Title: Cultural Values, Deep Mining Operations and the Use of Surplus Groundwater for Towns, Landscapes and Jobs

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Abstract

Trade-offs involving land use change, cultural values, water resources and jobs are critically important to understand the opportunity cost of resource extraction. Stated preference techniques can be particularly useful in eliciting the non-market values expressed as trade-offs. This study assesses preferences over the management of groundwater released from deep mining operations in Western Australia. A discrete choice experiment is used to investigate the trade-offs Australians are prepared to make for remote economic, ecological and cultural goods against costs. The results suggest that there is heterogeneity of preferences as indicated by a three-class structure of a latent class model. One class supports the use of released groundwater across a range of economic, ecological and cultural uses modelled: extending town water supply, restoring rangeland habitat, creating jobs for Aboriginal Australians and preserving cultural waterholes. The smallest class supports all these uses except job creation and the final class only supports preserving cultural waterholes. These results illustrate public attitudes towards cultural values as well as wider environmental policy tensions between instrumental and intrinsic values.

Keywords: discrete choice experiment; willingness to pay; groundwater; Aboriginal cultural values; town water supplies; biodiverse habitat

Highlights

- We find three distinct classes of preferences for released groundwater from mining
- Only one class supports a broad range of ecological and cultural uses
- Two classes do not support the creation of Aboriginal employment opportunities
- These same two classes support extending town water supplies

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1. Introduction

Consideration of a wide range of potential costs and benefits, including ecosystem services and broader socio-ecological and cultural values, is critically important to ensure that proposed resource development projects are in the wider interest of society (Guerry et al., 2015; Bateman et al., 2011). Stated preference techniques are required to elicit values where resources have public good aspects or involve the creation of environmental qualities which are unfamiliar to most people (Johnston et al., 2017; Baskaran, et al., 2013). These techniques have been widely used to estimate the value of habitat area (with recent examples such as Pienaar et al., 2019; Varela et al., 2018), whether terrestrial (Valasiuk et al., 2018), aquatic (Dias and Belcher, 2015) or marine-based (Davis et al., 2019).

The widely referenced ecosystem services framework suggests that ecological and cultural heritage can and should be considered in decision-making processes (Tengberg et al., 2012). However, it can be inherently difficult to obtain suitable representations of value in the case of landscapes with a diversity of cultural and heritage values, including spiritual values. Implicitly there are trade-offs associated with using landscapes for the provision of food and fibre and jobs within rural and remote communities, while at the same time preserving the connections of people to these landscapes. In the Australian context, there are also the cultural ties of Indigenous people including, Aboriginal and Torres Strait Islanders, which bind the people to the land through significant culturally important sites, often related to water, as woven into the oral traditions and cultural obligations to preserve and protect important sites (Barber and Jackson, 2011). Past policy, European agricultural techniques, resource development, extraction and processing has often been at odds with maintaining these cultural ties. Recent examples of conflict include mining operations and the caves at Juukan Gorge in Western Australia which contained some of the oldest examples of human occupation in the world and which had significant cultural and heritage values for the Aboriginal groups of the area and Australia as a whole (Turner, 2020). The conflict suggests that greater consideration of a range of values is warranted.

Evaluation of the development and expansion of mining operations requires information on the preferences of Australians for the trade-offs among economic, ecological and social-cultural values. A discrete choice experiment (DCE) is useful as a means of presenting different trade-offs including for ecological and cultural goods which might be viewed as “remote from and unfamiliar to respondents” (Börger and Hattam, 2017, p64). To this end, this paper presents an analysis of

Australians' preferences for various uses of surplus groundwater from mine dewatering. Using a DCE a series of choice tasks are presented to a national sample requiring trade-offs among economic, ecological, social-cultural value attributes and cost. Specifically, the objective of the paper is to estimate these trade-offs in the form of respondents' willingness to pay for four different groundwater management options. The options include preserving culturally important waterholes, restoring grazing land to biodiverse habitat, increasing the water available for small towns and creating jobs through an Aboriginal small and medium-sized enterprise (SME).

The paper proceeds with case study background and the literature followed by details of the methods, elicitation scenario, payment vehicle and experimental design. The role of potential protest behaviour with respect to the trade-off scenarios is explored in the results. A latent class specification which allows for heterogeneous preferences across groups is estimated and willingness to pay estimates reported. In the discussion, the policy implications for the willingness to pay values are discussed and compared with those in the literature, and the efficacy of implicit inclusion of protest behaviour in the analytical framework is considered.

2. Background and Literature

In assessing the interaction between Indigenous people and industrial development projects worldwide, Jiménez et al. (2015) found that mining and hydropower were jointly the two key areas of conflict. They found that mining conflict was focussed on water quality, water availability as well as more general impacts on hydrology and displacement of communities. In the Australian context, control of cultural flows and practices related to water-dependent ecosystems such as waterholes may be an additional source of conflict (Jackson et al., 2019; Bark et al., 2015; Zander et al., 2013; Zander et al., 2010).

