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VALUING THE PRESERVATION OF AUSTRALIA'S KAKADU CONSERVATION ZONE

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1. Introduction

LIKE MANY other countries, Australia has experienced an intensification in both the frequency and complexity of disputes over natural resources in recent years. The most contentious issues involve overlapping claims for the development and preservation of scarce natural resources. In response to the divisive debates over the issues of development and its environmental impact, the Australian government set up an independent body, the Resource Assessment Commission (RAC), to help assess the relative merits of various policy options.

In April 1990, the RAC was asked to undertake an inquiry to evaluate a number of options for the use of the resources of the Kakadu Conservation Zone (KCZ). The key issue was whether mining should proceed in the KCZ or whether the KCZ should instead be added to Kakadu National Park (KNP). The KCZ is a 50 square kilometre area lying entirely within the boundaries of the KNP. The KCZ was originally part of a government grazing lease when KNP was initially set aside as a park and has long been known as a potentially rich mineral area. It is believed to contain significant deposits of gold, platinum, and palladium at sites known as Coronation Hill and El Sherana. KNP is one of Australia's major national parks and, along with the Great Barrier Reef, is directly managed by the Australia Nature Conservation Agency. Much of the park is on the United Nation's World Heritage list for its unique ecosystem, extensive wildlife, and aboriginal archaeological sites.[1] The KNP was originally intended to encompass the entire drainage basin of one of Australia's major rivers, the South Alligator River. The headwaters of this river are located in the KCZ.

The key issue confronting the RAC in its KCZ inquiry was whether the potential gain from mineral development in the KCZ outweighed: (i) the permanent harm which might be done to the immediate area around the proposed Coronation Hill mine; (ii) the risk posed to the KCZ and the KNP from the mine; and (iii) any loss from not being able to use the KCZ as part of the KNP while mining activities were being undertaken. The major point of

[1] For a comprehensive description, see Australian National Parks and Wildlife Service (1986). KNP may be best known to those outside Australia as the film location for the movie Crocodile Dundee.

contention between the opposing interest groups (i.e. the mining industry and the environmental groups) centered around the nature of the risk to the KCZ and to the KNP and the value the public placed on avoiding that risk. The mining industry contended that the risk was very small, that it was limited to the immediate mine site, and that the public placed little value on avoiding it. The environmental groups believed the risk to be fairly large, that the risk extended beyond the boundaries of the KCZ to the KNP, and that the public placed a very high value on avoiding it.[2]

The disagreement between the two sides may be driven by disagreement over the actual nature and magnitude of the risk posed by the proposed mine or it may be driven by a disagreement over how the Australian public values a particular risk. The first is potentially reconcilable by ascertaining the objective scientific facts concerning the risk. The second is potentially reconcilable by determining the value the public places on a particular risk. In practice neither may be achievable because: (i) different parties are likely to have different interpretations of the same facts; and (ii) different interest groups tend to think it unreasonable that the public should not place the same value on a good as they do. The RAC undertook studies to examine the scientific facts and to estimate the public's value for different policy options.

The principal values in dispute between the two interest groups are typically referred to as existence values (Krutilla 1967), or more generally, as passive or non-use values. Measuring such values is important because Australians may be willing to pay to see the KCZ added to KNP even though they have no immediate intentions of visiting these places. Contingent valuation (Mitchell and Carson 1989) measures total value, that is direct-use values plus passive-use values. It is the only technique capable of including passive-use considerations in its estimate of value, which is an important consideration in the choice of a valuation technique when passive-use values are believed to be potentially large. This paper presents results of the contingent valuation study conducted by the RAC to estimate the Australian public's value for adding the KCZ to KNP.

2. Major Contingent Valuation survey design issues

Many design issues are faced in the development of a contingent valuation survey instrument. The major survey design issues discussed in this section are: (i) the accurate depiction of the actual good itself; (ii) the issue of determining the appropriate general context in which the good would be provided; (iii) the payment structure for the good; (iv) the value elicitation method used; and (v) the collection of attitudinal and demographic variables for predicting a respondent's willingness to pay (WTP) for the good. The complete text of the contingent valuation (CV) survey instrument and copies of the visual aids are contained in Imber *et al.* (1991).

[2] The environmental groups' perception of the risk was motivated in part by two large disasters on rivers from gold mining operations using large quantities of cyanide, one in the US and the other in Papua New Guinea involving a member of the consortium proposing to mine the KCZ.

2.1. *Depiction of good to be valued*

The crucial decision made early in the course of designing the CV survey instrument was to have two different characterizations of the risk posed by the mining activity. This decision was driven in part by the fact that the RAC's scientific investigation into the actual risk posed by the mining activity would not be completed until close to the time the RAC had to make its recommendation to the government. To the extent that the scope of the actual risk is bracketed by the two opposing interest groups' views of it, the valuation question is at least potentially a separate issue from the determination of the actual risk. This will be the case if the public's willingness to pay to avoid the environmental groups' view of the risk is smaller than the benefits of the mining activity or if the public's willingness to pay to avoid the mining industry's view of the risk is larger than the benefits of the mining activity.

Two scenarios were developed—a 'major impact scenario' and a 'minor impact scenario'.[3] Each scenario described four types of environmental impact: (i) mine-related traffic; (ii) chemicals used to extract minerals; (iii) mine process water and waste rock material; and (iv) possible injury to the environment and wildlife. The two scenarios differ primarily on the issue of possible off-site environmental damage. The major impact scenario was designed to describe a realistic worst case. The minor impact scenario was confined largely to the unavoidable on-site effects of mining in the KCZ. To a large extent, the compilation of the two scenarios reflected the positions of the two major interest groups—the environmentalists and the mining industry. