Using Choice Modelling to Account for Biodiversity Conservation: Non-use Value for Ningaloo Reef

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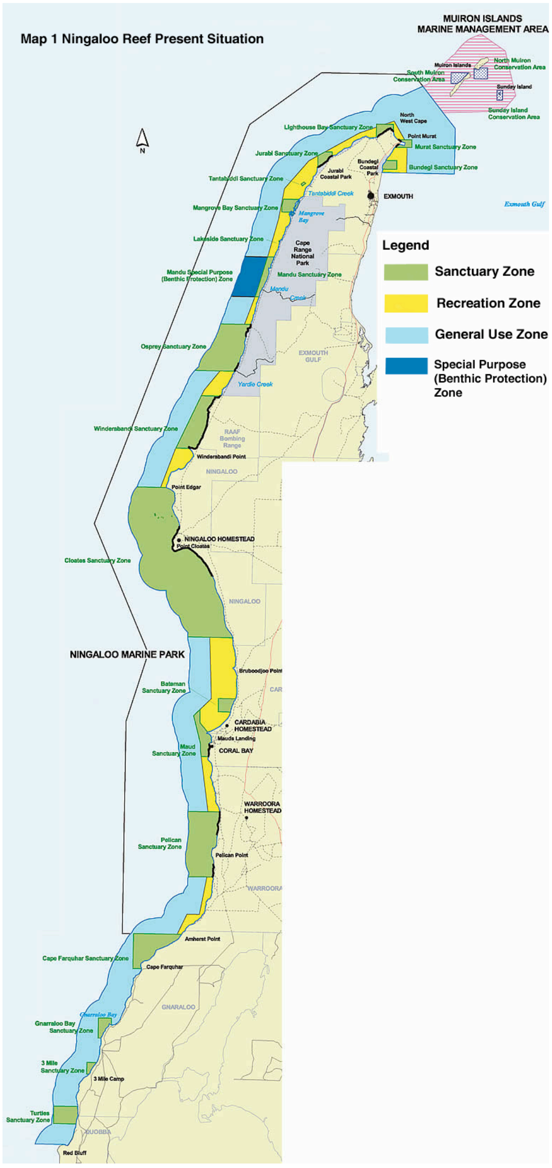
Keywords: *choice modelling, non-use value, logit model, coral reef*

EXTENDED ABSTRACT

Considered one of the healthiest reef environments in the world, Ningaloo sits in a special bio-geographic zone where the distributions of tropical and temperate marine and terrestrial organisms overlap. Currently, this fringing barrier reef system and its coasts are subject to significant human pressure due to its unique proximity to the coast, and commercial and recreational fishing have the potential for major negative impacts on the marine life in the Ningaloo Reef waters. This paper aims to assist policy makers in formulating efficient, effective and sustainable coral reef conservation and management policies by providing them with the results and information from a valuation study using Ningaloo Reef in Western Australia as a case study.

Choice Modelling, an economic valuation technique is employed to estimate the benefits of the non-use values of Ningaloo Reef and how these choices may be related to certain socio-economic characteristics. The application of the technique involved surveys of visitors in relation to coral reef protection and conservation in the region of the Ningaloo coast. Choice Modelling is found to provide a flexible and cost-effective method for estimating non-use values, particularly when different alternative proposals need to be considered. This study can aid the design of socially optimal policies for conservation and sustainable management of the Ningaloo Marine Park (Map 1), with implications for other coral reef regions in the rest of Australia.

Map 1. Ningaloo Marine Park zoning scheme



1. INTRODUCTION

The Ningaloo Marine Park is located along the coast of Western Australia, stretching for about 300 km northwards, from just below the Tropic of Capricorn (21°40'S to 23°30'S and 113°45'E). Ningaloo has more than 200 species of corals, a myriad of marine landforms, high water quality, gardens of captivating sponges, diverse life forms in the seabeds and fringing forests of mangroves. These support an amazing diversity of wildlife, including 600 species of shellfish and other molluscs, 500 species of fish such as whale sharks, manta rays and other tropical and subtropical fish, and a variety of other invertebrates. The reef is also on the migration path of humpbacks and other whales. Dugongs can often be seen in lagoons while the sandy beaches of the coast provide habitat for four species of turtle, three of which nest in the region (Hutchins *et al.,* 1996). Considered one of the healthiest reef environments in the world, Ningaloo sits in a special bio-geographic zone where the distributions of tropical and temperate marine and terrestrial organisms overlap.

