Silva Fennica

Silva Fennica 42(4) research articles

www.metla.fi/silvafennica · ISSN 0037-5330

The Finnish Society of Forest Science · The Finnish Forest Research Institute

Forest Owners' Decision Support in Voluntary Biodiversity-Protection Projects

Mikko Kurttila, Pekka Leskinen, Jouni Pykäläinen and Tiina Ruuskanen

Kurttila, M., Leskinen, P., Pykäläinen, J. & Ruuskanen, T. 2008. Forest owners' decision support in voluntary biodiversity-protection projects. Silva Fennica 42(4): 643–658.

New forest-biodiversity-protection instruments based on temporary protection periods and non-industrial private forest owners' voluntary participation have been recently introduced and tested in pilot areas located in Southern Finland. Thanks to their several benefits, the use of voluntary instruments is becoming more common in many other countries as well. Voluntary protection here means that forest owners voluntarily set aside tracts of forest to be protected and define their compensation fees. Depending on the objectives of the forest owners, the compensation fee reflects the forest owners' (positive) attitude towards biodiversity, scenic beauty, recreational values and/or the existence of long-term cutting possibilities. When a forest owner decides to offer part of his/her forest holding to be temporarily protected, the owner faces a new decision problem related to definition of the compensation fee, which should be based on diverse information concerning stand- and holding-level opportunity costs as well as on the biodiversity value of the stand. This article introduces three decision-support elements for assisting forest owners in defining their compensation fees. The first element relates to the assessment of the potential stand-level loss of timber harvesting income that the temporary protection of the stand may cause. The second element sets the holding-level opportunity cost of protection by utilizing the forest owners' holding level goals, the holdings' production possibilities and optimization methods. The third element describes the biodiversity value of the stand by means of a multi-criteria expert model. Case study material collected from the area of Central Karelia Herb-rich Forests Network pilot project is used to illustrate the characteristics of the decision-support elements and to point out some development needs for the future use of these elements.

Keywords biodiversity protection, compensation fee, multi-criteria decision support, multi-objective forest planning

Addresses *Kurttila* and *Ruuskanen*, University of Joensuu, Faculty of Forest Sciences, P.O. Box 111, FI-80101 Joensuu, Finland; *Leskinen*, Finnish Environment Institute, Research Programme for Production and Consumption, P.O. Box 111, FI-80101 Joensuu, Finland; *Pykäläinen*, Metsämonex Ltd., Joensuu, Finland **E-mail** mikko.kurttila@joensuu.fi

Received 8 January 2008 **Revised** 12 May 2008 **Accepted** 23 May 2008

Available at http://www.metla.fi/silvafennica/full/sf42/sf424643.pdf

1 Introduction

Biodiversity can be conserved by using several different instruments. For example Bräuer et al. (2006) distinguished the following market based instruments: (i) taxes, fees and charges; (ii) subsidies/support; (iii) tradable permits; (iv) eco-labeling; (v) financial mechanisms (e.g. green venture capital funds); and (vi) liability and compensation schemes. In addition, land-use regulations and related land purchases have frequently been applied in biodiversity conservation (e.g. Boyd and Simpson 1999). In Finland, land purchases, regulations and recommendations have so far been the dominating instruments in protecting forest biodiversity. The adoption of different instruments results in varying effects to forest owners, society and biodiversity (e.g. Boyd and Simpson 1999, Frank and Muller 2003, Mayer and Tikka 2006) and it demands a political decision to select which of them are adopted and to which extent they are used (e.g. Bräuer et al. 2006). Among others, the ownership structure of the area has a great influence, particularly in areas that are dominated by private ownership (for more details on the use of these instruments, see Bräuer et al. (2006) as well as Mayer and Tikka (2006) for the introduction of the voluntary incentive programs in private forests).

However, the principle for calculating the cost of biodiversity conservation is more ore less the same for all the above instruments. It is based on the difference of the most profitable economic activity and the economic value obtained by means compatible with conservation. This principle is referred to as the opportunity cost of protection (Boyd and Simpson 1999). However, also the other effects of the used instruments need to be evaluated with respect relevant criteria, such as positive effects on biodiversity, general acceptability and distribution of negative economic effects. In addition, the cost-effectiveness of the instruments varies and need to be taken into account. This whole setup is a demanding practical task (e.g. Boyd and Simpson 1999) and it has been shown that a certain mix of instruments, with their objectives clearly defined, could and should be used simultaneously (e.g. Doremus 2003, Bräuer et al. 2006).

New forest-biodiversity-protection instruments emphasize forest owners' voluntary participation in Finland (Etelä-Suomen… 2002) and in other countries where non-industrial private forests (NIPF) include valuable biodiversity resources (Doremus 2003, Frank and Müller 2003, Mayer and Tikka 2006). This can be a beneficial opportunity for the forest owners, because they then have a possibility to select new economically meaningful production lines for their forests. The results are expected to benefit society as well; for example, through improved cost-efficiency and the reduced negative image of biodiversity protection. From society's point of view, one drawback related to these tools may be that the cost of acquiring a meaningful network of protection areas becomes higher than the alternative of society actually purchasing these tracts of land. On the other hand, it is possible to formulate and use economic incentives so that they clearly promote the formation of ecologically-desirable networks of protection areas (Parkhurst et al. 2002).

In Finland, the so-called METSO programme (Etelä-Suomen… 2002) proposed the testing of new instruments such as competitive tendering, natural-values trading, and cooperative network projects on forest biodiversity. A common characteristic of these instruments was that forest owners can offer parts of their forest areas for permanent or temporary protection (mainly natural-values trading). The suitability of the areas offered for protection were evaluated by using common criteria (Etelä-Suomen metsien… 2003) that were created specifically for the needs of the said METSO programme.

The introduction of new tools creates a new kind of decision problem for the individual forest owner: he/she should be able to decide whether to use the forest area(s) in question for the current purposes or to enter into a biodiversity-protection contract involving a specific compensation fee. In addition, the forest owner should determine the compensation fee level he/she expects from the buyer (i.e. society). In such a situation, it is expected that if the forest owner has his/her own biodiversity goals (or other goals that are in positive correlation with biodiversity goals), then the compensation fee level requested can be lower when compared to the direct cutting income losses that the protection of the forest may cause (e.g. Boyd and Simpson 1999). A lower compensation fee might create the win-win situation both for the individual forest owner (income from protecting the forest area and utility from forest biodiversity) and for society (increased amount of protection areas and lower compensation fees compared to obligatory protection tools).

Several pilot projects were launched in Finland in 2003 and 2004 for testing the practical feasibility of the new instruments, the forest owners' willingness to begin to use these instruments, and the general ecological, economic and social effects of the projects. While the pilot projects underscore the importance of tests concerning the functioning of the new tools, traditional tools for protecting forest biodiversity based on current forest and nature protection laws are also applied in the same areas. The use of voluntary protection tools is new to all participants in the pilot projects (financiers, local authorities such as forestry centres, environmental centres, forest management associations, and for forest owners and other interest groups). The cooperative network pilot projects on forest biodiversity are particularly characterized by versatile cooperation between the participants, and they could and should create new kinds of cooperation and activities between forest owners of the project areas.

Another important characteristic related to the cooperation aspect of the projects is the information being shared with forest owners. Besides information concerning the principles and the rules of the new as well as old protection tools, forest owners need versatile decision support when they make decisions offering tracts of forest for protection and when they seek to define the compensation fee level. As forest owners' goals vary, and as many forest owners strive simultaneously to reach several goals (timber production being among them), stand-level information concerning decreased cutting possibilities is valuable, but not enough. Multi-objective decision support based on the forest owners' own management objectives and on the production possibilities of the forest owners' forest property at the holding-level is also needed.

In addition, the aim in the on-going pilot projects is particularly to acquire certain pre-specified nature values. Therefore, the compensation fee paid to forest owners should depend also on the biodiversity value of the tract of forest in question. However, all these information sources are important to the forest owners, particularly in a situation of the pilot projects, where experiences and reference compensation fees from earlier protection contracts are not available.

The objective of this paper is to introduce the three decision-support elements that were placed at the disposal of those forest owners, who offered forest land for the natural-values trading process applied within the Central Karelia Herb-rich Forests Network pilot project. These decision-support elements were as follows: (i) assessment of stand-level cutting-income loss; (ii) holding-level opportunity cost; and (iii) a score-based rating of the offered tract of forest with respect to the ecological criteria used in the selection of tracts of forest for protection. These elements are important, because they provide the quantitative information forest owners need when they are considering formulating their compensation fee request or when they are evaluating whether to accept the compensation fee offer made by the authorities.

2 Central Karelia Herb-Rich Forests Network Pilot Project and the Applied Protection Area Selection Process

The Central Karelia Herb-rich Forests Network pilot project (hereafter "Network pilot project") was managed by the Forestry Centre of North Karelia, and it was one of the four pilot projects implemented to test the functioning of the new "cooperative network on forest biodiversity" instrument that was outlined in the METSO report (Etelä-Suomen… 2002). It was implemented in the local districts of Tohmajärvi, Kitee and Kesälahti. The local authorities, including the regional environmental centre, two local forest management associations, local nature protection organization, representative of the local agricultural and forestry entrepreneurs, and researchers from the Finnish Forest Research Institute were the initiators of the Network pilot project and they also formed the project team (for more details see

Forest owner		Authorities (Forestry Centre)
Expresses his/her interest to participate in voluntary protection project.	→	Inventory (biodiversity characteristics and standing timber stock) Evaluation concerning suitable biodiversity protection tools
Forest owner participates in creation of product specification. Product specification together with (for example) help from local forest management association is used for supporting decision making, this mainly being forest owner's price demand.	←	If suitable for natural values trading, so called *product specification* for potential protection area is created in co-operation with forest owner. Product specification includes: (i) assessment of stand-level cutting-income loss; (ii) holding-level opportunity cost; and (iii) score-based rating of offered stand with respect to ecological criteria used in selection of forest tracts for protection.
Submits written offer to protect forest tract accompanied by compensation fee demand.	→	Several offers are examined and compared simultaneously in an advisory meeting; e.g. with respect to price/quality relationship, budget constraints, etc.
Forest owner receives decision. Further practical actions are launched.	←	Suitable offers are accepted.

Fig. 1. The forest tract selection process in Network pilot project (adapted from Kolström et al. 2006).

Kolström et al. 2006). The project lasted three years (2004–2006) and it was funded from the budget of the METSO programme administrated by the Ministry of Agriculture and Forestry.

The main objective of the Network pilot project was to retain the biodiversity values of the invaluable herb-rich forests within the project area. In addition, specific attention was given to the protection of nature values in the sunny areas that are often located near the eskers of herb-rich forests. Some specific forest-management operations were targeted at areas where the value of the herb-rich forest appeared to be at risk of declining unless active management measures were taken. The general objective was to create a network of protected invaluable herb-rich forests such that the network would enhance the connectivity of the protected areas. In addition to the use of a natural-values trading instrument, some other more traditional nature protection instruments and economic incentives were used to achieve this task.

The tracts of forest included in the Network pilot project by using natural values trading were evaluated in the process described in Fig. 1. In the case of the traditional biodiversity protection tools, the process is different and the compensation fee does not depend on the forest owner's preferences. This is why this study concentrates on the decision-support needs of the new natural-values trading process.

The project began with rather massive information sharing targeted at forest owners in the project area. This included newspaper articles, establishment of an Internet website, participation at several local events (autumn markets, etc.), presentations targeted at interest groups, and specific meetings arranged for forest owners. Information about the targeted biodiversity objects, the action plan, the timetable and the biodiversity protection instruments to be used were provided to forest owners through the aforementioned dissemination channels. In some sub-areas within the Network pilot project area, potentially promising areas were pinpointed during the regular forest planning process and this information was shared to the forest owners with holdings in these areas. In addition, the Forestry Centre pinpointed some of the most promising areas by means such as GIS applications (Kangas et al. 2000), and by making use of the knowledge possessed by people involved in the local organizations. Based on the information thus obtained, the Forestry Centre directly contacted these forest owners, including those living away from their forest properties and therefore unlikely to hear about the project otherwise. These owners were invited to meetings to learn about the objectives of the project and the possibilities to participate in it.

