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Putting the Spotlight on Attribute Definition: a knowledge base approach

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Abstract

Attributes definition is a crucial, yet neglected topic of critical inquiry in the choice modelling literature. In a policy context, attributes should reflect public interests. However, guidance on how to go about achieving this criterion is lacking. To address this concern, we offer a novel approach to attribute definition – the knowledge base approach. A knowledge base is the particular 'lens' through which a shared understanding of a topic is gained (i.e. different groups of people view the world in different ways). Knowledge bases have been used in evidence-based policy to account for different sources of information and perspectives in complex policy settings, with the intention of improving policy and program development. The knowledge base approach was applied to the design of a choice experiment, specifically looking at conservation priorities for the waterways and wetlands in the Kimberley region of Western Australia. We conclude that the approach is both comprehensive and expedient, and could improve the selection of attributes for choice experiments that value policy or program change.

1. Introduction

Choice modelling is a survey based technique that is used to estimate how people value, and make trade-offs between, different goods or policies. In a choice experiment, respondents are presented with a number of questions called choice scenarios. Each scenario is comprised of a number of hypothetical options, or alternatives, that offer variants of the good or policy. The alternatives comprise of a set of *attributes* that define the good, and respondents are asked to choose their most preferred alternative. The appeal of choice modelling comes from the ability to identify the marginal values of the attributes and the willingness to pay for any alternative of interest (Alberini *et al*. 2007).

Defining the attributes is a key stage in choice experiment design. All subsequent activities carried out in a choice study are influenced by the attributes chosen. Ideally, attributes are selected for inclusion in a choice experiment because it is known or hypothesised that they play a major role in the choice behaviour of interest (Louviere 2001). In previous literature, criteria for selecting attributes are limited to the following:

1. Attributes should be *relevant* - that is, a given set of attributes should (1) reflect public interests, (2) have a sound scientific basis, and (3) provide useful information to end-users (e.g. Blamey *et al*. 2000; Morrison *et al*. 1997)

2. Attributes should not be *causally prior* – that is, a given attribute should not be viewed as an 'upstream' condition that has to be satisfied before changes can occur elsewhere (Rolfe and Wang 2008, p. 14). Water quality is often used to illustrate this point, where improved water quality is seen as a precursor to improved fish stocks or recreation opportunities.

The use of focus groups has also been recommended for defining and selecting attributes. In particular, Rolfe and Bennett (1995) suggest that focus groups should be used to: (1) ascertain the extent of knowledge that people have about particular goods, and the ways in which they value those goods; and (2) identify and describe the major attributes that people consider when valuing particular goods.

Despite having these guidelines in place, a review on the topic by Cleland and McCartney (2010) suggests that:

1. Attribute selection and framing is typically dominated by expert judgement, and researcher discretion prevails.

2. There may be cases where causally prior attributes cannot be omitted. The issue of causally prior attributes may be better dealt with by making a more concerted effort to model attribute interactions through advanced experimental designs (Blamey *et al*. 2002).

3. The objectivity of attribute definition may be disputed on the grounds that focus groups are generally not used in a systematic or accountable fashion.

Even where focus groups have been carried out in a sound manner, issues with attribute definition remain. For example, Cleland and McCartney (2010) investigated attribute definitions for members of the public and scientists, with respect to the conservation of key environmental assets across three different environmental systems. Using focus groups and other comparable elicitation methods, the investigation showed that there are some major differences between attributes defined by the public and scientists. Critical points of divergence observed across all case studies included: (1) the way in which the public and scientists defined attributes that represented the biodiversity of the system; and (2) the public's inclination to aggregate attributes when asked to put forward the most important attributes. Additional points of divergence were observed, but these were case specific.

A number of ways to address this divergence have been proposed elsewhere, including a 'mediator process' (e.g. Cleland and McCartney 2010) and the application of economic production theory (e.g. Boyd and Krupnick 2009; Gibson and Burton 2009). However, both have potential limitations. The mediator process entails providing a relevant peak advisory group with attribute lists defined by both experts and members of the public, highlighting points of divergence, and allowing them to negotiate a 'revised' set of attributes. The mediator process is demanding in terms of the time and resources necessary to conduct focus group sessions with members of the public, engage experts, and establish appropriate networks to gain access to the relevant peak advisory group. The process also assumes that the peak advisory group is familiar with the relevant science, and at the same time, is able to adequately capture public sentiments.

The use of economic production theory to depict environmental attributes has only been laid out at a conceptual level (see Gibson and Burton 2009). The approach would involve systematically unbundling environmental systems into a series of endpoints that generate value, and using ecological production functions to link these endpoints. However, there is still the unresolved problem of whether experts and the public have the same endpoints in mind, and whose understanding of the ecological relationships should be used. Further exploration of these issues is necessary, and could possibly be advanced through cognitive modelling experiments that explicitly compare the public's 'ecological mental models' with those constructed by experts.

An unexplored option is the use of 'knowledge bases' to elucidate a set of attributes. A knowledge base is the particular 'lens' through which a shared understanding of a topic is gained and, if appropriate, used for a specific purpose. The concept is being used in *evidence-based policy* to account for different sources of information and perspectives in complex policy settings, with the intention of improving policy and program development.

An evidence-based approach requires the incorporation of 'rigorous and reliable knowledge' into decision-making (Head 2009). In the medical field, where the concept originated (see Cochrane 1972 and the Cochrane Collaboration at <http://www.cochrane.org/>), there is an evidence hierarchy

based on the credibility of different sources of information. For example, meta-analyses and systematic reviews are highly regarded, while case reports are less so. However, application of a strict evidence hierarchy has been criticised: particularly, where the knowledge and experience of professionals with field experience is downplayed (Rycroft-Malone *et al*. 2004).

With politicians now picking up the term evidence-based policy and issuing it as a government mandate (see Wells 2007 and Guenther *et al.* 2010), greater attention is being given to what constitutes as rigorous and reliable knowledge (see the Productivity Commission's 2009 Roundtable Proceedings on the topic of 'Strengthening Evidence-based Policy in the Australian Federation' available at <http://www.pc.gov.au/research/confproc/strengthening-evidence>). According to Head (2009) the knowledge base for policy making and evaluation is diverse. He suggests that scientific knowledge seeks a voice in a competitive environment, jostled by a number of key players in the wider context of social influences (Figure 1). Others have called for 'culturally sensitive' evidence-based policy whereby marginalised and disempowered groups should be considered as a source of knowledge, and also as a point for reflecting upon the underlying values and intentions (including potential biases) of researchers and decision-makers (e.g. Larkin 2006).

Political knowledge	Scientific knowledge	Professional-managerial knowledge	Client and stakeholder knowledge
← The mass media and culture →			

Figure 1. Types of knowledge relevant to evidence-based policy (adapted from Head 2009, p. 19).

The recognition of different knowledge bases underpins calls for 'co-producing policy expertise' (e.g. Corburn 2007) and 'knowledge brokering' (e.g. Bammer 2010). Focused on integration and implementation, proponents aim to bridge the gap between various knowledge bases in order to collectively engage researchers, professionals, decision-makers and the public, and ultimately implement policy that works. Indeed, placing knowledge bases at the forefront of attribute definition could be beneficial – it may offer a framework for selecting attributes that reflect public interests, have a sound scientific basis, and provide useful information to end-users.

This paper provides the conceptual framework for defining a set of attributes for establishing conservation priorities for the tropical waterways and wetlands of the Kimberley region using a 'knowledge base approach'. The policy setting for the case study is complex. This is supported by Jackson *et al.* (2008, p. 275) whom report that 'the values associated with tropical rivers have changed and diversified over time' and conclude that 'tropical river management must now contend with a more complex array of societal values and water management objectives'. Thus, it is not immediately obvious what attributes would be most appropriate for establishing conservation priorities.

The remainder of this paper is divided into a number of sections. Section 2 outlines the foundation for a knowledge base approach. It also briefly describes the method of narrative policy analysis, as a way of elucidating knowledge bases. Three policy narratives are presented, with each offering a refinement in scale. The third narrative provides an overview of the dominant and emergent knowledge bases relevant to the Kimberley case study. Section 3 applies this learning to establish key research questions, and in turn, defines a set of potential attributes for the choice experiment. Section 4 reviews qualitative feedback generated from a choice experiment, with a particular focus on whether the public sample felt that the survey adequately captured public interests, and whether the expert sample felt that the survey had a sound scientific basis. Section 5 compares attributes identified through the knowledge base approach with attributes identified in a series of public focus groups and a Delphi process applied to a panel of experts. Section 6 provides overarching conclusions and next steps to be taken in advancing the knowledge base approach.

The paper contributes to a broader research endeavour that aims to discern whether experts and members of the public place different priorities on key components of the environment. This is being evaluated using a series of choice experiments whereby survey participants (comprising of experts and members of the public) are asked to reveal their preferences for key components of an environmental system.

2. Background

2.1 Knowledge bases – what are they, and why are they relevant?

The notion that knowledge is 'multifaceted', 'heterogeneous' and 'disaggregated' was advanced by the scholarly work of Austrian economists (Vaughn 1994, p. 4). Most notably, Hayek (1945, p. 520) claimed that the economic problem was 'a problem of the utilisation of knowledge not given to anyone in its totality'. Building on this idea, Machlup (1962) classified knowledge into five classes: (1) practical knowledge[1], (2) intellectual knowledge, (3) small-talk and pastime knowledge, (4) spiritual knowledge, and (5) unwanted knowledge. Much of the subsequent economic literature has focused on knowledge as a commodity (i.e. the 'knowledge economy'), as well as the appropriate institutional arrangements for managing knowledge and the production and use of new knowledge (e.g. Adler 2001; Cooke 2001).

The social sciences have also provided various categorisations for knowledge (e.g. Flyvberg 2001). A popular distinction has been 'local' versus 'expert' knowledge. The common view is that local knowledge is embedded in geography and history, and is fixed through an articulation of place and identity. Expert knowledge transcends boundaries – it is applicable anytime and anywhere. Thus, experts have been treated as having a universal sense of what is best for any place (Fraser and

[1] Practical knowledge could be further broken down into: (1) professional knowledge, (2) business knowledge, (3) workman's knowledge, (4) political knowledge, (5) household knowledge, and (6) other practical knowledge.

Lepofsky 2004). Social critiques on the nature of science and its relationship with society suggest that up until recent times, scientific institutions enjoyed relative autonomy provided they communicated their discoveries (Gibbons 1999). However, the value and interest neutrality of scientific research has been called into question. In particular, the growing influence of science in the areas of resource exploitation, nuclear energy and biotechnology has given rise to public fears and disputes regarding the privileged status of scientists (Pellizzoni 2003).