Mining also is associated with benefits for local communities, principally around direct and indirect employment. Lockie et al. (2009) investigated direct employment opportunities for Aboriginal Australians to provide cultural advice to the Coppabella coal mine in Central Queensland, Australia. Their social impact assessments showed the mine was noted for working with Aboriginal groups, through efforts to support "cultural, economic and social development" and programs "put in place for Indigenous people and Aboriginal enterprises established to service the mine by providing for cultural heritage advice and management" (ibid p337). Jackson and Barber (2015) identified, from analysis of negotiated agreements, that in the Pilbara mining region of Western Australia, mines employ Indigenous Australians not only directly in mining operations but also in cultural heritage management. These studies suggest that indirect employment through the SME sector servicing mines and mine workers may provide an important potential employment pathway for Indigenous Australian communities.

Analysis of the limited data available in the literature provides a mixed picture, particularly with regard to Aboriginal SME opportunity. Through a comparison of mining and non-mining Statistical Local Areas (SLA) over the period 2006 to 2011, using Australian Bureau of Statistics (ABS) data, Kotey and Rolfe (2014) assess the impact of mining on remote Australia. They found a “vibrant SME sector” (ibid p71), however there was no information on the ownership of the SMEs. In their 2006 assessment, Lockie et al. (2009) find the rapid expansion of the non-mine SME sector had occurred largely without cultural heritage advice or co-management agreements to protect Aboriginal cultural heritage. Moreover, they conclude that “the marginal position of Aboriginal groups within the wider community and economy had been reinforced by the dramatic expansion of mining in the region” (ibid p337). This suggests that the Aboriginal ownership of new SMEs is lagging. Jackson and Barber (2015) also find that Aboriginal Australians may be excluded from mining-related growth due to rapid population growth coupled with low educational outcomes. Other research has shown the insufficiency of only providing training for Indigenous populations (Pearson and Daff, 2010; Jackson and Barber, 2015).

Whilst this literature flags there are pathways for Indigenous employment through direct mine employment and the indirect growth in SMEs in the region, one pathway that might prove more successful is to directly support the development of Aboriginal SMEs. Indeed, the negotiated agreement assessed by Jackson and Barber (2015) incorporates support for business development and contracting. These businesses could generate flexible employment that aligns with employees’ responsibilities to cultural practices as found by Pearson and Daff (2010) in East Arnhem Land in the Northern Territory of Australia. Of interest in this current paper, is the recommendation that negotiated agreements could incorporate initiatives to increase “local employment in water-related businesses or activities” (ibid p83). For instance, Rio Tinto Iron Ore supports a SME, the Ashburton Aboriginal Biodiesel Corporation, which aims to utilise groundwater from mining to grow a biodiesel crop and to generate long-term, flexible employment (Jackson and Barber, 2015).

2.1 Case Study Site

A key economic sector in the Pilbara region located in the north of Western Australia, see Figure 1, is extractive mining. Iron ore mining in the region accounts for over 90 percent of total iron ore production in Australia and about 40 percent of global iron ore exports (Government of Western Australia, Department of State Development, 2017). The Pilbara covers an area of 507,896 km^2 and has a resident population of around 66,300 (Government of Western Australia, Department of Primary Industries and Rural Development, 2018) with a fly-in fly-out workforce population of 50,000. Approximately 13.4% of the resident population identify as Aboriginal Australians (Pilbara Development Commission, 2016) and 33 distinct Aboriginal language groups are represented.

