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ESTIMATING THE BENEFITS OF BIODIVERSITY PROTECTION*

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ABSTRACT

What are the benefits of biodiversity protection? **Why** should those benefits be estimated? **When** should they be estimated … now or across future generations? **Where** should the benefits be estimated … locally, nationally or internationally? And, of course, **how** can they be estimated, if at all?

This sequence of questions forms the basis of this paper. The specific benefits associated with the provision of biodiversity protection are firstly defined. The role of benefit estimation in the process of making decisions regarding the future use of ecosystem resources is then briefly reviewed noting the importance of biodiversity benefits in that process. The "extent of the market" for biodiversity protection is considered with respect to the beneficiaries across both time and space. Some technical issues arising from the choice between alternative non-market benefit estimation techniques are analysed along with a discussion of the techniques' collective capabilities to perform the task. References to selected case study results, generated from recent applications of the Choice Modelling technique, are used to illustrate the arguments involved.

As a conclusion, it is suggested that research effort should be directed to the task of benefit estimation to determine priorities for the protection of biodiversity.

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1. Introduction

Biodiversity protection in Australia has become either the focus of nature conservation initiatives or a justification for frustrating natural resource development. The protection of biodiversity has been achieved through tracts of old growth forests in coastal NSW being quarantined from logging operations, tree clearing in Central Queensland being restricted and mining in the Northern Territory being curtailed.

The justification for these policy moves is summed up in this extract from the Commonwealth Department of Environment Sport and Territories' (1994) "Australia's Biodiversity: an overview of selected significant components":

> "Overall, Australia is an island continent that, due to its long geological isolation and special climatic features, is home to an enormous variety of uniquely evolved plants and animals. An exceptionally high proportion of these are only found in Australia … For some groups of plants and animals the number of species (species richness) is outstanding and for many others the numbers are relatively high compared to most parts of the world. These factors combine to make Australia's biological 'ark' globally significant in any terms." (p10)

However, the protection of biodiversity can be costly. In most cases, biodiversity protection and resource development are mutually exclusive. The foregone benefits of resource development can be extensive. So a decision to protect is, simultaneously, a decision to bear an opportunity cost.

In addition, biodiversity protection frequently requires more than a simple "lock-up" strategy. Designated biodiversity protection sites inevitably need to be managed to prevent externally driven environmental changes. For instance, invasive feral plants and animals may require controlling in order to prevent a decline in the biodiversity under protection. The money spent on rabbit control in Australia and possum control in New Zealand provides ample evidence of just how costly such management strategies can be.

These costs of biodiversity protection imply that, unless the benefits of biodiversity protection are infinite, there will be some finite point at which society will decide it is in its own interest to put a stop to further protection initiatives. What needs to be established is:

- Are the benefits of biodiversity protection are infinite?
- If they are not infinite, what is their order of magnitude?

With such knowledge, society can better understand the nature of the trade-off between the costs and benefits involved.

In this paper, the benefits of biodiversity protection are investigated in order to shed some light on these two questions. Biodiversity is defined and a delineation of the benefits that arise from its protection is provided. The conclusion that the benefits from biodiversity protection are not infinite is drawn from evidence of decisions that society has made that involve not protecting biodiversity. On the basis of a rationale for estimating the benefits of changes to the stock of biodiversity, some issues surrounding the estimation process are considered. These involve the distribution of the benefits – across time and space – and the viability of techniques used in their estimation. Finally, some conclusions regarding the use of benefit estimates in the development of biodiversity protection policies are drawn.

2. What are the benefits of biodiversity protection?

The Australian Federal Government's Biological Diversity Advisory Committee (BDAC) (1992) provides the following definition:

> "Biological diversity is the variety of life – the different plants, animals and micro-organisms, the genes they contain and the ecosystem of which they are a part." (p3)

Ehrlich and Ehrlich (1992) define biodiversity as "the vast array of non-human organisms of our planet" (p219).

The benefits of protecting biodiversity are both market and non-market, use and non-use, direct and indirect and consumptive and non-consumptive. They include:

Commercial production benefits. Species are harvested and used to produce goods including food, medicines, shelter and clothing. Elements of biodiversity are inputs into production processes (for example, soil micro-organisms play a key role in agricultural production). Ehrlich and Ehrlich (1992) refer to these benefits as direct and indirect economic values. The indirect values of biodiversity protection even extend to the beneficial role of fully functioning natural ecosystems with the establishment of climatic and water systems and the maintenance of evolutionary processes.

