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ANALYSIS

Incorporating stakeholder values into regional forest planning: a value function approach

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Abstract

Forest management involves multiple objectives, multiple stakeholders, complex socio-ecological and political interactions. Public involvement in forest decision making is a challenging task that involves controversies. Various participatory tools such as public consultation forums, public comment processes, opinion polls are used to consult and to obtain inputs from communities. All these methods can provide useful information but they fail to quantify the trade-offs systematically and offer little help in minimizing conflicts. The Australian Regional Forest Agreement (RFA) program was implemented in response to the decades of conflicts and debate between various stakeholder groups and government over the use and management of forest resources. So far, it has not been able to minimize conflicts in the forestry sector, partly due to its poor incorporation and integration of stakeholder values. This paper uses the value functions approach in modelling stakeholder values in regional forest planning. The results of the study indicate that this method can help to incorporate value preferences effectively into the decision making process. It can also increase the transparency and credibility of the forest planning exercises such as RFA process.

Keywords: Forest attributes; Regional forest planning; Stakeholder values; Value functions approach

1. Introduction

The importance of incorporating public input into forest planning exercises is a well-accepted notion (Buchy and Hoverman, 2000). Involving the public in forest management decisions leads to resolving conflicts, greater public commitment and reduced distrust between the government agencies and various stakeholders (Tanz and Howard, 1991). While the rationale for seeking public input is clear, an increase in public dissatisfaction has been evident in many forest policy programs (Kerley and Starr, 2000; Germain et al., 2001).

The value-based information provided by the public helps planning agencies determine what the participating public wants. Public input, gathered through traditional consultation mode, is difficult to manage and respond to, in comparison to

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technical information. The existing evidence suggests that despite growing consensus on greater public participation in environmental policy, there is a lack of tested methods to incorporate stakeholder values explicitly in decision making (Curtain, 2000; Harrison and Qureshi, 2000; Gregory, 2000).

Public consultation programs, public comment processes, public hearings and opinion polls are used widely to provide useful information but they fail to quantify the trade-offs systematically (Steelman and Ascher, 1997). Knopp and Caldbeck (1990) used participatory democracy method and Shindler et al. (1993) used opinion surveys to measure respondents' level of agreement or disagreement with forest policy. Kurttila et al. (2000) used Analytic Hierarchy Process to improve the quantitative basis of strategic forest planning. Satterfield et al. (2000) tested a Narrative valuation technique while Russell et al. (2001) conducted a comparative experiment using multi-attribute utility survey methods and willingness-to-pay technique in a multi-dimensional valuation of a forest ecosystem. Martin et al. (2000) analyzed stakeholder objectives of national forest management using multi-attribute value theory (MAVT). This paper utilises a value function approach based on the MAVT to solicit and analyze stakeholder values in regional forest planning in North East Victoria, Australia.

2. Methodology

The MAVT is a useful framework for decision analysis with multiple objectives (von Winterfeldt and Edwards, 1986). MAVT is firmly grounded in von Neumann and Morgenstern's utility theory and assumes an existence of a value function, based on utility maximisation. One advantage of the methodology is its ability to quantify public preferences in non-monetary terms. The approach involves constructing value functions, which allow an analytical study of preferences and value judgements. Value assessment involves choosing the decision attributes, defining attribute value scales and checking for their qualitative properties such as monotonicity, linearity, concavity and single-peakedness.

Decomposed scaling and holistic scaling are the most widely used assessment strategies (Beinat, 1997). In decomposed scaling, the marginal value functions and weights are assessed separately. The overall value model is built by combining these two parts through an appropriate combination—either additive or multiplicative. The simplest and most commonly used form of a value function is the additive representation. Holistic scaling is based on the overall judgements of multi-attribute profiles. Weights and value functions are estimated through optimal fitting techniques such as regression analysis or linear optimisation. Decomposed scaling holds a definite edge over holistic scaling with respect to simplicity of estimation and accuracy.

Decomposed scaling is often used to evaluate decision alternatives using multi-attribute value models. Decomposed scaling involves checking attributes for independence, estimating value functions for each attribute separately, assessing scaling constants or weighting factors and specifying a multi-attribute value function as weighted additive (or multiplicative) combination of individual attribute value functions (Beinat, 1997). Under the mutual preferential independence assumption, preferences over alternative levels of any subset of attributes do not depend on the levels of all other attributes. When mutual preferential independence prevails, attributes x_1, x_2 and x_3 can be incorporated into a value function in the following additive form (Keeney and Raiffa, 1976):

$$v(x_1,\ x_2,\ x_3) = \sum_{j=1}^{n} \lambda_j v_j(x_j) \tag{1}$$

where (a)v_j (worst x_j) = 0, v_j (best x_j) = 1, $j = 1, 2,\ldots n$; (b) $0 < \lambda_j < 1$, $j = 1, 2,\ldots n$; (c) $\Sigma_{j=1}^{n} \lambda_j = 1$.

$v(x_1, x_2, x_3)$ represents the multi-attribute value function of x_1, x_2 and x_3, x_j denotes generic notation for each attribute, $v_j(x_j)$ represents value functions for each attribute and λ_j represents the weighting factors.

Verification of mutual preferential independence is a pre-requisite for multi-attribute value elicitation studies. However, questions for checking preferential independence are too complex for lay respondents (Kwak et al., 2001). Most of the published work on MAVT and multi-attribute utility theory deal with case studies or a few selected respondents for whom the exhaustive checks on the necessary independence conditions were feasible (Keeney, 1992). However, this study deals with a relatively large sample of respondents. Furthermore, it was felt that the respondents lack the patience for a lengthy interrogation necessary for full testing of the assumptions. Hence, mutual preference independence is assumed, which allows the use of the additive form (Keeney and Raiffa, 1976).

