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A Participatory Approach to Tactical Forest
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A Participatory Approach to Tactical Forest Planning

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The paper examines the needs, premises and criteria for effective public participation in tactical forest planning. A method for participatory forest planning utilizing the techniques of preference analysis, professional expertise and heuristic optimization is introduced. The techniques do not cover the whole process of participatory planning, but are applied as a tool constituting the numerical core for decision support. The complexity of multi-resource management is addressed by hierarchical decision analysis which assesses the public values, preferences and decision criteria toward the planning situation. An optimal management plan is sought using heuristic optimization. The plan can further be improved through mutual negotiations, if necessary. The use of the approach is demonstrated with an illustrative example, its merits and challenges for participatory forest planning and decision making are discussed and a model for applying it in general forest planning context is depicted. By using the approach, valuable information can be obtained about public preferences and the effects of taking them into consideration on the choice of the combination of standwise treatment proposals for a forest area. Participatory forest planning calculations, carried out by the approach presented in the paper, can be utilized in conflict management and in developing compromises between competing interests.

Keywords conflict management, decision analysis, forest planning, heuristics, optimization, participative planning, public participation

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1 Introduction

The demand for public involvement evolved in the 1960's, mainly in Anglo-American countries as a counter-balancing force for representative democracy. Currently this ideology of participatory democracy has spread all over the so called western world. Citizens are demanding more control over decisions affecting their lives in almost all imaginable spheres of human interaction (Yankelovich 1991). Political and, to a greater extent, administrative decision makers, are losing their power for unilaterally making and implementing decisions. This can be evidenced among several professions, including foresters. The pendulum has swung from representative towards participatory democracy (Reich 1985).

Decision making in public forestry is political by definition; all decisions and actions that allocate benefits and costs among different interest groups are political regardless of whether they are made through a political process or not (Creighton 1985). Furthermore, as general opinion has grown more favorable toward less intensive and consumptive forms of forest use, many interest groups have gained legitimacy for their standing (Koch and Kennedy 1991). Accordingly, the unilateral use of power by authorities, who generally are non-elected, to make public forest decisions has become problematic. This can be evidenced through increased amount and intensity of forest conflicts.

The purpose of any planning process is to provide solid support for decision-making so that an acceptable or, ideally, the best possible decision can be made. In tactical forest planning, the planning horizon ranges generally from 5 to 20 years, the planning object is a forest area or a holding, and the primary calculation unit is a forest stand or a compartment. An end product of a tactical planning process is a forest management plan that presents a recommendation for an action plan of the forest area under review and predicts the probable consequences of implementing that plan. An action plan, in turn, consists of stand-specific treat-

ment proposals.

The goal in tactical forest planning is to formulate a plan that, once implemented, most probably results in the optimum realization of the objectives set for the planning object. In participatory forest planning there is no single decision-maker who determines these objectives. Instead, an heterogeneous public exists which perceives that their interests are at stake and therefore wants to ensure that their preferences are incorporated in the planning and decision making process.

Although defining the problem can be seen as a central part of the decision making process, it is not necessarily a part of the actual planning process. In terms of public forestry planning, the problem might be defined as accomplishing a legally and socially acceptable (i.e. locally weighted but nationally balanced) forest plan for the specified area, over a defined time period. Accordingly, the overall goal can be stated as maximizing the public utility of the forest area while taking the legal and administrative constraints into account.

In this study, an application of the decision analysis phase of the heuristic optimization method of Pukkala and Kangas (1993), called HERO, is developed for participative forest planning at tactical level. Before presenting the application and illustrating it by a case study, a context for the participatory planning approach is constructed. This general overview (1) defines public participation, (2) assesses the need for participation in natural resource decision making, (3) analyzes the current situation of participatory decision making in forest management, (4) defines the role of public participation in natural resource decision making, (5) examines the overall participation process and how specific elements fit into it, (6) reviews the criteria for effective public participation, and (7) evaluates the utility of some commonly applied participation methods and approaches. In the discussion, the introduced participatory method is evaluated against the criteria of effective public participation and its implications are discussed.

2 Public Participation in Natural Resource Management

2.1 Defining Public Participation

The term public participation, as used in this article, refers to direct institutional participation where the participation process is initiated either by public institutions (i.e. public agencies) or private industries. Other forms of participation include indirect institutional participation through parliamentary or corporate channels (e.g., parliamentary elections or labor union negotiations), and self-initiated direct participation, including societal civic movements and civil disobedience (Paldanius 1992).

The direct institutional participation which is scrutinized in this article is further defined as "the process by which public concerns, needs and values are incorporated into governmental decision making. Most often, public participation is two-way communication, with the overall goal of better decisions, supported by the public" (Creighton 1993). "The extent of public involvement lies along the continuum with public input – i.e. any information about the public and/or expression of preferences – at one end and participatory democracy at the other" (Knopp and Caldbeck 1990).

2.2 Demand for Participatory Decision Making in Natural Resource Management

The social values related to natural resources have differentiated and will continue to do so in the future (Bingham and DeLong 1990). The strong consensus for timber production which has traditionally dominated Finnish public forestry is disintegrating (Palo 1994). The use of public forests for recreational purposes is significantly increasing as general welfare and leisure time increases (Sievänen and Knopp 1992). At the same time, pressures for nature preservation

are growing due to perceived scarcity of suitable ecosystems, the number of endangered or threatened species using forests as their primary habitat and growing environmental awareness. Especially the national and urban forests will be targeted for such claims (Loikkanen 1994).

Decision making in public forestry has its own specialized features which differentiate it from other fields of public decision making. These include: broad variety of conflicting values or goals and objectives (i.e. utilities, both tangible and intangible), a great number of different stakeholders (i.e. interest groups) evolving constantly, large aerial surfaces with administrative rather than natural boundaries, long planning horizons, various optional treatments with long term effects and risk and uncertainty of outcomes and future prices of forest products. These features of natural resource decision making lead inevitably to conflict (Heberlein 1976). Furthermore, because "foresters do not merely manage physical stuff, but social values, and since many forest social values conflict with each other, foresters can be viewed as conflict managers" (Koch and Kennedy 1991). Accordingly, conflict management should be an integral part of natural resource decision making.

2.3 Who Should Participate in Public Forest Management?

The strong emphasis on expertise in developing more elaborate and comprehensive forest planning systems does not address the issue of democratic representativeness. As Wondolleck (1988) concludes: "experts alone are not able to represent the many interest at stake, no matter how systematic, how thorough or how objective they may try to be". This does not mean that public agencies should give up striving to accomplish effective management decisions. On the contra-

ry, it is in their best interest to ensure that the decisions made do not only meet the criteria for public acceptance, but in addition are the best possible (i.e. optimal) decisions under the circumstances.

A prerequisite for effective participation is that it should be based on the publics' perceived benefit or threat (Knopp and Caldbeck 1990). One should not require that only organized interest groups have a say in the participatory decision process. In order to ensure the representativeness of the process two other basic principles emerge in the literature. Namely, that (1) the publics should be self-defined (Landre and Knuth 1993), and (2) the publics' opinions and preferences should be actively sought for by the agency responsible for making the decision (Krimsky 1984). The latter requires applying less interactive methods to reach the passive segments of the affected publics. It is the organizing agency's responsibility to represent such voices in the process (Blahna and Yonts-Shephard 1989). Related to the former 'self definition' principle, it should be noted that the interested publics can evolve through the decision process (Creighton 1993). Accordingly, participation should be able to accommodate new parties throughout the process.

