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Designing choice experiments to incorporate tests for geographic scale and scope differences

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1. Introduction

The focus of this report is to outline the design of EERH Project #2: Estimating protection values at general and case study levels in Theme D: Valuing Environmental Goods and Services. The project is aimed at estimating protection values for the Great Barrier Reef (GBR), which for the purposes of this study incorporates the Great Barrier Reef Marine Park and the Great Barrier Reef World Heritage Area. The GBR is the largest coral reef ecosystem in the world and one of the world's most important natural assets (GBRMPA 2006). It spans nearly the whole length of the Queensland coast which makes it particularly vulnerable to the impacts of land-based activities. Many Australians are likely to view the GBR as an iconic natural asset, wishing to both enjoy some of the services it provides and see it protected into the future.

Concerns about the impacts of poor water quality in the GBR have been expressed in a number of recent studies and reports (Furnas 2003; GBRMPA 2008; Haynes et al. 2007; Productivity Commission 2003; Science Panel 2003; SQCA 2003). The GBR is coming under increasing pressure from activities within the area such as recreation, fishing, and shipping, and pressures from activities in adjacent areas such as agricultural and urban development. There are also concerns about impacts such as rising sea levels and higher temperatures from potential climate change. A number of initiatives such as increasing the area of green zones and controls on recreation and fishing activities have already been implemented. While further protection measures are possible, a case would need to be made that the benefits of increased protection were sufficient to justify the investment and associated costs.

In this case study, choice modelling (CM), a non-market economic valuation technique, will be used to assess community values and preferences to increase protection of the GBR. The size and diversity of the GBR and complexity of the different impacts means that the analyst has substantial choice about the way to frame a CM experiment. A study might be focused on different sections of the GBR, on different components of environmental improvement, and on different mechanisms to achieve improvements.

In this report, some of the considerations in selecting, describing and combining attributes to incorporate tests for geographic scale (size) and scope (complexity) differences into the design of the CM survey instrument are discussed. Here, the following definitions are offered to clarify the concepts involved: The **scope** of a good involved in a stated preference experiment refers to the elements used to define the good and the tradeoffs involved, the **scale** refers to the quantities involved, and the **framing** to the context in which the choices are made. **Scope** in relation to a CM study of the Great Barrier Reef will relate to the dimensions used to describe the good, including the choice of attributes and the policies with which they are applied. **Scale** in relation to a CM study of the Great Barrier Reef will relate to the amounts of the good involved, with **geographic scale** focused on the magnitude of the good under consideration (e.g. individual reef, region or whole reef), while **attribute scale** will describe the levels of the attributes (e.g. 100 or 1000 hectares).

Understanding the influence of scale and scope in a valuation context is an important part of assessing the suitability of values for application in subsequent benefit transfer.

The context in which a CM survey is framed can influence preferences (Rolfe et al. 2002) and a range of CM studies have now been conducted to incorporate tests for geographical scale and scope differences. However, the results have been mixed. For example, while van Bueren and Bennett (2004) show that values differ significantly between regional and national contexts, Rolfe and Windle (2008) found that the same value estimates could be used between regional and state contexts. For the GBR, a key question is whether the same value estimates can be transferred between local, regional, and whole GBR contexts.

There are several issues of complexity that are also relevant to the GBR context. These include choices about the best way of summarising the description of the GBR into key attributes and presenting choices to respondents, the level of protection that will be generated with different management options, and the level of uncertainty that may be associated with different protection measures. While these issues are relevant in the GBR, there has been limited research about how dealing with them in the context of non-market valuation techniques.

A more detailed review of scale and scope issues and the application of CM will be presented in a separate research report (Report 2), while the issues associated with incorporating issues of risk and uncertainty in CM experiments will be reviewed in Report 3. The focus of this research report is to provide an overview of the key issues of interest in the project and the tests to be performed to address these issues. The issues and tests can be summarised into three broad groups:

1. Scale differences – testing for value differences between the whole GBR; a regional section; and a local section;
2. Scope differences – testing for value differences when the changes in the GBR condition are described or summarised in different ways, and
3. Input and certainty differences – testing for value differences when the changes are achieved with different management options with different levels of risk and uncertainty.

The report is structured in the following manner. In the next section, the selection of attributes to describe the GBR is discussed, including options to have a single condition index or to 'unpack' the description of the GBR into specific attributes. The next section is focused on options to include scale tests in the survey design. This is followed in section three with a discussion on testing how protection values might vary with the scale of the GBR involved, and how this can be presented in a CM format. The fourth section is focused on how the possible management options available to help mitigate some of the pressure and threats to the GBR can be included within choice profiles. Different ways to include the uncertainty surrounding the impacts of any management actions are also discussed. In the final section, a number of different split sample formats for the CM experiments are presented. These will allow the different tests of interest to be performed, but further refinement with focus group participants will be required as the next step in the valuation design process.