Aesthetic benefits. People enjoy viewing species and the ecosystems in which they live.

Joint benefits. People enjoy activities, such as recreation and water catchment integrity, which are supplied simultaneously with biodiversity protection without any major deleterious effects.

Existence benefits. People enjoy knowing that species and ecosystems remain in existence. These benefits may arise because of an ethical belief. For instance, Ehrenfield (1988) states that "(bio)diversity is God's property, and we, who bear the relationship to it of strangers and sojourners, have no right to destroy it" (p215). Part of the reason why people may enjoy existence benefits is found in the bequest motive. The current generation wish to ensure that future generations have the opportunity to benefit from biodiversity. The bequest motive therefore gives biodiversity protection a value premium across generations. This premium is extended if the desire for leaving opportunities open is felt by individuals within a generation as well as between generations[1].

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[1] Where uncertainty regarding the future supply of biodiversity exists, the positive premium people may be willing to pay to ensure availability is referred to as option value.

3. Why estimate the value of these benefits?

The broadest definition of biodiversity, and its associated benefits, implies that without biodiversity, there could be no life on earth. Without biodiversity, there could be no "life support" system for humanity. This suggests that the value of biodiversity is infinite. However, the complete destruction of biodiversity is never a policy option and so the absolute value of biodiversity protection is not at issue. What must be considered from a policy perspective is the value of changes to the stock of biodiversity that would result from specific proposed changes in resource allocations. Given that alternative policies may result in some reductions or improvements in protection afforded to biodiversity stocks, it is the marginal value of biodiversity that is of relevance[2].

An examination of the definitions of biodiversity demonstrates that this marginal value is not infinite. Despite the apparent similarities between the Ehrlichs' and BDAC's definitions of biodiversity, they contain some tensions that make analysis of the value of biodiversity difficult. These tensions surround the involvement of humanity. The BDAC definition does not exclude people as a component of biological diversity, while the Ehrlichs' does[3].

Clearly, the biodiversity in existence today is a function of human involvement. Humanity has evolved along with the other species on the planet. But if humanity is to be excluded from the concept of biodiversity as it stands today, at what point through time does the impact of humanity cease to be incorporated? This is an important issue in so far as policy directed at protecting biodiversity is quite frequently targeted at the removal of, or at least the limitation of, human interference with ecosystems that provide biodiversity.

In Australia, there appears to be a de facto, if not de jure, recognition that pre-European settlement should be regarded as the appropriate exclusion point. The implication is that Aboriginal resource management practices, such as the use of fire, and their introduction of "exotics" such as the dingo, are consistent with "natural" evolutionary processes. In contrast, European introductions of species such as foxes, cats and rabbits are deemed to be somehow "unnatural"[4]. In New Zealand, the sentiment appears to be to regard pre-Maori times as the benchmark for biodiversity protection.

The common denominator across these two demarcations appears to be the level to which human societies have had an impact on the extent of biodiversity. In Australia, it was the European settlement that triggered a sharp decline in biodiversity while in

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[2] Furthermore, the Ehrlichs' rivet popper analogy for biodiversity loss (whereby biodiversity loss is likened to the rivets in an aircraft being progressively removed) implies that the value of any further reductions in biodiversity loss is infinite.

[3] In contrast, the Ehrlichs refer to "our planet" as though humanity exerts some ownership rights over the biodiversity included.

[4] The introduction of a species into an ecosystem is, at least initially, an expansion of the diversity of the genetic base. However, the extinction of other species that may result can mean that biodiversity is eventually reduced.

New Zealand it was the arrival of the Maori people that resulted in a reduction in biodiversity.

However, even with this acceptance of a benchmark for biodiversity, other complicating factors arise. For instance, how should humanity's ability to enhance biodiversity through genetic engineering be considered? Are the species that humanity has forced into extinction somehow different from those that in the future we may create? And should humanity attempt to exterminate elements of biodiversity that are harmful to our existence – such as the smallpox virus or HIV? Should humanity's increasing technological capability be used to maintain species against even non-human induced evolutionary change? At its extreme, this point can be expressed as the "Jurasic Park" argument: If advances are made that can bring extinct species back into existence, should artificial environments be created in order to sustain those species so that biodiversity can be supplemented?