2.4 Function of Public Participation

The function of public participation in forest management is to ensure that the social values towards the use of public forests define the outcomes this resource base will be managed for (Kweit and Kweit 1987). However, traditionally public participation has been sharing information about decisions already made (i.e. informing) or, at best, promoting decisions. This has contributed to publics' growing suspicion towards decision makers and a growing amount of escalating conflicts (Wondolleck 1988).

Public participation functions as a means of educating the affected community of interests about the potential benefits of the proposed action, alternative courses of action, and their respective consequences (Burdge and Robertson 1990). Moreover, public participation has the potential for addressing the reconciliation of various conflicting resource uses (Knopp and Cald-

beck 1990). It is a preventive overall planning approach for managing conflicts before the situation gets out of control and negative impacts accrue to the stakeholders as well as to the community by large.

Direct conflict management is a complementary approach for public participation. It includes such alternative dispute resolution methods as mediation, arbitration, mediated arbitration or mini-trials. Common to all these methods is the central role of oral communication and a presence of a third party. The objective of these methods is to manage manifested conflict productively, while the objective of public participation is to proactively manage forest related conflicts to prevent them from escalating beyond what is necessary for their effective management.

2.5 Process of Public Participation

The direct institutional public participation – which is examined in this article – can utilize numerous different avenues and methods in affecting public debate, the operational environment of public agencies and their functioning (Paldanius 1992). It is useful to differentiate between the overall public participation process and the specific techniques or methods used in implementing that process (Creighton 1993).

It is also useful to make a distinction between the broad categories of information exchange and participation techniques (Creighton 1993). The former relates to the information necessary for both the agency (responsible for guiding the planning process) and the publics to make well informed and justified decisions. The latter refers to methods available to elicit one's own preferences, and to learn about other's preferences related to the planning situation.

In order to accomplish its function, public participation needs to be integrated to the overall planning process (Landre and Knuth 1993). This requires defining what the agency specifically wants to accomplish by involving the public and when would it best fit the planning process. These agency-oriented pre-participation activities can be divided into broad categories of "problem setting" and "direction setting" as opposed to the actual participation phase (Gray 1991).

The problem setting phase includes (1) analyzing the planning situation, (2) identifying tentatively the affected publics, (3) assessing the conflict situation, (4) defining the level of shared decision making authority between the agency and the publics (see Thomas 1993), and (5) gaining internal commitment for the participatory approach. All these issues require careful analysis and thorough consideration before the agency responsible for the planning process is ready to proceed either with autonomous managerial decision making or with some level of participatory planning.

In the case participatory planning approach is chosen, the next stage is to set the direction for the process. This includes defining goals and establishing objectives for the public participation program, as well as choosing the appropriate participation techniques and defining the necessary information exchange.

Public participation techniques can be examined according to various decision attributes. The most central ones include: level of shared decision making authority, level of interaction needed, inclusiveness (i.e. size and type of audience), credibility as perceived by the publics, familiarity of meeting format, requirements for implementation (skills, time, geographic limitations, costs) and orientation (competitive – collaborative) (Cogan 1992, Creighton 1993, Pruitt and Rubin 1986, Thomas 1993). The goal is to match a specific decision situation, the affected publics and the resources available with the most appropriate participation technique(s) in order to maximize the attainment of the goals and objectives set for the overall decision process.

2.6 Criteria for Effective Public Participation

Rational decision making implies that 1) the problem is identified, 2) goals and priorities are specified, 3) alternative means are evaluated, 4) decision criteria are adopted, and finally 5) a decision which maximizes the attainment of the goals is made (Kweit and Kweit 1987). The first four criteria for rational decision making are value based, and thus, should form the essence of any public participation approach.

The criteria for effective public participation of the decision making process should be set separately for the specific techniques and the overall participation process. According to Blahna and Yonts-Shephard (1989) the tactics that contribute to success in the overall planning process consist of: obtaining public input early in the planning process, involving the public throughout the planning process, obtaining representative input, using personal and interactive methods, and using input in the development and evaluation of alternatives.

Furthermore, when evaluating the effectiveness of either specific techniques or the overall process, it is useful to make a distinction between process and outcome oriented criteria (Young et al. 1993). The process criteria include (1) accessibility (i.e. openness of the process and access to relevant information) (2) fairness (in terms of procedural aspects), (3) understandability (e.g., accuracy and quality of information) and (4) empowerment (i.e. perception of the impact each party has on the decision) – as perceived by the publics (Parenteau 1988, Knopp and Caldbeck 1990, Young et al. 1993, Landre and Knuth 1993). In general, the acceptability of a decision depends on how the process is carried out; it makes a difference how a decision is reached (Lewicki and Litterer 1985). The outcome oriented criteria have to do with the effectiveness of the final decision. The effectiveness in turn, refers to the efficient utilization of all available resources, i.e. the solution maximizes the overall utility and is pareto-optimal.

According to Knopp and Caldbeck (1990) "participatory democracy exists, when individuals have a known and quantifiable effect (more than zero) on the decision". Furthermore, they suggest following four guidelines in the quest: (1) there should be little room for variation in meaning and manipulation; (2) tradeoff decisions among the perceived benefits of the various alternatives are made by the participants; (3) in order to arrive at a collective decision, individual preferences should be combined in a clear, easily understood manner, so that participants know how they have affected the outcome; and (4) the results must be utilized holistically. The three first criteria can also be applied to evaluate specific participation techniques.

Furthermore, Tanz and Howard (1991) suggest taking the following criteria into account when using computer models and technology in deci-

sion making: The applications should (1) be easy to understand by non-technical lay-persons; (2) represent the forest resource dynamics; (3) be transparent – both objectives and constraints should be easily formulated and modified; (4) generate trust in the participants in terms of how they can affect the solution; (5) be based on process that is simple and clear for all parties after small introduction; (6) be user-friendly; (7) be microcomputer-based (allows portability) and relatively fast to run; and (8) provide outputs in a form easily interpreted.

2.7 Deficiencies and Strengths of Some Currently Applied Participation Techniques and Processes

2.7.1 Public Hearings

Public participation that takes place in a hearing format is often reactive, because fundamental decisions have already been made and only marginal changes in policy are likely (Krimsky 1984). This need not be the case, if the planner truly seeks for the publics' opinions. But even then, the best the hearings can accomplish is a more or less representative array of well grounded arguments for or against already specified decision alternatives; not an integrative search for a collaborative solution.

2.7.2 Content Analysis

The content analysis method applied e.g. by the USDA Forest Service, Northern Region (1992), is an effective technique for approaching less vocal interest groups and the non-organized citizens. The input data via letters, phone calls, personal contacts can be organized in the system according to several criteria and printed out as documented summary reports for further review (USDA Forest Service 1993). The database-grounded system has value for gaining cross-sectional information on the affected publics and input on the planning situation as well as for providing an continuing access for the publics to express their concerns and preferences. The method is not particularly effective for reconciling

different values and preferences, since the real value decisions are left to the agency as a decision maker (Wondolleck 1988). Furthermore, information will necessarily be lost in the process (Blahna and Yonts-Shephard 1989).