2.1. Assessing value functions

Value elicitation is complex and requires simplification of tasks to allow minimum cognitive demands. Attributes chosen for assessment and their value scales must be clear to the respondents. Gregory et al. (1993) provide some guidelines about the choice of attributes. Russell et al. (2001) suggest that chosen attributes must be orthogonal in design, the number of attributes should be small and should be described in simple words and the attributes should be ecologically meaningful.

2.1.1. Mid-value splitting technique

The mid-value splitting or bisection method (Keeney and Raiffa, 1976; von Winterfeldt and Edwards, 1986) is a widely used decomposed scaling technique. In this method, the respondent is asked to choose two extreme values from a value scale of the attribute. Put simply, the respondents identify and record their most- and least-preferred levels of each forest attribute. The respondent is then asked to choose the value that is half-way ($x_{0.5}$) between the most- and least-preferred levels of the attribute. Theoretically, this gives the mid-point value x, such that moving from the worst attribute level to x would have the same satisfaction as moving from x to the best attribute level. This requires posing specially designed elicitation questions. After assessing the $x_{0.5}$, the procedure may be continued to seek the levels $x_{0.75}$ and $x_{0.25}$, which are the mid-values of intervals ($x_{1.0}$, $x_{0.5}$) and ($x_{0.5}$, x_0).

Once the mid-value of the attribute is established, a functional form should be selected by drawing a smooth curve that passes through the elicited points. For example, if the preferences for attributes are assumed to have decreasing returns, then an exponential form is adopted. Put it differently, when moving from the worst level to the best level of the attribute, the initial move is worth more than the subsequent move. If the value function displays increasing returns to scale, subsequent movements toward the preferred endpoint will be valued more than the initial movements from the worst level (Martin et al., 2000). The exponential form was felt to be the most appropriate form for this study. The exponential attribute function is given as:

$$v_j(x_j) = a + b\mathrm{e}^{cx} \qquad (2)$$

where $v_j(x_j)$ is the single-attribute value function for the attribute x and a, b and c are coefficients. This approach is particularly appealing when the assessment is supported by graphical software and the curve shape can be modified interactively in real time (Beinat, 1997).

2.1.2. Scaling constants

Scaling constants or weights can be estimated using several techniques. Swing weights, direct rating and pairwise comparisons come under the numerical assessment category while the trade-off method comes under the indifference judgement category (see Beinat, 1997 for a detailed classification). In the direct rating method, the respondent simply assesses the importance of each attribute by implicitly considering their ranges. First, the attributes are ranked according to their importance. The ranking questions can take the form: 'If it is possible for you to have any one of those attributes changed from the middle level to your most-preferred level, which would you most want to have changed?' And then the numerical rating is carried out. In the ratio version, the respondent attaches a unit weight to a reference (or most-preferred) attribute. The elicitation question can take the form: 'How much more important are the attributes lower in the list, relative to those higher up?' The first choice is assigned a score of 100 and relative to that, scores are assigned to the other attributes down the list. These scores do not have to add up to anything in particular. This will provide the weights for attributes.

3. Empirical application

This study focuses on the North East Victoria (NEV) Regional Forest Agreement (RFA) region. NEV covers over 2.3 million hectares. Public land comprises about 1.2 million hectares or 54% of the area. State forests cover approximately 700, 400 ha or 30% of the total land in the region. One of the contentious issues in forest management in the region is logging in native forests[2]. Native forests provide habitats for endangered species such as Long-footed Potoroo (*Potorous longipes*), Spot-tailed Quoll (*Dasyurus maculatas*) and Squirrel Glider (*Petaurus norfolcensis*). One important aspect of the evaluation was to quantify key forestry trade-offs of the study area. This required identifying the key stakeholders, their objectives (attributes) and their values. Another purpose was to choose the best forest land-use option, which represents the values of the key stakeholders.

3.1. Decision context

Many forest policy decisions made in Australia have been a source of controversy due to competing demands of industry and conservation goals (Coakes, 1998; Lane, 1999). The Lake Pedder controversy (Kellow, 1989), Victorian Alpine National Park's Act (McKercher, 1998), Kakadu National Park controversy and the implementation of Ramsar Convention (Doyle, 1999) are some of the prominent examples. Under the Australian Constitution, the responsibility for the management of forests is vested with the State and Territory governments. In 1992, the Commonwealth and State/Territory level governments signed a National Forest Policy Statement (NFPS), which outlines the national objectives and policies for future forest management (Tasmania subsequently became a signatory to NFPS in 1995). The NFPS also established that the Commonwealth and State governments enter into RFAs.

The RFA programme is an outcome of several decades of conflict over the use of Australia's forests (Dargavel, 1998; Kanowski, 1997). RFAs are an attempt to resolve disputes over forest resources and provide some future certainty to all stakeholders (Lane, 1999). It involves the formulation of agreements between the Commonwealth and State governments for the future management of specific forest areas taking into account economic opportunities, conservation and heritage values and social impacts of various strategies (Coakes, 1998).

The RFAs will be in place for 20 years with 5-yearly reviews carried out, providing certainty for industry, conservation and needs of local communities. It has the following three objectives:

a) To protect environmental values in a Comprehensive, Adequate and Representative reserve system based on nationally agreed criteria (commonly referred to as JANIS criteria, which specify the preservation targets for each identified forest ecosystem);
b) To encourage job creation and growth in forest-based industries, including wood products, tourism and minerals; and
c) To manage all native forest in an ecologically sustainable way (Commonwealth of Australia, 1998a).

The RFA process commenced with the signing of scoping agreements followed by a Comprehensive Regional Assessment (CRA) for each RFA region. Each State has been divided into various RFA regions, each having a separate agreement. Up to now, 10 RFAs have been signed throughout Australia. These RFA regions belong to the States of Victoria, NSW, Western Australia and Tasmania.

[2] For instance, the land-use pattern of the Wongungarra reserve, an area known for its wilderness and biodiversity values was widely debated—whether logging should occur or it should be declared as a reserve. Subsequently, the Wongungarra area was declared as a reserve during the RFA negotiations.

There are several criticisms to RFAs. Broad scale tree clearing occur despite the RFA process (Sherwin, 2000). Issues of property rights, compensation, accountability and the level of legislative and policy backing to the RFAs (Forsyth, 1998; Bartlett, 1999) are other major issues. Lane (1999) concluded that RFAs have not succeeded in resolving conflicts over forestry but have successfully managed forest politics.

Tension and disagreements prevail with regard to management outcomes in several Victorian RFA regions (Bartlett, 1999; Lane, 1999). Several protests have been put up by environmental groups to disrupt logging activities in Gippsland. Different views exist among stakeholders on hardwood industry, which solely depends on native forests. Conservationists advocate that softwood industry based on plantations should eventually replace the hardwood industry. Attempts to grow native timber plantations on commercial scale have made little success in Victoria due to climatic problems and longer maturing processes.

Inclusion of public input and preferences in the RFA process has been identified as an important means towards minimizing conflicts and achieve sustainable forest use. Public involvement in RFAs was mainly through a 'consultation programme', and a 'social assessment' which included a variety of methods including public hearings, meetings and workshops, public comment opportunities on draft reports and mail and telephone surveys etc. Social assessment was a part of the CRA, which was carried out to predict the future effects of policy decisions upon the community (Commonwealth of Australia, 1998b). However, the extent and mechanisms of public involvement in the RFA process have been criticized by several commentators (Kirkpatrick, 1998; Lane, 1999; Dargavel et al., 2000). The public involvement in the RFA process ranged from merely providing information to consultation (Buchy et al., 1999). In several States, the public consultation process suffered some drawbacks as some stakeholders advanced their interests more effectively through the political process and that community support is clearly needed if the RFAs are to endure (Dargavel et al., 2000).

3.2. The objective hierarchy

An objective hierarchy was constructed to enable the decision makers to develop deeper insights into the problem. In this study, discussions with several key stakeholders, foresters and officials of the Department of Natural Resources and Environment (DNRE) were held to understand the nature of the decision problem and to identify objectives. Numerous RFA reports on the study region too were referred to make initial inroads into the decision environment. Based on the above efforts, an objective hierarchy was constructed to reflect the decision process and to obtain a deeper and more accurate understanding of the decision context. Ecologically sustainable forest management (ESFM) was chosen as the fundamental objective. ESFM is a key element of the current forest policy and it underpins the objectives articulated in the NFPS (Commonwealth of Australia, 1998a).

3.3. Selection of attributes

Forest management involves numerous objectives as they provide a wide range of economic, ecological and social benefits. The Social Assessment Report (Commonwealth of Australia, 1998b) identified economic values, social and cultural values, historic values, aesthetic values, environment values, recreation values and educational values for NEV. Fig. 1 illustrates a comprehensive list of attributes organised as an objective hierarchy for the North East RFA region. Selecting all attributes (illustrated in Fig. 1) for the present study was not feasible due to a number of factors. The value functions approach cannot accommodate a large number of attributes as it increases the respondents' cognitive burdens considerably. The respondents vary in their skills and hence there was a need to select a set of attributes, which is small and easily understood to obtain meaningful responses. Only three attributes were chosen namely, old-growth forest conservation, hardwood timber production and recreation intensity, representing ecological, economic and social objectives, respectively. Each attribute chosen is a rough representation of other attributes identified within

