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Valuing remnant vegetation in Central Queensland using choice modelling†

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In the Desert Uplands region of Central Queensland, many pastoralists are clearing vegetation in order to improve cattle grazing production. A choice modelling study was undertaken to provide estimates of the benefits of retaining remnant vegetation that are appropriate for inclusion in a cost benefit analysis of tighter clearing restrictions. Attributes included in the choice model were reductions in the population size of non-threatened species, the number of endangered species lost to the region, and changes in regional income and employment. A nested logit model was used to model the data in order to avoid violations of the independence of irrelevant alternatives condition. The estimated benefits are reported for several tree clearing policy regimes that are more stringent than those currently applied.

1. Introduction

Conjoint-based stated preference methods are increasingly being used for the assessment of community preferences regarding environmental and other social issues. Among the most popular of these techniques is choice modelling (CM).[1] Recent examples include Adamowicz, Boxall, Williams and Louviere (1998), Boxall, Adamowicz, Swait, Williams and Louviere

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[1] Choice modelling is otherwise referred to as contingent choice or choice experiment.

(1996), Rolfe and Bennett (1996), Morrison, Bennett and Blamey (1999) and Blamey, Gordon and Chapman (1999a).

Respondents to CM questionnaires are presented with a series of choice sets and asked to indicate the option they prefer in each choice set. Choice sets typically consist of a base alternative common to all sets and one or more other alternatives that vary from one set to another. The alternatives are described in terms of their characteristics or attributes. Differences between the alternatives are created by the attributes taking on different levels. An experimental design is used to ensure that the attributes are orthogonal. A choice model is then estimated over the entire attribute-space. Three different types of results can be derived from the model:

1. the marginal rates of substitution between the attributes (including implicit prices);
2. the predicted market or voting share for each of a given set of alternatives (including community rankings);
3. the monetary equivalent of the difference in utility between any two alternatives or choice sets.

In a recent edition of this journal, Blamey *et al.* (1999b) illustrated the use of CM in an analysis of water supply options in the Australian Capital Territory (ACT). The results presented included implicit prices, community rankings and monetary equivalents. However, the monetary equivalents calculated were not estimates of welfare changes of the type typically included in cost benefit analyses. This is because all the choice set alternatives, including the constant base, involved a solution to the forecast shortage of water. The 'do nothing' base alternative involved a necessary demand management regime including *inter alia* an A$50 increase in water rates. Consequently, the authors state: 'We are not attempting to estimate consumer surplus for changes from current water supply conditions, but rather willingness to pay in a constrained market where consumers are aware that some action has to be taken to address future water supply options' (Blamey *et al.* 1999b, p. 353). For monetary equivalents to be appropriate as estimates of the welfare impacts of change from *current* rather than future circumstances, the constant base alternative must be consistent with that status quo.

The objective of the present article is thus threefold. First, we describe a CM study primarily concerned with the estimation of monetary equivalents of welfare changes associated with environmental improvements that are consistent with the conventional practice of cost benefit analysis. Second, we demonstrate the use of nested logit model specifications that address the requirement of Independence of Irrelevant Alternatives (IIA) that can cause the multinomial logit model employed in the Blamey *et al.* (1999b) paper to fail. Third, this is done in the context of a case study involving the estimation of the benefits of retaining remnant vegetation in the Desert Uplands of Central Queensland.

An overview of CM, with emphasis given to the use of the nested logit model is given in the next section, followed by an outline of the case study. Then details of the design and conduct of the survey are given. Analysis and discussions follow in the next section, and, finally, conclusions are presented.

2. The choice modelling technique

Only a small number of recent studies (e.g. Rolfe and Bennett 1996; Adamowicz *et al.* 1998; Morrison *et al.* 1999; Blamey *et al.* 1998a; 1999a; 1999b) have begun to explore the use of choice modelling for estimating non-use values. Operationally, the CM technique involves several stages. The first stage involves the identification of key attributes relevant to the choices of interest. This needs to be done from both the perspective of the end-user (the population of interest) and the decision-makers/resource managers to ensure that the attributes are not only easily identifiable, but produce policy-relevant information (Blamey, Rolfe and Bennett 1997). As well, the levels across which each attribute is allowed to vary should also be identified. Generally, the levels should be set to cover the policy-relevant range for each attribute. Some monetary payment attribute (such as a tax increase) is also included within the scenario descriptions.