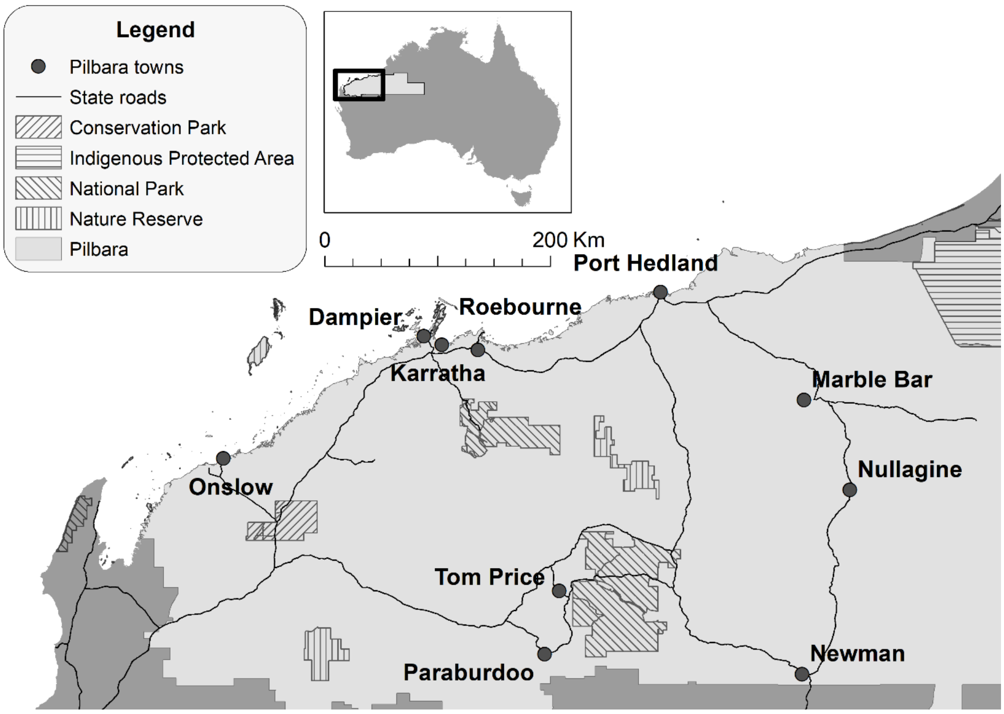


Figure 1: Map of the Pilbara Region, Western Australia

The Pilbara receives very little annual rainfall, between 200 mm to 350 mm, typically falling in the hot summer months, sometimes all within just a couple of days from tropical cyclones. Rivers generally flow only after significant rainfall events (3 to 5 times annually). With evaporation potential between 6 and 14 times the annual rainfall, and unreliable surface water, the region is reliant upon groundwater as the main water resource for people, business, ecosystems and other land uses (CSIRO, 2015). Water resource demands are concentrated in ports, coastal towns and resource-based communities in close proximity to iron ore, gas and petroleum extraction and processing (Government of Western Australia, Department of Water, 2013).

Conflict emerges between competing land uses where access to one economically important resource such as iron ore is at odds with the conservation of cultural heritage values or native vegetation such as woodland and grassland habitats. As mining operations continue to exploit deeper ore deposits there are problems with managing groundwater resources. To mine these deep deposits groundwater reserves are “dewatered”. This releases large volumes of groundwater directly to the landscape through creek line disposal. Through this process mine dewatering has the potential to alter vegetation. In an area where water is scarce there is an opportunity for a wider societal discussion of alternative uses of this “surplus groundwater”.

3. Methods

3.1 Survey design

The first part of the survey provided a simple explanation of the importance of groundwater in arid landscapes. Background information was presented about the Pilbara region, the predominant land uses (grazing, mining and conservation) followed by questions about the respondent’s familiarity with and experience in the region. The survey then provided a simple factual explanation of the need to pump groundwater in order to access iron ore bodies and the potential ecological, cultural and landscape implications of deep mining operations. Alternatives to creek line disposal of the 700GL of surplus groundwater were then described. In all cases alternatives were presented as opportunities to utilise the surplus groundwater locally in productive, beneficial ways, including: preserving culturally important waterholes, restoring grazing land, increasing the water available for small towns, and creating jobs through an Aboriginal SME.

Information was provided to respondents about the groundwater-reliant waterholes within the region that are culturally significant for local Aboriginal communities. Mining activities and dewatering were identified as leading to some waterholes drying up, affecting existing habitats for flora and fauna. One option identified was to utilise pumped groundwater to mitigate the effects of mining activities by artificially maintaining water levels in waterholes. Potential negative impacts of such “rewatering” in terms of ecological and cultural quality were also presented.

Other potential uses of surplus groundwater were presented. For instance, as a way to reduce the current impact of extensive grazing activities through growing hay. This in combination with other related management actions, such as fencing and feral animal control, was identified as an option to restore rangeland to support habitats for local flora and fauna. Another option was to extend (regional) town water supplies which would address declining groundwater supplies in regional centres throughout the Pilbara. For example, in the town of Tom Price groundwater levels fell by approximately 30 metres over the past 50 years and are projected to continue to fall in the future.

This option would inject surplus groundwater into confined aquifers to augment town water supplies, providing an additional 20 to 60 years of town water supply.

A final use involved addressing economic inequality through the creation of jobs in an Aboriginal SME. It was explained in the survey that a SME would bottle surplus groundwater to take advantage of the large number of trucks returning empty from the Pilbara to larger centres in Western Australia. This alternative described up to 150 long-term jobs being created, with Aboriginal workers being trained to run and manage the business. This attribute builds on the enterprise described in Jackson and Barber (2015).

In the DCE the potential uses of groundwater are DCE attributes, see Table 1 for a list of these attributes, their associated levels, and a cost attribute. In the DCE respondents were then asked to make choices among the status quo and two alternatives.