A less extreme example can be found in European conservation policy. The environment in Europe has experienced many more years of what in Australasia is regarded as "unnatural" human influence. The environment has therefore been extensively modified. But even in such circumstances, efforts are made to "revert" to environmental conditions that, while modified by human activity, are different from those that are currently more prevalent. Specifically, environmental conditions are deliberately created through the implementation of human land use practices that are no longer commercially viable. For instance, hedgerows in Britain are maintained as wildlife habitat despite demands for them to be removed for more cost-effective broad-scale agriculture. In Germany, meadows are not permitted to be ploughed but are also prevented from regenerating to forest by periodic mowing in order to maintain a landscape (and habitat) established centuries earlier. By undertaking these strategies, the diversity of ecosystems and hence the biodiversity present is enhanced. The question is therefore: Why aren't more modified environments created so as to expand further the biodiversity that is present?

The conclusion that must be drawn from these conundrums is that biodiversity is by no means clearly defined, at least in terms of what can be regarded as a definitive target for policy making. What is biodiversity and what type of biodiversity should be the goal of policy are by no means the subject of hard and fast rules. Biodiversity is necessarily a term that relies on an interpretation and in turn, that interpretation is dependent on the perceptions and values of those who have an interest in protecting it. Furthermore, biodiversity enhancement and protection are costly. It is not automatically the case that society chooses to implement measures to increase the protection afforded biodiversity. The value of such improvements is not infinitely positive. If it were, there would be no question as to the wisdom of adopting policies that would see it enhanced. And conversely, the value of a reduction to biodiversity protection is not infinitely negative. Choices are routinely made that see its stock diminished in order to achieve other benefits. Clearly society continually faces trade-offs between the benefits offered by improved biodiversity protection and the associated costs.

It is the existence of these trade-offs and the complexities of the interactions between biodiversity and humanity that makes the estimation of the benefits of biodiversity protection so important to the formulation of policies that impact on the natural environment. With benefit estimates, decision-makers can be better informed regarding the consequences of their actions. With improved information, improved resource allocations are more likely.

What are the alternatives? One approach is simply to ignore biodiversity values. The danger inherent in this approach is that resource allocations that deplete biodiversity would be viewed as being less costly than they really are and strategies that enhance biodiversity protection would not be considered as beneficial as they really are. The result would be increased resource allocations that deplete biodiversity. This would be to the detriment of society as a whole. Until relatively recently this was the predominant approach simply because of the lack of knowledge regarding the nature of ecosystem relationships.

A second approach is for decision makers to acknowledge biodiversity values by "guessing" their magnitude, relative to the other benefits and costs involved. This approach remains predominant today and even encompasses approaches such as threshold value analysis (whereby decision-makers are presented with estimates of the costs of biodiversity protection measures against which judgements as to the magnitude of the benefits of such measures can be made). In a democratic political environment, the decision-makers faced with the task of making the "guess" will be guided by their political motivations. This implies that rent-seeking behaviour may have a strong influence on the resource allocation outcome. Vested interest groups that can command strong support in marginal electorates may have undue power in swaying decisions in their favour. Of course, these interest groups may be from either the protection or the development sides of the resource allocation conflict. It is unlikely, however, that such rent seeking driven policy making will be in the best interest of the society as a whole.

A third approach is for policy makers to adopt an ethical position with respect to biodiversity protection. This usually implies a "fixed rule" approach that precludes development that would result in a predetermined consequence such as the the extinction of a species. In the economics literature, this approach is often referred to as the adoption of "safe minimum standards" (Randall 1991). There are, however, significant difficulties in the practical implementation of this approach. The complexity of biodiversity trade-offs are ignored by a simple rule. For instance, a biodiversity protection rule can come into direct conflict with other ethically based rules concerning humanity (such as the achievement of standards of living or the avoidance of starvation)[5].

