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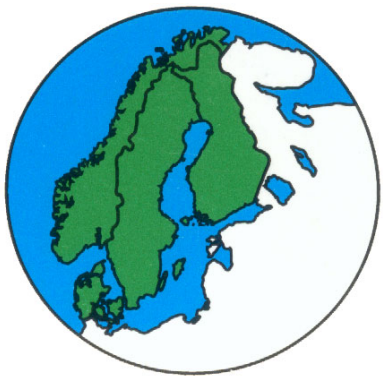

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Effect of information content on the choice among alternative forest plans

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Abstract
Multi-criteria decision support (MCDS) tools assist the decision-maker (DM) in selecting an appropriate forest plan among specified alternatives. The selection of appropriate criteria to compare the alternatives is related to the scales of planning and the availability of appropriate inventory data. Anyhow, the criteria should reflect the DM's objectives and address the production possibilities of the forestry unit at hand. The objectives of this study is to determine if DMs are able to identify/construct similar preferences for the forest with varying levels of information regarding the plans, and to determine if the identified preferences result in the selection of the same forest plan. A group of forest sciences students were chosen as testees. A representative sized forest tract from a forest managed by Metsähallitus was used as a case "holding" providing semi-authentic data. The MESTA internet application was used to guide participants into selecting a single forest plan, depending on the criteria presented to the participant. Results of a systematic experiment showed that approximately half of the participants selected the same forest plan in two out of three different decision scenarios. This result suggests one carefully pre-defined default set of criteria, but it also calls for further study.

Keywords: decision criteria, decision support, forest planning, multi-criteria decision support (MCDS).

1. Introduction

Contemporary research into multi-objective decision making has focused on developing methods and tools which allow for a comparison between alternatives. The comparison between alternatives focuses on relevant criteria which are (or are expected to be) important to the decision-maker (DM). The selection of criteria can be done with guidance from the planning coordinator (Diaz-Balteiro and Romero, 2004; Gómez et al., 2006; Eyvindson et al., 2010a) or independent selection from a list (cf. Kazana et al., 2003; Kajanus et al., 2004).

When the DM selects criteria, the decision should be based on his/her preferences. For individuals with poorly formed preferences the most appropriate grouping of criteria may evolve as his/her preferences develop. As a result, the initial criteria selected may not correspond to his/her preferences near the end of the decision process (Beshears et al., 2008). In participatory planning situations the determination of relevant criteria to be analysed can be a source of conflict (Mendoza and Martins, 2006). Depending upon the decision support tool, stakeholders may be required to analyse and evaluate the different plans based on the criteria selected for the group as a whole, or the stakeholders may select their criteria independently and then combine the evaluations of the plans (Kangas et al., 2008; Nordström et al., 2009).

While it may appear self-evident that careful consideration of the criteria being evaluated is a requirement for the appropriate use of MCDS tools, this may not necessarily be the case. In the context of determining what benefits the DM wishes to extract from the forest, the DM's preferences may be inconsistent, circular or not be very well defined. This can be further complicated due to the complexity involved in forestry decisions (Diaz-Balteiro and Romero, 2007), and the complications involved with the process of defining preferences (Beshears et al., 2008). In addition to these issues, there is also the availability of appropriate inventory data which can limit the feasible options for criteria-based analysis. The costs associated with obtaining data for a specific criterion may be prohibitive and may not provide much additional assistance in the decision making (Kangas, 2010). For these reasons, appropriate substitute criteria might be more suitable in the analysis than the criteria participants select for themselves.

Being able to accurately represent the preferences of the DMs is a requirement of effective and truly supportive utilization of decision support tools. The criteria chosen for use in the analysis might influence how the DM identifies and reveals his/her preferences. Therefore, the objectives of this study are to determine if decision-makers are able to select similar forest plans with varying levels of information regarding the plans, and to determine if there are differences in how DMs utilize decision support tools.

2. Decision experiment

Materials

A forest tract of 53.5 ha from Juupajoki, Finland was used to represent a privately owned forest holding. The forest area is part of a larger holding which is managed by Metsähallitus and used for research and teaching purposes. The majority of the forest stands in the representative holding were between 20-60 years old, and had a total volume of 11,800 m^3 of wood.

The composition of species is mainly a mix of Scots Pine and Norway Spruce, and only a small component of broadleaved trees. In the past 30 years, few management actions have taken place in the forest (figures 1 and 2).

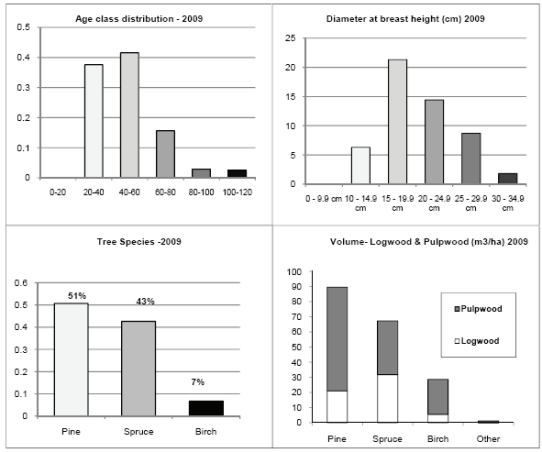

Figure 1. Basic Forest Inventory values for the year 2009.

Figure 2. Aerial image of the forest holding (Aerial image courtesy of National Land Survey of Finland)

A total of eight different forest plans were created using forest management planning system MELA (Redsven et al., 2007). The focus of the plans ranged from restraining final cuttings and only conducting young stand treatments which promoted good forestry practices (Metsätalouden kehittämiskeskus Tapio, 2006) to conducting harvestings 25% greater than the sustainable level. By utilizing such a wide range of alternative forest plans, it was hoped that at least one of the plans would be appealing to a wide variety of decision-makers.

The experiment was conducted in two phases (figure 3); the first phase was a questionnaire designed to sort the participants into potential ownership categories with respect to ownership's objectives (see Favada et al., 2009). Three different methods of sorting into ownership groups were used. The first asked the respondent to self-identify which group he/she belonged to, based on a brief narrative description (Multi-objective, Investor, Self-employed or Recreationalist). The second method was given as an Analytical Hierarchy Process (AHP) question, where the different ownership groups were compared to each other, and asked which group they more closely identified with, and on a Saaty (1980) scale of 1-9 asked the strength of perception. In the third method, the respondent answered a series of questions related to the objectives of ownership, which had been used in

an earlier study which analyzed the Finnish private forest owners (appendix 2 in Karppinen et al., 2002).

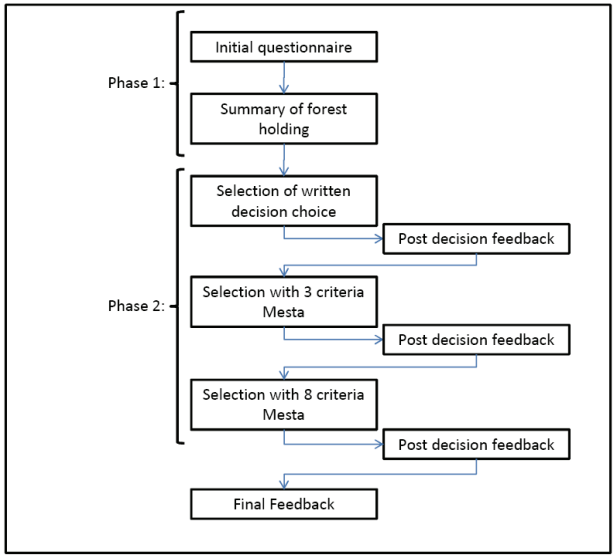

Figure 3. Flow chart of the experiment

Once the participants had completed the questionnaire they were provided with a briefing on the size, species composition and inventory of the forest to ease them to think of themselves as the owners of the holding. An alternative method would have been to provide the participants information about the forest holding prior to asking them to complete the questionnaire. The magnitude of the influence could be tested for, by conducting a test for comparison. However, the test would not illustrate which method is closer to the 'real' preference of the individual. So while this might influence how they answer the questions, it could be assumed that this source of uncertainty would be rather negligible.