The second stage is the selection of scenarios (alternatives) that will be used in the experiment. These do *not* correspond to the alternatives actually under policy consideration. Rather, the levels of the attributes characterising the different options are varied according to an experimental design, permitting estimates of the relative importance of the attributes describing the options to be obtained. Instead of 'being questioned about a single event in detail . . . subjects are questioned about a sample of events drawn from the universe of possible events of that type' (Boxall *et al.* 1996, p. 244).

The third stage is the performance of the actual survey. Respondents are generally chosen at random from the population of interest, and invited to complete a questionnaire. As well as a series of 'choice sets', CM questionnaires often include questions on background information, related issues, and the attitudes and socio-economic characteristics of the respondents. A glossary describing each of the attributes listed in the questionnaire may also be included.

The fourth stage involves the modelling and analysis. This includes selecting a statistical model with which to estimate a relationship between respondent choices and the attributes of the alternatives presented. Typically, the probability that a given alternative will be chosen (P) is assumed to be a function of the satisfaction (utility) derived from the alternative in question (V) and each of the other alternatives in the choice set. The alternative offering the highest expected utility has the highest choice probability. The most common statistical model employed in CM studies, and the one used by Blamey *et al.* (1999b) is the multinomial logit model (MNL).

For the MNL model to be applied, the random component of the utility derived by an individual (i) from the choice of the jth alternative (e_{ij}) must be independently and identically distributed (IID). If the presence of independent alternatives in the choice sets is not irrelevant to the choice made, then the IID assumption and hence the IIA requirement do not hold and the MNL model is inappropriate.

An alternative to the MNL model that allows for correlations among the error terms within different groups or classes of alternatives is the nested logit (NL) model (McFadden 1978; Daganzo and Kusnic 1993). In a two-level NL model, the probability of an individual choosing the hth alternative in class r (P_{hr}) is represented as:

$$P_{hr} = P(h|r)P(r) \tag{1}$$

where $P(h|r)$ is the probability of the individual choosing the hth alternative conditional on choosing the rth class of outcome, and $P(r)$ is the probability that the individual chooses the rth class. Following Kling and Thomson (1996):

$$P_i(h|r) = \frac{\exp[V_{ihr}/\alpha_r]}{\exp[I_r]} \tag{2}$$

$$P_i(r) = \frac{\exp[\alpha_r I_r]}{\sum_{k=1}^{R} \exp[\alpha_k I_k]} \tag{3}$$

where:

$$I_r = \log\left[\sum_{i=1}^{Jr} \exp(V_{ir}/\alpha_r)\right] \tag{4}$$

is referred to as the inclusive value. This is a measure of the expected maximum utility from the alternatives associated with the rth class of alternatives. The coefficient of the inclusive value (α_r) measures substitutability across alternatives. When substitutability is greater within rather than between alternatives, $0 < \alpha_r < 1$. In this case, respondents will shift to other alternatives in the branch more readily than they will shift to other branches (Train, McFadden and Ben-Akiva 1987). In addition to its capabilities in avoiding IIA violations, the popularity of the NL model is in part due to the way in which nested decision structures lend themselves to behavioural interpretations.

Three broad types of results are available from a CM experiment. At the simplest level, the statistical model estimated can be used to indicate the probability that a given alternative will be chosen from a specified set of alternatives. This information can be obtained for any set of alternatives that can be built from the attributes and levels used in the experiment, and is not restricted to the options that were presented in the choice sets. Choice probabilities can be aggregated across the sample to obtain estimates of market or voter share, which can be used to derive a community ranking of the set of policy options under consideration.[2]

The second type of result is marginal rates of substitution for specific pairs of attributes. When one of the attributes is monetary in nature, these are referred to as implicit prices. These can be thought of as the amount by which the monetary payment has to vary to have the same impact on utility (and hence the probability of choice) as the change in environmental and other attributes. For example, the loss of two endangered species may produce the same average loss in utility for a representative household as an increase in land rates of A$20. This implies that the loss of two endangered species is implicitly valued by the community at approximately A$20 per household. These are marginal values in the sense that they represent the value of a small change in just one of the attributes listed in the questionnaire. They are estimated on a *ceteris paribus* basis whereby everything else except the two attributes involved is kept constant.

The third type of result involves estimating the monetary equivalent for changes in the packages of attributes associated with specific policy options. Of particular interest are the values associated with changes from the status quo as specified by the policy proposals of interest. For example, in the context of tree clearing guidelines, the community's willingness to pay to obtain tighter (or weaker) tree clearing restrictions, described in terms of the associated environmental and economic implications, can be estimated. Such values are consistent with the requirements of cost benefit analysis.