Many avenues for bridging the knowledge-divide have been promoted: literature on the subject has focused on the nature and conduct of street-level bureaucrats (e.g. Lipsky 2010), the role of boundary organisations (e.g. Guston 2001), and regional modes of governance (e.g. Eversole and Martin 2005). However, the largest body of literature resides within the area of participatory democracy. Advocates argue that participation is about 'engaging people in the reasoning and discussion that defines their role as a citizen' (Fiorino 1990, p. 239). More so, meaningful participation of citizens can (1) help with problem characterisation, (2) offer insights about specific conditions, and (3) play a significant role in the consideration of social, ethical and political values (Fischer 2003). However, the process of engaging the public remains a topical area. The various forms of engagement (including focus groups) are vulnerable to criticism on the grounds of representativeness, especially with regards to the influence of individuals with vested interests or those who are particularly outspoken and dominate open forums (Hughes and DuMont 1993). Whilst efforts have been directed towards improving the capacity of those *willing* to contribute, defining the public voice is still a matter of contention (Ryfe 2005).

One topic that has been largely neglected in the participation debate is the notion of 'policy-relevant knowledge'. As noted previously, Head (2009) offers a simple categorisation for the purpose of defining evidence-based policy (Figure 1). However, Tenbensel (2006) provides the theoretical framework to advance the application of such categorisation. Based on Flyvberg and Aristotle's types of knowledge or 'intellectual virtues', Tenbensel (2006) demonstrates that knowledge claims are built around discourses on what is objectively true (*episteme*), what works (*techne*) and what should be done (*phronesis*). Epistemic and technical claims form the basis of long-standing arguments over whether it is more appropriate for policy to be rational versus 'muddled-through' (e.g. Lindblom 1959) or driven from the top-down versus bottom-up (e.g. Sabatier 1986). Phronetic claims provide a legitimate space for evaluating values.

When considering what types of knowledge are relevant to policy, Tenbensel (2008) concludes that is important to keep all knowledge bases covered. Similarly, Stange *et al*. (2001, p. 294) ask their audience to consider the 'junctions of knowledge' which occur between the objective and subjective, as well as the individual and collective. Indeed, Van Kerkhoff and Lebel (2006, p. 453) claim that 'the same issues, events and things observed by people with a different lens will generate different knowledge, and arguments that one is more valid than another are simply that – arguments'.

From this discussion it would appear that different kinds of knowledge exist, and that an inclusive approach is necessary to accommodate the different knowledge claims operating in a particular policy space.

2.2 Knowledge bases – how can we articulate them?

For the purpose of this study, we have indicated that a knowledge base is the particular 'lens' through which a shared understanding of a topic is gained and, if appropriate, used for a specific purpose. As such, it is likely that a knowledge base is derived from a shared set of beliefs, theories, values, desires, etc. Thus, the study of knowledge bases lends itself to the social sciences.

Various methodologies in the social sciences could be employed to articulate the prevailing knowledge bases in a particular policy space. However, it is not the purpose of this study to systematically review or evaluate the applicability of these methods. Instead, we chose a method that we were practiced in its application and which, in our opinion, showed a strong potential for elucidating – in a comprehensive and expedient manner – *a set of knowledge bases for the purpose of defining attributes for a choice experiment*. The method falls under the heading of 'narrative policy analysis' which is based on contemporary literary theory and policy analysis (e.g. Roe 1994).

At its simplest level, narrative policy analysis asks 'what are the fundamental stories that underwrite a pattern of policy decision or action'? It involves the 'systematic inquiry into the relevant characters of the story, their perspectives, structural relationships and strategies' (Lester 1996, p. 658). As such, Roe (1994) suggests that it gives voice to marginal interests in the policy process. This is an important consideration for elucidating knowledge bases – as previously noted, the knowledge base of marginalised and disempowered groups is often overlooked. In a similar line of thought, applying this method may also offer the opportunity to stray beyond the existing categorical representations of knowledge bases (i.e. lay and expert knowledge; political, scientific, professional, client, and stakeholder knowledge; epistemic, technical, and phronetic knowledge).

It is important to note that narrative policy analysis is 'consciously interpretive' whereby meaning is constructed through a process of translation and reconstruction, and the biases of the interpreter may come into play (Lester 1996, p. 658). Thus, the potential for alternative stories must be taken into consideration by the reader.

2.3 Policy narratives

This section presents three policy narratives relevant to the topic. Narrative 1 sets the scene, providing a very brief overview of the dominant and emergent knowledge bases underpinning the establishment of conservation priorities in Australia and elsewhere. Narrative 2 focuses on the management of surface water features in Northern Australia, and reveals what knowledge bases are currently informing policy and planning at a political and institutional level. Narrative 3 brings to light

the messy reality of conservation planning for surface water features in Northern Australia, where there are multiple frameworks for establishing priorities, informed to various degrees by different knowledge bases.

NARRATIVE 1: Knowledge bases underpinning conservation priorities

This narrative highlights that there are a number of distinct knowledge bases in conservation – these are founded on expert rationality, activist ideology, citizen pluralism and indigenous ecology. Each knowledge base has been discounted – to various degrees – on the grounds that it is too self-interested, eccentric, populist, ambivalent, spiritual, etc.

An emerging theme is the increasing emphasis and effort being placed on work at the boundary between knowledge bases.

Background

Various publications are available on the origin and course of conservation throughout time, often with a different emphasis on the role of key actors, institutions and events (e.g. Reiger 1986). Most attention has been directed to the 1960's and onwards, with the 1960's generally recognised as the start of the *conservation movement*.

The conservation movement has been driven by science, society and politics.However, the relationships between science and society, and science and politics, are not necessarily stable – they have changed over time, and in most cases are still evolving (e.g. Lengwiler 2008). This dynamic possibly explains why the conservation movement has not always been united in its priorities.

Indeed, conservation proponents do not necessarily align in their underlying motivations, modes of thinking and means of conduct. This theme will be briefly discussed with reference to experts, activists, citizens and indigenous peoples.

Expert rationality

The 'privileged status' of scientists in environmental decision making has been justified on the grounds that natural resource problems are inherently complex – they require a substantial amount of technical knowledge and precise information to be able to understand them. According to Fiorino (1990) the general public lacks the time, information and inclination to take part in technically based problem solving. More importantly, the public cannot be relied upon to make rational decisions.

The field of cognitive science, with its focus on 'intelligent' behaviour, is the most critical of non-experts in conservation. For example, White (2000) demonstrates through a series of behavioural experiments that lay people have naive conceptions of the way in which food webs respond to perturbations. Whereas experts demonstrate two-way causal thinking, lay people do not adequately

account for the processes of negative feedback operating through interspecies connections that define the structure of the food web. Indeed, the non-expert – whose judgements are subjective and trivial – can be of little significance in environmental conservation and protection (Carlson 2010).

Despite these, and similar claims, scientific advice is not routinely taken on board by politicians. For example, research professor Jessica Meeuwig is quoted in *UWA News* (2009, p. 16) saying:

> Yet despite a multitude of scientific publications on the ins and outs of marine parks – more than 950 articles in the last five years – as well as broader reviews summarising the ecological outcomes, marine scientists are regularly challenged to demonstrate the scientific basis for marine park establishment.

She goes on to argue that research-based academics are well placed for proposing conservation priorities on the grounds that experts are (1) knowledgeable, (2) relevant, (3) credible, (4) independent, and (5) lacking in vested interests. However, citing such virtues underplays the possible role of rent-seeking behaviour associated with 'the relentless need to publish papers, to secure research funding or, particularly for contract researchers, to create some semblance of job security' (Wildson *et al*. 2005, p. 49). Even if rent-seeking behaviour is ignored, Groom *et al*. (2007, p. 302) notes an 'eccentricity' in expert preferences by the way of 'the simple fact that the experts have invested their lives in acquiring the unique information they possess'. They give the example of a scientist who has spent 20 or 30 years digging around in the mud on the bottom of high mountain lakes representing a highly skewed set of preferences regarding this environment.

Wynne (1996, p. 52) argues that 'lay relationships with expertise are ... more sceptical, more ambivalent, and more alienated from expert institutions than is recognised ...' This has seen arguments put forward for a new social contract for science whereby the production of 'reliable knowledge' is replaced by generation of 'socially robust knowledge' characterised by its commitment to transparency and public participation (Gibbons 1999, p.C81). However, there is a call for a more sophisticated level of inquiry into the limits of participation. For example, Lengwiler (2008) suggests that rather than just focusing on the enlargement of actors, there should also be reflection on the eventual closure of consultation processes. In a similar vein, Guston (2001) and Kelly (2003) call for a closer examination of the role of boundary organisations in achieving effective engagement of both scientists and the public. Others remain sceptical: for example, Collins and Evan (2002, p. 271) warn against the 'romantic and reckless' extension of the meaning of expertise.

Activist ideology

According to Fischer (2004 p. 97) citizen movements are said to concentrate on espousing an ideology: 'instead of considering the technical issues at hand, they refocus the analytical process through their ideological lens'. Indeed, from the beginnings of the conservation movement environmentalists understood the importance of finding powerful images to represent ideas that otherwise might be difficult to grasp (Gold and Revill 2004). This has seen increasing contextualisation of environmental problems, whereby environmental activism has not only helped to protect certain

species and areas, it has also helped to market them to an international audience (Buckley 2002). For example, international environmental organisations have put a strong emphasis on global 'hot spots' of conservation, using metaphors such as the 'lungs of the earth' and the 'the treasury of biological diversity' (Peuhkuri and Jokinen 1999, p. 143).

Environmental organisations, such as Greenpeace and World Wildlife Fund (WWF), claim political legitimacy by way of their vast membership which implies representation of at least some of the public (Eden *et al*. 2006). There are also discussions emerging on their scientific legitimisation, with environmental organisations supplementing their 'more traditional roles in campaigning, activism, and ideological consciousness raising' with 'scientific and technical exchange, policy making and policy implementation' (Jasanoff 1997, p. 579). Taking this further, Jasanoff (1997, p. 581) claims that environmental organisations provide the means to 'bridge the lay-expert, activist-professional and local-global divide'. Whilst it has been reported that non-government organisations involved in waste issues in the United Kingdom believe that science is closed to outsiders (Eden *et al*. 2006), a lack of inquiry in this area makes it difficult to draw further conclusions. Irrespective, Jamison (2003) argues that environmental activism has led to the making of 'green knowledge' which is carried out in networks and is produced in relation to specific contexts of application or action.

Citizen pluralism

The popularised terms 'public ecology' and 'citizen science' call for the deconstruction of scientific autonomy where 'ecological scientists, professional environmental managers, and involved citizens are all stakeholders with an essential role to play in developing a body of managerially relevant environmental knowledge' (Hull and Robertson 2001, p. 976). Essentially, it focuses on broadening the boundaries of scientific knowledge so as to 'reflect the pluralistic and pragmatic context of its use' (Robertson and Hull 2003, p. 400).

Indeed, the construction of a citizen science has been advanced by the development of a 'domestically based intellectual elite' and a 'history of philanthropy, independent organisation and volunteerism' (Stone and Denham 2004, p. 6). This has occurred in two spheres: the undertaking of fundamental observational science and involvement in the policy process. However, there is a neglected question of whether the broader public actually wants to be involved in the setting of conservation priorities. A limited number of priority setting exercises in the context of health care have demonstrated that the public is reluctant to make trade-offs (Rosén 2006; Wanna *et al*. 2000) and there is a disutility associated with setting priorities (Coast 2000). In the context of conservation decisions, Morrison *et al*. (1997, p. 18) captured a similar reluctance to engage:

> I'd rather have someone tell me 'look there are so many numbers of birds and this is the cycle that we need ... to have them reproducing ... and this is how much area we need for them to successfully survive' ... I'm worried that a whole lot of people who don't really know anything about it will put all these forms in and then from that data comes the magic number which could be totally wrong ... there must be a very critical number ...