Currently, this fringing barrier reef system and its coasts are subject to significant human pressure. Unlike the Great Barrier Reef, Ningaloo Reef is particularly susceptible to visitor disturbance due to its unique proximity to the coast. Commercial and recreational fishing have the potential for major negative impacts on the marine life of the Ningaloo Reef waters. Some of these include: significantly reducing the distribution and abundance of target species thus changing the population structure; reducing population levels of non-target species through catch; major impacts on benthic communities including destruction of flora and fauna, and loss of demersal fish and other fauna through habitat modification, e.g. from trawling (Moran *et al.*, 1995).

The aim of this study is to provide policy makers with much needed information on the public benefits that Ningaloo Reef generates in terms of non-use values that accrue to the Western Australian public. The non-use value estimated in this study is the biodiversity conservation that can be used in benefit-cost analysis of alternative marine conservation management scenarios, thereby enabling sustainable management of the Ningaloo coast. To accomplish this aim, the non-use values of the Ningaloo Reef conservation are estimated using a recently developed non-market valuation method, namely Choice Modelling.

2. THE CHOICE MODELLING APPROACH

Choice Modelling (CM) is a stated preference valuation method that has its origin in conjoint analysis. It was initially developed in the marketing and transport literature by Louviere and Hensher (1982). There have been a number of applications to estimate the value of recreational and environmental goods (Boxall *et al.*, 1996; Christie and Azevedo, 2002). In recent years, it has been applied in environmental economics for analysing conservation choice and destination choice on the basis of the attractiveness of destination and trip attributes (Crouch and Louviere, 2004).

In a CM application, respondents are presented with a series of choice sets, each containing usually three or more alternative goods. An alternative is a combination of several attributes, with each attribute taking on a value, usually called a level. One of the alternatives in each choice set describes the current or future situation, and remains constant across the choice sets. From each choice set, respondents are asked to choose their preferred alternative. The attributes used are common across all alternatives. Their levels vary from one alternative to another according to an experimental design (Bennett and Blamey, 2001).

If human-induced changes in marine ecosystems can be meaningfully represented by a set of attributes, choices made by survey respondents among sets of alternatives can provide resource managers and policy makers with valuable information about public preferences for many potential states of the environment. The theoretical foundation of the discrete choice modelling is Lancaster (1966), who developed a characteristic approach for the analysis of demand. Since choice modelling elicits preferences from consumers, this method provides information about preference orderings within a set of choice options. The analysis of the data is based on random utility theory (RUM), originally proposed by Thurstone (1927).

The random utility model requires that the stochastic component enter the utility function directly. The utility is modelled as a random variable in order to reflect this uncertainty. More specifically, the utility that individual i is associating with alternative a is given by:

$$U_a^i = V_a^i + \varepsilon_a^i$$

where V_a^i is the deterministic part of the utility, and ε_a^i is the stochastic part (error) capturing the uncertainty.

The econometric analysis presented in this methodology is based on a multinominal logit model (MNL). Formally, given a sample of H individuals, with h=1,2,.......H and a set of alternative choices, j=1,....J, the random utility specification can be represented as follows (Louviere *et al.*, 2000):

$$Uhj=V_{hj}+\varepsilon_{hj}, \qquad [1]$$

where the latent and unobservable utility value for the choice alternative j made by consumer h is given by the sum of a deterministic component with a random term, ε_{hj}. The conditional logit specification is obtained by assuming that these random terms are independently and identically distributed (IID) according to a Gumbel (Extreme Value Type 1) distribution.

Transforming the random utility model into a choice model requires certain assumptions about the joint distribution of the vector of random error terms. If the random error terms are distributed independently and identically (IID) and follow the Gumbel distribution, the multinomial logit (MNL) model is obtained. The deterministic component usually takes the following linear additive form:

$$U_{hj} = \beta' x_{hj} \qquad [2]$$

With this specification, the deterministic component is a function of the attributes of the alternatives and (in principle) of individual characteristics, x_{hj}, and a set of unknown parameters, β.

