-farmer	41.4	
Age, a	50.9	13.4
Forest area, ha	65.3	61.7
Arable land	10.4	11.0
Production orientation, %		
Agriculture	21.2	
Agriculture and forestry	24.2	
Forestry	38.4	
Recreation and residence	16.2	
Timber production possibilities, %		
Good	41.1	
Fairly good	45.4	
Poor	13.5	
Importance of recreation, %		
Important	23.1	
Neutral	41.4	
Not important	35.5	
Short term price expectation, %		
Increasing	11.1	
No change	58.2	
Decreasing	30.7	
Future cuttings, %		
Extensive cuttings	37.0	
Sustainability	50.7	
Intensive cuttings	12.3	
Choice of taxation, % (before tax calculations)		
Realized-income taxation	44.0	
Site-productivity taxation	25.8	
Cannot say	30.2	
Choice of taxation, % (after tax calculations)		
Realized-income taxation	48.1	
Site-productivity taxation	38.2	
Cannot say	13.7	
Mean volume, m³/ha	128.2	41.6

sumed that the timber management strategies based on the NFI data would represent the areal proportion of the choice of each strategy in the TASO-data.

The NIPF landowners' preferences for, and their choices of, timber management strategies were studied according to twelve descriptive variables of the forest holdings and their owners (Table 6). The independent variables were selected on the basis of their statistical significance in the context of landowner behaviour, as demonstrated in earlier studies (e.g., Järveläinen 1988, Karppinen and Hänninen 1990, Kuuluvainen and Salo 1991).

Table 7. Volume of growing stock (m³/ha) according to area of forest holding.

Size of holding, ha	Volume	SD	Min	Max
5–19.9	120.6	44.3	37.1	226.0
20–49.9	115.7	40.9	45.9	231.7
50–99.9	117.1	35.8	59.3	207.5
100–	125.6	32.2	44.7	184.3
Total	121.1	38.5	37.1	231.7

3.2 Updating of the Data

The growth and removals of both TASO- and NFI-data were updated to the beginning of the year 1993. Without updating the data sets, the comparison of information on the forest resources and timber management strategies would have been difficult because the TASO data originated from the years 1988–1992 and the NFI data from 1990. In addition, updating the data enables the use of materials that are as recent as possible.

A statistical updating of the removals was required for the TASO data because the landowners have stated their cuttings, on an average, 30 % below those found in the statistics on commercial cuttings. A random updating was completed so that the annual cuttings according to the statistics were removed from the data for each year; starting from the year of inventory and ending at the beginning of 1993. Updating was done using the MELA system. The constraints used in the optimisations were annual removals based on statistics according to timber assortments, and the harvest areas according to harvesting methods.

3.3 Comparing the Data Sets

After updating growth and removals, the initial volume of the growing stock, (an average of the sample holdings) was 121.1 m³/ha (Table 7). The relative standard error of the mean initial volume varied between 4.0–5.7 % in the respective holding-size groups. The variance of the mean initial volume increased when the size of forest holding decreased. The mean initial volume of forest holdings varied within the range of 37.1–231.7 m³/ha.

The mean initial volumes of both the TASO and NFI data sets were very close to each other. The TASO data included more pine and spruce but, less birch than the NFI data (Table 8). Furthermore, there were more seedlings, and also more sawtimber trees, in the TASO data than in the NFI data.

Table 8. Volume of growing stock according to tree species and age class distribution in the TASO- and NFI-data.

	TASO	NFI
a) Volume (m³/ha)		
Average	121.1	123.0
Scots pine	37.7	31.6
Norway spruce	69.0	64.6
Hardwood	14.4	26.8
Sawtimber	58.8	53.2
b) Age-class distribution (%)		
–20	29.1	22.4
21–40	21.1	19.9
41–60	9.5	12.5
61–80	14.8	18.7
81–100	16.5	15.1
101–120	6.4	7.6
121–140	2.4	2.9
140–	0.2	0.9

4 Choices of Timber Management Strategies and the Factors Affecting Them

4.1 Economic and Non-Economic Benefits of Forest Property Use

The landowners' preferences in regard to the economic and non-economic benefits of forest property were asked before (first inquiry) and after (second inquiry) presentation of the calculations of the timber management strategies. After the presentation of the calculations, the average priority of economic benefits of forest property increased significantly. Prior to the presentation of the calculations, the average priority of the economic benefits of forest property was 0.64. After calculations, it was 0.71 (Figure 4).

The priorities of the economic and non-economic benefits were compared according to nine statistically significant (5 % significance level) descriptive variables (Table 9). Farmers felt the economic benefits to be more important than non-farmers. When the area of the forest holding increased, the importance of economic benefits increased. Moreover, an increase in the mean volume of the growing stock increased the importance of the economic benefits. Landowners that owned fields felt that economic benefits were more important than those who did not own farming land.

Compared to the rest of the landowners, landowners that had set considerable preference on recreation and residence as the alternative uses of forest property felt that the non-economic benefits were more important than economic benefits. The greater the intensity of planned future removals, the more important were the economic benefits. Landowners who chose site-productivity based taxation considered economic benefits to be more important than those who chose realized-income based taxation. The differences between the taxation systems were slightly higher in the second than in the results of the first inquiry.

4.2 Choices of Timber Management Strategies

In the maximisation of the utility function (1), the most preferred strategy obtained was "sustainability" (chosen by 62 % of landowners).

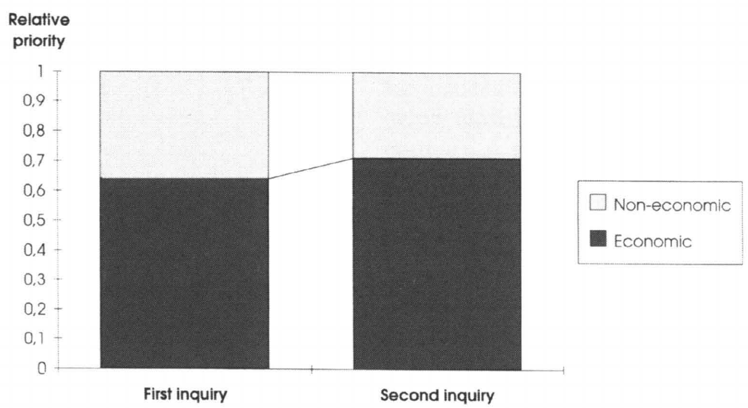

Fig. 4. Preferences for the economic vs. non-economic benefits of forest property use in the first and second inquiry.

Table 9. Priorities of the economic and non-economic importances of timber management strategies according to characteristics of the background information (priorities of first inquiry in parentheses).