Welfare estimates are obtained in MNL CM studies using the following general formula described by Hanemann (1984):

$$W = -\frac{1}{\mu}\left[\ln \textstyle\sum_{i \in C} e^{V_{i0}} - \ln \sum_{i \in C} e^{V_{i1}}\right] \tag{5}$$

where μ is the marginal utility of income, V_{i0} and V_{i1} represent the indirect observable utility of the ith alternative in choice sets 0 (before the change)

[2] See Blamey *et al.* (1999b) for an example.

and 1 (after the change), respectively. In CM, the absolute value of the coefficient of the monetary attribute in the choice model is taken as an estimate of μ. Changes in V_{i0} or V_{i1} can arise from changes in the attributes of alternatives or the removal (or addition) of alternatives altogether.

In the case of NL models, inclusive values are calculated using equation 4 for each node at each level of the tree, beginning with lower levels and working up. Inclusive values at lower levels feed into those at higher levels until the expected maximum utility for the entire choice set is obtained at the uppermost node of the tree. Equation 5 is then applied to the expected maximum utilities corresponding to before and after choice sets in order to obtain an estimate of change in welfare. In other words, V_{i0} in equation 5 becomes the expected maximum utility from the ith branch of the before-change choice set and V_{i1} becomes the expected maximum utility from the ith branch of the post-change choice set. Kling and Thomson (1996), Herriges and Kling (1997), and Choi and Moon (1997) discuss various complexities of welfare estimation in the NL case.

Each of the three types of results can be useful to decision-makers and resource managers. The choice probability models help to predict the proportions of a population that would choose between different options, as well as being able to disaggregate these choices across different groups of respondents. In a political environment where broad community support is often a prerequisite to successful policy implementation, this type of information may be particularly useful. In this way, a CM application can act as a mechanism for public participation in decision-making.

The implicit prices that can be estimated for particular attributes provide some indication of how people view the importance of each attribute in making choices relative to the other opportunities and constraints that they face. These values provide a convenient overview of the relative value of each attribute.

The estimates of value for differences between alternative packages of attributes and the status quo can be used to evaluate more complex choices between resource use options. Most resource use options involve trade-offs between different factors. In some cases, as in the application reported below, values for differences between alternatives and the status quo may already include internal trade-offs between environmental and/or social attributes. This type of information revealed in a CM application can be added to information revealed in markets under the framework of cost benefit analysis so that more fully informed decisions can be made.

3. Case study

The Desert Uplands is one of thirteen terrestrial biogeographic regions of Queensland. Covering some 6,881,790 hectares (4 per cent of Queensland), it straddles the low tablelands of the Great Dividing Range in central-western Queensland. The region is essentially a band of scattered woodland country between the open grasslands of the arid western plains and the semi-arid to sub-humid brigalow (*Acacia harpophilla*) country to the east. The region is relatively unproductive for pastoral and agricultural purposes compared to other regions in the south and east of Queensland. This is because of its relatively low rainfall and poor soils, and its vegetation that is relatively unpalatable to domestic stock (Rolfe, Blamey and Bennett 1997). One reason why the term 'desert' is attached to the area is because spinifex (*Triodia spp.*), a grass common to the drier areas of Australia, is a major grass species in the region.

The region is used almost exclusively for pastoral purposes. Cattle are bred and fattened for beef production over much of the region, and sheep are also run in some areas. Pastoralists have been attempting to increase the carrying capacity of their land by a variety of methods, including the clearing of trees and the introduction of non-native grass species. Initially these developments were limited to patches of more fertile soils. The region now has one of the highest clearing rates in Australia, with between 4 and 8 per cent of many broad country types being cleared between 1992 and 1995 (McCosker and Cox 1996).

While the region is still relatively undeveloped compared to the brigalow regions to the east, and the integrity of most ecosystems in the region remains high, trends in management and development appear to be impacting on biodiversity (Landsberg, Ash, Shepherd and McKeon 1998; McCosker and Cox 1996). Tree clearing is the most visible form of change, but overgrazing, land degradation and weed invasion are also problems.

Approximately 80 per cent of the region is held as leasehold tenure, where the State Government is the legal owner of the natural resources. Leaseholders must gain permission to clear trees through the Queensland Department of Natural Resources. In issuing permits for broadscale tree clearing, the State Government policy calls for a balance between the benefits of increased productivity (most of which accrue directly to the landholders) against the environmental costs of diminished vegetation cover (which are more broadly spread across the regional and national communities). These costs can be interpreted as the benefits of policies that restrict the extent of tree clearing compared to that currently allowed. The CM application described below is directed at estimating these benefits.