> ... you've got to have some specialist understanding of the whole situation cause otherwise you can't make an acceptable comment. It's not up to the average Joe Blow to be able to come up with the answer to the situation presented to us.

From these quotes it appears that some members of the public are content to accept the preferences of appropriate experts. For some, this finding simply adds merit to the argument that more work needs to be done on conveying the message that conservation is a common good like health, rather than being the exclusive domain of scientists (Horwitz *et al*. 2001). Towards this end, Hull and Robertson (2000, p. 99) suggest that the 'language of nature' needs to be more open so that the public better understands the rules of the game in order to enter into a debate about which nature they want and why.

Indigenous ecology

According to Grimm (1996, p. 88), indigenous refers to 'small-scale societies around the planet who share and preserve ways of knowing ... in particular languages, story cycles, kinship systems, world-view dispositions, and integrated relationships with the land on which they live'. The last element gives rise to what has been termed 'indigenous ecology', 'traditional ecological knowledge' or 'native science', which has been described as an intimate participation with the natural landscape that is 'open to the roles of sensation, perception, imagination, emotion, symbols, and spirit' (Cajete, quoted in Sterenberg and McDonnell 2010, p. 10).

Snively and Corsiglia (2000, p. 7) argue that 'Westerners freely acknowledge the existence of indigenous art, music, literature, drama and political and economic systems in indigenous cultures, but somehow fail to apprehend and appreciate indigenous science'. Reasons for this include the scientific community acting as the 'gatekeeper' of knowledge (Snively and Corsiglia 2000) and indigenous people not readily adopting white techniques of voluntary associations to fight for specific interests (Australian Heritage Commission 1985).

A major argument for the exclusion of indigenous ecology is that it is culture-dependent (whereas Western science operates on universal truths). Its contextual relevance is best captured by Rose (1996, p. 32) who states that:

> Knowledge, in all Aboriginal systems of information, is specific to the place and to the people. To put it another way: one of the most important aspects of Aboriginal knowledge systems is that they do not universalise. Moreover, the fact that knowledge is localised and specific is one of the keys to its value.

Indeed, with regards to environmental management, there is growing acknowledgement that indigenous ecology is 'time-proven, ecologically relevant, and cost-effective' (Snively and Corsiglia 2000, p. 6). Furthermore, Berkes *et al*. (2000) have found similarities between indigenous ecology and adaptive management, in terms of its emphasis on feedback learning, and its treatment of uncertainty. However, issues remain as to how to deal with the 'spiritual, mythological, and even fictional elements' of indigenous ecology (Snively and Corsiglia 2000, p. 15). Although, for some this is

not an issue – embracing indigenous ecology is seen as an awakening in itself: according to Rose (1996, p. 86) '… some have learned to listen to what Aboriginal people say about country. More daringly, perhaps, some have learned to listen to what country says about itself'. A more pragmatic concern is how to apply indigenous ecology more widely to conservation planning: according to Horstman and Whightman (2001, p. 100) it is not as simple as 'adding Aboriginal knowledge to scientific papers, or inviting Aboriginal people on research trips, it is about undertaking management planning with the people who speak for country, on their country'.

NARRATIVE 2: Knowledge bases underpinning water resource management in northern Australia

This narrative highlights that the government's political agenda, especially through the institutions it establishes is a strong determinant of which knowledge bases are given 'a voice' in decision making. With regards to water resource management in northern Australia, there is a political drive for good science to underpin decisions, and subsequently, expert knowledge has been given a strong voice. However, pressures to develop the region bring activist and other knowledge bases to the table. Interestingly, an activist may aptly fit one or more descriptions, such as conservationist, researcher, champion of the region, entrepreneur, indigenous rights crusader, etc. Dual roles may result in less rigid boundaries between knowledge bases.

Background

By world standards, Australia is a dry continent with limited freshwater resources (Whittington and Liston 2003). These features have prompted a familiar sequence in water management philosophy and policy – Australia has moved from an era of pioneering and expansion to an era characterised by scarcity and imminent or actual crisis (Shamir 2003). Today, the majority of waterways in southern Australia have been regulated with many contributing to large regional and inter-regional water transfer projects. Growing demands and extended periods of below-average rainfall have resulted in acute competition between users and locations. At the same time, waterways have become more stressed and conservationists have increasingly advocated the allocation of water to sustain water-dependent ecosystems (see Cullen 1997).

Setting priorities in relation to water resource management is currently of paramount political concern. At a national level this has seen the emergence of guiding principles and objectives for improved water use efficiency (e.g. the *National Water Initiative* signed by the Council of Australian Governments in 2004) and the integrated management of water for environmental and other public benefit outcomes (e.g. *National Principles for the Provision of Water for Ecosystems* set out by ARMCANZ and ANZECC in 1996). At a bureaucratic level, high-level priorities will be delivered through a ten-year, $12.9 billion investment in the Australian Government's *Water for the Future*. Key priorities include: (1) taking action on climate change; (2) using water wisely; (3) securing water

supplies; and (4) healthy rivers and waterways. At least 13 different federal government programs are directly addressing these priorities[2].

One program, Northern Australian Futures, acknowledges an increasing focus on the abundant water resources of northern Australia. Indeed, two-thirds of Australia's runoff occurs in the three drainage divisions comprising northern Australia – the Timor Sea, the Gulf of Carpentaria and the North-East Coast drainage divisions. Whilst there is the potential for new developments (that would rely on significant local and regional water resources) the region also includes a large proportion of Australia's pristine rivers and wetlands, rainforests, eucalypt savannas and native grasslands (Woinarski *et al*. 2007). In this context, conservationists have urged decision makers to learn from the mistakes made in southern Australia (Northern Australian Environment Alliance 2002). At the same time, the Northern Australian Land and Water Taskforce has recognised that there is an opportunity to ensure that development takes place in 'a strategic framework that is ecologically, socially and economically sustainable'. This will be achieved by 'drawing on good science' and the 'knowledge of local communities and stakeholders'[3].

The themes of 'good science', 'the knowledge of local communities and stakeholders', and how the two come together, will be explored in greater detail in the following sub-sections.

Good science

On the 'good science' front the Australian Government has:

- Established the Northern Australia Water Futures Assessment program to provide an enduring knowledge base to inform decisions about development of northern Australia's water resources, so that any development proceeds in an ecologically, culturally and economically sustainable manner[4].

- Established the Northern Australia Irrigation Futures (NAIF) to provide new knowledge, tools and processes to support debate and decision making regarding irrigation in northern Australia[5].

- Established the Tropical Rivers and Coasts Knowledge (TRaCK) consortium to provide the science and knowledge that governments, communities and industries need for the sustainable use and management of Australia's tropical rivers and estuaries[6].

These build on numerous former scientific ventures such as the Tropical Rivers Inventory Assessment Project (TRIAP)[7], the Cooperative Research Centre for Tropical Rainforest Ecology and Management

[2] See <http://www.environment.gov.au/water/>.
[3] See <http://www.nalwt.gov.au/>.
[4] See <http://www.environment.gov.au/water/action/northern-australia/>.
[5] See <http://www.clw.csiro.au/naif/>.
[6] See <http://www.track.gov.au/>.

(Rainforest CRC)[8], and the Cooperative Research Centre for Tropical Savannas (Tropical Savannas CRC)[9]. In addition, there are a number of ongoing initiatives such as the Australian Centre for Tropical Freshwater Research at James Cook University[10]. At the core of all such ventures is the premise that the scientific knowledge base is insufficient and/or too fragmented to support sound decision-making (Finlayson *et al*. 2003; Hamilton and Gehrke 2005).

Knowledge of local communities and other stakeholders

According to Jackson *et al*. (2008) community based management has recently emerged as a popular alternative in northern Australia and is evident in natural resource management with the growth of Indigenous environmental programs (e.g. Aboriginal ranger groups) and the formation of multi-stakeholder catchment management organisations (e.g. Ord River Land and Water). Whilst these groups have intimate knowledge of local waterway issues, it is unlikely that they will be mobilised on a scale where they are seen to have a single, persuasive voice in politics and government policy. For instance, the landcare movement[11] that swept southern Australia throughout the 1990's is unlikely to be repeated across northern Australia – the region is sparsely populated, many pastoral leases have been consolidated under corporate arrangements, and the Indigenous people of the region are disadvantaged in many respects.

Despite the remoteness of northern Australia, a strong knowledge base also exists outside the local community. For instance, the Kimberley Society meets on a monthly basis *in Perth* (some 2500 kilometres south of the Kimberley) to disseminate research and information about the Kimberley. Membership is open to anyone interested in the region, although its 200 members typically have interests in Aboriginal culture, Aboriginal rock art, archaeology, bird watching, botany, bushwalking, conservation, fauna, fossils, geology, history and tourism[12]. Similarly, environmental activist groups have become more involved in research activities to improve their knowledge of the region. For example, WWF secured funding under the Natural Heritage Trust to establish priorities for wetland conservation and management in the Kimberley region. The project set out to 'consolidate existing knowledge', 'fill some important gaps' and 'identify areas where further research is required'. In doing so, it also acknowledged the importance of traditional knowledge and sought to actively encourage dialogue between Indigenous and non-Indigenous natural resource managers[13].

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[7] See <http://www.environment.gov.au/ssd/tropical-rivers/>.
[8] See <http://www.rainforest-crc.jcu.edu.au/>.
[9] See <http://savanna.cdu.edu.au/>.
[10] See <http://www.actfr.jcu.edu.au/>.
[11] The term *Landcare* has come to represent a philosophy of environmental stewardship; a network of community groups; and a government program. The *Decade of Landcare* is the collective name given to a series of government NRM initiatives instigated between 1990 and 2000. One such initiative, the Natural Heritage Trust, gave rise to a riverine improvement program known as *Rivercare* and a water quality monitoring program known as *Waterwatch*. These popular programs were extended beyond the Decade of Landcare, with activities funded until 30 June 2008.
[12] See <http://kimberleysociety.org/>.
[13] See <http://wwf.org.au/ourwork/water/kimberleywetlands/>.

The core interest of these groups is the preservation of northern Australia, both in terms of its natural environment and its culture. There is a strong push for landscape-scale connectivity through the expansion of protected areas and protecting free-flowing rivers from dams and major water resource development (e.g. Blanch 2008). However, some segments of the population hold the view that Northern Australia is a place of untapped development opportunity. In terms of waterways management, there is a perception of abundant water resources going to waste (Jackson 2008). The most prominent example is the ongoing campaigns to transfer water from the Fitzroy River to a thirsty urban population in Perth (i.e. the Kimberley pipeline proposal was a focal point of the 2005 state election campaign). Such proposals clearly demonstrate that 'big rivers attract big plans to tame them' (Sawfish Survival, *Catalyst*, 27 September 2007).