	Economic	Non-economic	SE
Owner			
Farmer	0.733 (0.677)	0.267 (0.323)	0.011 (0.012)
Non-farmer	0.665 (0.579)	0.335 (0.421)	0.013 (0.013)
Forest area, ha			
5–20	0.667 (0.556)	0.333 (0.444)	0.021 (0.021)
20–50	0.685 (0.605)	0.315 (0.395)	0.015 (0.015)
50–100	0.714 (0.666)	0.286 (0.344)	0.016 (0.016)
over 100	0.760 (0.706)	0.240 (0.294)	0.020 (0.020)
Field (arable land)			
–5 ha	0.675 (0.575)	0.325 (0.325)	0.019 (0.011)
over 5 ha	0.730 (0.678)	0.270 (0.322)	0.010 (0.019)
Production orientation			
Agriculture	0.713 0.657)	0.287 (0.343)	0.019 (0.014)
Agriculture and forestry	0.730 (0.653)	0.270 (0.347)	0.018 (0.014)
Forestry	0.719 (0.635)	0.281 (0.365)	0.014 (0.012)
Recreation and residence	0.622 (0.502)	0.378 (0.498)	0.022 (0.019)
Timber production possibilities			
Good	0.725 (0.668)	0.275 (0.332)	0.014 (0.012)
Fairly Good	0.709 (0.626)	0.291 (0.374)	0.013 (0.011)
Poor	0.624 (0.528)	0.376 (0.472)	0.024 (0.018)
Importance of recreation			
Important	0.598 (0.496)	0.402 (0.504)	0.019 (0.014)
Neutral	0.730 (0.647)	0.270 (0.353)	0.014 (0.011)
Not important	0.736 (0.687)	0.264 (0.313)	0.015 (0.012)
Short time price expectation			
Increasing	0.721 (0.660)	0.279 (0.340)	0.027 (0.024)
No shange	0.705 (0.624)	0.295 (0.376)	0.012 (0.010)
Decreasing	0.696 (0.623)	0.304 (0.373)	0.016 (0.014)
Future cuttings			
Extensive cuttings	0.674 (0.610)	0.326 (0.390)	0.014 (0.016)
Sustainability	0.722 (0.656)	0.278 (0.344)	0.013 (0.013)
Intensive cuttings	0.727 (0.662)	0.273 (0.338)	0.018 (0.029)
Choice of taxation			
Realized-income taxation	0.685 (0.606)	0.315 (0.394)	0.014 (0.014)
Site-productivity taxation	0.736 (0.647)	0.264 (0.353)	0.018 (0.019)
Mean volume, m^3/ha			
–100	0.676 (0.582)	0.324 (0.418)	0.018 (0.018)
100–150	0.714 (0.656)	0.286 (0.344)	0.013 (0.013)
150–	0.712 (0.650)	0.288 (0.350)	0.017 (0.018)

The second in preference was "finance" (17 %) and the third was "saving" (11 %). "No cuttings" and "maximum cuttings" were the least preferred (9 % and 1 %, resp.). When presented according to the number of landowners, the distributions of the most preferred strategies were slightly different than when compared to the forest area represented by each strategy (Table 10, Fig. 5).

The non-farmers preferred the "no cuttings strategy" more than farmers did (Table 11). The own-

Table 10. Choices of timber management strategies according to area of the forest holding: proportion of number of landowners (a), and proportion of total forest area (b) (weighted mean was calculated according to area proportion of the official register on Finnish farm holdings).

Size of holding, ha	No cuttings	Saving	Sustainability	Finance	Max. cuttings
a) Proportion of number of landowners					
5–19.9	17.1%	14.6%	48.8%	17.1%	2.4%
20–49.9	4.1%	8.2%	69.9%	17.8%	0.0%
50–99.9	1.8%	7.0%	75.4%	14.0%	1.8%
100–	0.0%	4.8%	66.7%	26.2%	2.4%
Mean	5.2%	8.5%	66.7%	18.3%	1.4%
Weighted mean	*8.9%*	*10.5%*	*61.8%*	*17.4%*	*1.4%*
b) Proportion of total forest area					
5–19.9	18.0%	13.1%	49.9%	16.2%	2.8%
20–49.9	2.1%	7.9%	72.4%	17.6%	0.0%
50–99.9	2.3%	7.1%	75.9%	13.3%	1.4%
100–	0.0%	4.0%	68.6%	25.3%	2.0%
Mean	1.9%	6.0%	70.6%	19.9%	1.5%
Weighted mean	*4.4%*	*7.7%*	*68.8%*	*17.8%*	*1.3%*

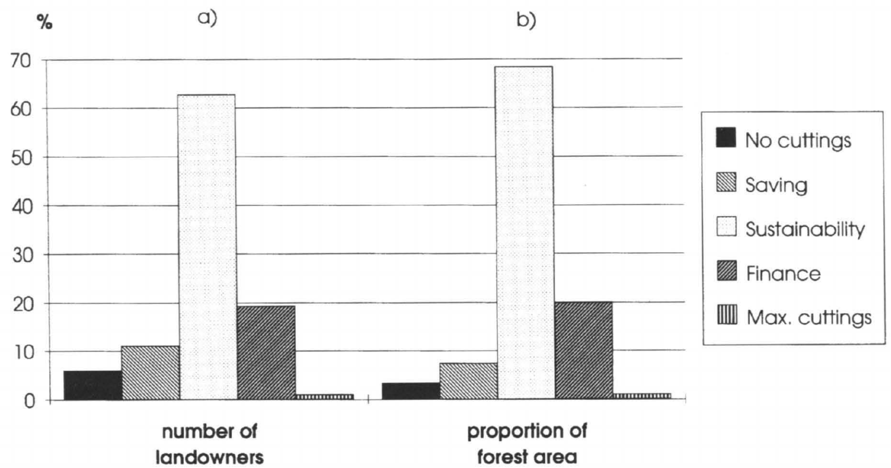

Fig. 5. The choices of timber management strategies according to a) the number of landowners, and b) the actual forest area represented by each strategy.

ers of the smallest forest holdings more frequently chose "no cuttings" and "saving" strategies than rest. On one hand, landowners with large forest holdings (forest areas between 50 and 100 hectares) preferred "sustainability" more than the average landowners. On the other hand, the owners of holdings of over 100 forest hectares chose the "finance" strategy more frequently than owners of smaller holdings.

Increase in the area of arable land (fields) led to choices of strategies favouring intensive removals. In addition, recreation and residence as the primary uses of the property referred to the choices of "no cuttings" and "saving" strategies. The strategy most favoured by landowners practising agriculture and forestry was "sustainability". Landowners practising solely agriculture on their farms preferred the "finance" strategy more than others.