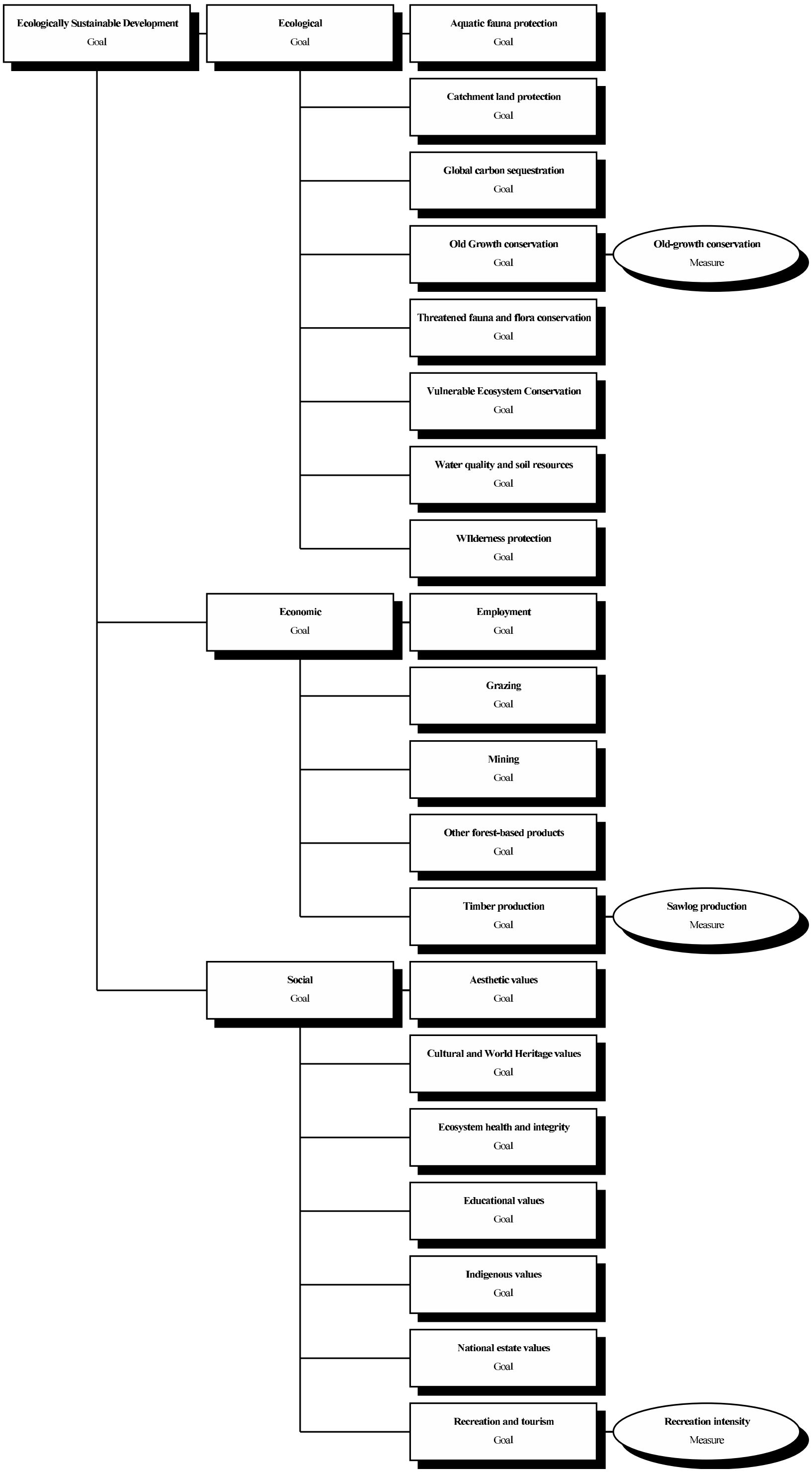

Fig. 1. An objective hierarchy to assess forest plans.

a major goal category. For example, old-growth forest conservation has links to catchment land protection, carbon sequestration, threatened fauna and flora conservation, vulnerable ecosystem conservation, water quality and soil protection and wilderness protection. Out of these attributes, old-growth conservation is assumed to be the best indicator attribute in terms of expressing preferences because it can capture bulk of the other values associated with attributes under the ecological goal. Sawlog production represents the main resource exhaustive economic activity in the forest. Recreation inextricably is linked with aesthetic values, educational values and national estate values. Moreover, these attributes were chosen after several discussions with stakeholders and forest officials of the DNRE. The three attributes were found to be monotonic in the natural scales.

Natural value scales were developed for each attribute. (The scales and their unit of measurements are summarised in Table 1). The implicit assumption is that the respondent understands the value scale and the consequences of choosing various levels on the value scale. Natural value scales mitigates the anchoring problem (Tversky and Kahneman, 1981) to some extent. The volume of hardwood extracted each year was taken as the measure for the timber production attribute. The NEV forest region produces about 64 275 m^3 of hardwood sawlog (Commonwealth of Australia, 1998a). This level of production is comparable with the maximum sustainable yield rate of the NEV forest region. The DNRE in accordance with the Forests Act 1958 periodically announces the maximum sustainable yield rates to which the timber industry has to comply. Theoretically, available sawlog (hardwood) volume could range from zero to a multiple of the current extraction level if conservation reserves are also included. However, the upper limit was set to 74 000 m^3, a realistic figure after consulting the Forest Managers of DNRE.

The NEV provides a range of recreation opportunities including the natural attractions of the high country, lakes and rural landscapes. Forested public land in the North East provides the basis for a diverse range of recreational activities such as picnicking, camping, bush-walking and wineries. Total recreational intensity, measured by recreational visitor days (RVD) per annum for the NEV region was around 1.2 million in 1996/1997 (Commonwealth of Australia, 1998a). The recreation attribute range considered was 0–1.6 million RVDs.

Old-growth forests are an important habitat for many types of plants and animal life. Woodgate et al. (1994) defined old-growth forests as forests, which contain significant amount of old-growth in the upper stratum and are negligibly disturbed. Two hundred and sixty one thousand hectares or 21% of public land has been identified as old-growth forest in the NEV region (Commonwealth of Australia, 1998a). Majority of the old-growth forest (242 000 ha) identified in the NEV region is within six Ecological Vegetation Classes: Grassy Dry Forest; Healthy Dry Forest; Herb-rich Foothill Forest; Montane Dry Woodland; Shrubby Dry Forest; and Sub-alpine Woodland. At present, 60% of old-growth forest is being reserved (Commonwealth of Australia, 1998a). The range for old-growth conservation was 0–100%.

3.4. Forest management options

Management options or strategies are the available actions that achieve some or all of the objectives of the decision problem. In theory, one can conceive of innumerable policy options but in

Table 1
Attributes ranges and measurements

Attributes	Description	Units	Range
x_1 = Timber production	Production of hardwood sawlogs per year	m^3	0–74 000
x_2 = Recreation	Recreational intensity per year	Recreation visitor days	0–1.6 million
x_3 = Old-growth forests	Conservation of old-growth forest	%	0–100

practice they are often represented as discrete choices due to various restrictions, which includes the difficulties faced by the respondents to evaluate a large number of options. Three hypothetical forest management options were considered for evaluation in this study. Table 2 presents the forest management options and attribute levels of each option. The hypothetical forest management options were constructed by taking the 'status-quo' as a base. Several discussions were held with officials of the forest service and various forest management reports were reviewed in developing the alternatives. The attribute levels described in Option B—the base case corresponds to the NEV RFA outcome. This option has an annual extraction of 64 000 m^3 of hardwood timber, recreational intensity of 1.2 million RVDs and 60% old-growth conservation level. The attributes mentioned earlier were assigned various values over the three management options. Precise technical information published or unpublished on the impact of timber production on recreational intensity was not available. It is assumed that more timber production will create more recreation opportunities. The general view is that with expanding timber extraction, more forest access roads would be established, creating more recreation opportunities. This assumption was verified with two forest consultants and a parks planner. Timber production was adjusted upwards and downwards by approximately 15% of the current level (by 10 000 m^3) to create attribute levels for Options A and C, respectively (Table 2). Old-growth conservation levels were set to change by 20% from the base case (Option B). The recreational intensity levels were set to vary from 0.4 m RVDs increments (decrements) from the base case, across the options. The decision problem was to choose the best forest management plan for the region using the above mentioned attributes.