During the three-year pilot project, 87 forest owners contacted the actors involved in running the pilot project. Preliminary or more detailed inventories were carried out in 83 of the potential tracts of forest (amounting to 182 ha) of which 72 (covering 166 ha) fulfilled the ecological criteria (Etelä-Suomen metsien … 2003). Based on these inventories, product specification was created for these forest owners. The product specifications included information concerning different nature-protection alternatives (temporary, permanent), the stand, and in some cases also the holding-level opportunity cost calculation [1], and (if the tract of forest was herb-rich forest) the evaluation of the offered land's biodiversity value by using the model described below. Based on this information and on the discussions between the project worker and the other parties (e.g. forest management association's personnel), it was expected that the forest owner would be able (i) to decide whether he/she is willing to participate to the project, (ii) to decide what kind of nature protection instruments could be applied; and (if the owner wanted to enter into natural-values trading) (iii) to decide what his/her the compensation fee request for protecting the tract of forest for the forthcoming period would be.

The end result of the project was that 11 permanent nature-protection contracts (covering 79 ha) and 25 temporary contracts (covering 52 ha) were concluded with the forest owners with forest holdings in the project area. This meant that half of the tracts of forest fulfilling the criteria were included in the network of protection areas. The length of the temporary protection period in most cases was 10 years (22 cases, covering 36.9 ha), but in some cases where the forest owner wanted to have a longer protection period, the length of the protection period was either 15 years (1 case, covering 3.2 ha) and 20 years (2 cases, covering 11.9 ha). The relatively short time period with respect to e.g. typical rotation periods of boreal forests results from the practices that were applied in all pilot projects. The short protection period can, however, improve the forest owners' willingness to participate to the projects (e.g. Bräuer et al. 2006). The average compensation fee in natural-values trading was €142 ha^{-1} a^{-1}. However, all of these protected areas were not herb-rich forests. Some other valuable forests, e.g. forests with high amount of decaying wood (Etelä-Suomen metsien… 2003) were also included in the network within the limits of the budget constraints.

1 The holding-level opportunity cost was calculated only for a small number of forest owners due to facts that the pilot project was not in direct connection to regular forest planning process and that practical means for its full application were not available.

3 Decision-Support Elements in the Product Specification

3.1 Stand-Level Opportunity Cost

When making a decision to temporarily set aside a certain forest stand, the forest owner has basically two alternatives. The first alternative is to accept the terms of the protection contract and usually to desist from applying the cutting option during the protection period, typically for the next 10-year period. At the end of the protection period, the forest owner can resume to manage the stand according to his/her normal goals. In the second alternative, the forest owner does not protect the forest and maintains the freedom to manage the forest within the constraints of the current forest legislation. If the forest owner is assumed to have only one holding-level goal, namely maximization of the net present value (NPV, including the incomes of the future rotations), the opportunity cost can be calculated at the stand level, because in this case there are no interdependencies between stands that would require holding-level examination.

At the stand level, one can calculate the opportunity cost of protection by defining the change in the stand's NPV in the above two situations. In practice, this means that the NPV from the unrestricted optimal treatment schedule is compared to the NPV from the restricted treatment schedule, which does not allow stand treatments during the forthcoming protection period. In this comparison, there are basically two options: (i) according to the economically optimal treatment schedule no treatments need to be carried out during the protection period; and (ii) according to the economically optimal treatment schedule the stand should be treated (e.g. regenerated) immediately or during the protection period. In the former option, protection does not cause any opportunity costs to the forest owner and the compensation fee that the owner receives from the buyer increases the owner's economic result. In the latter option, the opportunity cost and the compensation fee from the protection authorities need to be compared and evaluated, and the forest owner should receive the compensation fee reflected by the opportunity cost.

The calculation described in the above should be done by using the interest rate that corresponds to the forest owner's time preference. If the forest owner can not define the interest rate demand, the NPV can be calculated by using various interest rates. In addition to the above NPV calculation, the stand-level opportunity cost can be illustrated to the forest owner by some other stand-level economic measures that describe the economic profit of the stand compared to the profit of some alternative investment (e.g. bank account). For example, the winning value (or v-value) (see e.g. Viitala 2002) , which was used in the case study presented below, describes the coming year's profit or loss in comparison to the alternative investment that one year's delay in the cutting causes as follows:

$$\text{v-value} = I_a - i(A_{\text{land}} + A_{\text{timber}}) \qquad (1)$$

where I_a is the yearly value growth of the stand (€/ha/a), i is the forest owner's interest rate demand, A_{land} and A_{timber} are the values of bare land and timber stock of the stand (€/ha), respectively. The changes in value growth and timber value should be taken into account when calculating the future years' v-values.

In addition to these kinds of (usually deterministic) calculations, it may be important to consider the potential risks related to delayed (regeneration) cuttings. For example, the planning consultant can estimate the current log reduction factor and its development during the 10-year period. Then the development of the factor can be taken into account in the calculation of the v-value. In addition to the log reduction, the stand can be the object of various forms of forest damage affecting the cutting-income loss. In principle, statistical modelling techniques can be applied to the model and unexpected events can be simulated (e.g. Leskinen and Kangas 1998 for modelling of unexpected timber prices). On the other hand, in the case of sudden and large-scale forest damage, it is a contractual matter to cancel or amend the protection contract.

3.2 Holding-Level Opportunity Cost

Stand-level opportunity cost calculations are meaningful when the utilities produced by different forest stands are independent, i.e. the forest-level optimum is equal to the sum of the stand-level optima. This is the case for instance when the owner maximizes the timber sales incomes from his holding and there are no scale benefits. A more common situation is, however, that there are objectives that make stand decisions dependent on each other, like the requirement for a certain periodical cut from the whole forest. In this situation, the value of or utility from a certain forest stand depends on the characteristics and future treatments of other stands. In such cases, the opportunity cost should be based on the holding-level calculations. This applies especially to temporary protection periods, i.e. when the timber stock of the protected forest area returns to the production potential of the forest holding. In these situations, the opportunity cost depends on the structure and the production possibilities of the entire forest holding. The planning system should be able to account for the possibilities to adapt the treatments of other compartments due to the temporary protection of one part of the holding. Also the emphasis, which the forest owner places on economic goals compared to other objectives that may in some cases correlate positively with the protection of the stand, also affects the opportunity cost. The existence of multiple objectives and different stand characteristics result in complicated interdependencies between the stands and thereby justify holding-level examinations.

In tactical forest planning, the forest plan that best meets the forest owner's goals is typically found by formulating and solving a planning model consisting of (i) alternative treatment schedules simulated for individual forest stands, and (ii) the owner's utility model concerning the use of the forest resources. The utility model is optimized by seeking out the best combination of treatment schedules for the holding's compartments. This kind of multi-objective planning framework can be utilized in defining the holding-level opportunity cost that is caused by prohibiting regeneration cutting within a specified part of the forest holding.

In the calculation of a holding-level opportunity cost by using the approach proposed by Kurttila et al. (2006), a compensation fee is added to the "No treatment" alternative of the examined forest stand, and other treatments of the stand are prohibited. After that, the treatment schedule including a certain level of compensation fee and the treatment schedules of other stands are evaluated applying the forest owner's holding-level utility model in the optimization process. The result of optimization gives the optimal treatment proposal for each stand, and it also tells whether it produces more utility, at the whole holding level, to protect the examined stand with a given compensation fee, or whether the utility resulting from the reference forest plan, according to which the stand can be regenerated during the planning period, is greater.

Prohibiting regeneration alternatives (clear cutting and seed tree cutting) from the stand limits the production possibilities of the holding and affects the result of optimization. If the forest owner has biodiversity goals or if the forest owner wants to secure future timber production possibilities, the compensation fee needed will be less than the full compensation of timber sale losses. In addition, the substitutability of the objectives has an effect on the level of the compensation fee. For example, if the utility loss caused by a decrease in the cutting income can be partly or totally compensated for by an increase in the utility through increased standing timber stock, the holding-level opportunity cost will be lower.

The method is formulated in the following way in an example situation (Kurttila et al. 2006). Consider three goals, net income (INC), area of old forest (OLD) and timber volume (VOL) as the goal variables of the forest owner. The quantities that alternative forest plans produce of the goal variables are denoted by q_{INC}, q_{OLD} and q_{VOL}, respectively. These quantities are transformed to the utility scale measuring the utility values that the forest owner perceives from the goal variables. In order to do this, the first step is to specify the sub-utility functions, one for each goal. The sub-utilities are denoted by $u_{INC}(q_{INC})$, $u_{OLD}(q_{OLD})$ and $u_{VOL}(q_{VOL})$ where, for example, $u_{INC}(q_{INC})$ indicates the sub-utility that the amount of net income q_{INC} will produce to the forest owner.

After specifying the sub-utility functions, the next step is to estimate the overall utility U that alternative forest plans produce when all objectives are simultaneously taken into account. The traditional additive utility function can be used; the idea is then to calculate the overall utility as the weighted arithmetic average of the sub-utilities. In addition, it would be also possible to use multiplicative (e.g. Leskinen 2001), or partly multiplicative (e.g. Leskinen et al. 2003) utility functions, if the multiplicative structures describe the forest owner's preferences better than, for example, linear model. Then heuristic optimization methods (Pukkala and Kurttila 2005) can be used to optimize multiplicative utility functions instead of linear programming. In addition to the specification of the shape of the utility functions, the forest owner assesses also the weights w_{INC}, w_{OLD} and w_{VOL} that describe the mutual importance of the goals. Usually these weights are scaled so that their sum is one, i.e. $w_{INC} + w_{OLD} + w_{VOL} = 1$. In the example, the additive utility function has the form

$$U = w_{INC}u_{INC}(q_{INC}) + w_{OLD}u_{OLD}(q_{OLD}) + w_{VOL}u_{VOL}(q_{VOL}) \quad (2)$$

Model (2) measures the overall utility that alternative forest plans formed by the compartmentwise treatment schedules produce to the owner. The model is used to estimate the holding-level opportunity cost as follows:

(i) Find a treatment-schedule combination that maximizes the utility index U when there are no protection limitations and no compensation fees. Denote the optimum value of the utility index as U^* and the values of the objective variables at the optimum by q^*_{INC}, q^*_{OLD} and q^*_{VOL}.

(ii) Find a treatment schedule combination that maximizes the utility index U when a certain forest stand is protected and compensation fee is equal to S. The compensation fee is treated as if it were income from timber sales. Denote the optimum value of the utility index as U^*_S and the values of the objective variables at the optimum by $q^*_{INC,S}$, $q^*_{OLD,S}$ and $q^*_{VOL,S}$.

(iii) Enter different values for the compensation fee and determine the fee S'' such that $U^*_{S''} = U^*$. Then the compensation fee equal to S'' is the opportunity cost that compensates the utility losses caused by protection.

3.3 The Ecological Quality of the Forest Stand

In addition to stand- and holding-level opportunity costs, it is important to produce information depicting the ecological quality of the forest tract that the forest owner is offering for protection. This information is important both for the forest owner and for the authorities that accept or reject offers made by individual forest owners.

When evaluating the biodiversity value, one can use multi-criteria decision-support models (e.g. Kangas et al. 2000, Schmoldt et al. 2001, Pykäläinen et al. 1999). In this approach, empirical research results, ecological expertise, or both, are used in the model-specification phase, i.e. when the criteria, their relative importance, and the sub-priority models are defined. In the Central Karelia Network pilot project area, an expert decision-support model was used in evaluating the offered tracts of forest in two ways. First, information was produced for the forest owners