2. Selecting the GBR attributes

A key task in the application of the CM technique is the selection of attributes to represent the most important characteristics and tradeoffs. The GBR is a complex ecosystem, which makes it difficult to encompass in a limited number of representative attributes. There is a tradeoff between choice complexity and information elicitation. If respondents are presented with fewer attributes it may simplify their choice task which could increase respondent participation (either by completing the survey and/or selecting a choice alternative rather than the status quo option). On the other hand, a simple format restricts preference elicitation and reduces the information that can be gathered and subsequently applied for policy development and program evaluation. A simple format may also appear unrealistic to some respondents as it provides insufficient information on which to make meaningful choices[1].

In the context of this study, important insights about attribute selection have been gained in a previous GBR valuation exercise conducted by the authors. The valuation context in that study was specifically focused on GBR attributes, whereas the current study will include other attributes to account for geographic scope and scale differences. This requires some adjustments to be made to the valuation context presented in the previous study.

2.1 Lessons from a previous study

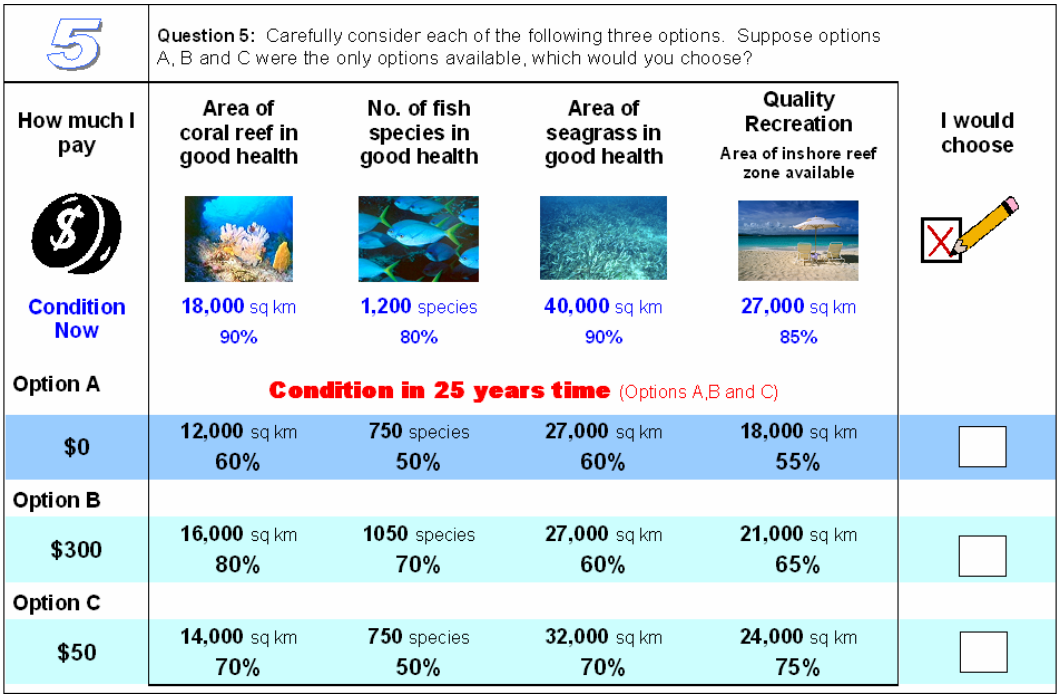
In 2005 a CM valuation exercise was conducted to assess the values for protecting the GBR. Considerable attention was paid to the design and development of the survey instrument and several focus groups were conducted to assist in the process. An example of a choice set used in the study is shown below in Figure 2.1. Although the results of the study were never released, the information gathered in the design stage can be applied to this valuation exercise. The other key contribution from that study is that the results provide information about prior attribute values which can be used to generate an efficient experimental design (Rose et al. 2008). Increasing the efficiency of the design will in turn reduce the sample size required to generate a robust model. This increases the opportunity to run more tests within a given budgetary restraint.

In the previous study, four attributes were used in the CM exercise:

Coral reef (area in good health);
Fish species (no of species in good health);
Seagrass (area in good health); and
Quality recreation (area of inshore reef available for quality recreation)

[1] Results from Hensher (2006) suggest that evaluation improved when the number of choice alternatives increased from two to four, a finding supported by Rolfe and Bennett (2006). Hensher's results also indicated that more attributes can be considered if there are a smaller number of levels. In effect, there is a tradeoff between effort spent on each attribute and the number of attributes and levels involved.