The second phase was a series of three decision experiment scenarios using different levels of information regarding the plans. The same plans were used in each scenario, and the order of the plans was randomized for each scenario. With the first scenario only a brief written description (table 1) was provided. The brief description was based on the objective function

formulation used in the forest planning software and the actual criterion values of the plans were not told to DMs. The next two scenarios used the internet based program MESTA (Hiltunen et al., 2009) with either three or eight criteria used in the analysis. From the written descriptions the respondents were to select the most preferred plan. MESTA required the participants to study the expected outcomes of the alternatives with respect to each criterion, to adjust acceptance thresholds and finally come up with the selected plan through holistic multi-criteria approval.

Table1. Brief description of the forest plans.

Plan A	Only conduct the minimum cutting needed to promote good forestry practices. Additional cutting (thinning) is carried out only to offset the costs of tending the forest.
Plan B	The only cuttings to be carried out are thinning harvestings; no regeneration cuttings are carried out. In the second 5 year period, the harvest is 50% more than in the first period.
Plan C	A high level of sustainable harvesting (70% of maximum) is conducted over the ten year period. Forest work is maximized during the period.
Plan D	Approximately half of the sustainable level of harvesting is conducted. No cuttings are conducted in broadleaved stands. The treatment objectives are to maximize the growth increment in broadleaved stands.
Plan E	While maintaining a sustainable level of harvesting, maximize the logwood removal during the 10 yr period, while keeping the amount of forest work equal throughout the time periods.
Plan F	Minimize regeneration cuttings, while ensuring a 25% income from what is possible for conducting sustainable harvesting.
Plan G	Harvesting is done at a sustainable level during the 10 year period. The second five year period has 50% more cuttings than the first period.
Plan H	Harvesting is done at a level of 25% greater than the long term sustainable level. At the end of the 10 year period, cutting levels could be returned to a sustainable level.

The criteria set used in the analysis were predetermined. The three criteria scenario had three alternative sets of criteria (criteria 1, 2, and 4; 3, 4 and 6; or 3, 6, and 8), while the eight criteria scenario had a constant set of criteria (all of the 9 criteria except 3) for all participants (figure 4). The criteria used in the experiment were:

1. Net income (in euros) - for the first five year period. Total income received from harvesting operations, less costs related to tending the forest.
2. Net income (in euros) - for the second five year period. Total income received from harvesting operations, less costs related to tending the forest.
3. Net income (in euros) - for the first and second periods combined. Total income received from harvesting operations, less costs related to tending the forest.
4. Regeneration cutting area (in hectares) - the total area of regeneration cutting (clear cutting) during the 10 year period.
5. Total wood volume at the end of the 10 year period in 2019 (in m^3) - includes pulp and saw logs. Can be thought of as total future cutting opportunities.
6. Mature forest area at the end of the 10 year period in 2019 (in hectares) - area of economically mature forests (over 80 years old). This increase can mean improvements to recreational activities and to the forest landscape.
7. Volume of broadleaved trees at the end of the 10 year period in 2019 (in m^3) – The existence of broadleaved trees can add beauty to the forest landscape.
8. Forest work throughout the 10 year period (days/year) – This is a measure of the amount of forest work is required from the forest owners during every year of the plan.
9. Net Present Value at a 4% discount rate (in euros) – This is the sum of cash flow (incoming and outgoing) over time, discounted at a constant rate.

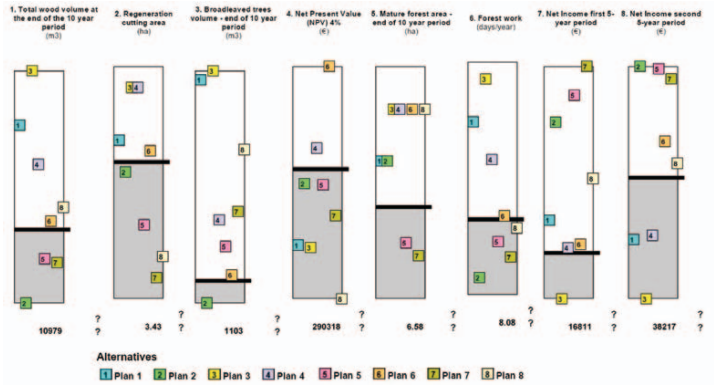

Figure 4. An example of the 8 criteria Mesta interface.