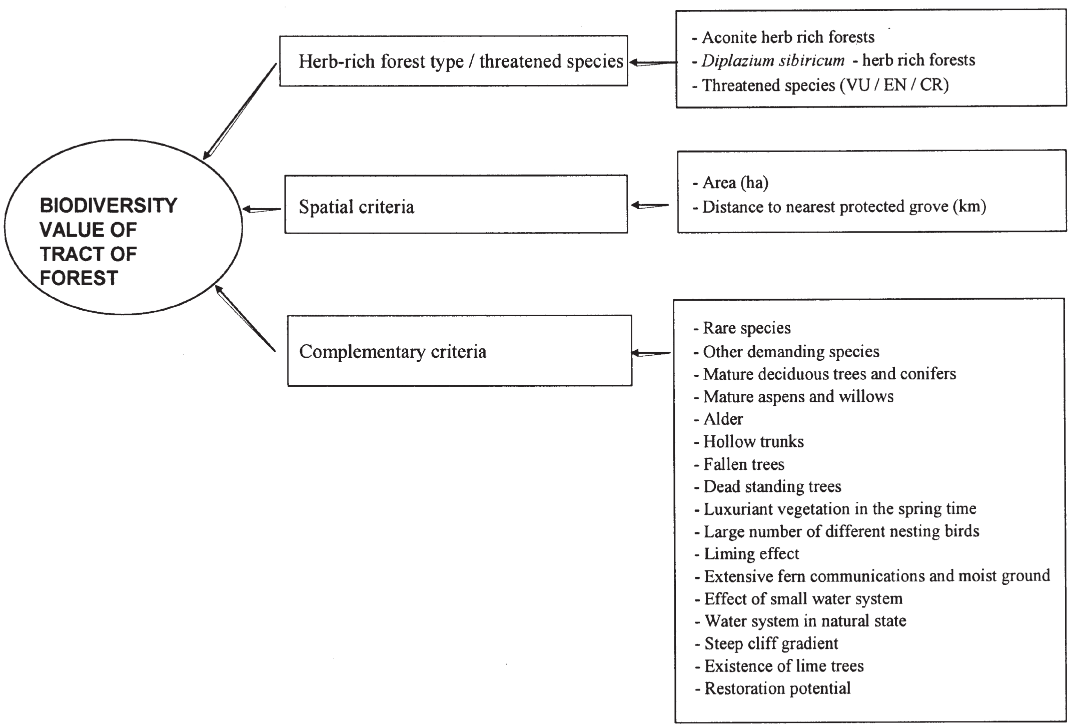

Fig. 2. The basic structure of the Metsätähti expert model and an illustrative list of the criteria to be applied in the Central Karelia Herb-rich Forests Network pilot project.

Table 1. Asterisk ratings, where the p is the priority value given by the model.

Asterisk rating	Description
*	The tract of forest possesses only modest biodiversity values ($p<0.075$).
**	The tract of forest possesses moderate biodiversity values. It includes some of the desired herb-rich forest characteristics ($0.075 \geq p > 0.15$).
***	The tract of forest is fairly good for protection. Typically, both the forest structure and the vegetation possess desired herb-rich forest characteristics ($0.15 \geq p > 0.225$).
****	The tract of forest is very good with respect to biodiversity values. It possesses several desirable herb-rich forest characteristics ($0.225 > p \geq 0.3$).
*****	The tract of forest is of excellent value for protection ($p>0.3$).

concerning the quality of the tracts of forest they are offering and this information was included in the product specification. Second, the authority deciding on the financing of the forest tracts and their inclusion in the protection area network uses the same model as decision support once a group of forest owners has made their offers. For this purpose, the model was augmented by an additional criterion depicting the importance of the cost of acquiring the tract of forest. Then the decision-support model was able to provide the global priorities and rankings for the offered areas based on both quality and costs (see Pykäläinen et al. 2005). In this article, we present only the results that concern decision support at the forest-owner level.

The criteria for the model were selected from among the primary structural criteria, area and location criteria, and the supplementary criteria defined to be used as the selection criteria in the herb-rich forests of Southern Finland (Etelä-Suomen metsien… 2003). These were complemented with some region-specific characteristics, such as the types of herb-rich forests that occur only in Central Karelia (Fig. 2). After defining the criteria, an expert in forest ecology defined the weights of the criteria and their sub-priority functions.

The data collected during the regular forest inventory is not sufficient for the model; one reason for this is that the existence of certain threatened or rare species of flora is not known following regular forest inventory. Therefore, the forest tracts offered for protection must be inventoried in more detail, and this phase requires ecological expertise. Particularly the identification of some specific herb-rich forests species can be difficult for forest planners. The measured data are entered into the model, which computes the priority for the examined tract (for more details on the model structure see Pykäläinen et al. 2005).

The priority value produced by the model is not useful to the forest owner as such. For example, he/she cannot compare it to the priority values of the areas that other forest owners have offered. Therefore, the model's result has to be explained to the forest owner in a more understandable form. This is why the priority values describing the quality of stands for protection are categorized into five classes designated by asterisks (Table 1). For example, a poor, but still suitable, area in terms of biodiversity protection gets one asterisk and an ideal area (whose characteristics are almost equal to the characteristics of a herb-rich area that is protected in specific herb-rich area protection program) gets five asterisks. In addition, the product specification included a verbal description of the area's characteristics.

4 Examples from the Case Study Holdings

The example cases come from five holdings located within the area covered by the Network pilot project. Three forest owners each offered two forest stands and two forest owners one stand

Table 2. The main characteristics of the case study forest holdings.

Holding	Forest land area (ha)	Growing stock volume (m^3ha^{-1})	Sawlog volume (m^3ha^{-1})	Pulpwood volume (m^3ha^{-1})	Cutting possibilities [a] (%)
1	69.5	143	80	56	42
2	41.9	115	50	57	3
3	47.6	135	65	62	22
4	68.9	146	58	76	18
5	51.2	99	50	41	28

[a] The proportion of the holding's forest land that belongs to development class "Mature forest", which can be immediately regenerated.

Table 3. The main characteristics of the examined stands (the owners of Holdings #1, #2 and #5 offered two separate stands for natural-values trading).

Holding.stand	Area (ha)	Main tree species	Growing stock volume (and sawlog volume) (m^3 ha^{-1})	Cutting value (€ ha^{-1})	Value increment (€ ha^{-1} a^{-1})
1.1	0.6	Spruce	295 (208)	11 541	158
1.2	1.2	Pubescent birch	189 (123)	6 754	177
2.1	0.6	Pubescent birch	70 (9)	1 034	49
2.2	0.9	Silver birch	160 (21)	2 521	114
3	0.7	Spruce	171 (117)	6 235	113
4	1.4	Silver birch	222 (140)	7 658	132
5.1	0.9	Spruce	132 (78)	4 571	158
5.2	1.4	Silver birch	162 (53)	3 674	62

for the natural-values trading. The two stands within the same holdings, however, formed only one protection area for the Network pilot project, but (due to different stand characteristics) they were kept separate in calculations. In Holding #5 the length of the examined protection period and the planning period applied was 20 years, and in other holdings it was 10 years.

The calculations were based on stumpage prices provided by the Forestry Centre of North-Karelia, and these were the prices that were used in creating private forest plans during the year 2005. The same prices were used with other forest owners who participated to the pilot project. In simulating treatment alternatives for the stands, the regeneration and thinning limits were adopted from official treatment recommendations (Hyvän metsänhoidon suositukset 2001). In addition to these earliest possible cuttings, also delayed regeneration cuttings, thinnings, and also the "No treatment" options were simulated for the stands. However, no alternatives were simulated for precommercial treatments or for first thinnings. During the interactive planning process with the forest owners, all the treatments simulated for the stands were inspected with the forest owners, and they had the option of declining from or adding new treatments for the stands.