The Queensland Government has recently been revising its tree clearing policies, with the result that vegetation communities that are endangered or vulnerable (whether through past clearing activities or limited initial occurrence) are now protected. Other vegetation communities can be cleared to 20 per cent of their original extent on individual properties, with 30 per cent of each vegetation type to be retained across the region.

In some cases, choices about environmental protection in the Desert Uplands may be very site-specific. Many of the smaller, unique ecosystems and endangered species are associated with the brackish lakes in the region and several moundsprings on the western side of the Desert Uplands. The estimation of values for both unique ecosystems and endangered species will help to determine protection values and appropriate trade-offs for individual sites within the region, providing valuable input into policy decisions.

At the same time, protection options are rarely neutral in relation to non-environmental factors such as the health of regional communities. Some protection options might be expected to reduce opportunities for production, and therefore impact on regional income and job opportunities. In common with many rangelands areas of Australia, the small townships and rural communities of the Desert Uplands are facing population loss and diminishing prospects. In this context, policy actions that reduce the viability of individual enterprises and regional communities can have dramatic social effects. However, some initiatives, such as changed management practices, may have very little impact on social factors.

These complexities mean that the CM application has to be able to address a wide range of situations. The essence of the important trade-offs has to be captured within the selection of attributes and the design of the scenario put to respondents in the questionnaire. Values may have to be estimated for a wide range of options built on different combinations of the attributes and model characteristics. These goals can be met in part by focusing on tree clearing as a mechanism for explaining environmental losses, even though a variety of other reasons contribute to environmental losses in the real-life situation.

4. Questionnaire design and survey logistics

A CM questionnaire was developed for the purpose of establishing the non-use values that Brisbane residents might hold for environmental and social attributes related to remnant vegetation protection in the Desert Uplands region. Design of the questionnaire followed a two-stage approach.

The first stage was a detailed overview of information available about the region relating to environmental attributes and the possible consequences of tree clearing activities. The level of knowledge in the community about environmental systems and relationships is not high, and there is very limited knowledge about the possible long-term effects of broadscale tree clearing and the extent to which it might occur (Rolfe *et al.* 1997). This uncertainty resulted in the selection of a very broad spectrum of possible outcomes, which is reflected in the wide range of levels across which each of the attributes was allowed to vary.

The second stage of the questionnaire design phase involved focus groups being held in both Brisbane and Emerald, the latter being a town adjacent to the Desert Uplands. The purposes of the focus groups were to identify the broad attributes of importance to people in making choices about the impact of tree clearing in the Desert Uplands, and to identify levels of knowledge and familiarity with the case study of interest.

A number of possible attributes were identified. These were subsequently condensed (for logistical and modelling purposes) to six attributes, being:

- levy on income tax;
- income lost to the region (A$ million);
- jobs lost to the region;
- number of endangered species lost to the region;
- reduction in population size of the non-threatened species (%);
- loss in area of unique ecosystems (%).

The levels chosen for each attribute reflected the broad possible range of resource use options in the biogeographic region, rather than just the outcomes relating immediately to tree clearing. For example, the number of endangered species reflected the total number that may be affected by development and grazing pressure options. Selection of attribute ranges in this way had the advantage of making the results broadly applicable to resource use options in the region, and avoided the difficulty of disaggregating changes between tree clearing and other development and management impacts. As well, it helped to ensure choices were framed against the array of possible development and protection outcomes.

An example of a choice set presented to respondents is shown in table 1. This shows that respondents were presented with a status quo option (Option A) that related to the current tree clearing guidelines and two options for increased protection that would be provided by more stringent tree clearing restrictions (Options B and C). While the same status quo option was included in all choice sets for all respondents, the attributes of options B and C varied according to an orthogonal[3] experimental design.[4]

The description for Option A, together with the background material presented, made it clear that some standards of protection were already being met under the current tree clearing guidelines.

[3] Orthogonality is required to ensure there are no correlations between the attributes so that the separate importance of all the attributes can be determined in the choice model.

[4] Implausible combinations of the jobs lost and income lost attributes were reduced through the use of a composite attribute in which an eight-level variable in the experimental design was used to assign pairs of jobs and income values to alternatives.