3. Results

The experiment was conducted with a total of 18 participants. Due to an error in the use of Mesta, the complete outcome data from the experiment were collected from only 9 of the participants. This error was limited to the final 2 choice scenarios, and prevents a comprehensive evaluation of the result of the decision-makers to make the same decision based on a variety of available information. However, the feedback concerning all the alternative scenarios was acquired and is valid.

Of the participants fifteen were male and three were female. Eight of the students were studying forest resources and technology, 7 were studying forest ecology, 2 were studying forest economics and one did not provide an answer. The majority (14) of participants identified themselves as multi-objective forest owners, two considered themselves to be self-employed owners, and the remaining were evenly spread on the alternative options. From the AHP question, all of the participants (with the exception of one) identified themselves in the same manner as they did in the self-identification question. Two thirds of the participants had parents who were forest owners, and a little over two thirds of the participants had done forest work when they were young. From the more detailed questionnaire it was difficult to associate any of the key questions to a particular ownership group. With more responses it is anticipated that a factor analysis should provide additional insight.

Immediately after each decision choice scenario the participants completed a short questionnaire (using a Likert scale of 1-7). The questions asked them how difficult the procedure was, and how confident they were

that they had made the correct decision. At the end of final decision choice scenario, the participants were asked which method they preferred and why. Out of all three decision experiments 13 preferred selecting the forest plan with the brief written description, 5 preferred the 8 criteria Mesta tool, and no one preferred the 3 criteria Mesta tool.

From those nine participants where all data were successfully collected, five (A, B, C, E, and I) were able to come to a similar plan with two out of the three methods used (table 2). The remaining four had selected different plans with each of the decision tests. One of those four participants indicated that he was very confident with the decision selected with both the written description and the 8 criteria Mesta program; however he did not select the same plan using the methods. Another participant who was initially confident with his choice from the written description became much less sure when conducting the experiment with the 8 criteria Mesta scenario. The participant commented that even though he was less confident with the decision made with the 8 criteria Mesta scenario, he preferred it because he had begun to realize the complexities regarding forest planning.

Table 2. Participants' choice of plan for each decision scenario.

	Written description	3 criteria Mesta	8 criteria Mesta
Participant I	D	C	D
Participant II	F	D	F
Participant III	D	D	F
Participant IV	E	B,C	D,A,F
Participant V	F	B,C,D	F
Participant VI	A	G,E	C
Participant VII	A	F	B
Participant VIII	A	B,H	B
Participant IX	F	F	D

4. Discussion

While it is difficult to conclude much with a confidence from the small dataset available, there are some interesting aspects worthy of discussion. Slightly more than half of the participants were able to the same plans in two of the three decision scenarios, in the third decision scenario the selected plan was quite similar to the plan selected in the other two scenarios. This could indicate that those participants had initially clear preferences and were able to match them with both quantitatively and qualitatively expressed forest plan alternatives. The remaining participants may not have clearly understood the tasks, their preferences were not clear

before numerical description of the decision alternatives, or that their preferences may have evolved during the completion of the tasks. This indicates the essence of level of previous knowledge and experience in selecting an appropriate DSS procedure. With less experienced owners, this result suggests using several approaches to facilitate learning and increasing consistency, while with more experienced owners the approach of their own choice could be selected without an effect of the outcome (in the latter case however, levels of satisfaction or confidence may alter based on the procedure even if the actual choice wouldn't).

Using students rather than actual forest owners may have, to some degree, affected the responses. The students involved in the process may not have been genuinely interested in outcomes of the forest plans and the actual planning process, as real forest owners would and they might not have identified their preferences correctly prior to considering alternative forest plans. When considering a specific forest plan, real forest owners could be expected to utilize a greater level of intensity, as both their next decade's income and surrounding ecosystem may be altered as a result of the choices they make in managing their forest property. However, the level of intensity dedicated when making a decision does not indicate if the decision is correct or incorrect (Gigerenzer and Brighton, 2009).