Table 1: Attributes description and levels

Attributes	Levels
WATERHOLE, Preserve culturally-important waterholes	No natural waterholes Preserve: 1, 2, 3, 4, 5 waterholes
TOWN SUPPLY, Increase water supply for towns	Groundwater supply falling (0 additional years) Years of additional water supply: 20, 40, 60
BIODIVERSE, Restore biodiverse grazing land	120,000 hectares degraded (No Ha restored) Hectares restored: 15,000 30,000 45,000 60,000 75,000
SME, Water for small business	No SME jobs Jobs created: 25, 50, 75, 100, 125, 150
COST, Levy per year for 5 years to your household	No additional cost $0 Levy/yr for 5 years: $25, $50 $75, $100, $125, $150

3.1.1 Elicitation question and payment scenario

Preferences regarding the potential uses of surplus groundwater were elicited through an online DCE which comprised of seven treatment conditions (three treatments are described in Hatton MacDonald et al., 2019). We focus here on the preferences elicited for one treatment which included an attribute on long-term job creation through development of an Aboriginal SME. The survey established the current industry standard to dispose of surplus groundwater into creek lines.

This practice meets national and state regulatory requirements, and therefore the alternatives represent options for which it will be necessary to pay. This established the rationale for the involvement of the government and the use of public funds. The payment vehicle was described as a household levy to fund the improvements necessary for capturing and redirecting the surplus groundwater to any of the alternative uses. Respondents were told that the levy would be paid by Australian households every year for five years.

Preceding the choice tasks was a cheap talk script reminding respondents to consider their individual household budget and the importance of answering truthfully as if they really have to pay (Morrison and Brown, 2009). Next, respondents were asked to consider alternative ways to manage the surplus groundwater. An example choice task followed by six choice tasks were presented as a referendum in which respondents were asked to vote as if they were the only options available.

Figure 2 shows an example of a choice task. Each choice task was composed of a status quo option and two alternative options for the four different attributes representing the alternative uses for the groundwater as well as the cost to the household. Two of the alternatives involve trading off higher costs with increases in at least one of the non-cost attributes. The other option represents the status quo, where none of the proposed uses of the groundwater is adopted and no additional costs are imposed on households. To minimize the potential for order effects, the order of the non-cost attributes was randomized across respondents. Household cost always appeared in the last row of the choice task.

PLEASE READ EACH OF THESE QUESTIONS CAREFULLY. EACH OPTION IS A PACKAGE TO COMPARE TO THE OTHER OPTIONS. YOUR ANSWERS WILL HELP DETERMINE THE BEST USE OF THIS SURPLUS GROUNDWATER.

If these were the only three options available to you, which option would you vote for?

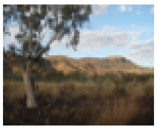
Features		Option A Maintain Current Situation	Option B Use water to:	Option C Use water to:
Culturally important waterholes		No natural waterholes remain	Preserve 3 natural waterholes	Preserve 2 natural waterholes
Water supply for towns		Groundwater supply falling	Supply 20 additional years of water	Supply 40 additional years of water
Grazing land		120,000 hectares degraded	Restore 30,000 hectares	Restore 45,000 hectares
Water for Small Business		No new jobs created	50 new jobs created	125 new jobs created
Household cost *Per year for 5 years*	$	$0	$125	$50
I would vote in a referendum for: *Click on one box only*		Option A ☐	Option B ☐	Option C ☐

Figure 2: Example Choice Task

3.1.2. Focus groups and pilot

During the development of the survey, five focus groups were run across several Australian states (one in Perth, Western Australia; two in Adelaide, South Australia; two in Sydney, New South Wales). These focus groups were used to evaluate the appropriateness of the survey language and alternative response formats, specifications of choice alternatives, and attributes across treatments. A base version of the survey (reported in Hatton MacDonald et al., 2019) was tested in a pilot stage. This base version contained the attributes culturally important waterholes, water supply for towns and grazing land (n=100).

3.2 Survey sample

The survey was administered by the Australian panel provider Online Research Unit (ORU). ORU is recognised as being one of the largest online panel providers in Australia (http://theoru.com/). ORU regularly refreshes its panel using online and offline techniques. Random sampling of the ORU panel was employed, stratifying by age, gender, and state. Potential respondents were sent an initial email invitation and up to two reminders to participate in an online survey. No other information was provided in the invitation to minimise the potential for self-selection based on concern for environmental, groundwater, or mining interests.

3.3 Experimental design

Initially an efficient experimental design for the project was simulated in a research version of Ngene using priors from the literature on habitat areas (e.g. Hatton MacDonald and Morrison, 2010). Other parameters were set to balance utility among the remaining attributes at the pilot stage. The efficient design was updated using estimated coefficients and standard errors from a model estimated using the pilot data. A final design with 60 choice tasks in 10 blocks was simulated with a Bayesian D-efficient error of 0.000081.

3.4 Econometric Specification

When a respondent makes a choice within a random utility maximisation framework (Hensher et al., 2015), respondent *n* receives satisfaction or utility from alternative *j* in choice situation *s* as the sum of a deterministic and random component:

$$U_{nsj} = V_{nsj} + \varepsilon_{nsj}$$

The deterministic component of utility, $V_{nsj} = X'_{nsj}\beta$, is expressed as a matrix, X_{nsj} of attribute levels shown for each alternative multiplied by their associated vector of taste coefficients β. In addition to the deterministic component, it is assumed that there is a stochastic component of the respondent's choice behaviour that is not explicitly observed by the researcher. For the Multinomial Logit (MNL), the error term is specified as following a type 1 extreme value distribution. Initially, the unobserved errors are treated as independently and identically distributed in the MNL. Based on the two specified components of utility the probability that a respondent selects alternative j is shown by:

$$P_{nsj} = \frac{\exp(X'_{nsj}\beta)}{\sum_i \exp(X'_{nsi}\beta)}$$

In order to relax the potentially restrictive assumption of Irrelevance of Independent Alternatives and allow for taste heterogeneity, we also present a latent class specification which allows for heterogeneous preferences across groups.

The Latent Class model (LC) can be used to identify a number of discrete classes in which each class represents a different set of taste parameters (Boxall and Adamowicz 2002; Scarpa et al., 2003). In contrast to the MNL, the LC assumes a discrete probability density function for the distribution of taste parameters. Solving for the probability that an individual belongs to a specific class as:

$$P_{nsj} = \sum_{c=1}^{C} P_{nsj|c}\, P_{nc}$$

where P_{nc} is the likelihood that a respondent belongs to class c. This probability is referred to as the class assignment function, which is estimated for each class.

4. Results

Potential respondents were randomly assigned to treatment conditions (other treatment conditions described in Hatton MacDonald et al., 2019). Data were collected in September-October 2013 with three reminders and a response rate of 12.6% across all treatment conditions, with 492 respondents completing the treatment analysed in this paper. The sample broadly represented a cross-section of the Australian population with similarity in terms of income, age, Aboriginal or Torres Strait Islander status and gender. Our sample, characteristics summarised in Table 2, was more educated than the population with proportionally more respondents having a university degree, and proportionally fewer respondents attaining an education level of below year 12.

Table 2: Sample Demographics

Sample Characteristics	Sample	Rest of Australia
Age (Median)	45.50	45.00
Household Size (Mean)	2.85	2.60
Mean no. of children per household	1.72	1.90
Gender (Proportion female)	51.63%	50.56%
Aboriginal status	1.84%	2.55%
Education (Highest level achieved):		
Year 10 or below	13.26%	27.21%
Year 11 or 12	16.33%	26.68%
Certificate or Diploma	33.27%	31.41%
University degree of higher	37.14%	23.68%

The first model is the simple base MNL model and is summarised in Table 4. All models were estimated using Python Biogeme (Bierlaire, 2016) using supporting code (Rose and Zhang, 2017). The estimated coefficients on the non-cost attributes are positive and statistically significant indicating that the probability of choosing a non-status quo alternative increases as the number of culturally important waterholes increases, the number of years of town water supply increases or the area of restored rangeland increases. The estimated coefficient on the household cost is negative and statistically significant. In the base model, the Alternative Specific Constant (ASC) is positive suggesting that the mean unobserved effects on utility are positive from selecting the alternative with no groundwater utilising option. This result may be an indication of protest behaviour.

In the development of the survey it was found that some respondents rejected the scenario of taxpayers being required to pay for management of surplus groundwater. Despite careful explanation of the regulations, a few respondents commented in the pilot that the mining companies should be responsible. Other respondents in the pilot commented negatively on government programs which support targeted job creation. To account for potential protest behaviour, respondents who selected the status quo alternative on more than three occasions were queried on the reason and presented with checkbox reasons. The reasons presented involved the rejection of the framing of the experiment, the payment vehicle, or job creation programs. A binary variable for protest behaviour could then be included in the modelling. A respondent was given a value of 1 if they selected at least one of the protest responses, or zero otherwise. Table 3 shows our identification rules for protest behaviour, with several of the statements identified being similar to those used by Barrio and Louriero (2013).

Table 3: Identification rules for protest behaviour

Protest	Description
No	I prefer the current situation
Yes	I think the mining companies should pay
Yes	I don’t think the mines should have been approved in the first place
Yes	I object to WorkStart programs
No	I cannot afford the cost increases
Yes	I object to increased taxes
Yes	I do not think the improvements in the Pilbara region will happen
Yes	I do not trust the government
No	I did not know which option was best, so I stayed with the current condition
No	It was not worth this amount of money to me
Yes	I prefer the landscape the way it is

Table 4: Estimated Models

Variable	**Base Model**	**Protest Model**
	Coefficient (Robust S.E.)	Coefficient (Robust S.E.)
Culturally Important Waterholes	0.234***	0.237***
	(0.0167)	(0.0169)
Town Water Supply (years)	0.012***	0.012***
	(0.0012)	(0.0012)
Biodiverse Land (1000 ha)	0.009***	0.010***
	(0.0009)	(0.0010)
Jobs for Aboriginal SME	0.004***	0.005***
	(0.0007)	(0.0007)
Household Cost ($/year)	-0.009***	-0.009***
	(0.0008)	(0.0008)
ASC (Status Quo)	0.405***	-0.815***
	(0.140)	(0.1840)
ASC (Status Quo)*Protest		3.740***
		(0.2230)
Diagnostics		
No. of Observations	2,952	2,952
Log-Likelihood	-2,931.279	-2,337.103
AIC	5,874.558	4,688.206
BIC	5,899.917	4,717.792
McFadden Pseudo R^2	0.096	0.279

*** 1% significance ** 5% significance * 10% significance. S.E. – standard error.

In the protest model, the ASC on the Status Quo Alternative was interacted with the protest variable. It was found that 100 respondents (20.3% of the sample) selected a protest response. The negative sign for the ASC coefficient indicates a positive impact on utility from selecting one of the policy-improving alternatives. The positive sign associated with the ASC for protest behaviour suggests that these individuals have an increased probability of selecting the status quo alternative with no groundwater utilising options. Improvements in the Bayesian Information Criterion (BIC) indicate that the model incorporating protest behaviour is a better model.

As the MNL model is restrictive with respect to preference heterogeneity, other econometric specifications were explored (other models available from the authors). Latent class (LC) models with different number of classes were estimated and a two-class model was selected on the basis of Akaike Information Criterion (AIC). Results from a three class LC model are shown in Table 5. In the LC model the class constant identifies the probability of membership of a given class. Alternative LC models employing two and four class structures were estimated but were found to be inferior when evaluating model AIC statistics. Various sociodemographic factors were also included in the class assignment model, including age, visiting cultural heritage areas in the Pilbara, gender, annual household income, education, the state the respondent lived in, and whether the respondent had previously lived or worked in the Pilbara region. Only the last factor was found to be significant in at least one of the classes.

Table 5: Latent Class Model results

	Base Model			Protest Model		
Variable	Coefficient (Robust S.E.)	Coefficient (Robust S.E.)	Coefficient (Robust S.E.)	Coefficient (Robust S.E.)	Coefficient (Robust S.E.)	Coefficient (Robust S.E.)
Latent Class	Class 1 (21.86%)	Class 2 (17.44%)	Class 3 (60.70%)	Class 1 (5.71%)	Class 2 (19.99%)	Class 3 (74.30%)
Attributes:						
Alternative-Specific Constant	2.396***	-4.701***	-1.604***	2.344***	-5.442***	-1.764***
(Status Quo)	(0.3719)	(1.0149)	(0.2570)	(0.3485)	(1.2647)	(0.2448)
Culturally Important	0.051	0.304***	0.288***	0.057	0.282***	0.288***
Waterholes	(0.0602)	(0.0763)	(0.0242)	(0.0538)	(0.0888)	(0.0236)
Town Water Supply (years)	0.009**	0.011*	0.015***	0.009**	0.007	0.015***
	(0.0043)	(0.0061)	(0.0016)	(0.0040)	(0.0075)	(0.0015)
Biodiverse Land	0.008***	0.008	0.011***	0.008***	0.012	0.011***
(1000 ha)	(0.0022)	(0.0067)	(0.0014)	(0.0022)	(0.0070)	(0.0013)
Jobs for Aboriginal SME	0.003	0.008**	0.004***	0.004*	0.008**	0.004***
	(0.0022)	(0.0034)	(0.0009)	(0.0022)	(0.0037)	(0.0009)
Household Cost	-0.011***	-0.062***	-0.005***	-0.011***	-0.068***	-0.005***
($/year)	(0.0036)	(0.0119)	(0.0010)	(0.0032)	(0.0146)	(0.0011)
Class Function:						
Class Constant	-1.021***	-1.247***		-2.565***	-1.313***	
	(0.1274)	(0.1923)		(0.2409)	(0.2069)	
Protest				5.216***	-0.393	
(1=Yes; see Table 3)				(0.4917)	(1.1501)	
Lived in the Pilbara Region	0.504*	-0.553		0.999***	-0.505	
(1 = Yes)	(0.2921)	(0.5439)		(0.4113)	(0.5377)	
Diagnostics						
No. of Observations			2,592			2,952
Log-Likelihood			-2,137.169			-1,993.792
AIC			4,318.338			4,035.584
BIC			4,410.705			4,136.347
McFadden Pseudo R2			0.341			0.385