In order to strike a balance in an increasingly political issue, the Northern Australia Land and Water Taskforce was convened by the Australian Government in 2007. The Taskforce was to examine the potential for further land and water development in northern Australia with particular emphasis on future agricultural development (NALWT 2009, attachment A). In doing so, a public consultation process was undertaken. Analysis of 91 written submissions, from a range of sectors[14], revealed the following:

> Relatively few submissions considered the overall context of land and water development in northern Australia, or the sustainability of their proposals or strategies in terms of economic, environmental and social cost-effectiveness. Those which did generally offered a research-based case for consideration. Some indicated the requirement for community engagement around proposals. A clear need for a balance of stakeholder interests in addressing future proposals or strategies was indicated (URBIS 2008, p. 2).

Further to this observation, URBIS (2008) recommended that the Taskforce (1) adopt a sustainability framework, (2) take a precautionary approach, (3) include local Indigenous knowledge, and (4) engage the community in future development proposals. These recommendations, together with criticisms that the Taskforce had focused too strongly on developing the Kimberley's irrigation potential (Government of Australia 2008a), prompted the newly elected government to 'overhaul' the Taskforce placing a 'greater emphasis on tackling the environmental, economic and social challenges facing northern Australia in the 21st Century' (Government of Australia 2008b, p. 1). Today, the Taskforce is described as a 'high level independent group of Australian experts drawn from broad areas including Indigenous business, science, conservation, agriculture and the minerals and energy resource industries'. Politicians have been removed from the Taskforce and 'members are invited to participate in their capacity as private individuals rather than as representatives of organisations'[15].

Here the implication is that *expert* is synonymous with *private individual*. This suggests that the Taskforce is perceived, at least by government, to be a credible knowledge base representative of the diverse public interests in Northern Australia. However, it could be argued that the Taskforce does not fully capture the interests and knowledge base of recreational fishermen and tourist operators in

[14] Submissions by sector: Indigenous organisations 7%; research institutions 8%; environment and conservation bodies 10%; government 14%; industry 20%; and individuals 41% (URBIS 2008, p. 7).
[15] See <http://www.nalwt.gov.au/>.

Northern Australia. On this point, Stoeckle *et al*. (2006) raises the issue of emerging conflicts between agriculturalists and recreational fishermen; and between local residents and tourists. It is also noteworthy that the membership categories do not specifically encapsulate Indigenous culture. This may be due to the fact that it is generally assumed that environmental conservation is complimentary with preserving Indigenous culture. However, there is little research to say whether the two are fully complementary (Stoeckle *et al*. 2006). In terms of water allocation, Jackson (2005) notes that where Indigenous values have been considered, there has been a tendency to assume that a surrogate environmental flow will address cultural requirements. However, it is not clear whether volumetric measures can address the less tangible values between water and identity, heritage, spiritual well-being and belonging.

Science and the local community

The sharing of information sets is often seen as the principle way to merge 'good science' with the 'knowledge of local communities and stakeholders'. According to WWF 'information on the location, conservation values and management of these water assets should be readily and freely available to all Australians at the click of a mouse button'[16]. This has been addressed in various forms with national and state-level datasets presented through simple web interfaces (e.g. Wetland Base[17]). Likewise, research hubs dedicate a portion of their funds to knowledge and adoption initiatives. This generally sees resources dedicated to coordinating, integrating and communicating findings.

More recent research initiatives have seen greater opportunities for the community and stakeholders to provide *input to*, and *participate in,* the research undertaken by academic institutions. However, much of the national research capacity for Northern Australia is based outside the region – this geographical separation creates challenges in terms of the involvement of local stakeholders and the generation of policy-relevant outputs (Hamilton and Gehrke 2005). Despite this apparent obstacle, there has been a rapid escalation in scientific analysis of Indigenous ecology in Northern Australia (e.g. Indigenous fire management regimes).

Such initiatives begin to address concerns held by Indigenous Australians that a 'large amount of knowledge is being lost as elders pass away before the knowledge can be recorded or passed on' (Sandra McGregor, directly quoted in McKaige 2009, p. 19). A number of research initiatives are also facilitating an *expanding* Indigenous knowledge base. For example, in the Gulf of Carpentaria, Indigenous rangers have been engaged to search for breeding colonies of waterbirds. This is done during the wet season, via boats and light aircraft, and is conducted at times when local Indigenous communities are unable to freely traverse much of their country due to inundation. According to Jaensch (2009), knowledge of waterbird linkages across the region was rare for local Indigenous groups.

[16] See <http://www.panda.org/about_our_earth/about_freshwater/freshwater_resources/?uNewsID=73880>.
[17] See <http://www.dec.wa.gov.au/content/view/3574/1556/ >.

Interviews conducted as part of a study on Integrated Cultural and Resource Management in Northern Australia also indicate that there is a changing perspective on Indigenous knowledge, by Aboriginals themselves. For example, Garnett and Sithole (2007, p. 21) observe that:

> Rangers are aware of the value of the work they are doing and distinguish between value at a personal level, at a community/clan level, regional level and for the country. Similarly, most elders expressed great pride in what the groups were achieving, in what the groups were representing and most importantly, they were proud of the way rangers were challenging stereotypes of Aboriginal people in many areas where the rangers are demonstrating action, leadership, knowledge and innovation. In many communities, ranger work or involvement in Aboriginal land and sea management was seen as the new hope for young people who now have something to look forward to.

The TRaCK research hub aims to take the issue of Indigenous knowledge one step further with a project that is focused on targeted training (i.e. learning by doing) to give local Indigenous communities the skills to effectively participate and be heard in mainstream water and land planning processes that are gearing up across Northern Australia[18].

In contrast, some science 'outreach' initiatives are not bound up in government and academic institutions. Scientists passionate about the future of freshwater systems in Australia have taken on activist-type roles, whereby they lobby government and enlist the public to their cause. For example, Kingsford and Nevill (2005) established a consensus statement signed by 40 Australian scientists which recommended a systematic expansion of freshwater protected areas in Australia. Similarly, in the book *The Nature of Northern Australia*, Woinarski *et al*. (2007, preface) boldly respond to the question 'why did we write this book' with:

> It is because we see something of value here, that is in the process of being devalued. It is because we are aware of the increasing momentum to transform these lands, largely by those unaware of or impervious to its intrinsic value. It is because we consider that the fate, health and societies of people in Northern Australia are bound inextricably with their natural landscapes. It is because it is time to consider systematically and realistically the future of this land, and mechanisms to guide it to that future. It is because of the failures of the past.

Whilst the book is written by scientists, and presents the state of scientific knowledge on the topic, it is written in such a way that it is appealing to a general audience. As such, The Wilderness Society used the publication as a political platform in their wild rivers campaign (The Wilderness Society 2007).

NARRATIVE 3: Knowledge bases underpinning conservation planning for surface water assets in Northern Australia

This narrative highlights that many approaches to conservation planning for surface water assets in Northern Australia have been championed by experts and activists. Whilst expert knowledge is pervasive across all approaches, experts may not necessarily be unified on the appropriateness of each approach to conservation planning.

[18] See <http://www.track.gov.au/>.

Background

Currently there is no nationally consistent approach to the identification, categorisation and management of surface water features. All jurisdictions use different approaches, tools and terminology (Sinclair Knight Merz 2007). Significant time and resources have been dedicated to debating the merits of alternative ecological approaches (Kingsford and Nevill 2005; Sinclair Knight Merz 2007; Blanch 2006). On this point, Pressey and Adams (1995, p. 95) do not view the differing approaches as a problem – it is of their opinion that they contribute to the conservation of the resource 'in many different ways and at many scales'. In contrast, WWF asserts that Australia has a 'jumble of jigsaw pieces' in the 'aquatic ecosystem management puzzle' and that these pieces need to be put together as a matter of priority (Blanch 2006, p. 5).

To date, there have been at least six general approaches for assigning priorities to the tropical waterways and wetlands of Northern Australia. Each approach focuses on a different feature or component of the environmental system. These include:

1. Representative ecosystems and assemblages of ecological communities
2. Threatened species and ecological communities
3. Wild rivers
4. Iconic places
5. Iconic species
6. Indigenous natural and cultural areas

The distinguishing features of each approach are outlined below.

Representative ecosystems and assemblages of ecological communities

The protection of representative examples of all major ecosystem types is a core tenant of conservation biology, endorsed through international declarations on the environment (e.g. Stockholm Declaration 1972, Rio Declaration 1992, Johannesburg Declaration 2002). The Australian government intends to improve the reserve system by including more representative ecosystems and assemblages. Towards this end, Australia has been divided into a set of representative habitats based on major geomorphic features otherwise known as landscape systems. There are 85 regions identified in the Interim Biogeographic Regionalisation for Australia (IBRA)[19]. Sub-regions within the IBRA have been used as the unit of analysis for continent wide assessments of biodiversity (Sattler and Creighton 2002) and landscape health (Morgan 2000).

Despite these efforts it has been argued that the IBRA is not effective in representing aquatic ecosystem patterns (Tait *et al*. 2002; Marchant *et al*. 2000; Wells and Newall 1997). This issue was formerly acknowledged in the National Reserve System (NRS) Direction Statement (NRMMC 2005,

[19] See <http://www.environment.gov.au/parks/nrs/science/bioregion-framework/>.

p.9) with the recommendation to 'review the current understanding of freshwater biodiversity in relation to the NRS CAR [comprehensive, adequate and representative] reserve system, and finalise an agreed approach, which may include future amendments of the NRS Guidelines, to ensure freshwater ecosystems are appropriately incorporated within the NRS'.

Substantial data collection and research is needed to progress a freshwater bio-regionalisation for Australia. This is particularly the case for Northern Australia, where a detailed assessment of its freshwater ecosystems is hampered by the lack of suitable data (Woinarski *et al*. 2007). In the interim, it has been proposed to work with the existing reserve system to identify the most significant gaps and address these as a matter of priority (Kingsford and Nevill 2005). However, doubt still exists with regards to the ultimate capacity of reserves to protect freshwater ecosystems. For example, Fitzsimons and Robertson (2005) point out that the provision of suitable water regimes for freshwater reserves is a major challenge, and even adequate reservation may not conserve constituent biodiversity.

Wild rivers

The notion of preserving areas of wilderness arose with the 18th and 19th century Romantics who found inspiration in nature and rejected an increasingly industrialised society (Welton 1986). The Romantics emphasised emotion over classical order and delighted in wild scenery, particularly 'wild torrents, fearful precipices, pathless forests, thunderstorms, tempests at sea ...' (Russell 1961, p. 654). Not only did they evoke strong impressions of the sublime and picturesque elements of natural landscapes, they 'bought knowledge of nature into harmony with feeling(s) for her' (Biese 1905, p. 325).

The conservation of wilderness areas was a primary motivator in the designation of national parks in the United States of America (e.g. Yellowstone National Park in 1872) and elsewhere. Various pieces of legislation have been enacted to protect wilderness areas, including acts to specifically protect wild rivers (e.g. the USA's *Wild and Scenic Rivers Act 1968*).