3.5. Stakeholders

Grimble and Wellard (1997) define the term stakeholder as 'any group of people, organised or unorganised, who share a common interest or stake in a particular issue or system'. Selection of representative stakeholder groups within the community is a difficult task. A broad range of stakeholder groups is involved in forestry. Often it is possible to identify many groups, which are affected by the decision problem or have some interest in the problem. However, a large number of stakeholder groups make the elicitation exercise unworkable (Harrison and Qureshi, 2000). Most MAVT studies have used small samples. For example, Keeney et al. (1990) used 23 respondents in a study analyzing public values for complex policy decisions. In a study examining wilderness preservation benefits, McDaniels and Roessler (1998) elicited preferences from 28 respondents. Martin et al. (2000) ranked forest management alternatives using preferences from three stakeholders. For the present study, a total of 36 respondents from five major stakeholder groups, namely timber industry (10), environmentalists (10), farmers (6), recreationists (8) and tour operators (2) were chosen. For each respondent three different value functions had to be estimated, totaling more than 100 functions. An increase in sample size would increase the burden of the interviews and adding more numbers may not necessarily improve the precision of the results significantly since preference analysis is not a statistical procedure.

The respondent selection process was not based on a 'one-shot' approach, but rather an iterative

Table 2
Attribute levels of forest management options for the NEV forest region

Option	Old-growth forest conservation (%)	Timber production (m^3/year)	Recreation intensity, RVDs/year (millions)
Option A	80	54 000	0.8
Option B	60	64 000	1.2
Option C	40	74 000	1.6

approach, where discussions with pre-identified stakeholders reveal other, previously unknown stakeholders (Harrison and Qureshi, 2000). This type of sampling is also known as 'Snowball sampling' or 'Referral sampling' (Hair et al., 2000). The Snowball sampling is a reasonable method of identifying and selecting prospective respondents for uniquely defined target populations. Reduced sample size and cost are primary advantages of this sampling method. However, there can be biases if there are significant differences between those groups who are known within the social circles and those that are not (Hair et al., 2000). The regional branches of the DNRE (Wodonga, Ovens and Benalla), Parks Victoria (Wodonga and Bright) and Wodonga Council initially helped identify representative members of each of these categories. The RFA mailing list, the Forest Management Plan Advisory Committee and independent forest consultants were also used to identify some of the stakeholders.

3.6. Value elicitation survey

The survey instrument comprised a brief explanation of attributes and their current use levels in the study region, value elicitation questions, weighting questions, ordinal ranking of forest management options, questions on personal information, illustrations to clarify value questions and land-use maps of NEV. Several versions of the draft survey instrument (DSI) were pre-tested on a selected group of stakeholders. Several strategies were used to collect information regarding the difficulties encountered in answering the DSI. This included 'Think Aloud' interviews where the participants were asked to talk through and reason out the rationale when they were making judgements or value preferences. In addition, the respondent was asked to give critical comments on the DSI and these were incorporated in the final questionnaire. The above strategies greatly helped to modify and to fine-tune the DSI and thereby lessened the cognitive demand on the respondent. Face-to-face detailed value elicitation sessions were carried out using the final version of the pre-tested survey instrument. Each respondent was briefed about the study region, the attributes and the current use levels of each attribute prior to the value elicitation. Each value elicitation session took approximately 45–60 min.

4. Results

4.1. Most- and least-preferred judgements

The differences between most- and least-preferred levels for the old-growth conservation were highly significant. However, this was not so for timber production and recreational intensity, which suggests highly variable preferences regarding these attributes. Mean preferences for the total sample with respect to timber production were 49 527 m^3 (most-preferred) and 44 222 m^3 (least-preferred) with standard deviations of 20 086 and 36 063, respectively. Mean recreational intensity levels for the total sample were 1.24 RVDs (most-preferred) and 0.74 RVDs (least-preferred) with standard deviations of 0.27 and 0.75, respectively. Mean old-growth conservation levels were 74.2% (most-preferred) and 26.7% (least-preferred) with standard deviations of 21.2 and 40.6, respectively. A summary of most- and least-preferred judgements by stakeholder groups is given in Table 3. A clear inclination towards old-growth forest conservation by the environmental group was observed in the means of the most- and least-preferred levels. The environmental group stated 88% of old-growth forest conservation as their best level with a standard deviation of 14%. In contrast, the timber industry group stated 60% of old-growth forest conservation with a standard deviation of 19.4% as their best level. The old-growth forest conservation attribute showed a high incidence of endpoint preference. In the case of timber production, the timber industry group preferred 64 000 m^3 of hardwood with a standard deviation of 8165 as their best level. This value exceeds the current legislated level of extraction. The environmental group stated 30 700 m^3 of hardwood as their best level, which is roughly a half of the current extraction level and maximum sustainable yield.

It should be noted that the preferred direction of the attribute varies among respondents and

Table 3
Most- and least-preferred judgement summary

Group	Timber production (m^3/year)		Recreational intensity (RVDs/year)		Old-growth conservation (%)	
	Most-preferred	Least-preferred	Most-preferred	Least-preferred	Most-preferred	Least-preferred
Environmentalists	30 700 (21 093)	51 800 (35 745)	1.08 (0.26)	0.89 (0.84)	88.0 (14.0)	0 (0)
Recreationists	48 500 (14 570)	55 500 (34 255)	1.10 (0.28)	0.93 (0.76)	72.5 (23.1)	17.5 (34.9)
Tour operators	40 000 (33 941)	37 000 (52 320)	1.30 (0.14)	0.80 (1.10)	80.0 (28.3)	50.0 (70.7)
Farmers	61 333 (6531)	24 667 (38 213)	1.42 (0.18)	0.47 (0.73)	75.0 (19.7)	36.7 (42.7)
Timber industry	64 000 (8165)	40 800 (35 990)	1.38 (0.20)	0.60 (0.69)	60.0 (19.4)	50.0 (47.1)

Means of most- and least-preferred levels. Standard deviations are shown in parentheses.

groups. For instance, 39% of the respondents chose zero hardwood timber production as the least-preferred level while 55.5% chose the extreme endpoint—74 000 m^3 as the least-preferred level. In the case of recreational intensity, 39% of the respondents preferred the current recreational intensity as their most-preferred level. However, preferences for old-growth conservation have been uni-directional for majority of the cases. For obvious reasons, the timber industry group preferred the greatest volume of timber extraction compared to all other groups. A level higher than the current old-growth forest conservation level was preferred by all groups except the timber industry. Preferences of environmentalists lie at one extreme while the preferences of the timber industry lie at the other extreme.