Figure 2.1. Sample choice set from previous GBR study



5

Question 5: Carefully consider each of the following three options. Suppose options A, B and C were the only options available, which would you choose?

How much I pay	Area of coral reef in good health	No. of fish species in good health	Area of seagrass in good health	Quality Recreation Area of inshore reef zone available	I would choose
Condition Now	**18,000** sq km 90%	**1,200** species 80%	**40,000** sq km 90%	**27,000** sq km 85%	
Option A	**Condition in 25 years time** (Options A,B and C)				
$0	**12,000** sq km **60%**	**750** species **50%**	**27,000** sq km **60%**	**18,000** sq km **55%**	☐
Option B					
$300	**16,000** sq km **80%**	**1050** species **70%**	**27,000** sq km **60%**	**21,000** sq km **65%**	☐
Option C					
$50	**14,000** sq km **70%**	**750** species **50%**	**32,000** sq km **70%**	**24,000** sq km **75%**	☐

All attributes were broadly defined to incorporate the range of differences in respondents' knowledge, understanding and perceptions about each attribute. Defining the quality status of an attribute as being "in good health" generally works well in this context and has been applied extensively in a range of other CM valuation surveys. (eg. Morrison and Bennett 2004; Rolfe and Windle 2008; Whitten and Bennett 2004).

The first two attributes were always mentioned by focus group participants and are clearly identified as key components of the GBR. The importance of these attributes means that care has to be taken in selecting other attributes in case the health of *coral reefs* or *fish* is seen as a precondition for other assets to be in good health. In this case the attributes of *coral reefs* and *fish* would act as priors, and other attributes might be subsets of those values.

Including *seagrass* as an attribute was a considered decision. It was included because it is one component of the GBR that is very directly influenced by water quality and land-based activities. Areas of seagrass are also important feeding grounds for dugongs and some turtle species, two of the high profile marine creatures that most people associate with the GBR. In that survey marine mammals/reptiles were included implicitly rather than explicitly in order to avoid attracting high valuations associated with their iconic status. However, seagrass is not a feature of the GBR that is well known to many people, which may have limited the accuracy of responses to the survey.

Recreation was included as an attribute to take some account of how protection values may have been influenced by preferences for current and future use of the GBR, in contrast to the environmental protection focus of the other attributes. However, it was difficult to define as an attribute, with impacts varying widely by usage and

respondent group. There were also issues of potential dependency with the levels of the environmental attributes.

2.2 Considerations for the current study

There are a number of modifications that can be made to the previous attribute selection. The first two attributes, coral reefs and fish appeared appropriate, and can also be used as key descriptors in this study[2].

While there are relatively few non-market valuation studies on the GBR, more is know about tourism and recreational use values than other non-use values (Rolfe et al. 2005). Rather than include recreation as a separate attribute, it would be possible to include separate questions in to the survey to assess the relative importance of recreational use values and how they may influence other attribute preferences.

The other attribute from the previous study which could be modified is the seagrass attribute. One option would be to give marine mammals/reptiles more explicit emphasis instead of focusing on seagrass. As well as providing more information, a dugong or turtle could be included in the attribute icon. There are two main advantages of keeping a direct association with seagrass. The first is that prior values exist and the second is that the attribute relates directly to water quality impacts. Another option would be to focus completely on marine creatures. The advantage of using a marine creature attribute is that it is very familiar and would have a similar profile as the coral and fish attributes. The main disadvantages are that not all marine mammals/reptiles associated with the GBR are vulnerable to changes in its condition or are more threatened by other factors. For example, humpback whales are not largely influenced by the condition of the GBR.

Marine turtles are a specific reptile that is high profile and impacted by a range of issues, all of which could be improved by with the proposed management options. They are affected by:

- Water quality impacts on seagrass beds;
- Costal development and the loss/destruction of nesting sites;
- The commercial fishing industry and getting caught in nets;
- Climate change and rising temperatures which affect their gender determination; and
- Damage from recreational use (boating – rudder damage, plastic bags, etc).

Dugongs on the other hand are more specifically influenced by water quality and the condition of seagrass beds, with some extra damage from recreational users. A marine mammal attribute could be described to emphasis the importance of turtles and dugongs and include a number of other factors such as the influence of seagrass condition more implicitly. Changing from an emphasis on seagrass to an emphasis on

[2] There was some consideration given to applying a qualitative or quantitative description to the fish species attribute. There are important qualitative differences between fish species, components of which will vary between user groups. For example, certain species are preferred for viewing purposes and others are valued as edible species. Defining fish species in quantitative terms overcomes some of the problems of qualitative definition.

marine creatures could also make the attribute more relevant to a local case study where seagrass beds may not be present. While there are no prior values for marine creatures, it would be possible to apply the seagrass values from the previous study, which included mention of dugongs and turtles.