According to the Wilderness Society of Australia, wild rivers have captured the imagination of Australia from the days of the Franklin River campaign in Tasmania[20]. A CSIRO report released in 1992 acknowledged that undisturbed or wild rivers were now rare in Australia (CSIRO 1992). Following on from this, the Prime Minister's Statement on the Environment set out a commitment by the federal government to assist agencies to identify rivers in a near-pristine condition and encourage protection and proper management of their total catchment. In turn, the Australian Heritage Commission launched the Wild Rivers Project which set out to: (1) systematically identify Australia's wild rivers; (2)

[20] See <http://www.wilderness.org.au/campaigns>.

develop guidelines for the management of wild rivers; and (3) communicate and consult to promote awareness of the values of wild rivers[21].

For the purpose of a systematic assessment, a wild river was defined according to the 'absence of alteration to the biological, hydrological and geomorphological processes associated with river flow by modern or colonial society' (Stein *et al*. 2001). At a technical level, river condition was rated according to: (1) the level of catchment disturbance in terms of land-use activity, settlements and structures, infrastructure, extractive industries and other point sources of pollution; and (2) the extent of direct alterations to the flow regime from impoundments, flow diversions or discharges and levee banks. These assessments are used to generate a River Disturbance Index (RDI). According to Stein *et al*. (2002, p. 1), the RDI has application beyond the identification of wild rivers:

> The disturbance indices generated provide a comprehensive and consistent characterization of river and catchment disturbance that has applications beyond the identification of wild rivers. These include identification of priorities for rehabilitation and restoration; development of systematic survey strategies for aquatic, riparian and estuarine biota and identification of reserve networks for river systems.

However, the most common application of the RDI, in terms of setting priorities, has been highlighting 'the scarcity of undisturbed river systems' (Stein *et al*. 2002, p. 22). In particular, it clearly shows that most of the remaining wild rivers are in northern, western and central Australia (Figure 2). Indeed, the RDI map became the launching pad for a Wild Rivers Campaign led by the Wilderness Society. Initially focussed on Queensland's wild rivers, the campaign eventually saw the introduction of a *Wild Rivers Act* in 2005. However, the Act has been marred by ongoing conflict. A particular point of contention is the rights of local Indigenous groups[22]. Interestingly, the Australian Heritage Commission (1998, part A) warned that guidelines prepared for the management of wild rivers 'may not be appropriate in catchments where Indigenous groups have an interest, and where the conservation of wild river values may not be compatible with Indigenous interests and uses'.

[21] See <http://www.environment.gov.au/heritage/publications/anlr/wild-river-identification.html>.
[22] See <http://www.wilderness.org.au/campaigns/wild-rivers/queenslands-wild-rivers?utm_source=apache&utm_medium=redirect&utm_campaign=wildriversorgau>.

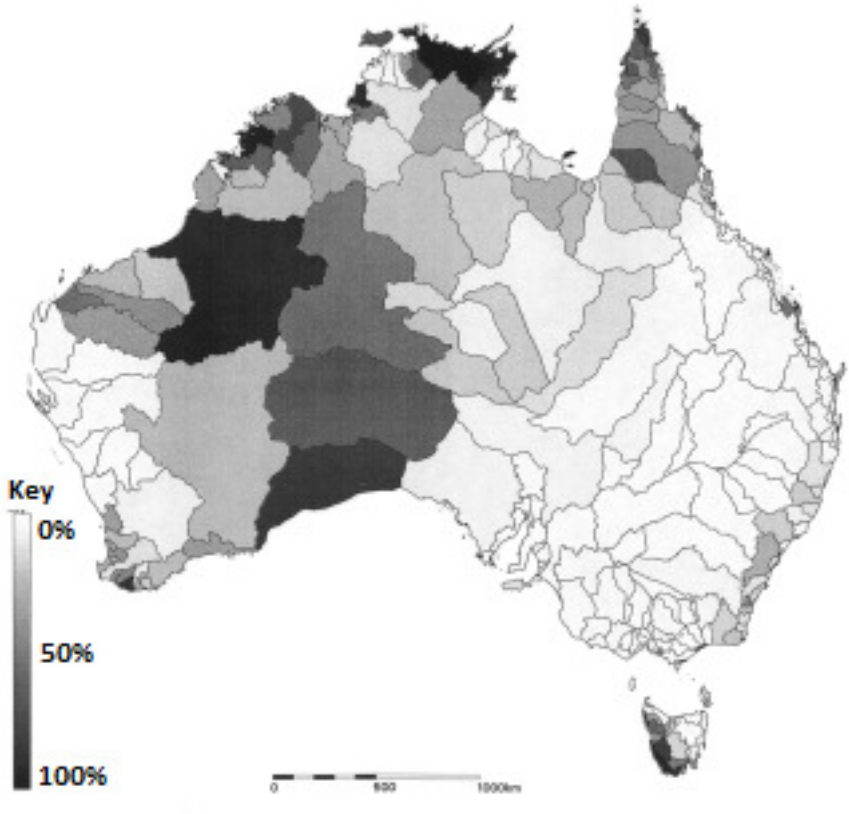

Figure 2: River Disturbance Index of Australia's river basins: percentage of undisturbed stream length (Stein *et al*. 2001, p.22).

Threatened species and ecological communities

Awareness of biodiversity loss at a global scale has been generated through products such as the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Established in 1963, it set a standard for species listing and conservation assessment efforts. The categories and criteria for listing have evolved over time, and a more precise and quantitative set was adopted by IUCN in 1994.

Identifying the conservation status of species has become a cornerstone in the management of biodiversity at national and regional levels. In Australia, lists of threatened species are maintained at both the Commonwealth and State and Territory level. However, different criteria and listing approaches have evolved across the country. Furthermore, the level of protection (afforded by legislation) and prioritisation of resources across threatened species differs between jurisdictions.

A major point of difference is the listing of ecological communities. Some jurisdictions do not have such a listing. Where there are such listings, there is the issue of what actually determines the assemblage of native species that make up an ecological community. Scale is an important consideration, in terms of defining the community, as well as determining the level of threat.

According to Hawke (2009, p. 207) in his independent review of the *Environment Protection and Biodiversity Conservation Act 1999*, there are 'complex scientific arguments to be had here'. Hawke (2009) also reported discontentment with the nomination process, particularly in terms of the level of perceived transparency and Ministerial discretion. Whilst the public nomination system was generally supported, many submissions argued that the process made it difficult for non-technical members of the public to contribute.

There are also broader debates on the effectiveness of listing threatened species and ecological communities. For example, species-by-species approaches have been declared 'fatally flawed' (Schwartz 1999, p. 85). Some argue that the time taken to prioritise species 'one-by-one' means that many species will be 'dead on arrival' (Gibbons 1992, p. 1386; Schwartz 1999, p. 86). This has seen a push for the inclusion of a category that allows for 'emergency' or 'transitional' listing. These concerns are particularly relevant for 'data deficient species', an issue likely to be of significance to Northern Australia.

Iconic species

Iconic species – also known as charismatic megafauna and megaflora – are usually larger animals and plants that have widespread popular appeal. They are most commonly mammals but also include a small number of birds, reptiles and fish. They may also include plants that are distinguished by their beauty, size, age, and/or weirdness (Weaver 2005).

The logic of prioritising iconic species for conservation is relatively straightforward. It garners public support by focusing on the emotional attachment, cultural significance and/or symbolism of a particular species. It also assumes that protecting one species will protect other species in the same area (Wikramanayake et al. 1998, p. 866-7). Taking such an approach avoids the 'fuzzy concept of species richness, or fuzzier concept of genetic diversity' (Leader-Williams and Dublin 2000, p. 55) and 'nebulous ecological concepts' (Bright and Morris 2000, p. 141).

From its inception, the conservation movement has championed the plight of iconic species and generated significant resources for their protection. This has seen large investments in iconic species research. However, most experts would appreciate that being a 'flagship' or 'umbrella' species is not necessarily synonymous with being a keystone or indicator species (Leader-Williams and Dublin 2000, p. 55-56).

Many species feature as icons of Northern Australia. For instance, the boab tree with its large swollen trunk capped with a wide, branching canopy is synonymous with images of the Kimberley. However, being common, such icons do not form the basis of popularised conservation efforts. This is not to say that such species will remain unthreatened. In the case of the boab, Woinarski (2007) warns that the long-term survival of boabs in north-western Australia will depend on appropriate fire management strategies.

Iconic places

Iconic places hold characteristics or qualities in their natural or built environment that reflect or contribute in a substantial way to identity and sense of place. Protection of iconic places has been incorporated into broader efforts to protect cultural and natural heritage. According to the Australian Heritage Commission (1985), only well after World War II did Australians develop a widespread consciousness of the need to preserve their heritage, and it was not until the sixties that concentrated conservation efforts began. According to the Australian Government, 'heritage is all the things that make up Australia's identity - our spirit and ingenuity, our historic buildings, and our unique, living landscapes. Our heritage is a legacy from our past, a living, integral part of life today, and the stories and places we pass on to future generations'[23].

According to Buckley (2002) being branded as a 'heritage icon' may increase the number of people who know about a site, the number who want to visit it, and the amount they are willing to pay to do so. This often creates both opportunities and issues for preserving the integrity of a site. In Northern Australia, the remoteness of many iconic places limits visitation pressures. Interestingly, the terms of reference for iconic places in Northern Australia is extending beyond sites to entire regions. For instance, the Kimberley is being branded as a 'tourism icon' with pressure from interest groups to add it to the national heritage listing (Fighting For Control of a Tourism Icon, *Stateline WA, ABC*, 27 August 2010). Similarly, eight prominent conservation groups have banded together under the campaign 'The Kimberley – Like Nowhere Else on Earth, So Help Protect It'[24]. Indeed, preservation of the Kimberley is a complex, and often sensitive issue, with local communities not only taking the environment into account, but also infrastructure, economic and cultural concerns.

Indigenous natural and cultural areas

The notion of combining cultural conservation with nature conservation was given formal recognition under the *Convention Concerning the Protection of World Cultural and Natural Heritage*, which was adopted by the General Conference of UNESCO on November 16, 1972. In Australia, the concept of Indigenous Protected Areas was first championed in the early 1990s with a growing movement seeking to re-establish Aboriginal and Torres Strait Islander land management traditions. In 1997, the first Indigenous Protected Area was declared at Nantawarrina in South Australia. There are now over 40 Indigenous Protected Areas (making over 23 per cent of Australia's National Reserve System) and over 40 consultation projects underway. These efforts have been concentrated in central and northern Australia.

According to the Australian Government, prior to declaration, Indigenous Protected Areas undergo an environmental assessment to ensure they meet international standards for protected areas. Management strategies rely on both traditional and western scientific knowledge. Day to day tasks

[23] See <http://www.environment.gov.au/heritage/>.
[24] See <http://www.likenowhereelse.org.au>.

include weed and feral animal control, fire management, revegetation, wildlife protection and monitoring. The Government has stated that this has helped protect threatened or endangered plants and animals across the country[25]. However, exact figures are not readily available.

2.4 Summary

It is clear that the process of identifying knowledge bases can generate a comprehensive overview of a policy space. With regards to conservation it can illuminate the basis of conflicts and cooperative efforts, and give merit to marginalised groups of society.