Table 11. The choices of timber management strategies according to the characteristics of the background information.

	No cuttings	Savings	Sustainability	Finance	Max cuttings
Owner					
Farmer	3.4	10.7	64.6	20.2	1.1
Non-farmer	9.5	11.1	61.1	17.5	0.8
Forest area, ha					
5–20	13.0	22.2	50.0	13.0	1.8
20–50	6.7	10.6	59.6	23.1	0.0
50–100	3.3	7.8	74.5	13.3	1.1
over 100	1.7	6.9	62.1	27.6	1.7
Field (arable land)					
–5 ha	11.9	12.7	59.3	15.2	0.9
over 5 ha	1.8	9.7	67.3	20.0	1.2
Production orientation					
Agriculture	3.1	14.1	51.6	31.2	0.0
Agriculture and forestry	0.0	9.6	75.4	12.3	2.7
Forestry	4.3	8.6	37.2	19.8	0.0
Recreation and residence	22.5	14.3	46.9	14.3	2.0
Timber production possibilities					
Good	2.4	6.5	67.7	21.8	1.6
Fairly good	5.8	14.6	65.0	14.6	0.0
Poor	17.1	14.6	43.9	24.4	0.0
Importance of recreation					
Important	11.0	17.0	52.0	20.0	0.0
Neutral	4.5	4.5	69.4	19.8	1.8
Not important	2.1	12.6	66.3	17.9	1.1
Short time price expectation					
Increasing	6.1	21.2	48.5	21.2	3.0
Same	5.8	8.1	71.7	14.4	0.0
Decreasing	4.4	12.1	54.9	27.5	1.1
Future cuttings					
Extensive cuttings	13.0	19.0	56.0	11.0	1.0
Sustainability	2.2	6.6	69.3	21.2	0.7
Intensive cuttings	0.0	3.0	51.5	42.5	3.0
Choice of taxation					
Realized-income taxation	10.9	13.9	57.6	16.1	1.5
Site-productivity taxation	1.9	5.8	67.3	25.0	0.0
Cannot say	2.2	15.2	65.2	17.4	0.0

The landowners' opinions regarding timber production possibilities were asked before the presentation of the strategy calculations. The strategies with extensive cuttings were the most favoured among landowners who felt their timber production possibilites to be poor. Short term positive stumpage price expectations led to choices of extensive strategies. The most favoured strategy was "sustainability" among landowners who felt that future stumpage prices would remain stable. Landowners with expectations of falling stumpage prices preferred the "finance" strategy more than others.

When the landowners were asked for their opinions on future cuttings before presenting the calculations of the strategies, the landowners who preferred extensive cuttings chose the "no cuttings" and "saving" strategies more frequently than the rest of the landowners. The "finance" strategy viewed with favor among landowners who preferred intensive cuttings. These choices coincided in both inquiries.

Landowners who chose forest taxation based on site productivity preferred the "finance" strategy more than those who chose forest taxation based on realized income. The "no cuttings" and the "saving" strategies were favoured by landowners who chose realized-income based forest taxation. In analysing the choices of strategies, the differences between the taxation systems were slightly bigger in the first than in the second inquiry.

5 Potential Allowable Cut in Pohjois-Savo

5.1 Comparison of Timber Management Strategies at the Regional Level

Timber management strategies were compared at regional level assuming that all landowners would follow the same strategy. Comparison were made for both the TASO and the NFI data sets in order to verify the reliability of the TASO data. The average removals in both data sets were compared over the entire 20-year planning period. Furthermore, the development of the removals, mean volume and growth was compared every five years period (1993–1998, 1998–2003, 2003–2008 and 2008–2013).

In the "sustainability" strategy, the average harvest rate in the NFI data was 3.9 % higher compared to the TASO data (Table 12a). In the "saving" strategy, the average harvest was, by definition, approximately half of the removals of the "sustainability" strategy. In the "finance" strategy, the average removals were smaller than in the "sustainability" strategy. With the "finance" strategy, the removals in the TASO data were 6.5 % greater than those in the NFI data. This difference may be due to the larger proportion of sawtimber in the TASO data.

When assuming that all landowners would choose the "max cuttings" strategy, the average removals were considerably greater in the TASO data than in the NFI data. This difference may be caused by the same reason as the difference observed when examining the "finance" strategy. However, the difference had only a small effect on the potential allowable cut, since only 1.0 % of the landowners had chosen the "max cuttings" strategy. The greatest cumulative removals were obtained in the TASO data with the "max cuttings" choice, and in the NFI data when choosing "sustainability". By generalising the results over the whole study area, the following average regional removals were obtained: 5.3 mill. m^3 in the TASO data, and 4.9 mill. m^3 in the NFI data (Table 12b).

In the smallest area group, the average harvest rates were also lowest for every strategy (Table 13), although the mean initial volume in this group did not differ significantly from the other forest

Table 12. Average removals over 20 years, according to strategies, m^3/ha (a), and cumulative removals, mill. m^3 (b), assuming that all landowners would follow the same strategy

	TASO	NFI
a) Average removals (m^3/ha)		
No cuttings	0.00	0.00
Saving	2.47	2.56
Sustainability	4.93	5.12
Finance	4.64	4.35
Max. cuttings	5.53	4.73
b) Cumulative removals (mill. m^3)		
No cuttings	0.00	0.00
Saving	2.36	2.45
Sustainability	4.71	4.90
Finance	4.44	4.16
Max. cuttings	5.29	4.53

Table 13. Average removals (m^3/ha/a) according to area of the forest holdings.