Estimating the extent of biodiversity protection benefits means that decision makers cannot ignore them. Estimates of benefits also act as safeguards against rent seeking behaviour. Because estimates are of the benefits enjoyed by people who are affected, the process is essentially an extension of democratic principles to the point of allowing each affected party an opportunity to have their preferences admitted into the decision calculus.

How are "affected parties" defined? Biodiversity benefits are potentially spread

[5] Rolfe () goes further to show that a rules based approach is consistent with the benefit estimation approach.

through both time and space. Future generations can be expected to benefit from policies which today protect biodiversity. Similarly, people in Australia may be beneficiaries of biodiversity protection in tropical South America through the discovery there of some potential miracle drug.

4. When should biodiversity benefits be estimated?

The benefits of protecting biodiversity are enjoyed not only by those people inhabiting the world now but also by future generations. By estimating the value of these benefits now, it can be argued that the interests of future generations are being ignored.[6]

Two factors counteract this criticism. First, one of the benefits of biodiversity protection is that the current generation enjoys is the “bequest value”. Although the bequest motive may be limited to an intergenerational effect of two or three generations, in terms of economic analysis that may be all that is relevant. Beyond that time span, the impact of discounting at even low rates will reduce the present value of expected benefits to insignificant amounts.

Second, the extrapolation of per annum value estimates made for the current year across future years provides a mechanism whereby future generations’ values can be taken into account. The implied assumption is that the values enjoyed by future generations are equivalent to those of the current generation. Given that the current generation’s value incorporates a bequest value component, the extrapolation process does have the advantage of providing a “roll-over” aspect.

5. Where should biodiversity benefits be estimated?

The benefits of enhanced biodiversity protection are not confined by regional or national boundaries. Many of the direct use benefits – such as the production of food, fibre and shelter – are traded internationally. Recreational values are enjoyed not just by locals but also by tourists. The indirect values associated with the maintenance of ecological functions have local regional and global significance. The non-consumptive benefits such as the provision of existence values are also potentially global.

The benefits of biodiversity are likely to extend well beyond the jurisdiction of those who are responsible for decisions that have an impact. For example, people benefit from the protection of tropical rainforest biodiversity in terms of non-use existence and the indirect, functional values of climate control. These people are just as likely, if not more, to live in temperate regions as in the tropics.

This partial separation of beneficiaries from control is complicated by distributional inequities. Much of the world’s remaining biodiversity is to be found in third world

[6] Following this argument further, it can be concluded that enhancements in biodiversity protection provide an infinite value. As each generation experiences some finite benefit and given an infinite stream of future generations, the value through time is infinite. Of course, this logic can also be applied to alternative uses of resources so that each use provides an infinite value stream. Hence, without biodiversity being “used” rather than “protected”, at least under the definitions that exclude humanity as a component of biodiversity, there would be no future generations.

countries where the lack of development has ensured its continued availability. However, it is from the developed world (where biodiversity has been diminished as a result of the development process) that most of the calls for biodiversity protection originate. The institutional structures by which the developed world's demands for biodiversity protection can be mobilised to compensate those in less developed areas who would bear the costs of supplying that protection are still in their embryonic form.

What is needed is a benefit estimation process that takes into account the internationally significant components of value. Because this approach extends the consideration of benefits beyond national jurisdictions, it must be coupled with the development of mechanisms whereby costs can be spread across all those considered as beneficiaries[7].

8. How can the benefits be estimated?

In the previous two sections, the "market scope" for biodiversity protection benefits has been defined. That is, the extent to which an estimation exercise "net" must be cast has been established. What can be done within that net to calculate a reliable estimate of value?

Three fundamental categories of benefit estimation techniques are available. They are market based techniques, revealed preference techniques and stated preference techniques.

Market-based techniques

Best known to economists, market based techniques rely on market generated information regarding the supply and demand functions for the good or service that is generating the benefit. While these techniques are both well understood and accepted as producing robust and reliable value estimates, they are limited in their application to circumstances where markets exist and are functioning well. This is the case for many of the direct use values of biodiversity protection such as the production of food and fibre.

The prime difficulty in applying these techniques to biodiversity protection is in determining just how an action to improve protection impacts on the markets for goods and services. The links are often tenuous and difficult to quantify. For example, to ensure the survival of the species growing there, a native grassland area may be set aside from grazing. Scientists may believe that one species so protected could be the source of useful genetic material in the breeding of a drought resistant pasture. While market information can help establish the benefit of such a pasture, the scientific and application uncertainties are very difficult to estimate.