The series of policy narratives also demonstrate that the scale of inquiry is important, in terms of how a knowledge base is captured and articulated. For instance, at a broad level experts are considered to operate within a realm of 'universal truths' and take a paternalistic approach. However, when considered in the context of water management in Northern Australia, experts are moving towards the engagement of local communities in their research endeavours. However, a disconnect remains at the level of conservation planning (for surface water assets), whereby established expert approaches are largely removed from the public. At this scale, it also appears that experts may not necessarily be in agreement over the appropriateness of different approaches.

Indigenous knowledge provides another example of scale-effects. At a broad level, indigenous knowledge is considered to be dynamic and place based. However, when considered in the context of water management in Northern Australia, there is a move towards action, collaboration and learning beyond one's traditional place. It is hoped that this will facilitate broader involvement of Indigenous Australians at the level of conservation planning (for surface water assets). Government investment in Indigenous Ranger Programs and expanding Indigenous Protected Areas are making some headway in changing the culture of Indigenous involvement in conservation.

3. Knowledge bases establish key elements of the choice experiment

3.1 Research agenda

Combining the priorities generated from all the conservation planning approaches could potentially encompass everything from entire regions to individual species. However, there still remains the issue of how to allocate limited resources amongst the suite of environmental assets. In other words, how do you reliably compare environmental assets so that better prioritisation decisions can be made?

One strategy could involve using expert judgement as a proxy for citizen preferences. However, the narratives above indicate that the management of surface water assets in Northern Australia is informed by knowledge bases other than expert knowledge. As such, expert judgements may not

[25] See <http://www.environment.gov.au/indigenous/ipa/envronmental.html>.

necessarily be aligned with citizen preferences. Furthermore, the preferences of experts may not necessarily be consistent: whilst expert knowledge is pervasive across the different approaches to conservation planning, experts may not necessarily be unified on the appropriateness of each approach.

Clearly, further investigation on this topic is needed.

3.2 Research questions

We used the choice modelling technique to specifically address the following questions:

- Do the preferences of tropical freshwater scientists diverge from public preferences?
- Do the preferences of tropical freshwater scientists diverge from one another?

3.3 Geographic scale of study

Rather than focusing on the entire Northern Australia, the Kimberley region was selected as a case study. The Kimberley offers the same breadth of surface water issues as Northern Australia, whilst providing the following additional benefits:

1. The region is a widely accepted unit of management for the purposes of information gathering (e.g. Department of Environment and Conservation); economic development (e.g. Kimberley Development Commission); promotion (e.g. Tourism Western Australia); and environmental activism (e.g. Environs Kimberley).

2. The region lies within the jurisdiction of one state government (i.e. Western Australia) offering the opportunity to streamline data gathering and reduce duplicate inquiries to equivalent authorities in different states.

3. The region offers a diverse suite of surface water assets and management scenarios.

3.4 Attribute scope

Attribute scope refers to the dimensions of the good being considered – it can be varied by changing the *definitions and number of attributes* used in choice sets (Rolfe and Wang 2008).

The knowledge base approach, and the purpose of the narratives in Section 2, was to provide a solid foundation from which to define a set of attributes that would be most relevant to the determination of conservation priorities for surface water assets in Northern Australia. As such, it was deemed appropriate to identify a potential set of attributes within the frame of the conservation planning approaches outlined in Narrative 3 (see Section 2). These included:

1. Representative ecosystems
2. Wild rivers
3. Threatened species and ecological communities
4. Iconic species
5. Iconic places
6. Indigenous natural and cultural areas.

With an attribute for the cost of choosing a particular option a necessary inclusion in the choice task, there were potentially seven attributes to accommodate – the cost and the set of six conservation planning approaches identified above. Choice experiments typically aim for four to six attributes to reduce the cognitive burden placed on respondents. Thus, reducing the total number of attributes was kept in mind[26].

Within the geographical scale of the case study (i.e. the Kimberley) an exhaustive literature review was conducted to identify attributes that aligned well with each conservation approach. Many were eliminated on the basis that they did not have sufficient data to be able to frame the attribute soundly (particularly in terms of its current status). It is not the purpose of this paper to provide the literature review and associated decisions regarding which specific attributes were deemed suitable or otherwise. However, it is important to illustrate how the knowledge base approach ultimately led to a set of attributes for a choice experiment. The final set of attributes appearing in the choice experiment is displayed in Table 1.

Two important points should be noted:

1. The 'threatened species and ecological communities' and 'iconic species' were 'unpacked' into bird, fish and plant groups commonly associated with the surface water features in the Kimberley. A split design was used, with either the birds appearing in the choice sets, or the equivalent fish and plant attributes in their place. This was considered to provide a more reliable estimate of these components with uncertainty over the relative values placed on species representing different biological classes.

2. 'Indigenous natural and cultural areas' is not represented as an independent attribute within the survey. Although it is recognised as an important potential attribute, for the purposes of the survey it was difficult to explicitly define as an independent attribute. Whilst one could frame the attribute in terms of expanding the total area of Indigenous Protected Areas, it was uncertain as to what this would exactly deliver in terms of conserving surface water assets in the Kimberley region (i.e. given the lack of data on the ecological impact of Indigenous Protected Areas). The indigenous knowledge base is also potentially captured within other

[26] For example, Louviere and Timmermans (1990, p. 13) offer a series of prompts to help rationalise the number of attributes:
1. Is it necessary to include an exhaustive list of salient attributes (can one ignore attributes that are largely idiosyncratically salient without significant bias)?
2. Which attributes can be retained, recombined, or reexpressed to keep the set of attributes as nonredundant and as few as possible to make an experiment tractable?
3. In planning or policy applications can one include nonsalient attributes that are actionable and interesting to managers?

attributes, for example, iconic attributes are relevant to the indigenous knowledge bases through both present and historical associations with traditional owners.

Table 1: Attributes selected using a knowledge base approach.

Knowledge Base Attribute	Attribute frame	Rationale for selecting attribute frame
Rare and/or threatened ecological communities and species	Number of Purple-crowned Fairy Wren populations protected by reserves	▪ Purple-crowned Fairy Wren is a vulnerable bird species reliant on riparian vegetation associated with waterways and wetlands ▪ Protection within reserve system is congruent with preferred CAR methods
	Number of Edgar Range Pandanus populations protected by reserves	▪ Edgar Range Pandanus is an endemic and endangered plant species reliant on spring-fed waterholes, restricted to a gorge site ▪ Protection within reserve system is congruent with preferred CAR methods
	Upstream migration of Freshwater Sawfish in the Fitzroy River during dry season	▪ Freshwater Sawfish is an endangered fish species, with the Fitzroy River representing a crucial nursery habitat for the species ▪ During the dry season migration upstream (which is an important part of the sawfish life cycle) can be prevented by barriers
Iconic species	Chance of seeing Brolgas at wetland sites	▪ Brolgas are characteristic waterbirds of the Kimberley's wetlands
	Percentage of wetland margin covered by Blue Lily's	▪ The Blue Lily is a characteristic aquatic plant of the Kimberley's wetlands
	Upstream migration of Barramundi in the Ord River during dry season	▪ Barramundi is an iconic fish species ▪ During the dry season migration upstream (which is part of the Barramundi's life cycle) can be prevented by barriers on the Ord River
Representative ecosystems and assemblages of ecological communities	Number of bioregions with at least 10% protected by reserves	▪ Bioregions are representative of distinct (terrestrial) ecosystems ▪ Current national government policy aims to have 10% reserve area in all bioregions across Australia
Wild rivers	Number of Priority 1 wild rivers	▪ Priority 1 wild rivers are rivers in a pristine or unmodified condition ▪ A number of wild rivers exist that are in near-pristine condition and could be returned to Priority 1 status with rehabilitation
Iconic places	Percentage area of native vegetation in good condition at iconic sites	▪ Iconic places in the Kimberley are associated with notions of remoteness and naturalness, but their popularity tends to result in disturbance ▪ The condition of native vegetation alongside water features is one measure of disturbance

Note that, because the different conservation priorities appeal to different knowledge bases, the set of attributes included in the experiment offer the potential for interesting comparisons between public and expert conservation preferences. For example, we expected there to be a divergence between the public and expert values placed on iconic attributes. Iconic places and iconic species may

appeal to members of the public, while experts may be more focussed on protecting catchment level or system based attributes. We also hypothesised that there would be heterogeneity in the values that scientists place on certain attributes that may be disputed in terms of their scientific merit. For example, protecting representative ecosystems is a familiar and accepted conservation approach for scientists; however, the bioregionalisation scheme used to frame the attribute may not be as applicable to surface water conservation as it is to terrestrial conservation.

More detail on the attribute frames (i.e. as featured in Table 1) and their associated levels can be found in McCartney *et al*. (2010), which includes the bird version of the survey in the appendix, and Rogers and Cleland (2010).

4. Survey feedback

The Kimberley tropical waterways and wetlands survey, featuring the knowledge base attributes, was conducted in 2009-10, surveying the general West Australian public and Australian tropical scientists[27]. The final experimental design, statistical modelling and empirical results of the choice experiment, including the marginal values and partworths for each attribute are reported in Rogers and Cleland (2010) and McCartney *et al*. (2010). Here we focus on the qualitative feedback generated from 1275 public and 33 expert web-based surveys for the purpose of (1) determining whether there was an overall positive or negative reaction to the survey (Section 4.1), (2) understanding the relevance of the survey, as perceived by the public (Section 4.2), and (3) understanding the scientific credibility of the survey, as perceived by the experts (Section 4.3).

Feedback was generated in two ways, referred to here as category 1 and 2 feedback. Category 1 feedback related to instances where respondents were given the opportunity to clarify or substantiate their answers to specific questions throughout the survey (e.g. on particular questions with multiple options, respondents could select an open-ended 'other' option and specify their response). Category 2 feedback was collected by asking respondents to provide any comments of a general nature at the completion of the survey.

4.1 Overall reaction to the survey

With regards to the evaluation of whether there was an overall positive or negative reaction to the survey, it was initially thought that Category 1 feedback would be completely removed from the analysis (since comments should have related to specific questions and not the survey generally). However, some of the comments made in this category could not be specifically linked to the

[27] Note that the *public sample* was generated and administered by the Online Research Unit (ORU), drawing a representative sample of the population based on gender and age demographics, and randomly inviting members of their online panel (by email) to participate in the survey about 'a local issue' (the Kimberley topic was not specified to minimise self-selection bias). The *expert sample* was selected from contacts made through the TRaCK consortium and web searches of relevant institutions, based on their specialist tropical science knowledge.

corresponding survey question and were of a more general nature – such comments were incorporated into the analysis with Category 2 feedback (see Table 2).

Of the 1275 public surveys, 392 individuals provided comments through categories 1, 2 or both, providing 499 comments in total. All 33 experts provided comments of some form, totalling 82 comments. Table 2 shows the number of relevant comments included in the evaluation of positive and negative feedback.

Table 2: Numbers of comments excluded and included in the evaluation of positive and negative feedback generated from the Kimberley waterways and wetlands survey.