Table 1 A typical choice set

Implications	Option A Current Guidelines	Option B	Option C
Levy on your income tax	none	A$60	A$20
Income lost to the region (A$ million)	none	5	10
Jobs lost in region	none	15	40
Number of endangered species lost to region	18	8	4
Reduction in population size of non-threatened species (%)	80	75	45
Loss in area of unique ecosystems (%)	40	15	28

The final version of the survey was administered in the form of a B5 booklet with a colour insert containing photos and an attribute glossary, and included a number of background, attitude and respondent characteristic questions as well as the series of eight choices. The surveys were administered in a door knock drop-off/pick-up format to 480 Brisbane households in November 1997.

5. Results

The MNL model was initially fitted to the choice data. However, the results of both a Hausmann and McFadden (1978) IIA test and a mother logit model (McFadden, 1986) indicated the presence of IIA violations[5] even with the inclusion of socio-economic variables to take account of respondent heterogeneity. To avoid this problem, a NL model was fitted to the choice data. In that model, respondents were initially seen to choose between 'doing something' and 'doing nothing'. The NL modelling revealed that the initial choice was heavily influenced by three key attitudes of respondents. If the 'doing something' branch of the 'nest' was chosen, respondents were found to choose between the two improvement alternatives (Options B and C),

[5] The Hausmann and McFadden test involves the comparison of the model estimated under a full MNL model with that estimated using a model in which one alternative has been removed. Consistent parameter estimates across the two models indicate that the IIA property holds. The mother logit test involves including in each utility function the attributes of other alternatives and conducting a likelihood ratio test to see if the model fit improves. A significant improvement indicates an IIA violation.

Table 2 Non-attribute variable definitions

Variable	Definition
const	Alternative-specific constant taking on a value of 1 for options 2 and 3 in the choice sets, and 0 for the base option.
const1	Alternative-specific constant taking on a value of 1 for option 2 in the choice sets, and 0 for the base option.
envatt	Dummy variable taking on a value of 1 for respondents indicating that, over the years, when they have heard about proposed conflicts between development and the environment, they have tended to 'More frequently favour preservation of the environment'; 0 otherwise.
confuse	Five-point Likert scale response indicating extent of disagreement with the statement: 'I found questions 3 to 10 [the choice set questions] confusing'.
object	Five-point Likert scale response indicating extent of disagreement with the statement: 'A tree levy is a good idea'.

mainly on the basis of their attributes. The status quo option (Option A) was the 'do nothing' alternative.

The variables describing respondents' attitudes are defined in table 2, and the results of the NL analysis are presented in table 3. The 'branch choice equations' indicate the relative utility of 'doing something' to protect remnant vegetation versus 'doing nothing'. Respondents with a pro-environment orientation (envatt=1) were more likely to choose one of the environmental improvement options than respondents with a pro-development perspective (envatt=0). Those who report being confused by the choices presented in the questionnaire (confuse=1) were more likely to choose the status quo, as were those who had problems with the notion of a tree levy (object=1). The results suggest that despite the best efforts to minimise confusion and protest through questionnaire design, a significant degree of confusion and protest remained. This appears to have generated a degree of bias toward the status quo, potentially similar to that reported by Adamowicz *et al.* (1998).[6] Respondent income was not found to have a significant influence on choice.

The choice between Options B and C is modelled as shown under the heading 'Utility Functions' in table 3.[7] The attributes in the utility function

[6] Status quo bias is typically associated with respondent protest or confusion.

[7] Non-linear models containing quadratic terms did not prove superior in terms of the statistical significance of the explanatory variables, log-likelihood and pseudo-R^2 statistics. While *a priori* a non-linear relationship would be expected to reflect diminishing marginal utility of each attribute, it is apparent that over the ranges of levels the attributes could take on in the choice sets, constant marginal utilities apply.

Table 3 Nested logit results

Variables	coeff.	s. error
Utility functions		
const1	0.1644 [a]	0.0663
levy on income tax	−0.0107 [b]	0.0011
jobs	−0.0324 [b]	0.0053
regional income	−0.0597 [b]	0.0138
number of endangered species	−0.1214 [b]	0.0111
population of non-threatened species	−0.0180 [b]	0.0029
area of unique ecosystems	−0.0392 [b]	0.0065
Branch choice equations		
const	−1.9738 [b]	0.5913
const × envatt	1.1344 [b]	0.1105
const × object	−0.5750 [b]	0.0501
const × confuse	−0.1550 [b]	0.0477
Inclusive value parameters		
do something	0.1904 [a]	0.0795
do nothing	1.0000	0.0000
Model statistics		
n (choice sets)	5769	5784
Log *L*	−1685.564	−1547.388
adj rho-square (%)	20.1	26.7