4.2. *Ranking of attributes*

The weights and attribute ranking are presented in Table 4. Among the attributes, the old-growth forest conservation attribute was the most important one, followed by timber production and recreation. Majority ranked old-growth forest conservation as the 'most important attribute' out of the three attributes. Timber industry stakeholders and farmers ranked timber production as the most important attribute. Farmers viewed timber industry as a form of farming and favoured relatively high levels of timber production. Recreationists and environmentalists ranked old-growth conservation as their most important attribute. Weights were derived using direct numerical ratio judgements of relative attribute

Table 4
Attribute ranking and weights

	Ranked first (%)	Ranked second (%)	Mean rank	Mean weights
Timber production	20.6	47.2	1.92 (0.73)[a]	35.19 (12.50)[a]
Recreation	11.1	38.9	2.39 (0.69)	27.03 (10.25)
Old-growth conservation	61.1	22.2	1.56 (0.77)	37.81 (12.19)

[a] Standard deviations are in parenthesis.

importance. Each respondent provided weights for the ranked attributes, beginning with an arbitrary 100 for the most-preferred one. The weights provided by respondents and the attribute ranking were consistent.

4.3. Value functions

Single-attribute value functions were constructed for the three chosen attributes by analyzing the elicited data (Appendix A). Single-attribute value functions were aggregated using attribute weights and the additive assumptions to obtain the multi-attribute value functions. Both single- and multi-attribute value functions were estimated using Logical Decisions™ for WINDOWS software. The estimated multi-attribute value functions were used to evaluate the forest management alternatives. Valuing alternative management options involved solving the multi-attribute value function for each option, using the attribute levels associated with that option.

4.4. Ordinal ranking of options

Respondents were asked to rank the three options according to their preferences. The ordinal ranking results are summarised in Table 5. A majority of respondents (47.2%) stated Option A as their most-preferred option. This suggests that the majority of respondents preferred a lesser volume of native timber extraction than the current level and a higher percentage of old-growth forest conservation than the current level. The Option B, which represents the current RFA outcome, was the second choice with 36.1% of the sample ranking it as the most desired choice. The Option C, which represents a higher volume of timber and lower level of old-growth conservation than the current level ranked last with only 16.7% of the sample preferring it as the best choice. The analysis of complete ranking reveals the rank order A > B > C as the most popular one (47.2%). The second most popular ranking was B > A > C (22.2%).

4.5. Cardinal ranking of options

Table 6 provides the ranking obtained by solving multi-attribute value functions. Based on the value function model, 58.3% of the sample ranked A > B > C. The Option A was the most-preferred option for 61% of the sample. The second most popular option and rank order were Option C (27.8%) and C > B > A (25%), respectively, implying some respondents intuitively preferred this ranking (C > B > A) though they did not express it in their ordinal ranking. If the cardinal or MAVT predicted ranking are a more accurate measure of stakeholder preferences, it is possible that respondents from the timber industry group are ‘locking’ themselves into specific and not necessarily true positions. This enhances the potential conflict in determining the desired management option. Interestingly, according to the value function model, only 11.1% of the sample chose the status-quo (Option B) as their first

Table 5
Ordinal ranking of FMP

Ranking	Frequency	Percentage	Cumulative percentage
C > B > A	2	5.6	5.6
C > A > B	4	11.1	16.7
B > C > A	5	13.9	30.6
B > A > C	8	22.2	52.8
A > B > C	17	47.2	100.0
Total	36	100.0	–

Table 6
Cardinal ranking of FMP

Ranking	Frequency	Percentage	Cumulative percentage
C > B > A	9	25.0	25.0
C > A > B	1	2.8	27.8
B > C > A	1	2.8	30.6
B > A > C	3	8.3	38.6
A > C > B	1	2.8	41.7
A > B > C	21	58.3	100.0
Total	36	100.0	–

choice. Other rank order combinations were insignificant, compared to the two endpoint ranking. Rank order predictions for all members of the environmental group were the same (A > B > C). Slight changes in rank ordering predictions have been noticed for recreationists, farmers and tour operators. However, the most popular rank ordering was A > B > C. The Option C was the most popular ranking for timber industry group while for some cases, Option B was the first choice.

Most of the rank predictions lie closer to either Option A or C, highlighting the critical trade-off between native forest logging and conservation. These results suggest that the majority of the public favoured a lesser timber extraction from native forests. In other words, they prefer to see an increased extent of native forests that is not subjected to logging. Further, an increased level of old-growth forest conservation was preferred than at present. Overall, these results indicate that the community would push conservation values further, making it difficult for those who depend on hardwood industry in the NEV forest region. The factual evidence also indicates that a number of hardwood mills are either downsizing or closing down operations completely. Given the difficulties that the hardwood industry is already facing, it would be extremely difficult to open up new native forests and old-growth forest areas for logging without considerable public opposition. The extent of agreement between the complete ordinal ranking and MAVT predicted cardinal ranking was examined. Agreement between the stated ranking and predicted ranking at the individual level was examined creating a score variable as indicated in Table 7.