The five case study forest holdings were fairly large in area and well stocked (Table 2). The immediate cutting possibilities in these holdings were significant, except for Holding #2, where only one stand could have been regenerated immediately. However, the proportion of middle-aged stands was very large in this holding (54%), indicating good thinning possibilities and that some stands will in near future be maturing.

The offered tracts of forest in these holdings were rather small, their size varied from 0.7 ha (Holding #3) to 2.3 ha (Holding #5) (Table 3), which is typical for herb-rich forests. The main tree species in three stands were spruce (*Picea*

Table 4. Summary of the decision-support material delivered to the forest owners. For a description of the ecological quality of the stand, see Table 1.

Holding.stand	Ecological quality of stand	Winning value with 3% interest rate (€ ha^{-1} a^{-1})	Proportion of the area of holding's mature stands (%)	Holding-level opportunity cost (€ ha^{-1} a^{-1})	Forest owner's negotiation position [a)]
1.1	-	–201	7	0	?
1.2	-	–38			?
2.1	***	5	-	90	Excellent
2.2	****	26			
3	***	–75	7	154	Moderate
4	***	–110	11	0 (240)	Good
5.1	*****	8			
5.2	***	–61	16	135	Excellent

[a)] Researcher's assessment based on quality of the stand and on forest owner's objectives and on resulting opportunity cost.

abies) and silver birch (*Betula pendula*), and in two stands pubescent birch (*Betula pubescens*). The growing stock volume, and as a result also the cutting value, were the largest in Stand #1 of Holding #1 and in Holding #4. In Holding #2 the growing stock volume of the two stands was rather low, the reason for this being that they had not yet reached the treatment limit set for mature stands.

In Holding #1 the two stands were not herb-rich forests, although they had some characteristics in common with herb-rich forests. They were ecologically desirable because they included fairly large amounts of dead and decaying woody debris. Therefore, their value could not be assessed using the model introduced in Chapter 3.3. In all the other holdings, the offered tracts were herb-rich forests, and their value could be assessed using the model (Table 4). In Holding #5, Stand #1 was classified to be an excellent stand for the purpose. In addition, its winning value was still slightly positive. In Holding #2, Stand #2 got 4 asterisks, and its winning value was slightly positive. The positive winning values indicate – from the economic point of view – that the forest owners do not have to hurry with (regeneration) cuttings. In the other non-mature stand in Holding #2, the winning value was also positive. In the other stands, the winning values were negative, ranging from €38 to €201 annual loss compared to income from the alternative investment source where the interest rate was 3%. However, these calculations do not include timber sales taxes nor any other possible additional fixed or variable costs.

The holding-level opportunity costs were calculated for the forest owners in connection with an interactive planning session using the MONSU forest planning software (Pukkala 2004). Because the compensation fee is expressed in monetary terms, each forest owner's objective function had to include the net income objective. All forest owners wanted to use net income without discounting, i.e. NPV with 0% interest rate. In addition, the forest owners' freely selected additional objective variables. The selected objective variables were fairly directly related to wood production, future cutting possibilities, and to the good growth of the forests. None of the owners selected multiple-use objectives. Thematic semi-structured interview (Pykäläinen 2000) was utilized in this phase's discussion with forest owners. Once the forest owners had selected their objective variables, they defined their relative importances and sub-utility functions.

The forest owners defined the sub-utility functions for the selected objectives so that the planning consultant asked them whether they had any goal levels for the objective variables. If a particular forest owner had no goal level for the objective variable, the sub-utility function used was linear between the minimum and maximum value of the objective variable, where the sub-utility was 0 and 1, respectively. If a forest owner had goal level for the objective variable, the sub-utility function was partially linear so that the goal value of the objective variable was given a value 0.9, and in some case also the value 1. The relative importance of the objectives were defined by utilizing the HIPRE software (Hämäläinen ja Lauri 1993) and its pairwise comparisons application. However, this phase defined only the initial importance of the objectives, and by utilizing the interactive planning application of the MONSU software, the forest owners could change a particular importance. The HERO heuristic optimization technique (Pukkala and Kangas 1993) with its 2-neighborhood search (Heinonen and Pukkala 2004) was utilized in searching for the optimal forest plan for the given objective function with the decision variables being the stands' simulated treatment alternatives that the owner had accepted.

The resulting plan prohibiting cuttings in the examined stands showed whether the protection caused any holding-level opportunity costs to the forest owner. In the event that the result of the optimization showed that the stands should, according to the optimal forest plan, be cut during the planning period, then the holding-level opportunity cost was sought as described in Chapter 3.2. Were the no-treatment alternative selected for the stand, the opportunity cost of temporary protection was €0 for the forest owner.

The holding-level opportunity cost was €0 for Holding #1 (Table 4). The result was produced by good cutting possibilities in the holding as well as the forest owner's objective according to which part of the cutting possibilities should be saved for the future. In this holding, the protected tract of land would represent only 7% of the area of the stands that could be immediately regenerated. The result was similar for Holding #4, where the forest owner did not want to utilize all of his fairly significant cutting possibilities. The forest owner's main objective was to retain the value and the production potential of the forest holding. After seeing the result, the forest owner of Holding #4 wanted to have another plan drawn up, in which the cutting possibilities were utilized almost totally during the planning period. This produced a holding-level opportunity cost of €240 ha^{-1} a^{-1}. The creation of this new plan provides additional decision support for the owner by illustrating the maximum holding-level opportunity cost.

In Holdings #2, #3 and #5, the opportunity cost varied between 90 and 154 ha^{-1} a^{-1}, depending on the forest owner's objective function and production possibilities of the holding. The objectives of these three forest owners were fairly typical for Finnish forest owners: they wanted to have income from their forest, but at the same time they wanted to retain cutting possibilities and maintain or improve the good condition their forest property (e.g. Tikkanen et al. 2006). Due to fairly good cutting possibilities and a wish to retain some of them to future, the holding-level opportunity costs were modest.

Based on the holding-level opportunity cost and on the ecological quality of the stand, the negotiation position of the forest owners was also assessed (Table 4). The position of two forest owners is excellent because the quality of their stands is fairly or very good and the opportunity costs are not very high. For owners of Holdings #3 and #4, their position is moderate or good, because of the moderate holding-level opportunity cost as well as the fairly good ecological quality of the stand. The position of the forest owner of Holding #1 could not be assessed due to missing information on the ecological quality of the stand.