Notes: [a] denotes significance at the 5 per cent level, [b] denotes significance at the 1 per cent level.

are all signed as expected and are highly significant. The negative coefficient on *Levy* indicates that respondents are less likely to choose options with increasing payment amounts. The negative signs on the other coefficients means that increasing amounts of the other attributes (e.g. more job losses, more endangered species losses) are negatively correlated with choice.[8] The positive and significant coefficient for const1 indicates that option B is associated with greater unobserved utility than option C. This is suggestive of the occurrence of a middle-position bias in which some respondents who were unsure which option to choose may have simply opted for the one in the middle of the choice set. Refer to Blamey *et al.* (1997) for further details.

The implicit prices of the attributes are reported in table 4. They are positive for all the attributes, implying that Brisbane residents have positive values for reductions in all environmental and social losses listed in the choice sets. For the environmental attributes, the mean WTP per household

[8] These results are explained in some detail in Blamey *et al.* (1998).

Table 4 Implicit prices for the attributes

Variable	Value of a one unit improvement (A$)
Jobs lost in local region	3.04
Loss in regional income (A$m)	5.60
Number of endangered species lost	11.39
Percentage reduction in population of non-threatened species	1.69
Percentage loss in area of unique ecosystems	3.68

to maintain endangered species in the region is A$11.39 per species, the mean WTP per household to avoid each 1 per cent loss in non-threatened species is A$1.69, and the mean WTP per household to avoid each 1 per cent loss in the area of unique ecosystems is A$3.68. For the social attributes, mean respondent household WTP for job preservation is A$3.04 per job, while the WTP to maintain each million dollars of regional income is A$5.60.[9] These results imply that one endangered species lost is valued similarly by the community to four jobs lost, and a 10 per cent reduction in the population of non-threatened species is valued similarly to six jobs lost.

These results illustrate the information that can be generated for resource managers and policy-makers. The implicit prices show that there is significant support for protecting both social and environmental factors. In relation to the social factors, there appears to be substantially more support for preserving jobs rather than regional income when policy options are considered. An option that preserved A$1 million in regional income but few jobs would have substantially less value than an option that preserved A$500,000 in regional income but 10 extra jobs.

Similarly, it appears that support for endangered species and unique ecosystems is higher than support for non-threatened species. Depending on the situation, it is clear that large areas of low-impact clearing may occur without high welfare losses, but also that small amounts of clearing impacting on endangered species and/or unique ecosystems would generate substantial environmental costs.

A further way of using the CM results is through the comparison of welfare estimates for different scenarios. Such welfare estimates can be generated as the difference in community value between the constant base,

[9] The significance of the jobs and regional income attributes in the choice model indicates that Brisbane people are willing to pay for protecting the jobs of other people and the viability of rural regions. These may be regarded as 'social existence values' (Portney 1994). The motivation for such values is not explored here.

Table 5 Welfare estimates associated with more stringent tree clearing guidelines

Attribute	Option A (current guidelines)	Option D1 (new guidelines)	Option D2 (new guidelines)	Option D3 (new guidelines)	Option D4 (new guidelines)	Option D5 (new guidelines)
Jobs lost in the region	0	0	10	0	30	40
Regional income lost	0	0	5	0	10	15
Number of endangered species lost to region	18	16	16	8	8	16
Reduction in non-threatened species %	80	50	50	35	35	75
Loss in area of unique ecosystems %	40	30	30	20	20	35
WTP (A→D) Per household	n/a	A$87	A$76	A$117	A$88	A$36

status quo, condition (Option A in the choice sets) and some other alternative (Options D1 to D5 in table 5). These options are generated from the attributes and levels involved in the choice experiment. Table 5 lists the mean WTP of Brisbane households for five different tree clearing options for the Desert Uplands.

For example, the adoption of new guidelines as described by Option D1 rather than staying with the current guidelines generates welfare improvements of A$87 per household. Brisbane households are thus prepared to pay an average of A$87 in a one-off tree levy to obtain the outcomes associated with Option D1. A cost benefit analysis of the various options would need to consider these value estimates along with other market and non-market values not addressed in the CM application, including the non-market values accruing to individuals living both within the local region, and other more distant regions.