2.7.3 Limits of Acceptable Change Planning Process

The Limits of Acceptable Change (LAC) process is an overall, strategic natural resource planning process originally developed for wilderness management. The planning process consists of nine interrelated steps leading to the development of a set of measurable objectives or indicators (i.e. operationalized criteria), and standards (i.e. norms) for these indicators that define desired (wilderness) resource and social conditions. It also specifies the management actions necessary to maintain those conditions. (Stankey et al. 1985).

The LAC process is only a conceptual process which requires specific planning methods and managerial field experience to be modified and applied in real-life situations (Stankey et al. 1985); it is not a planning method by itself. In addition, the LAC planning process can be applied both with or without public participation; the former is generally recommended (USDA Forest Service Northern Region 1992).

The LAC is not effective in finding efficient or optimal solutions for implementing decisions, nor does it produce accurate information on the benefits, costs and tradeoffs for refining the criteria or objectives set earlier in the process. The LAC process defines what is acceptable and for what goals the manager should strive; it does not define the most effective means (i.e. management activities) to accomplish this task nor how to maximize the net benefits for the publics involved. Besides, finding measurable indicators for essentially qualitative or subjective criteria is often problematic. Furthermore, the LAC has also been criticized for leading to only minimally acceptable management plans without incentives to improve the existing resource conditions (Krumpe and Stokes 1993). Despite these deficiencies, the LAC directs the overall planning process and provides useful information about the discrepancy between current and desirable resource conditions.

2.7.4 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a decision analysis method originally developed by Saaty (1977, 1980). It has been developed particularly for complex, multi-objective problems of choice. Both quantitative and qualitative decision criteria can be incorporated in the method, as is often the case with participatory forest planning. Kangas (1994) presented an application of the Analytic Hierarchy Process (AHP) for taking public preferences into account in choosing a management strategy for a forest area (see also Kangas 1992, Kangas and Matero 1993). The participants accommodate their preferences by structuring the decision criteria relevant for them in a hierarchical (utility) model, and further, by evaluating the importance of these criteria through pairwise comparisons. Finally the participants assess the priority of each decision alternative with respect to each decision criteria, or these priorities are assessed on grounds of objective information or expertise. Accordingly, the global (i.e. overall) priorities or values of the decision alternatives can be calculated.

The basic steps in applying the AHP to participatory planning consist of (1) determining the interest groups to participate in the decision making process (i.e. the ones with an importance weight more than zero); (2) constructing the decision hierarchy for each interest group; (3) assessing the weights for different interest groups; (4) estimating the utility models for each interest group; and (5) evaluating the alternative management strategies.

In the representative planning approach presented by Kangas (1994), a level of 'players' (i.e. participants) consisting of interest group representatives is located into the decision hierarchy immediately above the level of decision objectives. In the participatory planning approach participants could be thought to consist of the citizens perceiving they are affected by the forest plan (Kangas 1994). Through the AHP based approach, information can be obtained about public values and their effects on the choice of a management strategy as well as about opportunities to attain a resolution between conflicting interests.

Apparently, in forestry practice, the greatest advantage of the use of the AHP is the opportuni-

ty to prevent negative conflict escalation from occurring (Kangas 1994). The strategy is enhanced by providing a meaningful medium for developing compromises – if not collaborative solutions – between initially, seemingly competitive interests. The objective is achieved by pointing out areas of agreement, helping to isolate areas of conflict, and illustrating the tradeoffs involved between different options. Because of the hierarchical presentation of the decision situation and the ratio scale estimation technique applied in the model, the judgments made by various types of actors (i.e. agency, general public, interest groups and experts) can be integrated and applied at different parts of the decision schema. Public participation through the AHP in forest planning is most appropriate in determining the goals and objectives at quite a general level for the forest area to be managed, and their relative importance.

The main challenges of strategic forest management planning when applying the AHP in public participation include: (i) presenting the decision situation in the form of a simple and unobtrusive decision hierarchy, which depicts the decision situation accurately enough; (ii) overcoming the roughness of the scale used in the pairwise comparisons; (iii) keeping the comparison scale constant through the entire evaluation process (Kangas 1994); and overcoming the limitations concerning the number of decision alternatives. The standard form of the AHP is not feasible for tactical forest planning. For example, in the case of a forest area composed of 1000 forest stands with each stand having 10 alternative treatment programs, there would be 10 000 forest management plans for the participants to evaluate. This is simply too much; Saaty (1980) has recommended 10 as the maximum number of alternatives to be compared with each other. Furthermore, the AHP supposes that priorities of decision alternatives with respect to a decision objective do not depend on other objectives or alternatives.

Although the AHP cannot fulfill all the requirements for effective tactical forest planning, including those of routine and automation, some of its properties can be utilized in structuring the planning situation and in finding the optimal management alternative.

3 Planning Method

3.1 HERO Optimization Method with a Multi-Party Option

The objective of tactical forest planning is to find a treatment schedule for each forest stand, or compartment, in the forest area within the set time period that is optimal at the level of the whole area, with respect to the objectives set. In general, the planning proceeds according to two phases. First, several treatment schedules per compartment are produced through computer simulation over the selected planning period (e.g. Siitonen 1983, Pukkala 1993). The purpose of this simulation is to enable the prediction of the stand level dynamics and to compute the removal, cost, and income attributes under different treatment regimes. Secondly, an optimal combination of treatment schedules is sought through a specific technique of numerical optimization, such as mathematical programming or heuristics.

In this study, a heuristic optimization method called HERO developed by Pukkala and Kangas (1993) was applied. With HERO, the optimization step may be divided into two tasks: (1) estimation of the utility function, and (2) maximization of the utility function. The former task utilizes Saaty's (1977) ratio scale estimation technique.

Although HERO was originally developed for tactical forest planning in the case of a single decision maker, the approach can be applied as well with multiple decision makers; the HERO enables integration of public values and professional expertise into a comprehensive planning system. Focus in the decision analysis phase of the method is on the values and preferences of the publics in relation to the management objectives for the defined planning area. The applied technique elicits the benefits related to the resource as perceived by the involved publics and combines them into an overall utility function. The maximization phase of the HERO, in turn, converts these expressions of utility into an optimal management

plan consisting of specified, time-bound management actions. When applying the method to participatory forest planning, utility functions are estimated separately for each participant. The total utility function can then be calculated as a weighted sum of these utility functions containing each participant's assessed utilities.

The method is constructed on the premise of an additive utility function:

$$U = \sum_{i=1}^m a_i u_i(q_i) \quad (1)$$

where U is the utility, m is the number of objectives, a_i is the relative importance of objective i , u_i is the sub-priority function of objective i , and q_i is the quantity that the plan produces or consumes the objective variable i .

Objectives can be forest products and values, such as timber, amenities, biodiversity, or resources and inputs, such as costs and labour.

When combined with the multi-party decision making option, the overall utility function takes the following form:

$$U_{\text{tot}} = \sum_{j=1}^n w_j U_j \quad (2)$$

where U_{tot} is the total utility, w_j is the weight of participant j , U_j is the utility calculated by the utility function (Equation 1) of participant j , and n is the number of participants involved.

The relative importance of objectives in Equation (1) are computed using the eigenvalue method of ratio scale estimation (Saaty 1977). Objectives are compared by the participants in a pairwise manner using a graphical interface. The relative importance of the pairs of objectives to be evaluated are defined by adjusting the lengths of horizontal bars on the computer screen.

The comparisons are collected in an n -square reciprocal matrix of importance ratios of objectives, where n refers to the number of objectives.