Given the need to introduce other attributes into the survey design, another option could be to combine all GBR attributes together into a single 'Health of GBR' index. While this would may limit feedback on preferences, and restrict the information that can be associated with different management options, it would have some advantages:

- Policy makers often focus more on the very broad and generic values for an entire environmental asset rather than the component attributes;
- It was an option favoured by focus group participants in the previous survey;
- It would be possible to include mention of biodiversity and ecosystem function in a single generic attribute. These concepts are important but probably too complex to describe effectively as a separate attribute;
- It would avoid potential problems of correlation between attributes and simplify the choice task; and
- It would allow for the inclusion of other attributes.

If a single GBR attribute was applied, it would be useful to compare the results with a split sample survey where the GBR was described in terms of its primary attributes. This would be a type of scope test, where the value for a single attribute (Health of GBR) could be compared to the values of the independent attributes (Coral reefs, Fish, Marine Mammals).

3. Testing for differences in geographical scale

It is important for benefit transfer purposes to know if values for protecting the GBR can be readily transferred between different geographic contexts or if some adjustments are required. This can involve changes in both scope and scale, where the simple change in amount between local, regional and whole GBR levels is referred to as a geographical scale test.

Three broad levels of scale will be considered in the valuation exercise:

- whole of GBR;
- a regional section of the GBR; and
- a local case study.

In the application of a CM experiment, there are two main methods to test how community values may differ according to the scale of the GBR on offer. The first is to run separate valuation experiments for different geographical scales, while the second would be to incorporate scale as an attribute within a single survey, which essentially embeds the scale tests into the survey design. Within each of these methods, there are a number of alternative ways of presenting and testing for geographic scale differences. These are summarised in Table 3.1.

Table 3.1 Options to test the influence of geographical scale

#	Option	Considerations
	A single geographic scale offered in a survey	
1	Split-sample experiments where different geographic scales of the GBR are offered in separate versions of the surveys	Standard way of conducting tests Doesn't always help to reconcile scale differences Respondents may not always focus on the scale offered, particularly for an iconic asset such as the GBR Can be used for comparison with other formats
2	Single broadscale survey plus framing statements to keep whole GBR as the context for different experiments	Respondents reminded that the values generated from the experiment will be used for different scales May be confusing and increase choice burden for respondents Very difficult to be sure what frame respondents are adopting
3	Single broadscale survey plus post-hoc exercises	Respondents complete a single survey and are then asked to identify how values might be apportioned to different scales Clear distinction made between scales Difficulties in designing and ensuring consistency May be difficult to relate apportionment to different attributes
	Different geographic scales are presented within a choice set	
4	Incorporate scale as a primary attribute, common to all choice alternatives	Levels of other attributes need to be adjusted to suit Information assimilation more complex Difficult to set the baseline
5	Incorporate scale as labelled alternatives within a choice set	Attribute levels can be adjusted within an alternative Possible to set separate baselines for each alternative Information assimilation more complex than Option 5 May require larger (unknown) sample sizes if a particular labelled alternative is rarely selected
	Different geographic scales are presented within a survey	
6a	Incorporate scale as a label for each choice set, A mix of different scales offered across choice sets	All alternatives within the choice set relate to the specified label or regional scale Labels can be used to identify scale for the choice set Baselines/status quo can be set to match label
6b	Run separate choice experiments at different scales in the same survey Successive series of choice sets at different scales	Easier to process information than a random grouping Likely to be subject to ordering/anchoring effects Requires 2 or 3 groups in one survey to capture the different scales

Option 1 provides a sound baseline to determine values for the GBR at different levels of geographic scale, such as, whole of GBR, regional GBR and local GBR. It has several advantages:

- Information assimilation will be easier, as all information presented in a survey can relate to one specific geographic scale;
- The design and format of the choice sets will be simplified;
- It provides more opportunity to include a wider range of attributes;
- The results can be used for comparison with other split-sample scale tests.

Options 4-6 embed a scale test within the survey design, requiring respondents to specifically address scale issues in the one survey. This will provide more information on how respondents relate values to scale differences, but there is a tradeoff in terms of additional content and complexity.

Option 4 includes scale explicitly as a separate attribute in the choice set. In this case the level of the attribute would inform respondents about whether the choice profile related to a local, regional or whole GBR level. This option would provide specific values for different geographic scales of GBR protection and information about the influence of scale on other attribute values. This would increase information complexity which in turn reduces the potential to include other attributes. However, the main drawbacks are more technical as:

- other attribute levels in each choice alternative will have to be adjusted to match the regional scale attribute;
- it is not possible to set a baseline level unless the same baseline standard is used for all levels of scale. This would reduce the scale test to one simply of size differences and ignores the complexity of geographical scope differences; and
- framing may be unrealistic as declines in condition of the GBR manifest at the local and regional level rather than across the whole GBR (GBRMPA 2008).