It is notable that the value of Option D1 is only partly explained by the change in the attributes used in the CM experiment. The value for Option D1 shown in table 5 is lower than the simple sum of marginal values for the specified attribute changes (table 4). This is due to the influence of the constant and its interaction with the attitudinal variables in the branch-choice equation in table 3, and suggests that preservation values for rangeland ecosystems may relate to a wide variety of sources and influences. As noted above, a degree of bias toward the status quo option is apparent.

Now consider the influence that social costs in the form of losses in jobs and income in the Desert Uplands region have on welfare estimates. The above estimate for the difference between Options A and D1 focused only on changes in environmental attributes. In Option D2 in table 5, some human impact consequences are added to the environmental consequences listed in Option D1.

The estimate for the difference in value between the two alternatives (Option A and Option D2) is A$76 per household. This value is lower than that estimated for Option D1. Thus the addition of negative social consequences to outcomes of increased environmental protection measures reduces the values of those outcomes. Brisbane households thus appear to hold 'non-use' values regarding levels of employment and income in the Desert Uplands region.

Option D3 is similar to Option D1 in that it specifies environmental improvements without losses in jobs and regional income. However, in this case, the environmental improvements are much larger than in Option D1. Consequently, Brisbane households are willing to pay 35 per cent more for this option than Option D1. When the environmental improvements specified in Option D3 can only be obtained at the expense of 30 jobs and A$10 million in regional income (Option D4), mean household WTP falls to A$88.

The final option included in table 5 specifies the smallest environmental improvements included in any of the choice sets in the questionnaire and the maximum economic costs in the form of income and jobs. In this case, WTP falls to A$36. It appears that although increasing losses of jobs and income in the Desert Uplands region reduce the WTP of Brisbane residents, WTP for tighter tree clearing guidelines remains positive for all combinations of environmental and economic outcomes considered in the questionnaire.

The welfare estimates presented in table 5 are calculated at the mean values of envatt, object and confuse over the sample (see table 2). The values can be recomputed for different values of these variables to see how WTP varies between segments. For example, WTP for Option D2 falls to A$21 for respondents having a pro-development orientation, and rises substantially to A$128 among those with a pro-environment orientation, holding object and confuse at their mean values. Interestingly, respondents with a pro-development orientation are still willing to pay a positive amount of money to obtain the outcomes associated with Option D2 rather than Option A. However, WTP among this segment falls to zero when the number of jobs lost increases to 30 and A$14 million in regional income is lost. By contrast, WTP among the pro-environment segment only falls to zero when 150 jobs and A$50 million in regional income are lost.[10]

[10] This estimate involves extrapolation beyond the range of the jobs and regional income attributes in the experiment and hence should be treated with caution.

6. Conclusion

There is widespread recognition in Australia that rangelands systems are under increasing pressure from a range of different influences. The integrity and resilience of many ecosystems are being degraded, production and financial returns to some sectors of the pastoral industries appear to be spiralling downwards, and many rural communities are contracting. The interrelationships between these factors vary according to specific situations. In some cases there are clear trade-offs between environmental, financial and social goals, and in other cases there are complementary relationships. The simultaneous quantification of these influences is desirable from both the perspective of the policy analyst and for methodological reasons.

The CM application reported in this article has focused on valuing changes in resource use options that incorporate both environmental and social aspects. Significantly, the application was structured so as to generate estimates of welfare changes that are consistent with the requirements of cost benefit analysis. The results indicate that Brisbane households do hold values for the protection of both aspects, and that these may be offsetting or complementary according to the setting. Estimates of implicit prices and welfare estimates demonstrate how the technique is useful in generating explicit information for policy analysts.

As well as providing information that is useful to a cost benefit analysis of the tree clearing debate in Queensland, the article also demonstrates the use of the NL model as a tool for avoiding violations of the IIA property.

However, successful use of the technique in this application is tempered by its complexity and associated methodology issues. For example, the apparent occurrence of status quo and related biases in the present study suggests a need to understand better how respondents go about completing CM questionnaires, and how this varies with changes in questionnaire design. Being a stated preference technique, CM may also be susceptible to some other response biases, such as yea-saying, that are often discussed in relation to the contingent valuation method (CVM).

Research effort that has gone into the development of the CM technique is helping to streamline and simplify applications. Further work is needed in what is promising to be a successful direction in non-market valuation.

References

Adamowicz, W., Boxall, P., Williams, M. and Louviere, J.J. 1998, 'Stated preference approaches for measuring passive use values: choice experiments and contingent valuation', *American Journal of Agricultural Economics*, vol. 80, pp. 64–75.