The right eigenvector of the greatest eigenvalue of this matrix gives the relative importance of the objectives (Saaty 1980). These priorities are then taken as the coefficients a_i of the utility function.

The participants then estimate their sub-priority (i.e. partial utility) functions for each objective. The sub-priority function u_i of an objective describes the relative utility produced by different amounts of a product or resource. They are not necessarily linear. For example, decreasing marginal utility may be assumed: The more a scarce benefit is received (e.g. money), the less valuable each additional increment of that benefit becomes.

The sub-priority functions are estimated as follows: (1) the minimum and maximum value (i.e. the variation) of an objective are assessed by searching through all the possible treatment schedules of the forest compartments; (2) the range of variation is divided into a specified number of intervals of equal width; (3) the interval boundaries are then compared pairwise with respect to their sub-priorities. The computer interface applied in the comparisons is based on the adjustment of the lengths of horizontal bars on computer screen. The right eigenvector of the largest eigenvalue of the matrix composed of priority ratios gives the relative sub-priorities for the compared values. These sub-priorities are then scaled so that the highest utility gets a value equal to one. In the optimization phase the sub-priorities of the intermediate values of the utilities being compared are determined by linear interpolation.

The HERO can make use of a hierarchical presentation of the decision problem and, correspondingly, a hierarchical utility model. The overall goal (i.e. utility) of the decision problem is decomposed into decision objectives and their importances are determined in relation to each other (see Equation 1). An objective is decomposed into more detailed objectives or sub-criteria until the decision alternatives can be evaluated with respect to them. Then the importances of these detailed objectives, with respect to the objectives they refer to, are determined. Finally, the sub-priority functions are estimated for the objectives at the lowest level of the hierarchy.

Before initializing the optimization process, a treatment schedule is assessed randomly for each forest compartment. The values and the sub-priorities of the objectives, the separate utilities of

the participants and the overall, total utility are computed. After that, the heuristic optimization program considers, one compartment at a time, whether another treatment schedule would increase the total utility. This being the case, the current treatment schedule is replaced by the one that increases the total utility. After all the treatment schedules over all compartments are examined according to same criteria, the process is repeated. The program starts again the utility assessments from the first compartment and moves through all compartments until no schedules can be found that would increase the total utility.

For more details on the HERO techniques, readers are referred to Pukkala and Kangas (1993).

3.2 A Model for Applying the Participatory Approach in Forest Planning

The process of applying the participatory approach to tactical forest planning follows a seven step order as presented below. The ones responsible for accomplishing the various tasks are posted after each step in parenthesis. The agency responsible for the decision may or may not be involved in the process as an interest group. Furthermore, a skillful agency employee can function as a neutral process facilitator to substitute for the consultant.

Step 1. Defining the interest groups (agency together with a consultant and initially determined interest groups)

Step 2. Explaining how the decision making process will be carried out and gaining commitment for the approach; Modifying the process if necessary (the consultant and the agency)

Step 3. Building utility functions and finding the optimal solutions, in an iterative fashion, for each interest group separately (the consultant and the interest group representatives)

Step 4. Negotiating and agreeing upon the importance weights of the interest groups for the combined, overall utility function to be applied as a starting point in calculations and possible negotiations (the agency, the consultant and the interest group representatives)

* if no agreement is gained the weights are determined by the agency and the consultant

Step 5. Finding the optimal solution for the combined, overall utility function through HERO and calculating various production frontiers – i.e. tradeoffs between major objectives – and sensitivity analysis to be presented in step 6. (the consultant)

Step 6. Assessing how well each interest group's preferences and concerns are addressed by the optimal solution generated in step 5 (the consultant and the interest group representatives)

Does the solution meet the criteria set for it by each interest group?

* If yes, then the solution (i.e. management plan) will be accepted.

* If no, then negotiation (step 7) will be initiated.

Step 7. Negotiating a more acceptable solution; The modified management plan must be based on a consensus decision between all interest groups, agreed upon groundrules and defined time limits in order to substitute the original optimum solution generated in step 5 (a facilitator, the consultant, the agency and the interest group representatives)

Is an agreement achieved on a better solution?

* If yes, then it will replace the solution found in phase 5.

* If no: Can the parties agree on postponing the deadline?

* If yes: Reiterate step 7, i.e. continue the negotiation process.

* If no: The solution found in step 5 will prevail.

When negotiating for a better decision the following might be pursued: comparing the parties' utility functions; modifying the utility functions; running the optimization process; examining the tradeoff possibilities through sensitivity analysis and the feasibility of different objectives (e.g. biodiversity and total wood removal) and their combinations; and refining the parties' utility functions. The negotiations can be run either via integrative or competitive negotiation strategies. Because of the more or less continuous future relationship between the parties, pursuing collaboration is recommended (Lewicki and Litterer 1986).

4 An Example of the Use of the Method

4.1 Planning Area

An application of the participatory planning approach was carried out with forest inventory data from the Pitkäjärvi state forest managed by the Finnish Forest and Park Service (FPS). The area covers 1350 ha in North Karelia, eastern Finland. Scots pine is the dominant tree species with approximately 90 % of the total volume. The present stem volume in the whole area was calculated to be 98 500 m³ (73 m³/ha), consisting of different species as follows: pine (*Pinus sylvestris*) 90 100 m³ (91 %), spruce (*Picea abies*) 2700 m³ (3 %) broad-leaved species (mainly birch (*Betula pendula* and *Betula pubescens*)) 5700 m³ (6 %). The age distribution of the forest was two-peaked: there were many stands either younger than 60 years or older than 100 years, but notably less in between.

The Pitkäjärvi forest was first divided into 389 compartments. Then the FPS assessed each compartment in the field using ocular stand inventory techniques in which a few relascope plots are measured in every compartment. Before the actual planning phase, several treatment schedules per compartment were simulated over the 10-year planning horizon using the MONSU, a multi-resource forest planning program developed by Pukkala (1993). The purpose of the simulation phase was to predict wood removal and stand development characteristics under different treatment options. Approximately 1000 treatment schedules were created (i.e. combinations of possible treatment options).

The Pitkäjärvi forest and the inventory data exist, but the planning and decision processes, described below, are imaginary. Consequently, no details of negotiations are described. We decided to use an imaginary but still as realistic planning situation as possible for the case study in order to illustrate the computational and technical aspects of the proposed participatory planning approach.

4.2 Interest Groups

In the strategic planning stage, preceding the tactical planning stage described in this case study, the Pitkäjärvi forest had been allocated by the FPS for multi-resource use with an emphasis on timber production. Consequently, maximal sustainable timber yield in money terms was chosen to be the principal management objective in the tactical planning stage. However, as stated by the law, state forests in Finland should also provide employment and recreation opportunities for Finns, and be managed in an ecologically sound way.

Based on (1) the general duties stipulated by state forestry laws, (2) the specific objectives set for the Pitkäjärvi forest area, (3) a superficial social impact assessment, and (4) to keep the example simple but still realistic and useful for the convenience of the reader, three distinctive interest groups were defined to participate in the tactical planning process:

- 1 FPS
- 2 Nature preservationists
- 3 Local residents

4.3 Utility Functions and Optimal Plans for Participants

Each interest group selected objective variables to best reflect their aims (i.e. utilities). The importance of the objectives was determined on the basis of pairwise comparisons between them. For each objective, a partial sub-utility function was estimated from paired comparisons of different values between these objective variables as described in Chapter 3.