Size of holding, ha		Saving	Sustain-ability	Finance	Max. cuttings
5–19.9	Mean	2.35	4.61	4.78	4.85
	SD	0.99	1.98	1.74	2.41
20–49.9	Mean	2.49	4.97	4.75	5.18
	SD	0.84	1.67	1.44	2.25
50–99.9	Mean	2.42	4.82	4.59	5.26
	SD	0.68	1.36	1.06	2.02
100–	Mean	2.49	4.98	4.58	5.66
	SD	0.68	1.36	1.10	1.85
Total	Mean	2.45	4.86	4.68	5.23
	SD	0.80	1.60	1.35	2.15

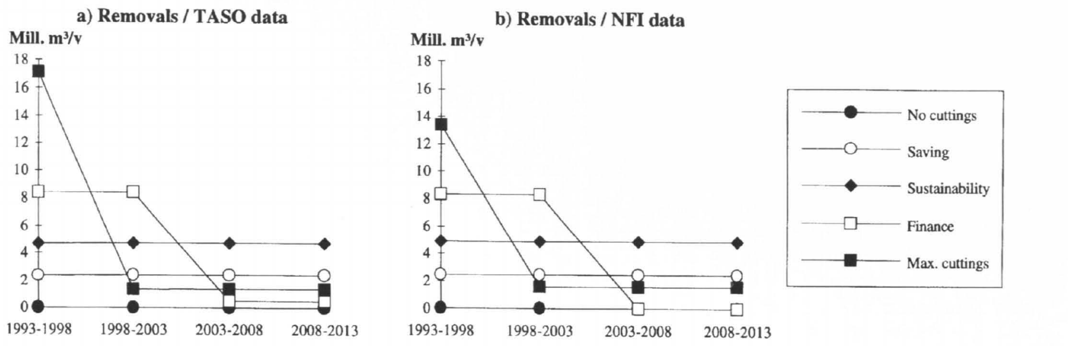

Fig. 6. The average removals (mill. m^3/a) under the assumption that all landowners would follow the same strategy.

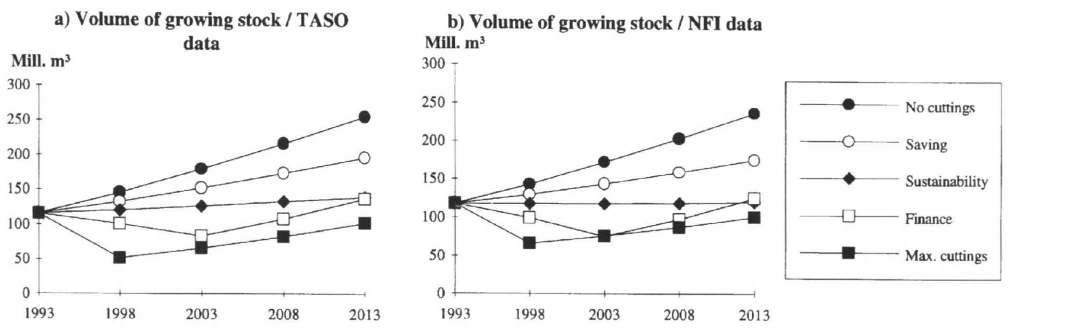

Fig. 7. The development of the volume of the growing stock (mill. m^3) under the assumption that all landowners would follow the same strategy.

area groups. However, the overall differences in cuttings between the area groups were not statistically significant. For all strategies, the relative standard error for the whole data varied between 2.0–2.8 % for the different strategies. In the different area groups, the relative standard errors varied between 3.0–7.8 % with the greatest errors being observed in the group consisting of the smallest holdings.

In the periodical analysis, the removals of the first period (1993–1998) of the "max cuttings" strategy were tripled, and those of the "finance" strategy doubled when compared to the removals of the "sustainability" strategy (Fig. 6). The differences between the data sets were relatively small, with the exception of the "max cuttings" strategy, in which the average removals of the first planning period were 3.7 mill. m^3/a higher in the TASO data. In the both "sustainability" and "saving" strategy, the average removals were almost the same in the both data sets. In the finance strategy, slightly higher removals were observed in the TASO data than in the NFI data during the first half of the planning period.

In all choices of timber management strategies, the mean volume of the growing stock attained at the end of planning period was higher in the TASO data than in the NFI data (Fig. 7). The lowest mean volume attained was 107.0 m^3/ha in the TASO data and 105.5 m^3/ha in the NFI data. The highest mean volumes were reached in the "no cuttings" strategy: 266.7 m^3/ha and 247.0 m^3/ha, respectively. The higher mean volume in the TASO data was due to the higher growth rate when compared to the NFI data (Fig. 8). For example, the average growth in the sustainability strategy for the whole planning period was 11.3 % greater in the TASO data than in the NFI data.

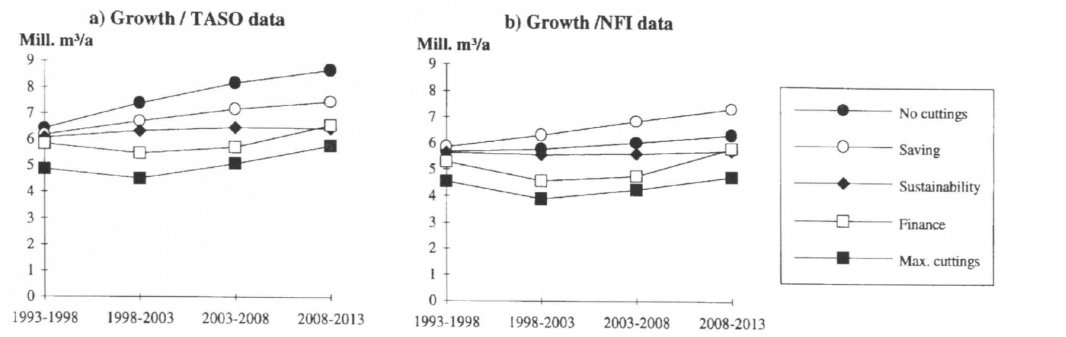

Fig. 8. The development of forest growth (mill. m^3/a) under the assumption that all landowners would follow the same strategy.

Table 14. The average removals ($m^3/ha/a$) according to choices of timber management strategies, and cumulative removals over the whole area

Size of holding, ha	No cutt.	Saving	Sust.	Finance	Max. cutt.	Average	Cumulative milj.m^3
			m^3/ha				
5–19.9	0.00	1.89	4.98	4.26	4.93	3.57	*0.59*
20–49.9	0.00	2.78	4.98	4.69	0.00	4.57	*1.48*
50–99.9	0.00	2.20	4.85	4.73	8.11	4.58	*1.23*
100–	0.00	2.57	4.99	4.59	5.10	4.79	*0.99*
Average	0.00	2.42	4.94	4.62	5.91	4.63	*4.29*

5.2 Potential Allowable Cut

In the analysis of the landowners' choices of strategies, the overall removals in the smallest holdings were smaller than in the rest of the area groups (Table 14). This was due to the below-average removals and the preferred choices of "saving" and "no cuttings" strategies by the owners in the smallest area group. On the other hand, the heavier removals in the area group of large holdings were often followed by a preference for the "finance" strategy. The average harvest rate based on the landowners' choices of timber management strategies was 4.6 $m^3/ha/a$. When weighted with the area group distribution of the Official Record of Finnish Farms (Pihljerta 1994), the average harvest rate obtained for both data sets was 4.5 $m^3/ha/a$. The smallest holdings presented 13.7 % of the weighted harvest rate.