Most of the participants preferred selecting the plans using the written description. This could be due to a preference of making decisions in a familiar way. However, the written descriptions did not include any information on the quantities of the outcomes, e.g. cutting incomes etc. This means that these DMs were willing to accept whatever outcome that is based only on the properties of the forest – their own income needs did not affect the decision. This could indicate that the forest property was not so important for them. On the other hand, deciding upon a course of action based only on numbers can seem unnatural to some decision-makers. For these participants, it may be more beneficial to have a carefully crafted description of the plans, from which they can choose rather than using a decision support tool they do not understand. For those individuals who chose Mesta as the preferred method, all of them selected 8 criteria Mesta as the preferred method. Part of the reason for this could be due to the order of the scenarios, where the first time the participants used the Mesta program was with the 3 criteria Mesta scenario. Learning how to use the tool may have influenced the perception of its usefulness. Alternatively, those people who chosen the Mesta tool could have preferred the 8 criteria version because of its more 'comprehensive' nature. By using different sets of 3-criteria it was hoped that this might have some influence on the decision chosen, however, with the limited data available it is impossible to speculate if there is any effect of using the different set of 3 criteria on the decision chosen.

An interesting facet of this experiment is that a slight majority of participants were able to roughly select similar plans even with through different decision scenarios. This could indicate that careful consideration of criteria prior to analysis need not be too detailed. If this is truly the case, a predetermined set of criteria which provides a fairly balanced representation of the forest resources would be a reasonable alternative to a negotiated set of criteria. In this way, the costs of inventorying and data analysis could be minimized. In addition the time taken in negotiation of appropriate criteria could be better spent during the final stages of negotiations.

Variations on this decision experiment could identify different ways individuals prefer to make decisions. Rather than comparing written plans to the numerical methods, the comparison could have focused either on only written plans or only numerical methods. Focusing on only numerical methods, it would be possible to determine if more criteria variables would be preferred to fewer criteria variables. In the present research, the data suggest a link towards preferring more criteria variables; however, that is only for those participants who prefer numerical methods over written methods. With the limited data available it is impossible to speculate if there is any effect of using the different set of 3 criteria on the decision chosen.

5. Conclusion

Developing a decision support tool which is acceptable and useful to both the decision-maker and the consultant is a difficult task (Belton and Hodgkin, 1999). The DM may not have previously made long-term decisions, or decisions with a wide variety of possible alternatives (Beshears et al., 2008). As a result, the DM may prefer written descriptions which provide a general outline of what the plan encompasses. This could indicate a difference between rule based decision making for the written descriptions and a utility maximizing behaviour for the Mesta decision choices (March, 1994). On the other hand, the aim of the consultant is to provide a specific plan, which strives to achieve the goals of the DM. In order to achieve this goal, the consultant must either guess at the DMs preferences, substitute his/her own goals for the DM, or use decision support tools to help define the DMs preferences. Mesta is one tool which can be used to extract a set of preferences from the range of feasible alternatives.

In order to comprehensively address the questions posed earlier, the decision experiment needs to be tested on more participants. With the limited data currently available, it is difficult to determine in detail how the changes in decision criteria influence the final plan selection. The present results suggest that for a portion of DMs the criteria set does matter, and warrants motivation for further study. With a larger data set, it should be possible to analyse changes which occur by moving from a 3 criteria decision problem to an 8 criteria decision problem.

Further research is required to determine if decision support tools assist the DMs in selecting plans which are closer to their identified preferences. For this experiment, participants were not allowed the opportunity to independently select their own decision criteria. For those participants who have a well defined preference structure regarding the use of the forest, allowing them the opportunity to select their own criteria might provide a more accurate list of preferences. In a jointly owned forest holding, the decision support tools may be better suited in deriving preference information from the DMs, and then used in generating potential alternative forest plans (Eyvindson et al., 2010b), which the owners can review in a more detailed manner.

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