The utility function of the FPS was determined to be:

$$U_f = 0.1676u_{1f}(N) + 0.8323u_{2f}(V) \quad (3)$$

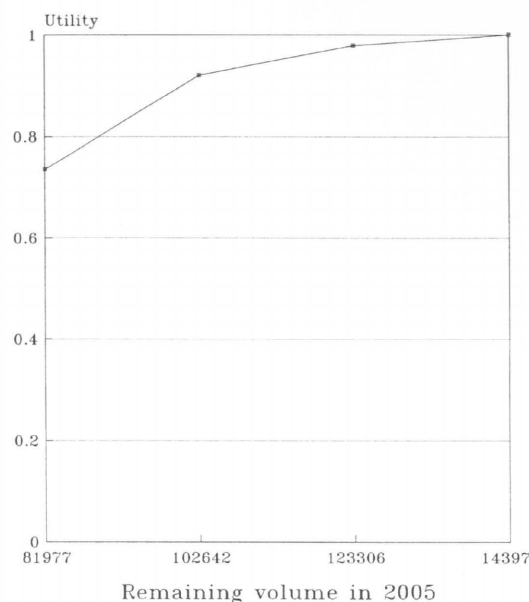


Fig. 1. An example of a sub-utility function. This function determines the dependence of the utility of the FPS on the remaining standing volume. The value 81 977 m³ is the lowest possible and 143 971 m³ the highest possible standing volume in 2005.

where N refers to the net income during the 10-year planning period (FIM), V refers to the remaining standing volume at the end of the period (m³), and u_{1f} and u_{2f} are their respective sub-utility functions.

Both sub-utility functions proved to be clearly concave, thus reflecting decreasing marginal utility (Fig. 1). Utility through net incomes increased rapidly up to 5 mill. FIM, which was the level of income defined as satisfactory by the agency for the Pitkäjärvi forest. A satisfactory level for the standing volume was considered to be 100 000 m³. Accordingly, the utility through volume increased rapidly up to 100 000 m³, and slowly thereafter.

Maximizing the FPS's utility function by the HERO-method resulted in a plan in which the remaining volume in 2005 equals 106 282 m³ and the net income during 1995–2004 planning horizon adds up to 5.57 mill. FIM (Table 1). This initial plan was clearly acceptable for the FPS, and they did not conceive of having to modify their utility function.

The utility function estimated by the nature preservationists included only one objective, namely, the biodiversity defined by the biodiversity index variable (BD) at the end of the planning period:

$$U_c = u_{1c}(BD) \quad (4)$$

The utility through biodiversity was chosen to depend linearly on the biodiversity index. In the planning program the biodiversity index was computed with the following formula (Kangas and Pukkala 1996):

$$BD = a_1p_1(B) + a_2p_2(D) + a_3p_3(O) \quad (5)$$

where B is the total volume of broad-leaved tree species (m³), D the total volume of dead and decaying wood (m³) and O the total surface area (ha) of old growth forests (i.e. compartments defined in the process to be older than 80–120 years, depending on tree species). Biodiversity depends on these variables as determined by functions p_1 , p_2 and p_3 . Parameters a_1 , a_2 and a_3 define the weights of the broadleaf volume, the volume of decaying wood and the area of old growth forests, respectively.

The function for BD was estimated by an ecologist, specifically for this particular forest area and planning situation. The values of parameters a_1 , a_2 and a_3 were set 0.1898, 0.4912 and 0.3189, respectively, which means that decaying wood volume was regarded the most important component of biodiversity and the volume of broad-leaf trees the least important one. All second-order functions (p_1 , p_2 and p_3) were very concave. Accordingly, each indicator increased biodiversity rapidly with low values, but the marginal increase sharply decreased. The age limits for "old growth forests" were determined separately for the main tree species.

Maximizing utility function (4) produced a plan in which the biodiversity index attained its maximum possible value (0.3) in 2005. In this plan, no cuttings were proposed for old stands or stands which would have attained their respective age limits of old growth forest within 10 years. However, many regeneration cuttings were proposed for pure conifer stands not achieving the age limit of old growth forest. This was because regenerative cuttings enhance broadleaf coppicing, as well as, germination and growth of seedlings of broad-

leaved species. In this way regenerative cuttings increased the value of the biodiversity index through enhancing the volume of hardwoods.

After studying the results, it was acknowledged that this plan was clearly not the optimal one for the nature preservationists, because the area of old growth forest and biodiversity may achieve their maximum values by year 2005 and not improve thereafter. The improvement of biodiversity after 2005 could be ensured by initially aiming at a higher overall standing volume for 2005. Therefore, a second utility function was estimated for the nature preservationists:

$$U_c = 0.8302u_{1c}(BD) + 0.1698u_{2c}(V) \quad (6)$$

where (BD) stands for the biodiversity index and (V) stands for the remaining total volume.

Maximization of this utility function yielded a plan in which the cutting area was almost nil (Table 1). This plan was considered to be satisfactory by the nature preservationists. So, the utility function of preservationists was estimated through interaction and iteration.

The local inhabitants selected four objective variables for their utility function:

$$U_p = 0.4250u_{1p}(H) + 0.1550u_{2p}(V) + 0.2951u_{3p}(BY) + 0.1248u_{4p}(RS) \quad (7)$$

where H is the total harvested volume during 1995–2004 (m³), BY is the estimated mean annual berry

yield in 2005 (kg/ha) and RS represents the mean recreation score of all stands in 2005.

Harvest removal (H) is an indicator of local employment possibilities, and it was assumed that utility is directly proportional to the harvested timber volume. Remaining volume (V) is a good estimate concerning the cutting possibilities after this 10-year planning period. The sub-utility function estimated for the local inhabitants on the remaining volume indicated decreasing marginal utility. The berry yield models (Pukkala 1993) estimate the quantities of common forest berries produced. The recreation score (Pukkala et al. 1988) measures the suitability of forest compartments (based on their characteristics) for recreational activities, such as hiking and picnicking, which are additional ways to utilize the forest by the local people. Utilities through berry yield and recreation score were assumed to depend linearly on the respective variables.

The plan that maximized utility function (5) proposed a removal of 56 310 m³ (Table 1). By implementing the plan the standing volume would decrease from the present 98 574 m³ to 82 102 m³. Berry yield would decrease from the present 16.2 kg/ha to 16.1 kg/ha and the recreation score from 5.2 to 4.7 (on a scale ranging from 0 to 10). Even though the forecasted values of three objectives (out of four) showed slight decrease, the plan was accepted, because it satisfied very well the principal objective.

Table 1. Values of objective variables and optimal cutting areas in alternative forest plans.

Variable	FPS	Optimum for Conserv.	People	Overall optimum	Unit
Net income	5.57	-0.009	8.37	5.57	mill. FIM
Removal	34959	0	56310	37198	m ³
Remaining volume	106282	143799	82102	103136	m ³
Broadleaf volume	8890	9326	7032	7750	m ³
Deadwood volume	734	1072	643	823	m ³
Old forest	118	252	60	196	ha
Biodiversity index	0.24	0.30	0.10	0.26	–
Berry yield	16.5	16.9	16.1	17.2	kg/ha
Recreational value	5.1	5.8	4.7	5.3	–
Areas of treatments					
– clear felling	138	0	261	72	ha
– thinning	5	3	249	248	ha

4.4 Weights of Participants

The FPS evaluated the weights that should be given to each group when making the final decision. Paired comparisons were applied as an evaluation technique to assess each group's weight in combining the overall utility function. This overall utility was then maximized through the HERO technique to find the optimum solution for the groups. The pairwise comparisons resulted in the following joint utility function:

$$U = 0.5389 U_f + 0.1669 U_c + 0.2942 U_p \quad (8)$$

where U is the total utility, and U_f , U_c , U_p utilities computed from the utility function of the FPS, nature preservationists and local people, respectively.