Option 5 presents scale as an explicit label for each choice alternative. This option has some advantages over Option 4 as it is easier to adjust attribute levels to suit the context of each labelled alternative. It is also possible to set a separate baseline for each labelled alternative. The main disadvantages are that the presentation of different scale labels within a choice set increases the complexity of the choice task, and it may be difficult to specify a status quo option that relates to alternatives at a different scale.

Option 6 incorporates geographic scale as a label within a survey, but minimises some of the complexity by grouping the tradeoffs to reduce complexity, either by presenting a choice set at a time (Option 6a) or by groups of choice sets (Option 6b). Respondents would need to be provided with background information for each scale level and advised that different choice sets will be presented which relate to different geographic scales. The format has the following advantages:

- The scale label for each choice set would be easily presented in a graphic (map) form at the top of each choice set, clearly identifying the relevant scale for respondents; and
- Baseline and attribute levels could be set specifically for each scale level.

Offering the different scaled choice sets in blocks (Option 6b) should minimise choice complexity for respondents For example, the design might include six choice sets, where three sets relate to the whole of the GBR and three relate to a local GBR situation – or two relate to the whole GBR, two relate to a regional section and two relate to a local section. The main disadvantages with the grouping option are that respondents do not explicitly make tradeoffs between alternatives at different scales, and choices are likely to be influenced by anchoring or ordering effects. It would be important to alternate the ordering of the different label groups or experiments to identify any effects.

Overall, it would appear that there are four main options available, being Option 1, Option 5, Option 6a and Option 6b. The standard approach of split-sample experiments at different scales (Option 1) would provide good baseline information on which to compare other methods, but is expensive in terms of survey collection costs and limits the potential for other methodological tests to be conducted. Option 5

is the most robust in terms of asking respondents to explicitly consider tradeoffs at different scales, while Option 6a and 6b make the choice tasks more manageable.

3.1 Selecting and defining the scale attribute levels

A key issue in testing for geographic scale differences is to define how differences in scale can be presented to survey respondents. There is variation in the characteristics and condition of the GBR across regions and within each region at a local level, which would suggest a multiple level geographic scale attribute might be more appropriate. These differences include:

geographic differences in regional GBR characteristics;
geographic differences in the regional catchment areas;
regional and local differences in the condition of the GBR,
regional differences in pressures and threats from land-based activities;
local patterns and pressures of GBR usage; and
future trends in land-based pressures.

For management purposes, the GBR region is classified into four regions (Table 3.2.). The adjacent catchment areas are divided into seven different natural resource management (NRM) regions (Table 3.2), with management groups that operate to improve resource use. Among their charter is the minimisation of impacts and pressures on the GBR.

There are two main factors to consider in deciding the most appropriate number of attribute levels for geographic scale and the reference points for those selected – the research priority and respondents' familiarity with the issues. The latter is important to consider if respondents are to make realistic and informed choices.

If the research priority is to provide insights into value differences between the three main levels of geographic scale then only three attribute levels need to be considered. The main issue then is to determine which region and local case study are used as the reference. If on the other hand it is important to explore valuation differences within a level of geographic scale, then a subset of attribute levels will need to be applied. For example, the following classification could be applied to identify differences in protection values between regions of the GBR:

North (Cairns/Cooktown);
Central (Townsville/Whitsunday); and
Southern (Mackay/Capricorn).

It might prove easier to unpack the regional scale into a subset of regional components, compared with the local scale. For local case studies the generic attributes of Coral reefs, Fish and Marine Mammals may not be specific enough to capture the relevant tradeoffs. Attention will need to be paid to the appropriate description of local case studies and whether they should be sub-regional areas (i.e. the Whitsunday region or the Burdekin inshore area) or an identifiable area (a specific reef).

Table 3.2 Options for regional and local scale attribute levels

GBRMPA Management Areas	NRM region	Local attribute level	Key pressures
Far northern	Torres Strait	No well known example	Minimal - GBR in most natural state
Far northern	Cape York	No well known example	Minimal - GBR in most natural state
Cairns/ Cooktown	Far North Qld	Single reef off Cairns	High tourism impact
Townsville/ Whitsunday	Burdekin	- Townsville inshore area - Single reef - Burdekin estuary area	- Water quality impact: agriculture & coastal development - Large catchment area
Townsville/ Whitsunday Mackay/ Capricorn	Mackay Whitsunday	- Whitsunday islands - Whitsunday inshore area	- High tourism impact - Water quality: agriculture & coastal development
Mackay/ Capricorn	Fitzroy	- Fitzroy estuary area including Keppel Bay and islands - Single Is – Keppel Is	- Water quality: agriculture - High recreational fishing impact - Future tourism and coastal development - Large catchment area
Mackay/ Capricorn	Burnett Mary	- Single reef - Inshore area	Water quality: agriculture and coastal development