*** 1% significance ** 5% significance * 10% significance. S.E. – standard error.

Both LC models have statistically significant positive coefficients for all attributes in Class 3 with signs as expected. If respondents are members of Class 2 or 3, the negative coefficient for the ASC suggests that they receive utility from choosing groundwater utilising alternatives compared to the status quo. The ASC for Class 1 is positive which indicates that members of this class prefer the status quo to the groundwater utilising alternatives, holding the attribute levels constant. The positive and significant value of the protest variable indicates that protest behaviour increases the probability of belonging to Class 1. This interpretation is also the case for households who indicated that they had lived or worked in the Pilbara previously.

There is a statistically significant positive class constant in both models, which is used to estimate the class structure. The results show that in the base model there is a 21.86% probability of being a member of Class 1, a 17.44% for Class 2, and a 60.70% probability of being a member of Class 3. In the model which accounts for protest behaviour there is a 5.71% probability of respondents belonging to Class 1, a 19.99% for Class 2, and a 74.30% probability of belonging to Class 3. Based on the class function coefficients a respondent who was identified as both indicating protest behaviour and had lived or worked in the Pilbara region was more likely to be belong to Class 1. Across all classes the cost coefficient is negative and significant. Class 1 is classified as having a positive significant coefficient for culturally important waterholes, town water supply, and biodiverse land. For Class 2 the coefficients for culturally important waterholes and aboriginal SMEs are positive and significant at the 5% level of significance. Finally, Class 3 has positive and significant coefficients for all the non-market attributes.

Table 6 summarises the mean willingness to pay estimates for the MNL and LC models from the three class classes for all attributes. The 95% confidence interval is specified in parentheses.

Table 6: Willingness to Pay Estimates with 95% Confidence Intervals

Attribute	MNL	LC: Class 1	LC: Class 2	LC: Class 3
Culturally Important Waterholes	$25.46 ($20.66 to 30.25)	$5.32 (-$4.11 to 14.75)+	$4.18 ($1.34 to $7.02)	$57.95 ($33.49 to $82.41)
Town Water Supply (years)	$1.33 ($1.05 to $1.76)	$0.87 ($0.10 to $1.64)	$0 (-$0.12 to $0.32)+	$2.98 ($1.69 to $4.26)
Biodiverse Land ('000 ha)	$1.04 ($0.80 to $1.27)	$0.72 ($0.19 to $1.24)	$0 (-$0.03 to $0.36)+	$2.25 ($1.27 to $3.23)
Jobs for Aboriginal SME	$0.50 ($0.38 to $0.62)	$0 (-$0.01 to $0.69)+	$0 (-$0.01 to $0.22)+	$0.90 ($0.50 to $1.30)

+ The 95% confidence interval overlaps with $0

Willingness to pay was calculated for MNL and LC models incorporating the protest variable. All the non-cost attributes are positive and statistically significant for Class 3. The MNL model estimates that households are willing to pay $25.46 per year for 5 years for each additional culturally important waterhole preserved (over the range of preserving 0 to 5 waterholes). In terms of biodiverse land, over the range of restoring between 0 and 75,000 hectares, households are willing to pay $1.04 for every 1,000 hectares that support habitat restoration for native flora and fauna. For every additional year of town water supply, between the range of 0 and 60 years, the willingness to pay is $1.33. Finally, in terms of jobs for Aboriginal SME, households are willing to pay $0.50 for every additional job created, involving the creation of up to a maximum of 150 jobs.

When comparing the MNL to the LC results, the results for Class 1 have relatively lower mean willingness to pay estimates for every attribute except jobs for Aboriginal SME. The jobs for Aboriginal SME attribute is significant in the MNL model, and is insignificant for Class 1. For Class 2, only the attribute for culturally important waterholes has an estimated willingness to pay with confidence intervals that do not overlap $0. All willingness to pay estimates for Class 3 are significant and relatively larger when compared to the MNL estimates.

5. Discussion

The results from the DCE demonstrate Australians have a positive willingness to pay for several surplus groundwater management options. Individuals are willing for their household to pay additional taxes over 5 years to preserve culturally important waterholes (which underpin the delivery of a range of cultural ecosystem services), restore biodiverse rangeland, provide extra years of available town water supply, and create jobs through an Aboriginal SME. In terms of culturally important waterholes, the results add to recent literature which reports that in Australia and New Zealand, the public are willing to pay for water uses that provide a cultural value (Miller et al., 2015; Zander et al., 2013; Zander et al., 2010). Negative willingness to pay for cultural sites found by Rolfe and Windle (2003) may be context-specific.