4.5 Overall Optimum

Once the weights and the utility functions of the interest groups were agreed upon, the total utility function, amenable to numerical maximization, was formulated as:

$$U = 0.5389 [0.1676u_{1f}(N) + 0.8323u_{2f}(V)] + 0.1669 [0.8302u_{1c}(BD) + 0.1698u_{2c}(V)] + 0.2942 [0.4250u_{1p}(H) + 0.1550u_{2p}(V)] + 0.2951u_{3p}(BY) + 0.1248u_{4p}(R) \quad (9)$$

The plan that maximized this overall utility function (9) consisted of approximately 103 000 m³ of the remaining volume and 5.58 mill. FIM of net incomes (Table 1). This plan accommodated well the goals set by the FPS. The recreation score would improve from 5.2 (in 1995) to 5.3 (in 2005), berry yield from 16.2 to 17.2 kg/ha and the biodiversity index from 0.22 to 0.26. The plan based on this overall utility function (U) filled the objective variable requirements set by the FPS for its own utility function (U_f). And, as a matter of fact, the values of these variables were almost equal after maximizing both utility functions.

However, there was one clear difference in the plans maximizing U and U_f . Namely, in the plan maximizing the joint utility function the area of clear fellings was much smaller and the area of thinnings much larger than in the plan based on maximizing the FPS's own utility function (Ta-

ble 1). This means that the participation of the nature preservationists and the local people resulted in a significant shift from clear fellings to thinnings in the forest management scheme. Because the interests of the nature preservationists and the local inhabitants contradicted not only with each other, but also internally, their net effect on the objective variables of the FPS remained negligible.

4.6 Sensitivity Analysis

Mapping the production possibility boundaries between some of the most interesting objective variables (Figs. 2 and 3) and sensitivity analysis (Figs. 4 and 5) were carried out to provide additional information for the potential negotiations between the interest groups (see steps 5 through 7 in section 3.2). Production possibility boundaries provide information about the tradeoffs between objectives. When computing the production possibility boundaries for two objectives, these variables were selected as the sole objectives. The importance ratio between the objectives was changed gradually, and the optimum

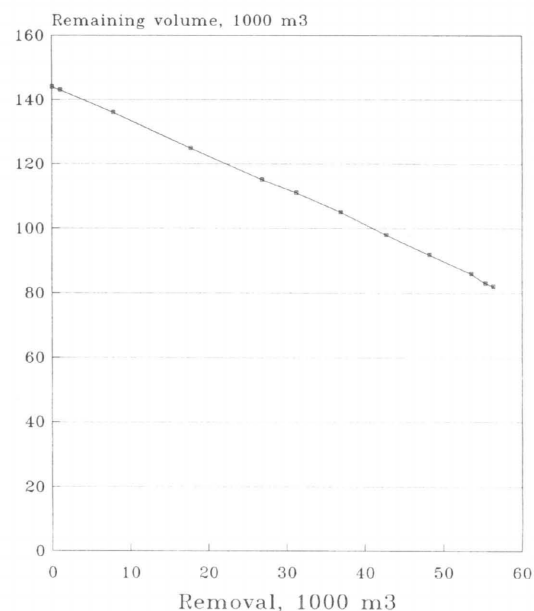


Fig. 2. Production frontier between harvested and remaining volume.

sought after every change. The optimal values of the objective variables in different solutions are separate points in the production possibility boundary.

The relationship between harvested volume and remaining volume was almost linear, with one harvested cubic meter decreasing the remaining volume by almost one cubic meter (Fig. 2). The tradeoff curve between harvest and biodiversity index was totally different (Fig. 3): 40 000 m³ could be harvested without any notable change in the biodiversity index in 2005. Most probably the wood extraction would consist of thinnings and regenerative cuttings in such conifer stands which are not achieving the age limit defined for old growth. Moreover, in these pine and spruce dominated forests mortality would play only a minimal role in the forest dynamics over the planning horizon. Based on the tradeoff curve between wood removal and biodiversity, the nature preservationists could be recommended to aim at a removal level lower than 40 000 m³. Below this level the biodiversity index remained at a quite high and relatively constant level, and thus the preservationists could be more indifferent about such lower level removals.

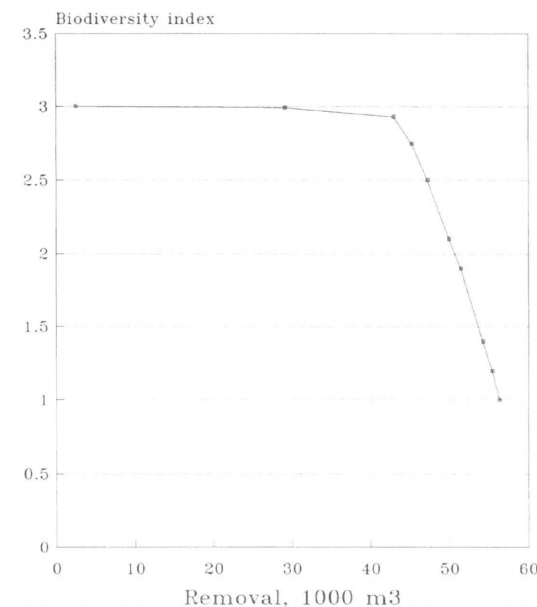


Fig. 3. Production frontier between harvested volume and biodiversity index in 2005.

The sensitivity of the objective variables to the change in weights between the interest groups (Fig. 4) was analyzed by modifying the joint objective function and solving the problem after every change. When changing the weight of a given interest group the ratio of the weights of the other groups was kept constant. In addition, the sum of the weights always equalled one. Furthermore, besides the objective variables, the sensitivity of the utility indices of interest groups against the changes in their weights were analyzed (Fig. 5).

Changing the weight of the FPS had only a minimal effect on respective objective variables or utility index (Figs. 4a and 5a). This means that the other parties can be granted more decision making authority when negotiating the overall utility function weights on the condition that their relative weights do not change. Increasing the weight of nature preservationists from the original 0.166 did not increase the remaining volume or biodiversity index immediately; the weight should have been at least 0.4 for any change in objective variables or utility index to occur (Figs. 4b and 5b). For local people, the range of their weight which had the greatest effect laid from 0.4–0.7 (Figs. 4c and 5c). Consequently, below 0.4 or above 0.7 the local people could remain indifferent.

The sensitivity analyses revealed that the optimal plan was not very sensitive to the changes in the interest group weights in this case. This was due to the fact that the interest groups had contradicting objectives. Accordingly, the sensitivity analyses can be used to identify such situations where additional negotiations might prove unnecessary. This is the case when changes in the weights do not affect the optimal forest management plan. These situations were surprisingly common in our case study. However, differences within interest groups were not studied.