Respondent familiarity should also be considered. Given the complexity associated with some of the design options outlined above, it will be important to consider respondents' familiarity with regional and local issues within the GBR area, as this may restrict the extent to which a multiple level attribute for geographic scale can be implemented. There will be at least two population samples in the CM survey – a local GBR community (eg. Townsville) and a remote community (eg. Brisbane). It is likely that most respondents in a local GBR community will be familiar with the issues associated with both a regional and a local section of the GBR in their area. It would be expected that they would have stronger preferences for environmental improvements in their own region compared with other regions of the GBR.

Respondents in a remote location are unlikely to be familiar with regional differences and distinctions. Most will probably only be familiar with high profile tourist destinations. It is not known how their preferences may vary across different regional contexts. This means any subregional classification will need to be simple with a very clear differentiation between distinguishing characteristics.

4. Including management options and outcome uncertainly (scope differences)

Another key focus of the GBR valuation study is to identify how values may be sensitive to different ways of scoping the tradeoffs. Here, two key aspects of scope are considered, which are inter-related to some extent. The first is to identify the tradeoffs by the input measures used to achieve them. This can be done by describing the effects of different management options that can be implemented to help improve the protection of the GBR. The second is to identify the level of certainty associated with each choice alternative. As there is some relationship between the method of achieving protection and the certainty of outcome, these two aspects of scope will normally need to be jointly presented.

Johnston and Duke (2007) report one case study where the willingness to pay for agricultural land preservation varied with the policy mechanism employed. The choice experiment involved six attributes, one of which identified the policy technique and implementing agency. The land preservation could be implemented by either preservation contracts or outright purchase with either the state government or land trusts, or by conservation zoning. The results demonstrate significant differences in values, with conservation zoning the least valuable implementation option, and a land trust conservation agreement the most valuable implementation option.

Each region within the GBR area is subject to different pressures and threats from land-based and other activities. Some regions are more susceptible to episodic or catastrophic events and some regions are more vulnerable to the impacts of these events. The potential impacts of climate change (such as coral bleaching) are presenting new challenges to ecosystem resilience and may be associated with increased frequency of episodic and catastrophic events. These impacts will be more consequential in areas of the GBR that are already more vulnerable and at risk from land-based and other anthropogenic activities.

The principal pressures from land-based activities come from the agricultural sector and coastal development. Impacts on water quality and increased sediment, nutrient and pesticide loads are the main threat from agriculture. Coastal development can result in a wider range of impacts such as:

habit loss;
water quality (stormwater, sewerage, erosion during development);
hydrological changes; and
increased local recreational use – onshore and offshore.

Pressures from agriculture and coastal development are common across all GBR regions, apart from the far northern section where human activities have little influence. This means that there may be little regional variation in the outcomes of broadly defined mitigating activities. For example, reducing the impacts of water quality from agriculture or coastal development will have the same benefits in all the main regional sections of the GBR identified above. However, there may be important distinguishing differences at a local level.

There are four main factors to consider in assessing the relative impacts of management mitigating activities. The first is the level of detail associated with the

activity. For example, water quality impacts in the Burdekin estuary result from nutrient, pesticide and sediment loads, whereas in the Fitzroy estuary mouth, sediment loads are the main water quality issue. If a mitigating strategy focused on sediment reduction or general water quality improvements from agriculture, both the Burdekin and the Fitzroy would benefit. If the focus was only on nutrient or pesticide reduction then the benefits would be greater in the Burdekin.

The second issue to consider is current trends and the influence that certain land-based and other anthropogenic activities may have in the future. This will be of particular importance if a future baseline is used in the valuation context, which is common practice. There has been considerable effort and public funding directed at addressing issues of water quality from agriculture and other sources, while there has also been more direct controls over fishing and recreation impacts. The interplay between the effectiveness of those measures and future pressures on resource condition will determine trends in condition.

The third issue concerns the impacts of mitigating activities on particular components of the GBR. For example, increasing fishing restrictions will almost exclusively impact on fish stocks, with some additional benefits of reduced by-catch and boating damage. In contrast the benefits of improving water quality from agriculture will be more wide-ranging, more influenced by local conditions and involve significant time lags. For example, water quality improvements are likely to provide improvements in the condition of seagrass beds; the importance of which vary from place to place. In turn there will be a direct flow on benefit for dugongs and an indirect benefit for some species of marine turtle. There may also be beneficial impacts for coral in some places as well as other GBR flora and fauna.