Given the presence of the random term in equation [1], the probability of choosing the alternative i can be expressed as follows:

$$P(i|C_h)=P[(V_{ih}+\varepsilon_{ih})> (V_{jh}+\varepsilon_{jh})]. \qquad [3]$$

Expression [3] defines the probability that consumer h chooses i within the choice set C_h as the probability that the sum of the systematic and random utility terms of option i is greater than the corresponding terms for any other option j in the choice set C_h.

The IID assumption across alternatives for the ε_s entails the property of independence of irrelevant alternative (IIA), which means that the relative probability of an alternative being chosen over another is independent of the availability of additional attributes or alternatives. Broadly speaking, once a choice has to be taken between three scenarios, the decision does not depend on the existence of other alternatives (McFadden, 1984). Therefore, if some alternatives are excluded from the choice set, the estimates are still consistent. Thus, the information provided by a dataset with a smaller number of choice alternatives is still representative of consumers' behaviour (Train, 2003).

Hence, provided that IIA holds, in order to mimic the choice process actually undertaken by consumers in real life, econometric analyses do not need to consider simultaneously all real alternatives (which would make experiments or data collecting quite complex and difficult). In the conditional logit model, the probability that an individual h picks alternative i out of J alternatives can be represented as follows:

$$P[y_h=i] = \frac{1}{\sum_{j=1}^{J} \exp\left[-(V_{ih} - V_{jh})\right]} \qquad [4]$$

where y_h is a choice index, which represents the choice made by individual h. The estimation of equation [4] yields the β coefficients which can be used to evaluate the rate at which respondents are willing to trade-off one attribute for another. This substitution rate can be easily calculated by dividing the β coefficient of one of two attributes into consideration by the β coefficient of the other attribute and multiplying by -1.

$$Substitution\ rate = -\frac{\beta_k}{\beta_s} \qquad [5]$$

When the attribute to be "sacrificed" (x_s) in order to obtain more of the other (x_k) is expressed in monetary terms (e.g. willingness to pay), this estimated trade-off is an "implicit price", such as in the case of this study, the amount of money respondents are willing to pay in order to obtain more of the other attribute (more conservation on Ningaloo Reef) (x_k).

3. APPLICATION FOR NINGALOO REEF BIODIVERSITY VALUATION

This section describes the application of Choice Modelling for the valuation of Ningaloo Reef. For Choice Modelling results to be useful as inputs into a benefit-cost analysis, the framework of the CM application must be consistent with the principles of benefit-cost analysis. It is of particular importance therefore that the issue to be examined using Choice Modelling is established in accordance with the concept of change at the margin.

3.1 Questionnaire development

So, if Choice Modelling results are to be consistent with this marginal value framework, the issue under consideration must be defined in terms of change from a *status quo* situation. In this case study the *status quo* is called '*Scenario Present Situation'* (see Map 1) that represents the present situation of the Ningaloo Marine Park. Considering that the aim of this study is an economic evaluation of biodiversity conservation (non-use value), respondents to a Choice Modelling questionnaire are asked to compare two different hypothetical scenarios against the *status quo*.

The alternatives/scenarios represent two hypothetical situations of Ningaloo Reef. The first is called '*Scenario II Ningaloo Reef with increased conservation'* and is an option to the *status quo* where the sanctuary zone increases in size (from the present 33% to 66%). This scenario represents minor environmental impacts to the coral reef's biodiversity caused by human activities, such as recreational fishing, boat access, commercial activities, mining and petroleum exploration. In this scenario, the protection and conservation of flora and fauna along the coast are not total (the sanctuary zone represents 66% and not 100%) because it does not exclude completely recreational fishing which represents an important activity for Western Australians. A 100% protection is likely to be chosen only by few environmental activists and such a scenario is not a real alternative to the *status quo*. The difference between the *status quo* and *Scenario II* is the percentage of sanctuary zone, but the recreational and commercial activities allowed inside the Park remain the same in both scenarios. *Scenario II* will be chosen by Western Australians who have a 'pro-conservation' attitude because the aim of this scenario is to increase the protection of the reef ecosystems and reduce the areas dedicated to any sort of human activities that have a negative impact on the environment. The second alternative/scenario is called '*Scenario III*, *Ningaloo Reef without conservation'*, an option where inside the Ningaloo region any industrial, commercial and mass tourism activities are allowed. In this scenario the economic benefits are massive, considering the natural resources available in the north-west coast of Western Australia, the increased job opportunities related to the activities and also the opportunities for international companies to invest in industrial and tourism infrastructure activities. With 0% of sanctuary zone, a drastic decline in the abundance and diversity of marine life along the cost as well as decline of coral coverage are inevitable.

3.2 Selection of attributes and levels

The attributes (see Table 1) were used to describe a combination of financial and non-financial considerations important to the decision for the conservation and protection of Ningaloo Reef. The attribute levels associated with each option varied in each choice set and there were three choice sets in the survey. Respondents were asked to make a series of similar, but different choices. In this study, the main issues relating to biodiversity conservation of the Ningaloo Marine Park were condensed (for logistical and modelling purposes) into six possible attributes (Table 1).

Table 1. Attributes and levels

Attribute	Level
Percentage of Sanctuary Zone	Status quo 33% Scenario II 66% Scenario III 0%
Reduction in coral reef coverage	Status quo 60% Scenario II 30% Scenario III 100%
Decrease of marine life biomass	Status quo Low Scenario II Low Scenario III High
Decrease income of local fisheries	Status quo High Scenario II High Scenario III None
Loss of income for Mining	Status quo High Scenario II High Scenario III None
Park entrance fees (WTP)	Status quo $0 Scenario II $20 Scenario III $0

3.3 Experimental design

A starting point is a *full factorial design*, which is a design that contains all possible combinations of the attribute levels that characterize the different alternatives. In general, a factorial design is simply the factorial enumeration of all possible combinations of attribute levels. A complete factorial design guarantees that all attribute effects of interest are truly independent. Thus, the statistical effects or parameters of interest in such models can be estimated independently of one another and all possible effects associated with analysis of multiple linear regression models can be estimated from a complete design factorial analysis. Despite the statistical advantages possessed by complete factorial designs, such designs are practical only for small problems involving small numbers of attributes and/or levels. In this case study the complete factorial is too large. In fact, we have in total six attributes with three levels each. If we denote the six attributes by capital letters and the levels indicated in parentheses we have: A(3) x B(3) x C(3) x D(3) x E(3) x F(3) or more simply 3 x 3 x 3 x 3 x 3 x3.

The complete factorial involves 729 total combinations, it is very large and not tractable in a choice experiment. Such problems can be reduced to practical sizes by using *fractional factorial design*. Fractional factorial design involves the selection of a particular subset or sample of complete factorials, so that particular effects of interest can be estimated as efficiently as possible. So the 3^5 components related to the three scenarios options presented in the choice sets is a three level blocking factor used to create three versions of scenarios and reduce the number of choice sets.

3.5 Sample sizing and data collection

A general problem with applying a choice experiment to an environmental good is that respondents are not necessarily familiar with the attributes presented. In order to make clear and homogeneous the comprehension of attributes and to facilitate the individual decision process, the oral explanation of these characteristics and levels was accompanied by the presentation of drawings and photos representing each scenario. A face-to-face survey was conducted in the months of October and November 2006 with a total 150 interviews. The questionnaire was designed to gather information on the perception of Western Australian tourists about some characteristics of current and hypothetical scenarios for the Ningaloo Marine Park, to be used in choice modelling to analyse the attitude of Western Australians towards the conservation of Ningaloo and their willingness to pay (WTP) to preserve the biodiversity of Ningaloo. The collected information includes the individual features of tourists, their general marine biodiversity knowledge, their attitude toward conservation or industrial development, the characteristics and the evaluations of the tourist experience at Ningaloo. Interviews were carried out in different places in order to collect information also from those tourists whose main reason for spending holidays at Ningaloo is not the seaside resort. We started to interview people in vacation along the north west coast, from Gnaraloo Bay in the middle of October 2006, which coincided with the Australian school holidays and can be considered as peak season. Then we continued the interviews going up north in the following spots: *Warroora*, *Elles Camp, Maggies, Coral Bay, and Exmouth.*

3.6 Estimation methodology

In this study two different multinominal logit (MNL) are estimated using the data from the Ningaloo Reef survey. The definitions of the variables used in these models are presented in Table 2.