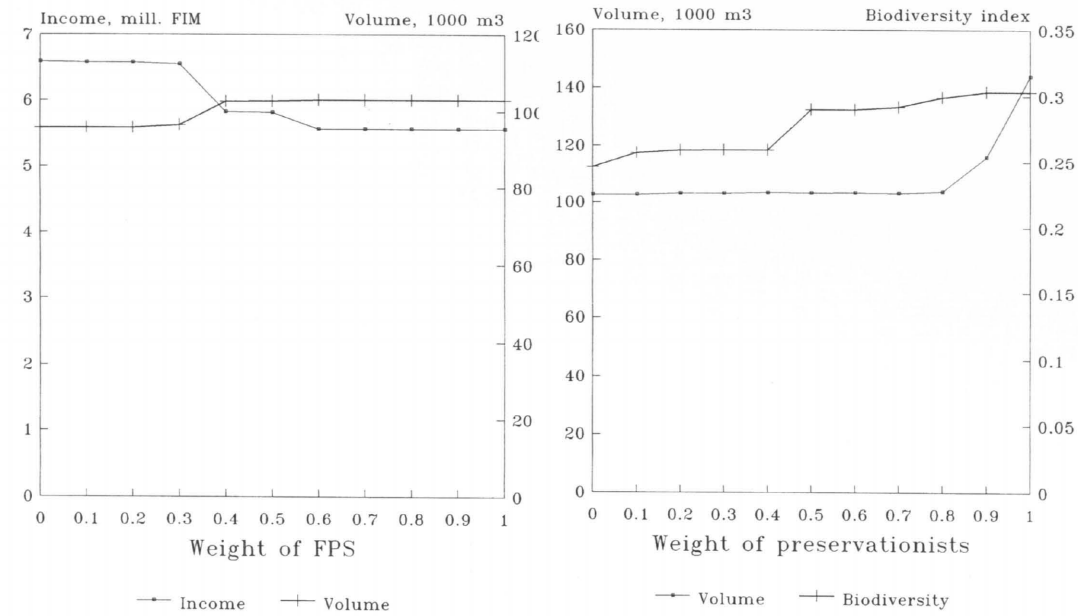


Fig. 4. Effect of the change of the weight of the interest group on the objective variables of the group.

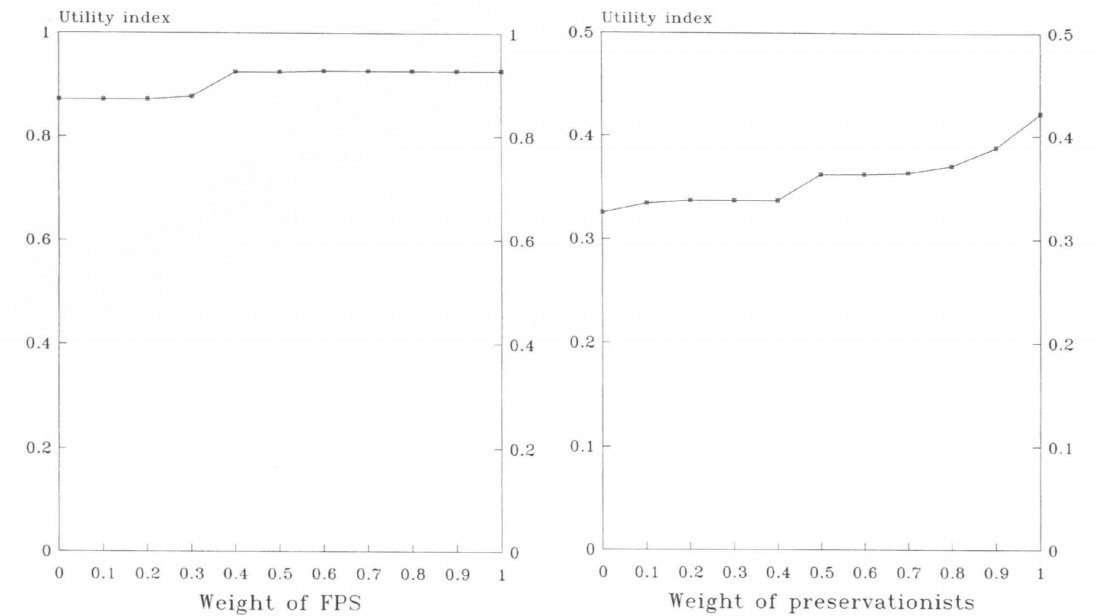
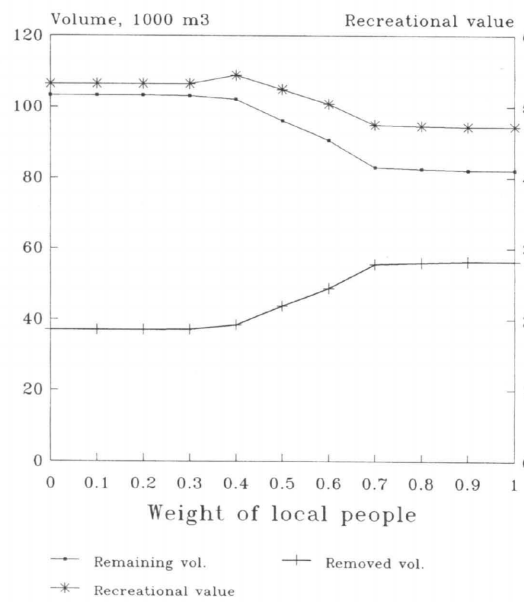
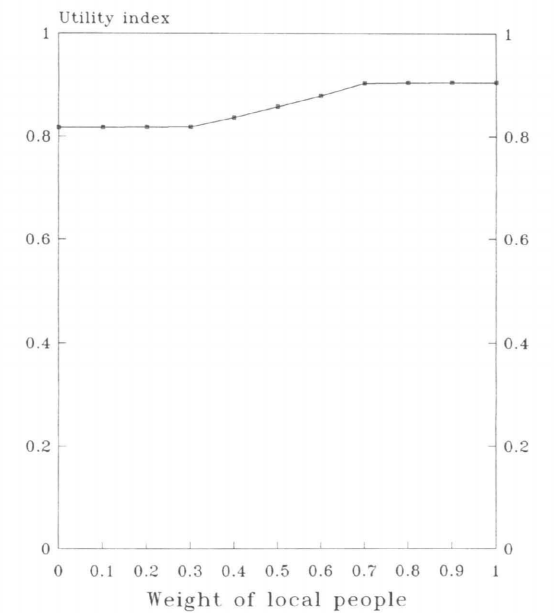


Fig. 5. Effect of the change of the weight of the interest group on the utility index of the group.



5 Discussion

The techniques of preference analysis, professional expertise and heuristic optimization, as applied in the method presented in this study, make it possible to extend public participation from ideals, general policies and vague discussions to the forestry practice; to tactical forest planning and the choice of operational practices. It helps to evaluate alternative forest plans from the viewpoints of participants involved in the planning process. By using the method, support can be obtained both to the choice of production programmes at forest area level and to the decisions concerning treatment schedules in individual forest stands.

The method serves as a numerical core of the participatory approach. It does not solve all the problems related to public participation and conflict management. To be able to utilize the method, a more general context of participatory planning is needed as a framework for application. For example, the method takes no stand on the choice of the participants or on the weighting of them. The numerical method presented in this study serves as a technical facilitator, which enlightens the complex decision situation both to the decision makers and to the participants, and helps to understand the existing tradeoffs as well as competing interests. As any computational method applied to forest planning, it does not produce ready decisions; it only can provide decision support.