The fourth issue relates to the uncertainly surrounding the outcomes associated with different mitigating activities. These are discussed in the next section.

4.1 Selecting the management mitigating options

There are a range of different mitigating activities that could be undertaken to help maintain (prevent future deterioration) or improve the condition of the GBR. Threats to the GBR can be classified into three main groups:

1. Land-based activities (eg. agriculture; coastal development);
2. Anthropogenic activities within the GBR area (eg commercial and recreational fishing; tourism, shipping); and
3. The impacts of climate change.

Within each of these areas, there are a number of mitigating activities that could be undertaken (Table 4.1).[3]

Including all these options in a management attribute would be unwieldy. The main options to include in a management attribute are:

1. Land-based activities
    a. Agriculture – reduce water quality impacts
    b. Coastal development – reduce water quality impacts

[3] Identified and discussed at a workshop with GBRMPA staff on April 8th 2008.

2. Activities within the GBR
    a. Fishing – increase restrictions, particularly for recreational fishing
    b. Tourism – increase restrictions on development and activities
    c. Coastal development – increase restrictions on recreational use
3. External influences
    a. Reduce carbon emissions

Table 4.1 Selecting levels for a management option attribute

Activity	GBR impact	Considerations
1. Land-based activities		
Improving water quality from agriculture	inshore coral seagrass beds some marine mammals fish recruitment crustaceans	a familiar issue management changes can have an impact some improvements already implemented some specific causal relationships between WQ and GBR impacts are still unclear time delays
Reducing the impact of coastal development	inshore coral seagrass beds some marine mammals fish recruitment recreation impacts	rapidly expanding local economic benefits of development local onshore and offshore recreation a range mitigating activities need to be applied to address different issues
Improving water quality from aquaculture	inshore coral seagrass beds some marine mammals fish recruitment	substantial growth in the last decade but little development within the GBR 2004 GBRMPA Aquaculture Compliance Audits indicated few non-compliance issues – many associated with non-environmental permit conditions such as monitoring requirements
2. Activities within the GBR		
Restricting fishing (commercial and/or recreational)	fish stocks by-catch boat damage	reductions in commercial fishing effort have already been made recreational fishing effort is increasing particularly in some areas with coastal development recent increases in Green Zone coverage
Restricting offshore tourism/tourist development	localised impact on coral and associated species affects range of GBR attributes	heavy tourist use can have adverse impacts on the GBR and the industry (reduced quality of experience) growing tourism demand might be better to restrict future development to particular areas could have negative impacts on local economies
Control over shipping	oil spill would affect range of GBR attributes	there have been few major events/oil spills potential impacts could be great impacts would be localised
Increased bio-security vigilance	could be great hard to predict	often associated with recreational and commercial shipping/boating and illegal fishing activity main threat in far northern section
3. External influences		
Climate change mitigation – reducing carbon emissions	coral bleaching best known future threat of increased ocean acidification rising sea levels rising temperatures	precise impacts of climate change remain unclear unclear if specific actions would have any noticeable impact reducing carbon emissions at a local level may have little impact on the GBR reducing carbon emissions is a familiar and acceptable mitigating activity time delays

These activities could be tailored to differentiate between inputs at the regional/local level and between outputs (eg. impact on fish or impact on coral). Another possibility would be to focus on more broadly described management options which could be applied to address a range of pressures and would have a broader range of outcomes. For example, activities within the GBR could be addressed by a single management option to "increase protected areas" which could be applied to reduce the threats of fishing; tourism and recreational use. This would result in four main management options (or three if the first two are combined).

1. Reduce water quality impacts from agriculture;
2. Reduce water quality impacts from coastal development;
3. Increase protected areas within the GBR; and
4. Reduce carbon emissions.

4.2 Including uncertainty about management outcomes

There are different levels and aspects of uncertainly associated with the management options suggested above. Increasing green zones (protected areas) is likely to have a reasonably certain and immediate beneficial impact. Fish populations have more than doubled in the short time since areas were designated as a green zone in 2004.[4] In contrast, reducing carbon emissions will have a very uncertain impact on the GBR. Although there is considerable uncertainly associated with predicting environmental outcomes, few CM valuation studies have explicitly addressed the issue. Roberts et al. (2008) compared two CM split samples where in one sample, probabilities were attached to the environmental outcomes described in the attribute levels (eg. 10% chance of algae bloom). The results showed that consumer preferences were significantly affected by the inclusion of uncertainty in the choice model.