Table 2 Variables description

VARIABLE	DEFINITION
ASC1, ASC2	Alternative specific constants (Scenarios II & III)
SANCT	Percentage of Sanctuary Zone inside Ningaloo
REEF	Reduction of coral reef
BIO	Decrease of marine life biomass
FISH	Decrease in income of local fisheries
MININ	Loss of income for mining and petroleum companies
WTP	Willingness to pay for conservation
INCOME	Respondents' household income
EDU	Education
AGE	Age
BIOK	Dummy variable: marine biodiversity knowledge

The first model shows the importance of the choice set attributes in explaining respondents' choice across the three different options (the scenarios). The second model includes both socio-economic and attitudinal variables in addition to the attributes in the choice sets.

Three utility functions ($V_{1\text{-}3}$) are derived from the initial MNL model. Each function represents the utility generated by one of the three options. Option 1 is the status quo: Scenario I, option 2 is Scenario II with increased protection and option 3 is the hypothetical scenario without conservation: Scenario III.

Status quo $V_1=\beta_1.SANCT+\beta_2.REEF+\beta_3.BIO+\beta_4.FISH+\beta_5.MININ+\beta_6.WTP$

Scenario II $V_2=ASC1+\beta_1.SANCT+\beta_2.REEF+\beta_3.BIO+\beta_4.FISH+\beta_5.MININ+\beta_6.WTP$

Scenario III $V_3=ASC2+\beta_1.SANCT+\beta_2.REEF+\beta_3.BIO+\beta_4.FISHI+\beta_5.MININ+\beta_6.WTP$

The β values are the coefficients associated with each of the attributes. For the three utility functions, utility is determined by the levels of the six attributes in the choice sets (SANCT, REEF, BIO, FISH, MININ, WTP). Hence, the model provides an estimate of the effect of a change in any of these attributes on the probability that one of these options will be chosen. The second method used to include socio-economic and attitudinal variables is through interactions with the alternative specific constant (ASC1 and ASC2). In this model four variables are included as interactions with the alternative specific constant for scenario 2 and scenario 3 (INCOME, BIOK, EDU and AGE). These interactions show the effect of various attitudes and socio-economic characteristics on the probability that respondent will choose either scenario 1, 2 or 3. The specification for the second model is as follows:

$V_1=\beta_1.SANCT+\beta_2.REEF+\beta_3.BIO+\beta_4.FISH+\beta_5.MININ+\beta_6.WTP+\beta_7 WTP*INCOME+\beta_8 WTP*BIOK+\beta_9 WTP*AGE$

$V_2=ASC1+ASC1.INCOME+ASC1.BIOK+ASC1.EDU+\beta_1.SANCT+\beta_2.REEF+\beta_3.BIO+\beta_4.FISH+\beta_5.MININ+\beta_6.WTP+\beta_7 WTP*INCOME+\beta_8 WTP*BIOK+\beta_9 WTP*AGE$

$V_3=ASC2+ASC2.INCOME+ASC2.BIOK+ASC2.EDUCATION+\beta_1.SANCT+\beta_2.REEF+\beta_3.BIO+\beta_4.FISH+\beta_5.MININ+\beta_6.WTP+\beta_7 WTP*INCOME+\beta_8 WTP*BIOK++\beta_9 WTP*AGE$

4. RESULTS

The socio-demographics characteristics of the survey respondents are given in Table 3. The results presented in this paper were analysed using the software package STATA. The multinominal logit model was designed with the assumption that the observable utility function would follow a strictly additive form.