5 Discussion

The tested decision-support elements serve in clarifying the new decision problem of temporary protection to the forest owner by addressing the issue from different perspectives. Stand-level and holding-level information describe the opportunity costs that the forest owner faces if (s)he decides not to cut the forest areas in question. From society's demand aspect, the information concerning the ecological quality indicates how desirable the tract of land is for society and to some degree also how high or low is the compensation the forest owner might get from retaining the area. The correlations between the economic losses and the ecological quality of the herb-rich forest stand are not highly positive in all cases. This means that even in a young well-managed stand the flora and fauna might be very valuable and worth protecting. Consequently, temporary protection does not lead to serious economic losses to the forest owner; instead, it provides additional economic income to the forest owner to enable temporarily protecting the stand even against a small compensation fee. In some other situations, e.g. in the case of economically mature stands that include large amounts of decaying woody debris, the positive correlation between economic loss and ecological value is usually significant. The true opportunity costs, however, depend on forest owners' forest management goals and forest holdings' forest structure as a whole. This emphasizes the point that the evaluations should, whenever possible, be carried out at the holding level.

According to the experiences gained from the Network pilot project, stand-level opportunity cost can be calculated and applied fairly easily in practice by using the planning tools that are typically applied in Finnish forest planning. The basic idea is to evaluate the possible cost of delayed cuttings. The assumptions are that the development of even an old stand can be assessed reliably and that the timber prices develop as assumed. As the calculation is based on the maximization of NPV only, the result of the model can be readily understood and adopted. Also, the implications of the negative winning values should be rather easily adopted, at least in the case of economically-oriented forest owners. If the forest owner wishes to maintain a certain amount of cutting possibilities, additional evaluations concerning matters such as the examined stands' winning value in relation to other stands' winning values could be made.

If the forest owner has several objectives and the above simple holding-level analysis between different stands is not enough, the opportunity cost should be assessed by applying more advanced planning calculations. Compared to the use of optimization as described in this study, an easier way to assess the importance of the examined stand at the holding level is to evaluate how large a proportion of the holding's cutting possibilities it includes (see Table 4). If the proportion is low, and the owner has moderate cutting intentions, it can be assumed that the holding-level opportunity cost is not very high. One should, however, note that stand-level and holding-level evaluations can easily yield opposite results. At stand-level, the winning value can be positive, but if the forest owner wants to get a lot of cutting income immediately, the holding-level opportunity can be fairly high.

The holding-level opportunity cost depends on the forest owner's objectives and on the production possibilities of the entire forest holding. The use of this method requires that monetary objective variable (e.g. NPV) is included in the objective function. If the forest owner wishes to save some cutting possibilities for the forthcoming planning periods, the holding-level opportunity cost may be very low, as in this case it is calculated from the difference between the delayed cutting schedule of the examined stand and the earlier cutting of some other stands. If the forest owner does not put (much) weight on economic objectives, the holding-level opportunity cost is close to €0, and it indicates that it is in line with forest owner's objectives not to cut the stand.

The correctness of the utility function applied is a key factor in defining the holding-level opportunity cost. The opportunity cost depends greatly on the objectives, their weights, and sub-utility formulations (Kurttila et al. 2006). Therefore, it would be important to analyse the potential uncertainties involved. In particular, the uncertainties involved in the decision-maker's preferences could be measured and incorporated into decision-making by statistical modelling techniques (e.g. Alho et al. 2001, Leskinen 2001).

The best situation in which to use the above decision support elements would naturally be in a regular forest-planning process, which includes forest inventory, goal analysis and the creation of the forest plan. In the inventory, the characteristics of valuable areas could be measured in more detail and information about their existence could be given to the forest owner. During goal analysis, the forest owner's willingness to participate could be clarified. In this kind of a planning process, the decision-support elements listed in Chapter 3 could then be computed fairly easily. However, the forest-planning consultant may not be able to perform all the measurements needed to define the ecological quality of the tract of forest. In a situation where positive preconditions for considering protection alternative exist, persons expert in assessing the quality of herb-rich forests could, for instance, carry out additional measurements. Finally, if the protection contract is signed, its preconditions and consequences can be included in the forest plan. This kind of a procedure would genuinely integrate biodiversity considerations with the fundamental parts of the regular process of forest planning.

The assumption in defining the holding-level opportunity cost is that the value of the utility function is really maximized and it defines the forest owner's objectives correctly. If the utility function in the above described planning process is used only to find a satisfactory forest plan, the resulting opportunity cost is probably biased: e.g. the correct objective variables, their weights and sub-utility functions have not been defined. However, this assumption is at the back of many other analyses and calculations and it is often the best alternative to assume the utility maximization. In some cases, it could also be possible to use some small amount of "typical" objective formulations for the forest owner's holding in a semi-automatic manner (e.g. Pesonen 1997). For example, the holding-level opportunity cost could be defined for the following cases: (i) utilize all cutting possibilities in the holding; (ii) utilize as much as possible the cutting possibilities during the first 5-year planning period but let the growing stock value decrease at maximum 30% from the initial value; and (iii) apply an even cutting flow and maintain the value of the forest at the initial level etc. The owner could then select the opportunity cost that best meets his forest management goals.

In case study calculations, additional operational expenses to the owner were not taken into account. In practice, time consumption for specific management of the protected area, time used to possible reporting and pest outbreaks control etc. should also be included in the compensation fee. In addition, all factors affecting the planning environment (tree growth, mortality, forest damage, timber prices) were assumed to be deterministic. Similarly with the preferential uncertainty, also the timber prices, for example, can contain uncertainty, i.e. random variation (e.g. Leskinen and Kangas 1998) and some forest owners follow price development actively. In addition, in some old forest stands, there is a risk that part of the sawlog timber being lost to decay in amounts greater than what mortality models show. Taking into account these risks by applying stochastic analysis would be one important topic for future research.

The model used to define the ecological quality of the stand was specifically tailored to meet the characteristics of the herb-rich forests of Central Karelia only. There might, however, be a need to make comparisons between several different forest types within the same region. In this case, either a more general model is needed, or alternatively, one should develop more detailed models for each forest type. In the latter case, the comparisons of different types would be needed at least when the authorities are making decisions on which areas will be included in the protection area network. The weighting ratios between the different forest types would reveal society's preferences.