Ben-Akiva, M. and Lerman, S. 1986, *Discrete Choice Analysis: Theory and Application to Travel Demand.* The MIT Press, Cambridge, MA.

Blamey, R.K., Bennett, J.W., Louviere, J.J., Morrison, M.D. and Rolfe, J.C. 1998, *Attribute Selection in Environmental Choice Modelling Studies: The Effect of Causually Prior Attributes*, Choice Modelling Research Report No 7, University College, University of New South Wales, Canberra.

Blamey, R.K., Bennett, J.W., Louviere, J.J., Morrison, M.D. and Rolfe, J.C. 1999a, 'A test of the use of policy labels in environmental choice modelling studies' *Ecological Economics* (in press).

Blamey, R.K., Gordon, J. and Chapman, R. 1999b, 'Choice modelling: assessing the environmental values of water supply options', *Australian Journal of Agricultural and Resource Economics*, vol. 43, pp. 337–57.

Blamey, R.K., Rolfe, J.C. and Bennett, J.W. 1997, *Environmental Choice Modelling: Issues and Qualitative Insights*, Choice Modelling Research Report No 4, University College, University of New South Wales, Canberra.

Boxall, P., Adamowicz, W., Swait, J., Williams, M. and Louviere, J. 1996, 'A comparison of stated preference methods for environmental valuation', *Ecological Economics,* vol. 18, pp. 243–53.

Choi, K-H. and Moon, C-G. 1997, 'Generalized extreme value model and additively separable generator function', *Journal of Econometrics*, vol. 76, pp. 129–40.

Daganzo, C.F. and Kusnic, M. 1993, 'Two properties of the nested logit model', *Transportation Science,* vol. 27, pp. 395–400.

Haneman, W. 1984, *Applied Welfare Analysis with Qualitative Response Models,* Working Paper 241, University of California, Berkeley.

Hausmann, M.J. and McFadden, D. 1984, 'Specification tests for the multinomial logit model', *Econometrica*, vol. 52, pp. 1219–40.

Herriges, J.A. and Kling, C.L. 1997, 'The performance of nested logit models when welfare estimation is the goal', *American Journal of Agricultural Economics*, vol. 79, August, pp. 792–802.

Kling, C.L. and Thomson, C.J. 1996, 'The implications of model specification for welfare estimation in nested logit models', *American Journal of Agricultural and Resource Economics*, vol. 78, February, pp. 103–14.

Landsberg, R.G., Ash, A.J., Shepherd, R.K. and McKeon, G.M. 1998, 'Learning from history to survive in the future: management evolution on Trafalgar Station, north-east Queensland', *The Rangeland Journal*, vol. 20, pp. 104–17.

McCosker, J.C. and Cox, M.J. 1996, *Central Brigalow Bioregional Conservation Strategy Report*, Australian Nature Conservation Agency, Canberra.

McFadden, D. 1978, 'Modelling the choice of residential location' in Karlquist, A., Lundquist, L., Snickars, F. and Weibull, J. (eds) *Spatial Interaction Theory and Planning Models,* North Holland, Amsterdam, pp. 75–96.

McFadden, D. 1986, 'The choice theory approach to marketing research', *Marketing Science,* vol. 5, pp. 275–97.

Morrison, M.D., Bennett, J.W. and Blamey, R.K. 1999, 'Valuing improved water quality using choice modelling', *Water Resources Research*, vol. 35, pp. 2805–14.

Morrison, M.D., Blamey, R.K., Bennett, J.W. and Louviere, J.J. 1996, *A Comparison of Stated Preference Techniques for Estimating Environmental Values*, Choice Modelling Research Report No 1, University College, University of New South Wales, Canberra.

Portney, P. 1994, 'The contingent valuation debate: why economists should care', *Journal of Economic Perspectives*, vol. 8, pp. 3–17.

Rolfe, J.C. and Bennett, J.W. 1996, 'Valuing international rainforests: a choice modelling approach', paper presented to the 40th annual conference of the Australian Agricultural Economics Society, Melbourne, 11–16 February.
Rolfe, J.C., Blamey, R.K. and Bennett, J.W. 1997, *Remnant Vegetation and Broadscale Tree Clearing in the Desert Uplands Bioregion of Queensland*, Choice Modelling Research Report No 3, University College, University of New South Wales, Canberra.
Train, K., McFadden, D. and Ben-Akiva, M. 1987, 'The demand for local telephone services: a fully discrete model of residential calling patterns and service choices', *Rand Journal of Economics,* vol. 18, pp. 109–23.