Table 3. Socio-demographic of the survey respondents

Age	39.6 (mean)
Sex (%male)	53.2%
Education	17.2% (completed Year 10)
	18.2% (completed Year 12)
	14.3% (tertiary degree, diploma)
	30.8% (higher degree)
Household income	$48,120 (mean)

The models were specified so that the probability of selecting a particular marine conservation scenario for Ningaloo was a function of the attributes of that scenario and of the alternative specific constant (ASC), which was specified to equal 1 for the *status quo* and Scenario II with biodiversity protection and was specified0 0 when neither protection for Ningaloo was selected. The results for model 1 and model 2 are shown in Table 4. The negative sign for the ASC coefficient implies that respondents are highly responsive to changes in choice set quality and they make decisions that are closer both to rational choice theory and the behaviour observed in reality. In this case ASC1 for *Scenario II* is negative (-0.30); it means that respondents are highly responsive to change in the choice set from the *status quo* to *Scenario II* 'increased protection'. In this questionnaire, 68% of respondents chose Scenario II. The WTP coefficient is highly statistically significant and has the result that would be expected *a priori.* The value of this coefficient can be employed to determine the willingness-to-pay measure associated with changes in the levels of other attributes. What is very significant in this study was that respondents with university education and higher marine biodiversity knowledge are more likely to choose higher payment levels, as the interaction between both of these characteristics and payment attribute are positive.

The coefficient for the variable AGE was very low and no significant in relation to the willingness to pay of the respondents. In order to test for the accuracy of the assumption of IID error terms a mother logit was estimated. The likelihood ratio test indicated that at the 5 percent significance level the multinominal logit model was the true model. Hence the inclusion of socio-economic and attitudinal variables was sufficient to avoid any violation of the IID assumption. The compensating surplus for the change from the *status quo* to the new scenario with increased protection was estimated by calculating the difference between the utility of the *status quo* and the utility of the new option *Scenario II* and multiplying this by the negative inverse of the coefficient for rates. The willingness to pay estimate was -$26.12. The negative sign indicates that to maintain utility at the level of the *status quo*, given the improvement in biodiversity conservation in Ningaloo Marine Park, income must be reduced by $26.12.

5. POLICY IMPLICATIONS AND CONCLUSIONS

This paper contributes to the literature on estimation of non-use values of coral reefs using choice modelling, and is one of the few coral reef valuation studies that have been undertaken in Australia. The results indicate that there are positive and significance non-use values about biodiversity conservation associated with environmental, economic, and social attributes of Ningaloo Reef. The impacts of social, economic and attitudinal characteristics of Western Australian respondents on their valuation of Ningaloo Reef are significant and conform with economic theory. These results assert that choice modelling can produce valid non-market estimates of non-use value. The biodiversity conservation non-use value estimated in this paper can be combined with direct and indirect use values of the Ningaloo

Marine Park to conduct a benefit-cost analysis.

Table 4 Multinominal logit models 1 and 2

	Model 1 (standard error)	Model 2 (standard error)
ASC1	-0.3024*	-1.58***
ASC2	5.4246* (0.0846)	5.82* (0.0074)
SANC	0.5688*** (0.1323)	0.5564*** (0.1588)
REEF	0.4792*** (0.1621)	0.4934*** (0.1124)
FISH	0.0164*** (0.0124)	0.01466***(0.0122)
MININ	0.0228*** (0.0134)	0.01369***(0.0117)
WTP	-0.1268***(0.8126)	-0.1348***
WTP*INC	- -	0.0071*** (0.0028)
WTP*BIOK	- -	0.0026*** (0.0018)
WTP*AGE	- -	0.0007* (0.0005)
ASC1*INC	- -	0.9868*** (0.0003)
ASC1*BIOK	- -	2.5344*** (0.2468)
ASC1*EDU	- -	4.4487*** (0.78239
ASC2*INC	- -	0.2489*** (0.7654)
ASC2*BIOK	- -	1.0834*** (0.0848)
ASC2*EDU	- -	2.8642*** (0.0034)
Summary statistics		
Observations	450	
Log-likelihod	-1874.457	-1127-995
χ^2 (constants only)	362.038	498.086
ρ^2	0.147	0.193
ρ^2 adjusted	0.156	0.210

*** 1% significance level, ** 5% significance level, * 10% significance level with two-tailed tests

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