In addition to above-described decision-support elements, information concerning examples from realized compensation fees would be valuable for the forest owner in setting his compensation fee demand. As relevant as this information is, it is not yet available, since voluntary protection programs have been tested only on small scale in just a few pilot projects in different parts of the Finland. In addition, it is evident that the changes in timber prices will affect the compensation fees.

Acknowledgements

This study was carried out in the project "Ecological considerations in landscape-level collaborative planning of private forestry", which belonged to the Finnish Biodiversity Research Program MOSSE, and it is partly based on the Master's thesis of Tiina Ruuskanen. In addition, this study was supported by the Academy of Finland (decision number 210417).

References

Alho, J.M., Kolehmainen, O. & Leskinen, P. 2001. Regression methods for pairwise comparisons data. In: Schmoldt, D.L., Kangas, J., Mendoza, G.A. & Pesonen, M. (eds.). The Analytic Hierarchy Process in natural resource and environmental decision making. Kluwer Academic Publishers, Dortrecht. p. 235–251.

Boyd, J. & Simpson, D. 1999. Economics and biodiversity conservation options: an argument for continued experimentation and measured expectations. The Science of the Total Environment 240: 91–105.

Bräuer, I., Müssner, R., Marsden, K., Oosterhuis, F., Rayment, M., Miller, C. & Dodoková, A. 2006. The use of market incentives to preserve biodiversity. Final report, a project under the Framework contract for economic analysis ENV.G.1/FRA/2004/0081.

Doremus, H. 2003. A policy portfolio to biodiversity protection on private lands. Environmental Science & Policy 6(3): 217–232.

Etelä-Suomen metsien monimuotoisuusohjelman luonnonsuojelubiologiset kriteerit. 2003. Ympäristöministeriö. Suomen ympäristö 634. (In Finnish).

Etelä-Suomen, Oulun läänin länsiosan ja Lapin läänin lounaisosan metsien monimuotoisuuden turvaamisen toimintaohjelma. 2002. Ympäristöministeriö. Suomen ympäristö 583. (In Finnish).

Frank, G. & Müller, F. 2003. Voluntary approaches in protection of forests in Austria. Environmental Science & Policy 2003 6(3): 261–269.

Hämäläinen, R. P. & Lauri, H. 1993. HIPRE 3+ users guide. Systems Analysis Laboratory, Helsinki University of Technology.

Heinonen, T. & Pukkala, T. 2004. A comparison between one- and two-neighbourhoods in heuristic search with spatial forest management goals. Silva Fennica 38(3): 319–332.

Hyvän metsänhoidon suositukset. 2001. Metsätalouden kehittämiskeskus Tapio. 95 p. (In Finnish).

Kangas, J., Store, R., Leskinen, P. & Mehtätalo, L. 2000. Improving the quality of landscape ecological forest planning by utilising advanced decision-support tools. Forest Ecology and Management 132: 157–171.

Kolström, M., Kurttila, M. & Pykäläinen, J. 2006. Metso-ohjelman kokeiluhanke. Yhteistoimintaverkosto. Keski-Karjalan lehtoverkosto. Loppuraportti. [Online document]. Available at: htp://wwwb.mmm.fi/metso/asiakirjat/Loppuraportti_Keski-Karjalan_lehtoverkosto_271006.pdf. [Cited 1.11.2007].

Kurttila, M., Pykäläinen, J. & Leskinen, P. 2006. A utility-theoretical approach to defining the forest landowner's minimum price demand for a biodiversity object. European Journal of Forest Research 125: 67–78

Leskinen, P. 2001. Statistical methods for measuring preferences. University of Joensuu, Publications in Social Sciences 48. 111 p.

— & Kangas, J. 1998. Modelling and simulation of timber prices for forest planning calculations. Scandinavian Journal of Forest Research 13: 469–476.

— , Kangas, J. & Pasanen, A-M. 2003. Assessing ecological values with dependent explanatory variables in multi-criteria forest ecosystem management. Ecological Modelling 170: 1–12.

Mayer, A.L. & Tikka, P. 2006. Biodiversity conservation incentive programs for privately owned forests. Environmental Science & Policy 9: 614–625.

Parkhurst, G.M., Shogren, J.F., Bastian, C., Kivi, P., Donner, J. & Smith, R.B.W. 2002. Agglomeration bonus: an incentive mechanism to reunite fragmented habitat for biodiversity conservation. Ecological Economics 41: 305–328.

Pesonen, M. 1997. Estimation of potential allowable cut using modelling of landowners' strategic decision making. Doctoral thesis. Finnish Forest Research Institute, Research Notes 625. 56 p. + annexes.

Pukkala, T. 2004. Monsu metsäsuunnitteluohjelma. Ohjelmiston toiminta ja käyttö. (In Finnish).

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

— & Kurttila, M. 2005. Examining the performance of six heuristic optimisation techniques in different forest planning problems. Silva Fennica 39: 67–80.

Pykäläinen, J. 2000. Defining forest owner's forest-management goals by means of a thematic interview in interactive forest planning Silva Fennica 34(1): 47–59.

— , Kangas, J. & Loikkanen, T. 1999. Interactive decision analysis in participatory strategic forest planning: experiences from state owned boreal forests. Journal of Forest Economics 5(3): 341–364.

— , Kurttila, M. & Hakalisto, S. 2005. Evaluating potential protection areas by means of multi-attribute priority analysis for the Central Karelia herb-rich forest network pilot project in eastern Finland. In: Veltheim, T. & Pajari, B. (eds.). Forest landscape restoration in Central and Northern Europe. EFI Proceedings 53: 145–151.

Schmoldt, D.L., Kangas, J., Mendoza, G.A. & Pesonen, M. (eds.). 2001. The Analytic Hierarchy Process in natural resource and environmental decision making. Kluwer Academic Publishers, Dortrecht.

Tikkanen, J., Isokääntä, T., Pykäläinen, J. & Leskinen, P. 2006. Applying cognitive mapping approach to explore the objective structure of forest owners in Northern Finnish case area. Forest Policy and Economics 9(2): 139–152.

Viitala, E-J. 2002. Metsän optimaalinen kiertoaika: Lähestymistavat ja niiden talousteoreettinen perusta. Finnish Forest Research Institute, Research Notes 848. 128 p. (In Finnish).

Total of 28 references