Using the above scoring scheme, ordinal and MAVT predicted ranking was compared. Approximately 42% of the sample, prediction and stated ranking (complete) matched perfectly. In the first choice prediction (most-preferred option), 53% of the sample matched perfectly. Wilcoxon Signed Ranks test was carried out to examine the difference between the ordinal ranking of forest management plans (FMP) and the MAVT predicted ranking. Table 8 presents the predictive validity results. The differences between the ordinal and predicted ranking are not different at the 10% significant level. Spearman rank order correlation was calculated to see whether the ordinal and cardinal ranks for six possible orderings are similar. For ordinal and MAVT predicted ranks, the calculated correlation coefficient was 0.40, implying that there is a positive correlation between the rank orderings.

5. Concluding comments

Establishing a balance between conflicting stakeholder objectives and values, which is critical for policy-making can be achieved by examining the value of alternatives to stakeholders and comparing it with ordinal preferences, which was carried out in this experiment using the MAVT. The MAVT seems to be valuable for assisting respon-

Table 7
Ranking scores

Ranking	Score
A > B > C	6
A > C > B	5
B > A > C	4
B > C > A	3
C > A > B	2
C > B > A	1

Table 8
Predictive validity of the value function model

Test	Correlation coefficient	*P* value
Wilcoxon Signed Ranks test		
(a) 1st choice prediction	–	0.883
(b) Complete ranking	–	0.861
Spearman's rho		
(a) 1st choice prediction	0.320*	0.028 (1-tailed)
(b) Complete ranking	0.409**	0.007 (1-tailed)

* Significant at < 5%.
** Significant at < 1%.

dents in determining preferences for multiple-use forestry. The stated preferences and MAVT predicted preferences were consistent, though they do not match perfectly. The forest management Option A was ranked as the best choice by the majority of the respondents. It should be noted that the assessment of attribute values and scaling constants are critical to the ranking of the management options. Although there are potential problems with each weighting technique, this type of systematic procedure is capable of uncovering inconsistencies of ordinal ranking. For policy-making processes, the approach provides a useful starting point in understanding the value trade-offs. This information allows the planner to develop increased number of forest management options that incorporate these trade-offs. This type of management flexibility is not available using ordinal ranking.

It is interesting to note that the most-preferred forest management option has greater percentage of old-growth forest conserved and a reduced volume of native timber harvest than the current levels. The NEV region did not develop formal forest management options for public scrutiny during the RFA negotiations but simply achieved the set nationally agreed forest reserve (JANIS) criteria. The national forest reserve criteria require conservation of 60% of old-growth forests in the NEV region. The results of this study show that the public is willing to conserve more than 60% of old-growth forests. The maximum allowable hardwood volume is set by legislation and hence at present no value input from the public is sought out regarding native hardwood logging.

It may be useful to have this information in advance for policy-making. However, the number of stakeholders that should be involved, the representativeness and selection criteria for stakeholders are some of the unresolved issues in this approach. Nevertheless, the implied message is that more efficient outcomes with public endorsement can be achieved by using decision analytic technique such as MAVT.

The MAVT may pose considerable cognitive burdens on respondents. However, if properly crafted, the judgement context set out by the technique could reduce the cognitive effort required of the respondent (Arvai et al., 2001; Gregory, 2002). Nevertheless, these techniques can enhance informal reasoning of the analysts as well as the participating public, leading to efficacious choices. They also provide an increased understanding of the choice problem, the objectives and preferences. Moreover, these methods help appreciate the trade-offs involved in the decision problem. However, this approach cannot be successfully carried out by a mail questionnaire. Hence, the elicitation exercise involves a substantial cost if applied to large samples. Direct public involvement in decision making is most appropriate for determining broad land-use allocations such as regional forest planning. Such decisions are more likely to involve subjective or normative values of the public (Knopp and Caldbeck, 1990). At this level, technical information may guide the public in forming their value preferences. However, the distinction between whether the decisions should be based on value information or technical information is not always straightforward. For instance, the extent of old-growth forest conservation can be a value-based decision as well as a technical one. Therefore, value-based decisions should be integrated with scientific input (Gregory and Wellman, 2001; Gregory, 2000) and within the legal boundaries. MAVT achieves this to some extent.

The results of this study revealed that the MAVT approach could effectively elicit public values and evaluate forest management options successfully. The approach can accommodate multiple objectives and can be used in conjunction with participatory methods, which offer transparency in decision making by actively involving relevant stakeholders in the decision process. Forest managers and participating stakeholder groups are able to understand and clarify the difficult trade-offs involved in forestry, generating compromise management options, which represent the best possible management plan under the given circumstances. Overall, this technique offers a great potential for any forest planning exercise, increasing the credibility of the process, which is essential for sustainability.

Appendix A

Table A1. Single-attribute value functions for timber production

Respondent No.	Timber (x)
1	$v(x)=190.5-189.5e^{0.00000007x}$
2	$v(x)=1.181-0.0064e^{0.000007x}$
3	$v(x)=1.122-0.1217e^{0.0000297x}$
4	$v(x)=-0.004+0.0000000002e^{0.00034x}$
5	$v(x)=3.414-2.194e^{0.000006x}$
6	$v(x)=1.309-0.0034e^{0.00008x}$
7	$v(x)=1.68-1.68e^{0.000014x}$
8	$v(x)=0.00002e^{0x}$
9	$v(x)=-0.7841+344e^{-0.00008x}$
10	$v(x)=1.784-344e^{-0.0000822x}$
11	$v(x)=1.51-0.00002e^{0x}$
12	$v(x)=1.386-0.0001e^{0.000128x}$
13	$v(x)=0.0000156e^{0x}$
14	$v(x)=19-19e^{-0.0000007x}$
15	$v(x)=1.234-1.234e^{-0.000034x}$
16	$v(x)=1.854-1.854e^{-0.00001x}$
17	$v(x)=1.309-0.1029e^{0.000034x}$
18	$v(x)=2.126-2.126e^{-0.000009x}$
19	$v(x)=1.425-0.1689e^{0.000029x}$
20	$v(x)=-0.225+4.455e^{-0.00004x}$
21	$v(x)=1.22-0.0093e^{0.000006x}$
22	$v(x)=-0.9792+2.403e^{-0.000012x}$
23	$v(x)=-0.00005+0.00005e^{0.000173x}$
24	$v(x)=-0.4248+254.8e^{-0.000086x}$
25	$v(x)=4.51-4.51e^{-0.000004x}$
26	$v(x)=-0.5431+0.5431e^{0.000003x}$
27	$v(x)=-0.0563+0.0563e^{0.000046x}$
28	$v(x)=0.000015e^{0x}$
29	$v(x)=1.309-0.1029e^{0.000034x}$
30	$v(x)=2.521-2.521e^{-0.0000079x}$
31	$v(x)=-0.8536+1.854e^{-0.000010x}$
32	$v(x)=-0.1895+0.1895e^{0.000029x}$
33	$v(x)=3.017-0.6799e^{0.000020x}$
34	$v(x)=1.039-0.00000000003e^{0.0003x}$
35	$v(x)=1.198-0.0015e^{0.000090x}$
36	$v(x)=1.784-0.0852e^{0.000041x}$