As a generalisation of the results for the whole district of Pohjois-Savo, the average removals of the 20-year planning period were 4.3 mill. m^3/a for the TASO data and 4.4 mill. m^3/a for the NFI data (Fig. 9). During the first half of the planning period, the removals were heavier due to the accumulation of removals in the "max cuttings" and "finance" strategies. The proportion of sawtimber in the removals was somewhat higher in the TASO data than in the NFI data.

In both data sets, the mean volume increased towards the end of the planning period (Fig. 10). In addition, the mean volume in the TASO data was a little higher, particularly concerning the proportion of sawtimber. This was due to the higher level of growth observed in the TASO data when compared to that in the NFI data (Fig. 11). The average growth for the planning period was 6.3 mill. m^3/a in the TASO data and 5.7 mill. m^3/a in the NFI data.

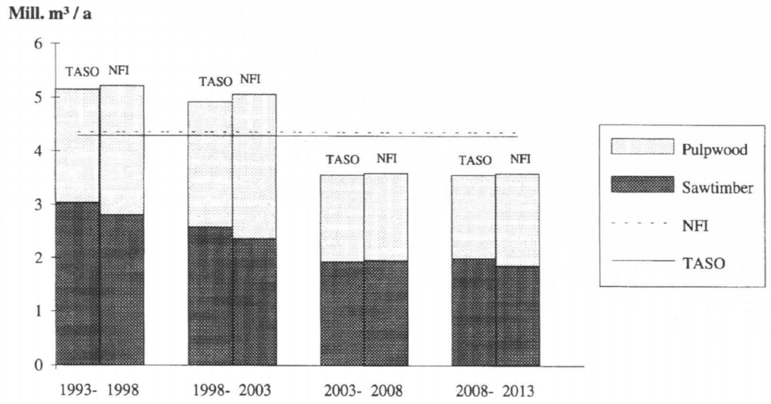

Fig. 9. The removals (mill. m³/) according to the choices of preferred strategies during each five-year period, and average removals.

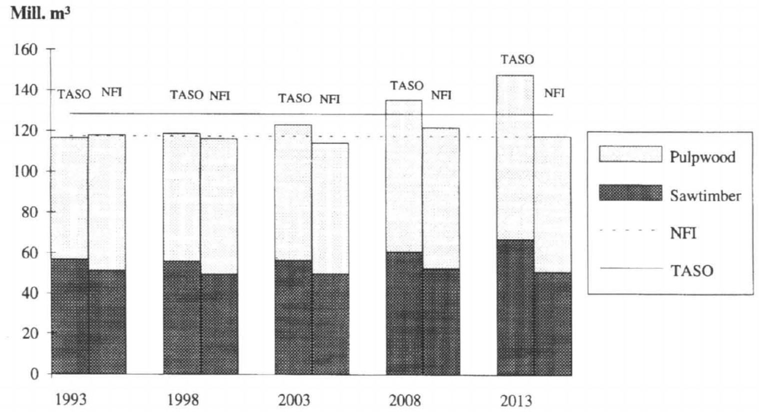

Fig. 10. The total volume (mill. m³) according to planning periods, and the average volume during 20 years.

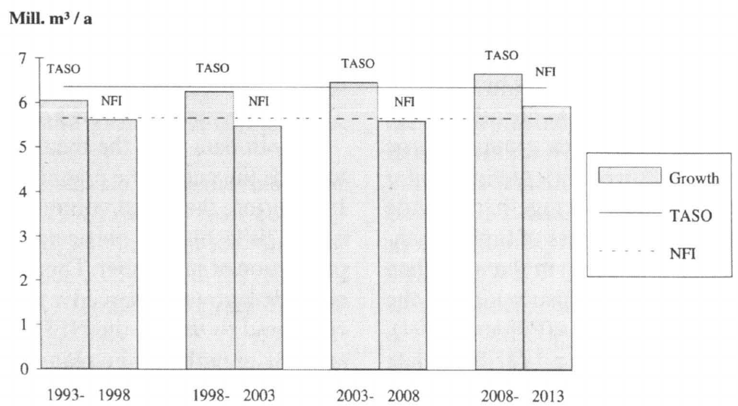

Fig. 11. The growth (mill. m³/a) according to the time periods, and the average growth.

6 Discussion and Conclusions

6.1 Comparing the Cutting Budgets

The potential allowable cut determined in this study was 20 % higher than the average realized cuttings in the Pohjois-Savo district during the years 1988–1993 (Fig. 12). However, during the years of economic boom, 1989–1990, the potential allowable cut almost reached the level of removals as well as the greatest sustained cut according to NFI7. Compared to the greatest allowable cut (based on sustained yield) of NFI8, the potential allowable cut of this study was 12 % smaller. Furthermore, the cutting budget based on combining the forestry plans was 20 % smaller than the one presented in this study.

The differences between the cutting budgets based on combining forestry plans and the potential allowable cut as defined in this study are due to two reasons: the principle of discretion in NIPF planning and the older, NFI7-based growth models used in the TASO planning system. The underestimation of the actual cutting possibilities on sustained yield basis in the TASO forestry plans can be almost 20 % (Pesonen and Räsänen 1993). Forest planning of non-industrial private forests is still based on standwise propositions of treatments made by professional planners. The planners seldom have full knowledge of the sustained cutting possibilities at the forest holding level.

In comparing the NFI8-based, forest-resources oriented cutting budget and the potential allowable cut of this study, two main reasons for the difference can be outlined: ignorance of landowner-specific forestry goals in the former and the constraints caused by the requirement of forest-holding level sustainability in the latter. The fact that the owners of small forest holdings preferred the choices of "no cuttings" and "saving" strategies reduces the potential allowable cut from NIPF lands. The requirement of sustained yield at the forest holding level has been reported to decrease regional cutting possibilities by over 10 % (Pesonen and Soimasuo 1994).