There are a number of different ways an uncertainty attribute could be described in a choice set. These could include:

1. Using a percentage likelihood that the described outcomes would occur. A range of levels could be applied which differ from one management option to another.
2. Applying a range of values rather than a single number for other attribute levels within the choice set. Increased uncertainly could increase the potential range.
3. Identify the time involved for a specific management action to generate a beneficial outcome.
4. Applying a simple descriptive attribute that related at all management options and outcomes, such as:
    a. Certain outcomes
    b. Somewhat certain
    c. Very uncertain.

The issues involved in incorporating risk and uncertainty into the presentation of choice alternatives will be addressed in more detail in a separate research report.

[4] Brisbane Times 24th June 2008

4.3 Incorporating management and uncertainty attributes in choice design

As discussed above, depending on how they are described, the management options may impact differently in different regions of the GBR and on the different primary GBR attributes within a region. There is some relationship expected between the types of management actions and certainty with which outcomes are achieved. There will also be relationships in some cases between management actions and changes in specific attributes. These relationships create specific issues in the design of a CM experiment because the management action is not independent from the outcomes.

There are several options to address the design issues. A key option is to include management actions as labelled alternatives rather than simply as an attribute. This would allow the levels of other attributes, including a 'certainty' attribute, to be tailored to each management alternative. However, this may limit the potential for alternatives to be labelled by the geographic scale, as discussed in an earlier section.

A second option is to condense the description of the GBR into a single 'Health of the GBR' index. This would reduce the need for the relationship between management actions and GBR condition to be identified, and make it easier to present management options and condition as more independent.

5. Summary and potential design options

In the sections above, a range of possible scope and scale attributes have been discussed for inclusion in a CM valuation exercise. In each case, there has been some discussion about the tradeoff between content and complexity. This problem will be confounded when all desired attributes are combined together. Potential design options will need to be pre-tested in some detail at community focus groups to identify cases where complexity of the choice sets becomes problematic to respondents. A number of the potential design options and associated issues are summarised in Table 5.1.

A simple presentation of the main options outlined above is outlined in Table 5.2 and would mean the following tests for scope and scale differences could be applied.

Population test 1: Testing if there are differences between major population groups – compare Option 1a with Option 1b

Scale test 1: Test if difference with different scales – compare between split-samples in Option 1a

Scale test 2: Testing scale as an internal or external focus – compare Option 1a with Option 2a.

Scope test 1: Testing the influence of management options and uncertainty on preferences and values – compare Option 3 with Option 1a.

Scope test 2: Testing the influence of attribute packaging – compare Option 4 with Option 3a.

Scope test 3: Testing the influence of a single management focus – compare Option 5a or 5b with Option 3a.

Scope test 4: Testing the difference in preferences for inputs and outputs Option 5b.

Table 5.1 Attribute selection and combinations

#	Option	Attributes	Labels	Comments
1	Standard single scale, split samples across regions	Coral, fish, marine creatures	None	Test how values are consistent according to geographic scale 3 split samples required: Whole GBR, Regional GBR, Local GBR
1b	Population test across two centres	Coral, fish, marine creatures	None	Test if values are consistent between a local and distant population Townsville and Brisbane Additional 3 split samples required
2a	Different scale choice sets in same survey	Coral, fish, marine creatures	Choice sets are labelled for scale	Single survey has choice sets for whole, regional and local GBR No of sets needs to match #1 Randomise order + test for effect
2b	Different scale alternatives in choice sets	Coral, fish, marine creatures	Scale labelled alternatives	Labelled choice sets by scale May be too complex for respondents #2a better comparison with #1
3a	Single scale, additional attributes	Coral, fish, marine creatures, management, uncertainty	None	Use regional scale – eg Burdekin Compare with #1 – effects of extra attributes on primary GBR values
3b	Single scale, management labels, risk attribute	Coral, fish, marine creatures, uncertainly	Management labelled alternatives	Easier to apply if mngt option affects attribute levels Could use mngt labelled sets #3a better comparison with #1
4	Same as #3	GBR – single attribute, management, uncertainty	None	Compare single GBR attribute with primary components
5a	Specific case study area, single management focus	Coral, fish, marine creatures	none	Burdekin region WQ from agriculture Focus on outputs associated with single management option
5b	Specific case study area, single management focus	Coral, fish, marine creatures + Sediment, nutrient, pesticide	none	Focus on outputs and inputs Inputs labelled by change in key pollutants Need to relate change in pollutants to outputs Need to present input and output measures in same survey

Table 5.2 Valuation format and context for different options

Option	Scale	Management	Uncertainty	GBR outputs	GBR inputs
1	External			unpacked	
2	Internal			unpacked	
3	Single	x	x	unpacked	
4	Single	x	x	packed	
5	Single	x		unpacked	x

The next stage in the project will be to test these different design options at community focus groups. As well, some prior values for certain attributes will need to be collected to generate a more efficient experimental design to underpin the choice selection process.

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