Table A2. Single-attribute value functions for recreation

Respondent No.	Recreation (z)
1	$v(z)=1.543-1.543e^{-0.65270z}$
2	$v(z)=1.309-0.00279e^{2.406z}$
3	$v(z)=1.0-0.625e^{0z}$
4	$v(z)=1.096-143.5e^{-6.094z}$
5	$v(z)=1.018-0.00002e^{6.76z}$
6	$v(z)=-0.5431+4.384e^{-1.305z}$
7	$v(z)=-0.0957+0.0957e^{2.031z}$
8	$v(z)=1.198-1.198e^{-2.251z}$
9	$v(z)=-4+3.333e^{0z}$
10	$v(z)=1.096-143.5e^{-6.094z}$
13	$v(z)=0.7143e^{0z}$
14	$v(z)=0.625e^{0z}$
15	$v(z)=-1.028+6.293e^{-1.132z}$
16	$v(z)=1.096-1.096e^{-1.523z}$
17	$v(z)=-1.333+1.667e^{0z}$
18	$v(z)=2.521-2.521^{-0.3158z}$
19	$v(z)=1.198-0.0671e^{1.801z}$
20	$v(z)=1.018-2.001e^{-3.38z}$
21	$v(z)=1.096-0.00006e^{6.094z}$
22	$v(z)=-0.1624+0.1624e^{1.406z}$
23	$v(z)=0.625e^{0z}$
24	$v(z)=1.309-1.309e^{-1.203z}$
25	$v(z)=4-2.5e^{0z}$
26	$v(z)=-0.309+0.309e^{1.203z}$
27	$v(z)=-0.00405+0.00000015e^{-13.78z}$
28	$v(z)=-0.00405+0.00000015e^{-13.78z}$
29	$v(z)=1.309-0.0279e^{2.406z}$
30	$v(z)=-0.09574+0.09574e^{1.523z}$
31	$v(z)=0.8333e^{0z}$
32	$v(z)=2.274-2.274e^{-0.4138z}$
33	$v(z)=-3+2.5e^{0z}$
34	$v(z)=1.096-0.000064e^{6.094z}$
35	$v(z)=-0.309+0.309e^{1.203z}$
36	$v(z)=4-2.5e^{0z}$

Table A3. Single-attribute value functions for old-growth conservation

Respondent No.	Old-growth (y)
1	$v(y) = 1.001 - 1.001e^{-0.06922y}$
2	$v(y) = 1.039 - 1.039e^{-0.0443y}$
3	$v(y) = -0.095 + 0.095e^{0.02443y}$
4	$v(y) = -0.096 + 0.0002e^{0.1219y}$
5	$v(y) = -0.039 + 0.039e^{0.03281y}$
6	$v(y) = -0.004 + 0.004e^{0.06891y}$
7	$v(y) = -1.5 + 0.025e^{0y}$
8	$v(y) = 1.004 - 1.004e^{-0.06891y}$
9	$v(y) = -0.386 + 0.0002e^{0.1279y}$
10	$v(y) = 3.017 - 22.59e^{-0.04027y}$
11	$v(y) = 3.017 - 22.59e^{-0.04027y}$
12	$v(y) = 1.014 - 1.014e^{-0.07153y}$
13	$v(y) = 0.01667e^{0y}$
14	$v(y) = 2.521 - 1.341e^{0.006316y}$
15	$v(y) = -0.7841 + 4.059e^{-0.01644y}$
16	$v(y) = 0.01667e^{0y}$
17	$v(y) = 1.198 - 1.198e^{-0.01801y}$
18	$v(y) = 1.018 - 1.018e^{-0.0676y}$
19	$v(y) = 1.296 - 1.296e^{-0.01478y}$
20	$v(y) = 1.03 - 1.604e^{-0.04431y}$
21	$v(y) = 1.001 - 1.001e^{-0.06922y}$
22	$v(y) = -0.1978 + 0.1978e^{-0.01801y}$
23	$v(y) = 1 - 1e^{-0.5373y}$
24	$v(y) = 1.039 - 27.65e^{-0.1094y}$
25	$v(y) = 1.309 - 1.309e^{-0.02406y}$
26	$v(y) = 1.543 - 1.543e^{-0.01305y}$
27	$v(y) = -0.09574 + 0.09574e^{-0.06094y}$
28	$v(y) = 2.5 - 0.025e^{0y}$
29	$v(y) = 1.096 - 1.096e^{-0.03047y}$
30	$v(y) = -0.096 + 42.42e^{-0.06094y}$
31	$v(y) = 1.198 - 1.198e^{-0.01801y}$
32	$v(y) = 1.386 - 1.386e^{-0.01279y}$
33	$v(y) = 1.039 - 1.039e^{-0.06563y}$
34	$v(y) = 1.096 - 0.002e^{-0.06094y}$
35	$v(y) = -0.5431 + 7.39e^{-0.02611y}$
36	$v(y) = 1.543 - 0.1134e^{-0.02611y}$

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