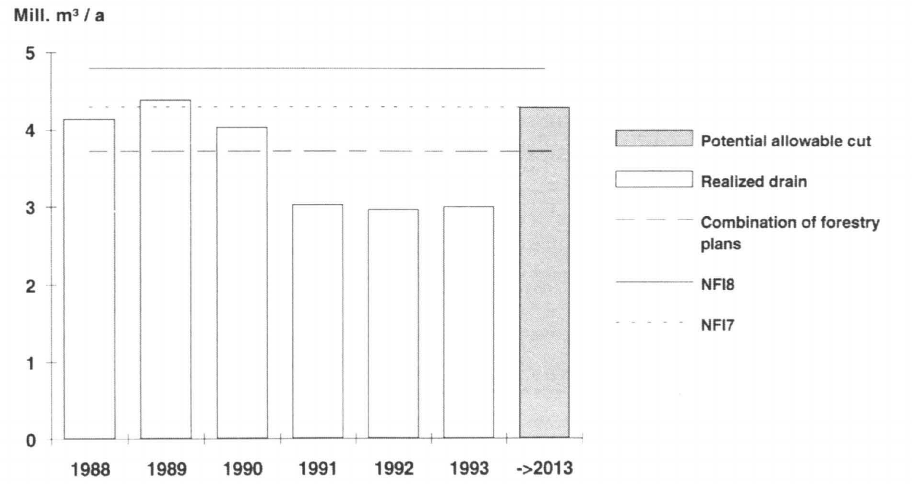

Fig. 12. The realized drain (mill. m³/a) in Pohjois-Savo, and cutting budgets calculated applying the alternative methods.

6.2 Timber Management Strategies

In this study, the utility functions were formulated in order to find out the landowners' choices of timber management strategies. After strategy calculations, the importance of the economic benefits of forest property increased. Thus, the importance of non-economic factors – such as recreational use of the forest – decreased when the landowners realised the increasing possibilities of removals and regular stumpage earnings.

The factors that increased the importance of the economic benefits of forest property were as follows:

1 Farmer as landowner and possession of arable land (fields),
2 Increase in the area of the forest holding,
3 Agriculture and forestry as the main activities on the property,
4 Good or fairly good timber production possibilities,
5 Neutral or weak importance of recreation as an alternative forest use,
6 Positive short term price expectations,
7 Increase in the intensity of future removals,
8 Choice of forest taxation system based on site productivity,
9 Increase in the mean volume of the growing stock.

"Sustainability" was the preferred choice of strategy for nearly 70 % of the landowners. It is likely that at least some of the landowners did not realize how much heavier removals were included in this strategy compared to realized drain and the removals proposed in their forestry plan. However, 23 % of the landowners were willing to increase their removals after seeing the alternative timber management strategies.

The choice of timber management strategy was slightly sensitive to changes of preferences of the economic and non-economic benefits of the use of forest property (Fig. 13). If all the weight was placed on the economic benefits, the relative proportions of choices of "sustainability" and "finance" increased. On the contrary, if all the weight was placed on the non-economic benefits, the relative proportions of the choices of "no cuttings" and "saving" strategies increased (Fig. 13).

The size of forest holding had a significant effect on the choice of timber management strategy. Owners with forest holdings less than 20 ha in forest area preferred the choices of "no cuttings" and "saving" strategies, while owners of large holdings of more than 100 ha preferred the "finance" strategy. In addition to this, the following facts resulted in the area-based choices of timber management strategies: forestry plans were made for above-average sized holdings, one of the sampling methods favoured large holdings, and evidently the owners of forest holdings above-average in size were more interested in participating in the study.

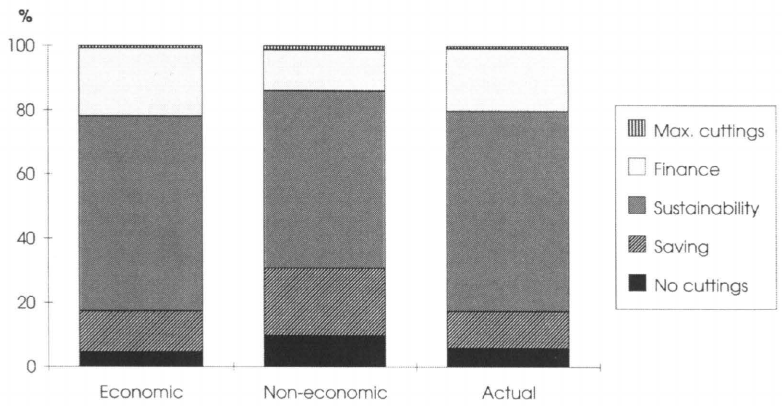

Fig. 13. The relative frequencies of the choices of timber management strategies when using a) total weight on economic beneffts, b) total weight on non-economic benefits, and c) actual weights obtained from pairwise comparisons.

The following factors led to the choices of strategies with intensive cuttings:

1 Farmer as landowner and ownership of arable land (fields),
2 Increase in the area of the forest holding,
3 Agriculture and forestry as the main activities on the property,
4 Negative short term price expectations,
5 Increase in the intensity of future removals,
6 Choice of taxation system based on site productivity.

The results of the choices and the factors affecting these choices of timber management strategies may be summarised as follows:

"No cuttings"
This group consisted of small forest holdings (less than 20 ha in area), which were usually owned by non-farmers. They owned only little arable land or not at all. Furthermore, the landowners in this group preferred residence and recreation as alternative uses of the forest holding. The realized-income taxation was the choice of forest taxation system for these landowners.

"Saving"
This group also consisted of relatively small forest holdings (less than 20 ha in area), and the owners considered their timber production possibilites poor, or at the best, normal. They preferred recreation as the alternative use of forest property, and, like their fellows in the "no cuttings" group, their choice of forest taxation basis was realized-income taxation. Moreover, these landowners anticipated a rise in timber prices in the near future.

"Sustainability"
"Sustainability" was chosen by the landowners with forest holding sizes between 50 and 100 ha in area. For these landowners, the main activities on their holdings were agriculture and forestry. In addition, the landowners in this group considered their timber production possilities to be good. They did not prefer recreation as an alternative use of forest property, and they thought that the timber prices would remain stable in the near future.

"Finance"
This group consisted of the largest forest holdings (over 100 hectares in area), and the owners practised mainly agriculture on their holdings. The short-term timber price expectations of this group were that they would decrease.

"Max cuttings"
Only three landowners (1.0 % of the sample) chose this strategy; thus, conclusions could not be drawn regarding it.

6.3 Reliability of the Data and Methods

The additive utility function, the function form used in this study, is the easiest to interpret (Pukkala and Kangas 1993). In several studies, it has been noticed that the additive utility function produces a utility index which best describes the preferences of the decision-maker (Tell 1976, Laskey and Fischer 1987). It has also been stated that landowners are utility-maximizers who consider both the economic and the non-economic benefits of their forests (Boyd 1984, Hyberg 1987).

Due to its simplicity, effectiveness and ability to deal with qualitative as well as quantitative criteria (this is also indicated by the results of this study) the AHP is well-suited to dealing with problems with forest management planning (e.g. Kangas 1992). When applied to the mail inquiries, the weakest point of the method is the question of whether all respondents are able to concentrate on the numerous comparisons required by the AHP. Therefore, the results would be improved by the application of personal interviews in conjunction with data collection.