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[7] The work detailed in Tacconi and Bennett (1997) on forest protection in Vanuatu takes this approach. Benefits of setting aside forest protected areas are estimated for tourists visiting Vanuatu and for Australian residents who have never visited that country. To spread the costs of the set asides across the international community, a trust fund was established to accept payments from overseas donors. From this fund, lease payments were made to the traditional owners of the forests who agreed not to allow their trees to be harvested.

Market estimation techniques are, of course, limited to circumstances where the good or service of interest is marketed and where the situation proposed can be extrapolated from existing cases.

Revealed preference techniques.

Revealed preference techniques are useful where markets for goods and services that produce benefits have not formed but where related markets exist. People's revealed actions in the related markets can be used to infer their values for the non-market good or service. Included in this category of techniques is the Travel Cost Method whereby people's expenditures on visits to recreational sites can be used to estimate the benefits they enjoy from the non-marketed recreation experience. In so far as biodiversity reserves can provide recreational benefits, the Travel Cost Method may be useful.

The Hedonic Pricing Method is another revealed preference technique. This method is useful when a non-marketed good or service has an impact on, or is an attribute of, a marketed good. By determining the effect of the non-marketed factor on the price of the related marketed good or service, an estimate of the factor's benefit can be made. The method is widely used to estimate the benefit of pollution reductions through real estate market data. Aspects of biodiversity protection may have impacts on marketed goods. For instance, the view of a biodiversity reserve may influence neighbouring property prices or the quality of water sourced from a reserved catchment may impact on the price paid for that water. Hence the method may also be useful in the estimation of such aesthetic benefits.

The revealed preference techniques are widely regarded as being capable of providing accurate estimates of non-market benefits because of their foundations in the actions of individuals in markets, even if those actions are once removed from the good or service of interest. They are however, limited to circumstances where related markets exist and where an existing situation can be used as the basis for an extrapolation to the case at hand.

Stated preference techniques

Stated preference techniques rely on beneficiaries answering a questionnaire in which they are asked to indicate their intended behaviour if faced with a hypothetical situation.

Best known of these techniques is the **Contingent Valuation Method** (CVM). Respondents to a CVM questionnaire are asked if they would be willing to pay a pre-specified cost to ensure a change away from the status quo allocation of the non-marketed good under consideration. Both the status quo and the proposed resource allocation are described to respondents in the questionnaire. The benefit estimates that result from binary logit analyses of these responses are theoretically consistent with estimates of benefits and costs generated by market based estimation techniques.

A stylised CVM question is presented in Figure 1. In this example, the two options available to the respondent are detailed in terms of their attributes, including a cost associated with the proposed option.

Figure 1: A Contingent Valuation Question

Question: Which option do you prefer?

	OPTION	
Attributes	**CURRENT**	**PROPOSED**
No. of non-threatened species	25	32
No. of Endangered Species	10	15
•	•	•
•	•	•
•	•	•
Cost to you	0	$50
Your Choice…	☐	☐

The stated preference techniques are capable of estimating benefits where:

- the goods and services providing the benefits are not marketed;
- related markets do not exist; and
- completely new circumstances make extrapolation from established cases impossible.

Because so many benefits of biodiversity protection match that description, stated preference techniques are especially significant where proposed resource re-allocations have impacts on the natural environment. For instance, the non-use values of biodiversity protection are not marketed and nor do they have related markets. Many of the indirect use values such as climatic control have no history on which extrapolations of benefit estimates can be based.

The CVM has proven controversial in its application. Most criticism has been based on the assertion that the techniques yield biased and hence unreliable estimates of non-marketed benefits. These biases result primarily because the benefit estimates obtained are based on respondents' statements of their intended behaviour rather than their actual behaviour. Much of the research effort devoted to the development of CVM has been centred on ways to overcome these biases. Despite these efforts, the method is yet to be established on the same footing as market estimation procedures and related market techniques.