	Total number of comments	**Category 1 comments relating to a specific question (removed from evaluation)**	**Category 1 and 2 comments of a general nature (included in evaluation)**
Public (n=1275)	499	209	290
Expert (n=33)	82	72	10

The researchers – with their previous experience in administering choice experiments – were surprised by the large number of positive comments that members of the public provided. A total of 159 comments out of a possible 290 (i.e. over half) were positive. Positive comments related to the appeal of the survey format and its relevance (see below for further discussion on relevance). Some comments were very complimentary, such as 'this is one of the best questionnaires I have completed!'; 'thought it was well planned and brilliant'; and 'I found this a very interesting & engaging way of undertaking a survey/doing research - I am a bit of a internet survey junkie, but most are throwaway; this survey felt like it might Make a Difference'.

Negative comments provided by members of the public amounted to less than one-fifth of the total number of general comments (49 comments out of 290). Comments largely related to the choice scenario format being challenging, particularly in terms of having to make numerous and difficult trade-offs. Whilst these comments could be seen as a negative for this survey, they are more a comment on the somewhat demanding nature of choice experiments. The remaining public comments (82 comments out of 290) were deemed neutral or were statements of a political orientation.

In contrast to the public feedback, no positive comments were provided by the experts. There were a total of seven negative comments. Experts expressed a similar sentiment to the public regarding the demanding nature of the choice task. The following comment is provided as an example: 'I thought the management scenarios were too repetitive for their complexity. It was difficult to maintain focus'. However, this response may be fuelled in part or fully by the fact that experts were presented with

more choice scenarios than the public (i.e. the public were presented with 9 choice scenarios, whereas the experts were presented with 15).

A number of negative comments were made in relation to the experimental design of the choice scenarios. For example, one expert stated that 'Some of the questions provided too few options'[28]. It is not uncommon for people to prefer more options in a choice experiment, as it means they can find an option that is more closely aligned to their true preferences and make better, more honest decisions (McCartney 2010). However, there is evidence to suggest that as the number of alternatives in a choice scenario increase, the variance associated with the choices made also amplifies, likely due to increased cognitive complexity (e.g. see Caussade *et al*. 2005; DeShazo and Firmo 2002). There is also a point to only having a small number of options (such as the three used in this case study) – you want to force respondents to make trade-offs between attributes and their levels in order to estimate the relative marginal values of the attributes.

Another expert commented that 'Uninformed people would willing accept the questions as valid and reasonable, but unfortunately, they are not realistic scenarios/choices, which influenced my answers'. Thus, the respondent does not consider the combinations of attributes and levels in the scenarios to be realistic, which again relates to experimental design. Attribute levels are arranged across alternatives and choice scenarios according to an underlying design (often generated by a computer algorithm, as was the case here) that aims to maximise the amount of information available from every choice made. Typically, this means that every level of one attribute appears with all levels of other attributes at some stage across the set of choice scenarios. This can result in combinations of attributes that appear counter-intuitive[29]. Consider an alternative that offers some amount of protection of Attribute A, and no protection of attributes B, C and D, for a cost of $150. Now consider a competing alternative that offers no protection of Attribute A, but some protection of each of B, C and D, for a cost of $50. Unless the individual has strong preferences for Attribute A, the first alternative seems inferior to the second which offers more conservation (overall) for a lower cost. From a modelling perspective, though, these types of choices are important because they will reveal those individuals that do have strong preferences for Attribute A.

Thus, it would appear that the comments made in relation to experimental design are protests against the choice modelling technique itself, rather than the survey employed in this particular case study. Instructions are provided to respondents in an attempt to convince them that all alternatives presented are plausible (which they technically are, even if some appear less rational relative to others); however, it is difficult to avoid some level of protest of this nature. It would appear that experts are more sensitive to this issue than are members of the public.

[28] It is assumed that this comment was made in relation to the choice scenarios, as the supporting questions in the survey offered a comprehensive selection of answers to choose from, and allowed open-ended answers where appropriate.

[29] Note that in some circumstances, alternatives can be dominant. For example, an alternative that offers maximum conservation of all attributes at no cost would be considered dominant to an alternative that offers the minimum amount of conservation of all attributes at some cost. Such choice situations do not reveal useful information about preferences (with the exception of circumstances where they are included to check choice consistency) and can be avoided with careful designing, as was the case here.

4.2 Public feedback on the relevance of the survey

To reveal truthful responses from individuals in a choice experiment, the survey must be consequential in nature. That is, individuals must consider the survey to be relevant and important[30]. Nearly half of the positive comments were directly related to the *relevance* of the survey. This can partly be attributed to the topic being of wide community interest, illustrated by the comment 'I think there are many problems in the Kimberley that need addressing, conservation being one'. However, there were just as many comments relating to the encompassing and realistic nature of the survey. This is captured in the following comments (italics added):

- It was a great *community* based questionnaire
- Wonderful - very glad to be in a '*real*' survey

The perceived relevance of the survey may also explain requests to be kept informed on the results and outcome of the survey in terms of it being included in policy decisions relating to the management of the Kimberley. One respondent even went as far as expressing their concern that other respondents might not take the survey seriously enough (i.e. 'My only concern is that some people answering this survey may not understand the full implications of listing their views and how this information can be used'). Some respondents were hopeful that the results would be used – a smaller number were hopeful, but sceptical. An example of a more optimistic outlook is given by the following statement: 'Only hope the agencies responsible take on board the findings of this survey and make a difference for all the right reasons. An example of a more sceptical outlook was: 'My belief is that Government departments have their own long term concepts and regardless of political or external decisions the original concept envisaged by the Department will prevail'.

It appears that relevance was also engendered by the public's perception that there was a *systematic and representative* collection of opinions. The most insightful comments included:

- These areas, like many others Australia wide do need a consistent and considered approach from academics, Indigenous, Local and Persons with special interest who will lobby politicians to be more than puppeteers to a budget. Good luck with the results and I hope they have an impact on how we monitor, operate and look after our country into the future.
- This is the first of this type of survey I have received and believe all issues of this nature should be forwarded to Australian residents if the Government is not willing to include [it] in ballot form at election time.
- The answers to this survey and the opinions given herein should be considered by authorities regarding this subject as the resources in question are the property of each and every Australian, and especially West Australians. It is very appropriate to consider the opinions and

[30] Note that the consequential condition relates to the issue of incentive compatibility in choice modelling, discussed further in McCartney and Cleland (2010).

thoughts of the population when regarding such issues as it is the general population that the resulting decisions will effect.

- Even though I am not a resident of the Kimberley region I believe it important to obtain opinions from a large cross-section of the WA and wider Australian community for conservation of our land. Well Done.

- I hope the Government does take note of the opinions of the ordinary people like me who have lived in the Kimberley and love it.

One respondent did suggest that 'Much of the information provided in the survey will bias the answers you receive. The information placed too much importance on the environmental value of the Kimberley.' However, this comment may be more of a general protest against conservation, rather than the attributes not being sufficiently representative. Indeed, another respondent noted that 'Too much emphasis is put on conservation, and not enough thought is given to the necessity of people having jobs and thus income to have a reasonable standard of living.'

Another respondent was concerned that the 'Survey model should have been designed to exclude anyone who already works/participates in an environmental field (enviro sciences, biology, govt conservation, conservation ngo's) as by including responses from people in those areas it does not allow the result to screen out their potential bias'. This indicates that there is likely a lack of understanding as to the potential statistical use of information collected on socio-demographics, which in this case included the collection of data on membership to an environmental organisation and working in an environmental field. This may not be a problem across the board as other respondents made the distinction between a public and expert sample (i.e., 'It is great to have 'experts' deal with these decisions but sometimes the expert may not have the life skills/practical thinking that others do'; 'Let's hope that the results support conservation and that it supports the experts (environmentalists and eco system type scientists)').

4.3 Expert feedback on the scientific credibility of the survey

As noted, it was anticipated that experts may protest against the inclusion of iconic attributes. This expectation was supported with comments on the iconic fish attribute, Barramundi. These included comments such as 'I don't consider barramundi movement in the Ord as an important component of the whole of Kimberley approach to management' and 'Plenty of barramundi available in a range of rivers across the north, does not strike me as a pressing conservation issue'.

Also of particular note, the expert feedback captured scientific debate and uncertainty on the relevance of the IBRA to freshwater aquatic systems. For example, one respondent commented that 'The bioregions are designed for terrestrial ecosystems and are unlikely demarcate significant partitioning of freshwater biodiversity. I gave the criterion little weight in my decisions'. There was also criticism directed towards the categorisation of wild rivers. For example, one respondent

commented that 'The concept of Wild Rivers is also flawed - many rivers in good condition do not classify as Wild rivers due to the extreme philosophy adopted in classifying rivers as Wild (i.e. basically need to be pristine to classify as P1)'.

4.3 Summary

The feedback is most insightful in terms of understanding the basis for positive and negative reactions to the survey. Negative comments, both from members of the public and the experts were largely focussed on the choice modelling technique itself – particularly in relation to the demanding nature of the choice task presented to them.

The public had an overwhelmingly positive response to the survey in terms of its relevance. It was seen as encompassing of public interests, and that the results of the survey should be used in policy decisions.

Some experts were sceptical of the scientific credibility of the survey. Their concerns related to the inclusion of iconic attributes and differences of opinion in relation to the use of the IBRA and wild rivers categorisations. However, these concerns were actually prompted by the design of the survey – we deliberately included (1) iconic attributes, as we hypothesised that there would be a divergence between the values placed on them by members of the public and experts; and (2) attributes that may be disputed in terms of their scientific merit, as we hypothesised that there would be heterogeneity in the values that scientists placed on them.

5. Comparison of the knowledge base approach with a participatory approach (i.e. focus groups, Delphi process)

The overarching research project – that aims to discern whether experts and members of the public place different priorities on key components of the environment – provided an excellent opportunity to investigate the topic of attribute definition.

This was tackled in a number of ways:

1. The knowledge base approach was conceptualised and applied to the Kimberley tropical waterways and wetlands case study.

2. Participatory techniques were used to compare attribute definitions of experts and members of the public, across three case studies, including the Kimberley tropical waterways and wetlands. The outcomes from this are reported in Cleland and McCartney (2010).

By virtue of these investigations, a third avenue for investigation now exists: the participatory and knowledge base approaches to attribute definition can be compared for the Kimberley case study. It is

important to note that the knowledge base approach was completed prior to implementing the participatory approach to attribute definition.

For the purpose of this comparison, a brief overview of the participatory approach is provided below. This is followed by a comparison of (1) the short-list of attributes from each approach, and (2) the pragmatic elements of each application.

5.1 Participatory approach – in brief

Cleland and McCartney (2010) elicited attributes for various environmental systems (including the Kimberley waterways and wetlands) via a participatory approach. For members of the public, a series of focus group sessions were held to derive a set of attributes generated from open-ended discussions, brainstorming and prioritising tasks. For experts, different avenues were taken depending on the institutional setting and planning frameworks. In the case of the Kimberley waterways and wetlands, an iterative Delphi process was applied to a panel of experts.