The consistency ratios (CR) were slightly higher than was acceptable: 18.5 % in economic and 17.2 % in non-economic comparisons. This may be partly due to the fact that the inquiries used in the study were made by mail, and all kinds of landowners did tens of AHP comparisons. However, there is no unequivocal upper limit for the level of inconsistency in pairwise comparisons, and moreover, the inconsistency in comparisons can also be due to a conscious choice, and must therefore be accepted (e.g., Wedley 1993, Apostolou and Hassell 1993). It can thus be concluded, after all, that the majority of landowners did understand the differences between the strategies, and they were also consistent with their comparisons.

The AHP method and the use of mail inquiry in data collection limited the alternative choices of strategies to five. In spite of this, the alternative strategies and choices made by the landowners were based on the actual, forest-holding level development of cuttings, income from timber sales and other forest characteristics. Although few landowners chose the extreme alternatives – "no cuttings" or "max cuttings" strategies – these strategies were included in the comparisons in order to describe the whole range of timber production possibilities.

The applied sampling methods did not significantly affect the definition of the potential allowable cut. The results of the data obtained from systematic stratified sampling did not differ from those obtained with data from random sampling. Thus, after being compared, the two samples were combined.

The objectives of the landowners may also vary according to the point of time, and/or region. Lönnstedt and Törnqvist (1990) stated that the choice of timber management strategy is affected by the needs and objectives of both short- and long term perspective. The goal structure of the landowners could have been clarified better. In this study, the landowners were able to compare only five precalculated timber management strategies. It would be possible to ask more specific questions about the objectives of the landowners in the first inquiry, and with that information in mind, calculate the strategies more individually.

The removals corresponding to the timber management strategies calculated using the TASO data were slightly overestimated. This was demonstrated by combining the forest holdings into a single, large forestry unit, and then recalculating the strategies; with the single unit, the removals corresponding to sustainability were 5.5 m3/ha/a which is 5.5 % more than those given by the NFI data. In spite of this, the overall differences between the results from the two data sets (TASO and NFI) were small. Based on this study, the material from the standwise inventory is reliable enough to enable the definition of regional cutting possibilities, although considerable measurement errors have been reported in standwise inventories due to personal characteristics of the planners (Laasasenaho and Päivinen 1986).

The study material (the TASO data) was representative in comparison with the reference material (the NFI data) in regard to the forest resource information. No major differences between the data sets were found concerning the mean volumes, proportions of sawtimber and tree species, and age class distributions. The only substantial difference was caused by the greater growth given by the TASO data, which was partly due to the greater proportion of seedling stands in the TASO data compared to the NFI data. In "sustainability", for example, the growth in the TASO data for the first five-year period was 6.9 % greater and 11.3 % greater during the whole planning period than in the NFI data.

Due to requirement of sustainability at the forest holding level, the removals resulting from the TASO data were smaller and led to the faster volume increase and higher growth rate. One reason for the difference could have been in the fact that in the NFI data, the diameter distribution was constructed using the measured sample trees, while in the TASO data, the diameter distribution was formulated using the theoretical, Weibull-distribution (Kilkki et al. 1989). The reliability of the results could have been further increased by selecting diameter distribution from the NFI data by using the standwise information of the TASO data.

The effects of no-response observations were examined by comparing the average planned removals of landowners included in the first inquiry to those of landowners who were included in the second inquiry. In the comparison, it was assumed that all landowners would have chosen the "sustainability" strategy. The average removals did not differ significantly between the first and the second inquiry. Furthermore, the data of the 213 landowners used to calculate the potential allowable cut did not differ from the data of the first inquiry. Moreover, in regard to the distributions of the choices of timber management strategies

and forest area, there were no significant differences between the data used to calculate the potential allowable cut (n = 213) and the data of the second inquiry (n = 306).

The representativiness of the data was also tested by a no-response mail inquiry addressed to 51 landowners. The variables that had signifigant effects on the choices of timber management strategies were examined in the no-response survey. Generally, the characteristics of the no-response data were well in line with the actual study material. Thus, the no-response observations had little effect on the external reliability of results.

The landowners that had not responded to the mail inquiry were asked for their reasons for not answering the inquiry. Half of the no-response landowners could not give any particular reason for not responding. Lack of time and being busy with work were reported as the reasons by 25 % of the landowners. About 15 % of landowners were fed up with continuous inquiries. Other reported reasons for no-response included serious illness or death of the landowner, and problems with mailing. In this study, the preferred timber management strategy could not be clarified for the non-response landowners, and for landowners that did not have an up-to-date forestry plan.

An essential aspect to note is that the potential allowable cut, as defined in this study, is a far more sensitive and dynamic concept than the completely forest-resource-oriented cutting budgets. The attitudes, values and objectives of the landowners vary much more and more frequently than forest growth, for example. The allowable cut presented in this study is based on the landowners' concepts and objectives in the spring of 1993.

6.4 Conclusions

The potential allowable cut presented in this study appeared to settle in the middle of the realized drain and the greatest allowable cut based on the National Forest Inventory. When compared to the realized drain, landowners would have cut 20 % more annually, assuming that they were to follow their choices of timber management strategies.

The results of this study indicate that the landowners' future harvesting intentions in Pohjois-Savo will ensure the availability of wood raw material for future investments by forest companies. Furthermore, the region's landowners could be activated to practise intensive management and harvesting by demonstrating to them the strategic alternatives in timber management. The results of this study may also help to direct the development of management planning on NIPF lands.

An interesting issue for future research would be to monitor the sample forest holdings – will strategic calculations affect the future harvesting behaviour of the owners? In addition, forestry plans based on the choices of timber management strategies could be made for the sample holdings and then proceed to monitor owner's harvesting behaviour. Comparisons of harvesting behaviour could then be made between the owners of sample holdings, those of forest holdings without forestry plans, and those forest holdings with up-to-date plans, made by state-funded forestry organisations.

References

Aarne, M. (ed.). 1993. Yearbook of Forest Statistics 1992. The Finnish Forest Research Institute. 317 p.

Apostolou, B. & Hassell, J. M. 1993. An empirical examination of the sensitivity of the analytic hierarchy process to departures from recommended consistency ratios. Mathematical and Computer Modelling 17(4/5): 163–170.

Boyd, R. G. 1984. Government support of nonindustrial production: The case of private forests. South. J. Econ. 51: 89–107.

Forest 2000 Program. 1985. Main Report. Council of Economics. Section of the Forest 2000 Program.

Hansson, K., Lönnstedt, L. & Svensson, J. 1990. Decision support system for nonindustrial private forest owners. Swedish University of Agricultural Sciences. Dep. For. Ind. Market Studies. Rep. 12.