Choice Modelling (CM) is a recent advance in the use of stated preference techniques. In a CM survey, a sample of beneficiaries is asked to make a sequence of choices between alternative resource allocation options. Each option is described in the CM questionnaire as a set of attributes. The options available differ from each other by variations in the levels of the attributes. The variations are systematically ascribed to options according to an orthogonal experimental design. A stylised CM question (which would be one of a sequence of such questions in a CM questionnaire) is displayed in Figure 2.

Figure 2: A Choice Modelling Question

Question: Which of the following options do you prefer?

Attributes	OPTION		
	Current	A	B
No. of non-threatened species	25	30	25
No. of endangered species	10	15	20
•	•	•	•
•	•	•	•
•	•	•	•
•	•	•	•
Cost to you	0	$50	$100
Your choice ..	☐	☐	☐

By making their selections of their most preferred option, respondents display their willingness to trade-off between the attributes. So long as one of the attributes is monetary (usually a cost associated with achieving an option) and one option in every choice set is maintained as the status quo (ie kept constant), estimates of the implicit prices of the non-monetary attributes and the benefits associated with changes away from the status quo allocation can be made[8].

One of the potential advantages of CM over CVM is that the output of a CM application contains a wealth of detail regarding respondents' preferences[9]. This detail enables the analyst to provide an array of information to policy makers well beyond that afforded by a CVM application. While a CVM application is capable of producing an estimate of the benefit or cost associated with one scenario of change from the status quo, the CM approach can yield a series of value estimates

[8] See Morrison, Blamey, Bennett and Louviere (1996).
[9] A detailed analysis of the pros and cons of Choice Modelling is set out in Bennett, Blamey Morrison and Rolfe (1998).

corresponding to a range of change scenarios.

The capacity to generate multiple value estimates from a single application is derived from CM's focus on the attributes that constitute a resource use alternative. This ability is especially relevant to the issue of estimating the benefit of biodiversity protection.

Stated preference techniques rely on the scenario being presented to respondents as plausibly as possible. Only when the question setting is perceived as real will the responses generated be reliable. This implies that stated preference techniques are usually employed to generate estimates of the total economic values associated with proposed changes in resource allocation. The various components of benefits generated by a change are not usually distilled. The overall change in resource allocation is what constitutes a realistic setting for a question and so it is the benefit generated by that overall change that is estimated.

In a CVM application, the only data that are generated relate to the overall value of one proposed change. However, with a CM application, estimates of the benefits of multiple proposed changes can be generated. By varying the levels of the attributes to reflect different resource allocation outcomes, the benefits associated with each of those outcomes, relative to the status quo, can be estimated. If the attributes are designed to reflect specific components of the overall benefit, then by selectively varying specific attributes, the contribution made by each benefit component can be estimated. Hence, if elements of biodiversity protection can be presented as attributes of the alternatives put before respondents, then the benefits associated specifically with those elements can be estimated.

This CM capability is illustrated in Table 1. Selected results from an application to the Macquarie Marshes, a wetland of international significance located in Central Western New South Wales, are presented[10].

Table 1: Benefit estimates for alternative wetland management strategies-Macquarie Marshes

Attribute	Status Quo	Alternative 1	Alternative 2	Alternative 3
Irrigation employment	4400	4400	4400	4400
Wetland area (sq km)	1000	1000	1000	1250
Frequency of bird breeding events (years)	4	4	2	2
Endangered and threatened species present	12	20	20	20
Benefit ($ per household)	-	22.41	69.01	79.89

[10] The study reported here is detailed in Morrison, Bennett and Blamey (1998).

Alternative 1 differs from the existing situation in that 20 instead of 12 endangered and threatened species would be found in the wetlands. This would be a significant increase in the biodiversity present in the Macquarie Marshes. The CM results indicate that the benefit associated with this improvement is estimated to be $22.41 per household[11]. If biodiversity is defined as being broader than simply species diversity, then it is possible to take this into account in the benefit estimation process by changing other attribute levels.

Alternative 2 involves an improvement in the frequency of bird breeding events (from once every four years to once every two years) as well as the improvement in species diversity. The benefit afforded by this alternative relative to the status quo is $69.01 per household.

Alternative 3 involves an increase in the area of the wetland from 1000 to 1250 sq km, in addition to the improvements contained in the first two alternatives. This scenario yields a benefit estimate of $79.89 per household.