Some general information was provided to all participants (both members of the public and experts) to prime them to understand what was required as an outcome of the participatory process – that is, a *prioritised set of attributes (i.e. the key elements of the system) with their associated attribute frames (i.e. how these key elements are characterised)*. To help participants grasp what this meant, a generic example of a choice scenario involving wine products was presented to them. It was explained that the wine scenario contained a series of attributes (e.g. type, vintage, cost), and that these attributes could be framed using different categorisations (e.g. for type: red; sparkling; white). The participants were then asked to apply this 'format' to the environmental system under consideration to develop a list of relevant attributes.

For the public, this information was provided at the introduction of the focus group session. Participants then discussed the topic in stages via a brainstorming process around the table: firstly defining the attributes that they considered to be important with respect to conserving the asset; and secondly providing suggestions for framing each of the attributes. A comprehensive list was derived, and then participants were asked to consider that only a limited number of attributes can be included in a choice scenario, with reference made to the wine scenario as an example. Participants then generated a prioritised set of attributes, either by way of (1) selecting those that were most important from the original list or (2) condensing several from the original list into one more encompassing attribute. The prioritisation process was achieved via group discussion, with participants easily reaching consensus.

For the experts, this information was provided via email. Each expert, independently, provided a list of attributes and attribute frames they considered important. Responses were collated and redistributed via email. The experts convened to discuss (face-to-face) the collated attributes and

refine the list to a prioritised set. Similar to the public focus group sessions, consensus was easily reached.

5.2 Comparison of short-listed attributes

Table 3 captures the short-listed attributes from the knowledge base and participatory approaches. It is clear that there is a high degree of overlap, with the knowledge base approach offering a comprehensive list that incorporates the majority of elements that were considered the most important by members of the public, as well as the expert panel.

Table 3: Potential attributes for a choice experiment, elicited from different approaches to attribute definition (i.e. knowledge base; participatory, including public focus groups and an expert Delphi process) for the Kimberley tropical waterways and wetlands case study.

Knowledge Base Approach	Participatory Approach	
	Public Focus Groups	**Expert Delphi Process**
Threatened species and ecological communities	Fauna and flora	Endemic species
Iconic species		
Wild rivers	Wetlands (representing all types of water bodies)	Flooding
		Catchment activity
Iconic places	Remoteness and landscape	
	Gorges	
Indigenous natural and cultural areas	Indigenous culture and communities	
Representative ecosystems		Representative habitats
	Environmental resources (the water and soil)	

Overlap between the knowledge base and public short-lists will be considered first. When it came to prioritising the attributes (with the explicit intent of being left with four to six attributes suitable for a choice experiment) the public found ways to combine various attributes so that their reduced list of attributes still captured a broader set of elements.

The fauna and flora attributes identified by the public were a combination of various categorisations for the living elements of a system, including wildlife generally and biological classes (i.e. plants, birds, fish, etc.). Iconic species were noted as examples (e.g. Barramundi, boab) within a number of the biological classes. The attribute frame also extended to include endemic species, species with restricted ranges, relic species, and rare species. This detail (sitting behind the fauna/flora attribute) provides a clear overlap with the iconic species attribute, as well as the threatened species and ecological communities attribute, in the knowledge base approach.

The wetlands attribute identified by the public actually represents wetlands and pristine rivers. With the pristine rivers being framed in terms of uniqueness, numbers and catchment activity, it has a direct overlap with the wild rivers attribute in the knowledge base approach.

The public also placed a priority on the attributes for remoteness and landscape, and gorges. These were described in terms of their uniqueness and aesthetics, capturing the 'essence' of the region. This provides an overlap with the knowledge base attribute for iconic places. Similarly, Indigenous culture and communities appeared in the short-list. The public described this attribute not only in terms of artefacts and sites, but also with community health (in relation to connection with land) and participation in environmental management in mind. This was also a theme identified in the knowledge base approach.

There were a number of attributes that did not overlap. The public did not mention representative ecosystems, although across many of the attribute frames there was mention of climate, habitat, food sources and interconnections. The knowledge base approach missed environmental resources. This attribute was the combination of the water (e.g. flow dynamics) and soil (e.g. fertility). It is important to note that the public described them in terms of being fundamental components of the ecological system, rather than taking an 'ecosystem services' focus that highlights their associated value to humans.

We now turn to the overlap between the knowledge base and expert short-lists. Prioritising saw experts seeking attributes that best captured system-level processes (i.e. flooding and catchment activity) and the ecological 'uniqueness' of the system (i.e. endemic species and representative habitats). With regards to system-level processes, it was seen that protecting the integrity of the system essentially flows on to affect the things the community really cares about, such as biodiversity. Whilst flooding and catchment activity do not explicitly appear as knowledge base attributes, system integrity is captured in the representative ecosystems and wild rivers attributes. Representative ecosystems are also captured in the expert nominated attribute of representative habitats.

There was some discussion around the expert nominated attribute for endemism. The expert panel considered that biodiversity was important overall, but too broad a term to be used as an attribute. A number of experts considered that endemic species was an appropriate attribute to represent biodiversity, another preferred rare/threatened species as a measure, while another was content with either provided that biodiversity was represented in some way. Consensus was quickly reached that endemism was the most appropriate attribute as many rare/threatened species are also endemics. Hence, there is a degree of overlap with the knowledge base attribute for threatened species and ecological communities.

There was no overlap from the expert nominated attributes with the knowledge base attributes of iconic species, iconic places and Indigenous culture and communities. However, the expert panel recognised that the community probably considers cultural, social and iconic attributes to be very important, but from their scientific perspective they placed minimal weight on the inclusion of these

types of attributes given that the topic was about conservation of the Kimberley's tropical waterways and wetlands. They had a general preference that any such inclusions appeared not as attributes, but where appropriate as related characteristics that would be protected as a by-product of the environmental attributes. For example, protecting endemic species also protects traditional Indigenous food sources, or better catchment management preserves the integrity of pristine iconic locations.

5.3 Practical concerns

Conceptualising the knowledge base approach required an investment of time in terms of clarifying the problem area, finding ways of tackling the problem, and working out how to apply this 'new' thinking. However, this process could be considered as a one-off investment of time. Likewise, providing a written background to the approach (including the overarching policy narrative, that is, Narrative 1) would not be as time consuming, or may not even be necessary.

Writing the case specific policy narratives (i.e. Narratives 2 and 3) was expedient, requiring an overview of the relevant scientific and policy literature; government sites; and popular web-sites, such as tourist sites, interest group sites, etc. Compiling these narratives also had a large positive spin-off in terms of providing the majority of the background material needed to frame the choice experiment.

In comparison, the participatory approach was costly. There was a substantial investment of time to organise the logistics of the group sessions/meeting. For the public focus groups, a monetary incentive was also offered as part of the recruitment strategy. With the expert panel residing outside WA, there was also additional travel costs (i.e. flights, accommodation) associated with running the expert meeting. Successfully running the group sessions/meeting required the time of two personnel: one to facilitate and one to scribe. Time was also required to interpret the scribed notes.

A positive spin-off associated with the participatory approaches was an in-depth view gained of how the public and experts frame attributes. In other words, how they characterised the attribute in terms of their specific features. Such information would be highly valuable at the stage of determining attribute levels for the choice experiment.

There may also have been other positive spin-offs that did not feed directly back to the study. For instance, involving members of the public in the 'design stage' of research projects (whilst compensating them for their time) can improve understanding and establish good-will between the general public and academic institutions. Likewise, extending the network of expert contacts assists with disseminating research results across disciplines and fosters collaboration between institutions.

5.4 Summary

The comparison between the knowledge base and participatory approaches to attribute definition has been both insightful and reassuring. The comparison suggests that the knowledge base approach can cut across, or offer a middle ground, between public and expert nominated attributes. This is an important finding as the knowledge base approach is likely to be a more cost-effective option – in terms of allocating researchers' time and project resources – than running public focus groups and expert panels. Although, some may argue that you do not need to run both public focus groups and expert panels, and costs would be significantly less. However, it has been demonstrated that there are elements of divergence when it comes to the way in which the public and experts define attributes.

6. Conclusion and next steps

Choice experiments can offer a rich information set about values and trade-offs, via the ability to frame choices according to a number of attributes (Rolfe *et al*. 2002). The way in which attributes are defined is crucial in terms of the particular relevance of the choice experiment. However, attribute definition is largely a neglected area of research and appraisal. Greater attention has been placed on experimental design and statistical modelling.

If a choice experiment relates to government policy and decision making, then it should describe conditions or outcomes *relevant to society*. However, attribute definition has generally been at the discretion of researchers, with variable levels of consultation with other members of society. Typically, experts are drawn upon for specific technical information on attributes and public focus groups are run to identify broad issues and/or pilot the survey to determine whether respondents are comfortable with its content (Cleland and McCartney 2010).

Clearly, work is needed to develop a set of protocols or best-practice guidelines for defining attributes. Most importantly, advice needs to be generated from critical inquiry and empirical observation.

It is our hope that this paper initiates dialogue on the topic. We have proposed a novel approach to attribute definition. We have termed it the 'knowledge base approach' whereby attributes map onto particular knowledge bases. Here, a knowledge base is the particular 'lens' through which a shared understanding of a topic is gained and, if appropriate, used for a specific purpose. The concept is embedded in literature emerging on evidence-based policy, where it has been used to account for different sources of information and perspectives in complex policy settings.

Various techniques can potentially be applied to identify knowledge bases (relevant to a particular policy setting). Typically, existing categorisations frame inquiries (e.g. lay versus expert knowledge). We believed such categorisations had the potential to bias our inquiries, and thus opted to use a more interpretive approach via the construction of a series of policy narratives. A policy narrative asks

'what are the fundamental stories that underwrite a pattern of policy decision or action'? Three narratives were established, each offering a different resolution and subsequent insights on the conservation 'lens'.

We applied the knowledge base - policy narrative approach to a case study on the Kimberley's tropical waterways and wetlands. Viewed collectively, the policy narratives grounded our key research questions. These were: (1) do the preferences of tropical freshwater scientists diverge from public preferences; and (2) do the preferences of tropical freshwater scientists diverge from one another. The policy narrative offering the finest resolution provided the best means to define attributes. These were: representative ecosystems, wild rivers, threatened species and ecological communities, iconic species, iconic places and indigenous natural and cultural areas. Whilst expert knowledge is pervasive across all approaches, other knowledge bases inform them to various degrees.

Positive qualitative feedback was received from the choice experiment that applied the knowledge base approach. People viewed the survey as being important and policy relevant. Negative feedback related more to the complexity of the choice modelling technique itself, rather than the knowledge base approach. In addition, experts were not interested in iconic attributes and there was an unfavourable reaction towards the scientific merit of some attributes. However, this highlights the importance of the knowledge base approach in ascertaining attributes that represent both public and (heterogeneous) expert interests. This is depicted in Section 5 through comparisons of attribute definition methods (knowledge base approach; participatory techniques including public focus groups and an expert Delphi process), where the knowledge base approach is shown to offer a middle ground. At a pragmatic level, the knowledge base approach was more expedient and cost-effective.

It is important to note that there has only been the one application using the knowledge base approach. It would be useful to have an empirical application of the comparison in Section 5 (i.e. apply choice experiments using each of the different attribute definition processes). It would also be beneficial to assess the usefulness of the knowledge base approach in contexts other than the conservation of Northern Australia's surface water assets.

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