Application of the tactical planning method presented in this paper satisfies the precondition of participatory democracy that the participants have a known and quantifiable effect on the decision. The effects of the participants on plans and decisions can be efficiently analysed and illustrated by using the method. This being the case, the method generates trust in the participants in terms of how they can affect the solution in the process of public participation.

The application of HERO as a part of a participatory planning process helps to meet the criteria

for effective public participation set by Knopp and Caldbeck (1990) for participatory democracy. Besides the method being illustrative and unambiguous, there is a minimal room for variation in meaning and manipulation, tradeoff decisions among the perceived benefits of the various alternatives are made, and individual preferences can be combined in order to arrive at a collective decision or a recommendation for a decision. Nevertheless, the presented as well as any method, do not totally eliminate the possibility of manipulation. The potential for achieving the criterion that the results must be utilized holistically also exists, but its realization rests on the agency's willingness to do so.

The interactive phase of the tactical planning approach offers participants the potential for iteratively refining and adjusting their utility functions. The use of simple and easily comprehensible sensitivity analysis and production function graphics helps the parties to thoroughly consider tradeoffs between the criteria in order to further reassess and rejustify their priorities. Accordingly, the participants can add or remove criteria or change priorities in their utility functions to more accurately reflect their values, interests and preferences. In addition, it is possible to add new parties to the process if the time schedule for the overall planning process allows it. The method always produces a solution, no matter how many participants or criteria are involved.

The fairness of the tactical planning approach depends on how well it is carried out. Certainly the opportunity exists for effective collaboration through communicating clear expectations, providing adequate resources for the parties and following mutually agreed ground rules. It is very easy to demonstrate how much impact each party has on the overall decision. This can be accomplished by comparing the results obtained through the optimization process while a party's importance weight is modified in the overall utility func-

tion in relation to the weights of the other parties.

The approach is an effective conflict management tool. By using the approach, compromises between competing interests can be developed by pointing out areas of disagreement, helping to isolate the areas of conflict, and illustrating the tradeoffs involved between different options and objectives.

The tactical planning approach examined assists a decision maker in solving complex problems involving many criteria and several courses of action. One of the major advantages of the planning approach is that it enables the decision maker to organize effectively complexity by visually structuring it, so that one need not to consider elements in isolation. The decision analysis phase of the approach enables the participants to identify, group and evaluate factors in relation to each other, thereby transcending their cognitive limitations and thus amplifying their problem solving capabilities. The grouping option – which consists of dividing criteria further into subcriteria and comparing then these groups with each other – helps to organize and effectively manage issues with large number of criteria. This is of vital importance when dealing with inherently complex natural resource issues.

Moreover, the HERO accommodates the expression of judgments about aspects of a problem for which no scale measurements exists; it is as feasible to apply purely subjective criteria as it is to apply objective ones without having to subordinate the former ones to the latter ones. These judgments can be done through purely verbal, meaningful comparisons, by adjusting graphic bars (as in the case study), or giving numerical, real number figures – which ever is most convenient for the user. However, quantification of qualitative criteria should be made by the variables the planning package applied allows. In this study, HERO was integrated with the planning package MONSU (Pukkala 1993). Other software could be used, if desired.

In relation to the complexity issue, the decision analysis phase of the method accepts small inconsistencies between the subjective assessments, as often is the case in reality between human cognitions and attitudes. The calculated inconsistency ratio depicts how consistent the evaluations have been and functions as a control device for alerting

the parties to check against major judgmental mistakes. The major 'drawback' is that people are forced to work through their dissonant cognitions, which might prove mentally painful.

Moreover, the approach provides good documentation which can be used to overcome barriers of differentiated opinions on the problem between negotiators and their constituencies. The documentation also establishes a rationale for the decision and this rationale can be utilized for backing up the management plan or it can serve as the starting point for defining similar problem situations later on.

Our planning approach establishes a forum for discussion in a shared decision making process. It permits the full range of considerations to be taken into account succinctly and comprehensively. Discussion of the various aspects of a planning situation is facilitated and the expertise of participants will be recognized and utilized. It is the participants who provide the real value judgments in the decision making process.

The approach can be applied with a variety of parties involved over the whole continuum of shared decision making authority between the agency and its publics, from autonomous managerial to public decisions (see Thomas 1993). The importance weights of different interest groups can be agreed upon jointly or decided by the agency. The weights can also be assessed according to some mutually agreed criteria. In the case, where the agency has formulated its own utility function as one of the involved parties, the weights might be initially agreed upon, stated clearly and kept constant over the decision making process to prevent agency manipulation.

The importance weights communicate directly to what extent the corresponding parties influence the management plan. In the case each party has equal weight, the planning phase can be seen as fully democratic, with the final decision making authority being granted commensurately for each party involved. On the other hand, the agency can reserve the right to modify these weights for the advantage of those under-represented or in order to take into account the legal or administrative constraints (e.g., its legally mandated employment obligations). In any case, roles and expectations should be clarified in the beginning of the participation process.

The decision analysis phase of the HERO can be implemented in a more or less interactive mode depending on the assessment of the potential for integrative negotiation, i.e. how well the parties get along with each other (see Lewicki and Litterer 1985), and the objectives set for the overall participation process (Creighton 1993). It should be noted that the approach alleviates the problem of dominance by stronger participants: attention is focused on the problems instead of letting the meeting drift from topic to topic.

The utility functions can be formulated either separately between the agency or a neutral third party and each interest group, or all together in a large meeting format. A generic hierarchical utility model could be used as a basis for refinement and modification for all the participating groups, or each group could build its own utility function with the help of a process facilitator. Expert information can be applied when jointly determining criteria or sub-priority functions with the public for their overall utility functions and for defining appropriate management actions and criteria. The evaluation (i.e. the pairwise comparisons) between the different levels of criteria are then done separately by each interest group or they are defined through some form of group decision making (e.g. consensus process or voting).

The tactical planning approach can be applied for running all the phases of rational decision making. Other participatory methods than the decision phase of the HERO might be applied to implement at the phase of limiting the planning area and setting the time horizon for the forest

management plan, since the method does not particularly facilitate this phase of the process. In addition, some other, highly interactive participatory method, e.g., the nominal group process, might be utilized to complement step (3) of the approach. In other words, the acceptable means or management practices might be defined before they are utilized in the heuristic optimization process in finding the best alternative management plan.

The planning approach – like other decision models – can be criticized on semantic basis, i.e. to what extent are the meanings which participants attach on similarly labeled criteria different from each other. This is a real concern for all less interactive public participation activities, which do not provide opportunities for sharing one's views and assumptions. On the other hand, the issue will be partially addressed by reserving sufficient time for the decision analysis phase. The likelihood of semantic differences can be essentially reduced with the help of a substantively knowledgeable process facilitator, who ensures that the participants will thoroughly and iteratively structure their utility functions until the hierarchically arranged criteria and sub-criteria cannot be decomposed into smaller meaningful elements. Moreover, the semantic difference problem can be further minimized by arranging opportunities for mutual learning, i.e. occasions where participants jointly discuss interests, issues, and criteria that are relevant to them, as well as explain the meanings they attach to these criteria, prior to initiating the actual planning approach.

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