Another option for using CM results to gain an appreciation of the components of benefit estimates is through the implicit prices of the attributes. Implicit prices are the marginal rates of substitution between the non-monetary attributes that are used to describe resource allocation options and the monetary attribute. They reflect the willingness of respondents to pay for single unit improvements in the non-monetary attributes, ceteris paribus.

The implicit prices for the Macquarie Marshes attributes are set out in Table 2.

Table 2: Implicit prices of wetland attributes – Macquarie Marshes

Attribute	Implicit Price	95% CI lower bound	95% CI upper bound
Irrigation employment	$0.131	$0.04	$0.21
Wetland area (sq km)	$0.044	$0.03	$0.06
Frequency of bird breeding events (years)	$23.301	$17.15	31.02
Endangered and threatened species present	$3.76	$2.52	$5.12

Hence an additional endangered or threatened species inhabiting the wetlands is estimated to benefit a household by $3.76. Additional wetland area is estimated to be worth about four cents per sq km to a household, but improving the frequency of bird breeding events appears to be particularly beneficial. Note that the CM application integrated respondents' preferences for employment creation/destruction into the

[11] The benefit estimates reported are equivalent to present values. The payment vehicle used was a one-off payment of a surcharge on water rates to be used to buy back water entitlements from irrigators. The survey that generated these results involved a sample of Sydney residents.

analysis of wetland benefits. An additional job provides a benefit to respondent households (who will experience no direct gain from that job) of around 13 cents.

In another CM application, Blamey, Bennett, Morrison, Louviere and Rolfe (1998) estimated the implicit price of an endangered species in the Desert Uplands region of Central Queensland at $11.39 per household[12]. The value of a percentage decline in the population size of non-threatened species was estimated at $1.69 and a drop of one percent in the area of unique ecosystems was found to be worth approximately $3.68 per household. Again, these estimates can be related to the various components of benefit that are generated by biodiversity protection.

There are significant caveats to CM, many of which parallel the caveats associated with the use of CVM. Like CVM, CM is prone to problems associated with the framing of the issue under analysis. What this means is that, whenever questions are asked of respondents regarding a specific environmental issue, there is a danger that the answers provided will be based on an unrealistic understanding of the relative importance of the issue under analysis. The immediate issue, by being the subject of the questioning, achieves an inappropriate prominence in respondents' minds. Upwardly biased benefit estimates may result.

There are many and varied biodiversity protection policy issues facing decision makers at any particular point in time. Performing separated stated preference benefit estimation exercises for each issue raises the dual problem of cost and inappropriate framing. Too many biodiversity protection initiatives may result. What is required is a benefit estimation process that is able to:

- identify the relative merits of protection initiatives so that some ranking of potential projects can be established; and,

- determine the appropriate point down the ranking list where the additional costs of protection exceed the additional benefits generated.

Choice Modelling provides some potential in this regard because choices in a CM questionnaire can be structured to make explicit the alternative biodiversity protection initiatives that are available and under consideration by policy makers. For example, Rolfe (1998), in a CM study of the values Australian residents hold for international rainforest protected areas, found that changing the "frame" of alternative options resulted in significantly different part worth estimates. Where the questioning "frame" did not involve sufficient Australian rainforest protection options, the value of "extremely rare" rainforest areas was $68 higher than areas which were only "fairly rare". A more appropriate frame yielded an estimate of $24. This type of research is only in its infancy. Much has yet to be achieved.

8. Conclusion

This paper has attempted to outline the issues involved in defining and estimating the benefits of biodiversity protection. Choice Modelling, an innovative non-market

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[12] Sampling for the Desert Uplands application was undertaken in Brisbane. The payment vehicle used was a levy on income tax.

valuation technique able to provide a more detailed understanding of the components of environmental benefits, has been demonstrated. Application of this method will give a better knowledge of the extent and composition of peoples' preferences for biodiversity protection.

Biodiversity protection, while a commonly used justification for nature conservation initiatives, is difficult to define and its benefits difficult to estimate. The CM technique provides a significant breakthrough in our appreciation of biodiversity protection benefits however, its application is yet to be fully developed. Research effort now needs to be directed to the task of benefit estimation to determine priorities for the application of biodiversity protection effort.

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