Hirshleifer, J. 1984. Price theory and applications. Prentice-Hall. 536 p.

Hyberg, B. T. 1987. Multiattribute decision theory and forest management: A discussion and application. Forest Science 33(4): 835–845.

Järveläinen, V-P. 1988. Hakkuumahdollisuuksien käyttöön vaikuttavat tilakohtaiset tekijät maan länsi- ja itäosissa. Summary: Factors affecting the use of the allowable cut in western and eastern parts of Finland. Folia Forestalia 707.

Johnson, K. N., Stuart, T. W. & Crim, S. A. 1986. FORPLAN version II: an overview. Land Management Planning Systems Section, USDA Forest Service, Washington, DC.

Jonsson, B., Jacobsson, J. & Kallur, H. 1993. The forest management planning package. Theory and application. Studia Forestalia Suecica 189. 56 p.

Kangas, J. 1992. Multiple-use planning of forest resources by using the Analytic Hierarchy Process. Scandinavian Journal of Forest Research 7: 259–268.

— & Pukkala, T. 1992. A decision theoretic approach applied to goal programming of forest management. Silva Fennica 26: 169–176.

Karppinen, H. 1992. Changing goals of private forest owners. Work Efficiency Institute. Forestry Bulletin 508.

— & Hänninen, H. 1990. Yksityistilojen hakkuumahdollisuuksien käyttö Etelä-Suomessa. Summary: Actual and allowable cut in nonindustrial private woodlots in southern finland. Folia Forestalia 747.

Kast, E. K. & Rosenzweig, J. E. 1974. Organization and management. A systems approach. Second edition. 389 p.

Kilkki, P. 1968. Income-oriented cutting budget. Acta Forestalia Fennica 91. 54 p.

— , Maltamo, M., Mykkänen, R. & Päivinen, R. 1989. Use of the Weibull function in estimating the basal area dbh-distribution. Silva Fennica 23(4): 311–318.

— & Siitonen, M. 1976. Principles of a Forest Information System. XVI IUFRO World Congress, Division IV. Proceedings. p. 154–163.

Kuuluvainen, J. & Salo, J. 1991. Timber supply and life cycle harvest of nonindustrial private forest owners: An empirical analysis of the Finnish case. Forest Science 37: 1011–1029.

Laasasenaho, J. & Päivinen, R. 1986. Kuvioittaisen arvioinnin tarkistamisesta. Summary: On the checking of inventory by compartments. Folia Forestalia 664. 19 p.

Laskey, K. B. & Fischer, G. W. 1987. Estimating utility functions in the presence of response error. Manage. Sci. 33: 965–980.

Lönnstedt, L. 1989. Goals and cutting decisions of private small forest owners. Scandinavian Journal of Forest Research 4: 259–265.

— & Roos, A. 1993. Cutting levels for nonindustrial forestry: An estimate based on the state of forests and the goals of forest owners. Swedish University of Agricultural Sciences. Dep. of Forest-Industry-Market Studies. Report 26.

— & Törnqvist, T. 1990. The owner, the estate and the external influences: Nonindustrial private forest owners' management decisions. Swedish University of Agricultural Sciences. Dep. of Forest-Industry-Market Studies. Report 14.

Mendoza, G. A. & Sprouse, W. 1989. Forest planning and decision making under fuzzy environments: An overview and illustration. Forest Science 35(2): 481–502.

Mykkänen, R. 1994. Aspiration-based utility functions in a planning model for timber flow manangement. Acta Forestalia Fennica 245. 66 p.

Pesonen, M., Kettunen, A., Heikkinen V.-P. & Räsänen, P. 1994a. Yksityismetsänomistajien puuntuotantostrategiat ja potentiaaliset hakkuumahdollisuudet Pohjois-Savossa. Metsäntutkimuslaitoksen tiedonantoja 515. 50 p.

— , Räsänen, P. & Kettunen, A. 1994b. Modelling non-industrial private forest landowner's decision making by using logistic regression and neural networks: Case of predicting the choice of forest taxation basis. Metsäntutkimuslaitos. Manuscript.

— & Räsänen, P. 1993. Metsäverovalinta – strateginen ratkaisu. Metsäntutkimuslaitoksen tiedonantoja 472. 78 p.

— & Soimasuo J. 1994. Tilakohtaisen kestävyyden vaikutus alueellisiin hakkuumahdollisuuksiin. Metsäntutkimuslaitos. Manuscript.

Pihljerta, K. 1994. Maatilalaskennan tilastoja 1988–1994. Verohallitus.

Pukkala, T. & Kangas, J. 1993. A heuristic optimization method for forest planning and decision making. Scandinavian Journal of Forest Research 8: 560–570.

Ranta, R. 1991. Metsätalouden suunnittelulaskelmat. In: Tapion taskukirja. 21. painos. Kustannusosakeyhtiö Metsälehti. p. 334–337.

Revised Forest 2000 Program Committee. 1992. Forestry Division, Ministry of Agriculture and Forestry, Helsinki.

Ripatti, P. 1992. Forest area changes of nonindustrial private forest holdings in southeastern Finland, 1986–1991. Silva Fennica 26(3): 177–186.

Saaty, T. L. 1977. A scaling method for priorities in hierarchical structures. Journal of Mathematical Psychology 15: 234–281.

— 1980. The analytic hierarchy process. McGraw-Hill, New York. 287 p.

Siitonen, M. 1983. A long term forestry planning system based on data from the Finnish National Forest Inventory. Proceedings of the IUFRO subject group 4.02 meeting in Finland. University of Helsinki, Dep. of Forest Mensuration and Management, Research Notes 17. p. 195–207.

— 1993. Experiences in the use of forest management planning models. Silva Fennica 27(2): 167–178.

Tell, B. 1976. A comparative study of some multiple-criteria methods. The Economic Research Institute at the Stockholm School of Economics. 203 p.

Wardle, P. A. 1965. Forest management and operational research: a linear programming study. Ser. B, Management Science 11(10): 260–270.

Ware, G. O. & Clutter, J. L. 1971. Mathematical programming system for the management of industrial forests. Forest Science 17(4): 428–445.

Wedley, W. C. 1993. Consistency prediction for incomplete AHP matrices. Mathematical and Computer Modelling 17(4/5): 151–161.

Winterfeldt, D. v. 1988. Expert systems and behavioral decision research. Decision Support Systems 4: 461–471.

Zahedi, F. 1986. The Analytic Hierarchy Process – A survey of the method and its applications. Interfaces 16(4): 96–108.

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