When considering the LC results, there is an interesting divergence between each of the classes, with Class 3 having significant willingness to pay for all attributes implying that in addition to the value of town water supply there is a value to preserving culturally important waterholes, improving the ecological condition of the region in terms of biodiverse land and provision of employment opportunities through Aboriginal SME. Both Class 1 and 3 have significant willingness to pay for additional years of town water supplies. These results suggest that whilst a majority (~80%) of the

Australian public would support public expenditure for a range of policy alternatives which capture non-use, intrinsic, cultural and ecological values that there is a minority (~20%) who support expenditure only on options which capture use and instrumental values.

When comparing the estimates for biodiverse land to past studies, Hatton MacDonald and Morrison (2010) estimated South Australian household's willingness to pay to restore scrublands, a similar type of habitat, at $0.72 per 1,000 ha each year for five years. The similarity of the results demonstrates some stability in the preferences for restoring habitat area. However, it should be noted that Van Bueren and Bennett (2004) estimated a willingness to pay of only $0.07 annually per household for every 10,000 hectares of land restored (which is the equivalent of less than 1 cent for every 1,000 hectares).

The estimated coefficient for town water supply is consistent with the DCE literature when considering individuals willingness to reduce the risk of contaminants and improve the drinking water quality of groundwater systems (Tempesta and Vecchiato, 2013; Baskaran et al., 2009). These studies support the consideration of the willingness to pay for the direct use value of water. Whilst research in southeast Queensland found a negative willingness to pay for groundwater as a decentralised water system (Alcon et al., 2014; Tapsuwan et al*.,* 2014), the result is potentially due to the perceived effort of installing groundwater bores, and not a negative value from receiving groundwater.

There has been a growing body of work on the value different societies hold for the provision of additional employment. The importance of jobs to Aboriginal communities and the wider value to society of increased Aboriginal employment in remote areas has qualitatively been identified (Dillon, 2016). More generally, in Australia, Morrison et al. (1999) estimate a value per household of $0.13 ($0.05 to $0.22) per rural job. In follow-on work, Morrison et al. (2002) estimate there are small positive values ($0 to $0.21) for irrigation-related jobs. Miller et al. (2015) find the median estimate per job for households is NZ$0.16 annually for 5 years. Meanwhile, two studies in Greece and the United Kingdom calculate the value per household of retraining an employee to be €0.13 (€0.08 to €0.18) (Birol et al., 2006) and employing someone, £0.06 (£0.04 to £0.08), respectively (Birol and Cox, 2007). Our somewhat higher estimates suggest the willingness to pay may be capturing additional values such as reducing structural unemployment, strengthening Aboriginal communities, improving the local economy, or upholding values of social justice. This supports careful consideration of Aboriginal job creation in negotiated agreements (Jackson and Barber, 2015).

A significant, unexpected sign on the ASC attribute of the base MNL model led to the investigation and identification of a potential impact of protest behaviour. While efforts were made in the survey to explicitly define the legal role of mining companies and where the responsibility of government lay with respect to surplus groundwater options, a portion of participants indicated that mining companies should pay. Although we attempted to identify the influence of respondent characteristics, a potential limitation is that there were no questions in the survey that explicitly investigated the potential role of political affiliation, attitudinal scales towards Aboriginal people, or other follow-on questions. Despite this limitation, accounting for protest responses has led to a significant improvement in the fit of the model and has highlighted the distinct groups of preferences. This finding is similar to other studies who have accounted for protest behaviour in the context of ecosystem service provider's preferences (Villanueva et al., 2017) or the management of biosphere reserve management programs (Barrio and Loureiro, 2013).

6. Conclusions

This study addresses management of land and water resources and the cultural impacts of deep mining operations. Using a DCE patterns of preferences for economic, ecological, and cultural goods are identified. Protest behaviour is identified using a set of experimental framing and payment vehicle questions. The protest models have a better fit and indicate that a small proportion of respondents give zero value to ecological and cultural goods in remote mining areas. As these same respondents support extending water town supply to remote mining towns and this is suggestive that they are not opposed to mining.

The current research focussed on waterholes as cultural sites which would be impacted by dewatering activities. However, methodologies could be more extensively applied to consider the wider potential cultural heritage impacts of mining. Whilst this paper aims to identify relative preferences, in monetary terms, of the Australian general public, the authors are respectful of the cultural value that Indigenous Australians place upon the land and water. The values identified offer a policy tool for ranking alternative uses for surplus groundwater from mining operations. We identify that the majority of the Australian general public place an economic preference for the use of environmental resources to support Indigenous Australian employment and their cultural heritage links to the land and water. However, we do not anticipate that the values identified fully capture the intrinsic values Indigenous Australians place on the cultural ecosystem services of the Australian landscape. Here lies a potential extension of the research in terms of identifying appropriate methodologies to incorporate Indigenous Australian values in the decision-making process.

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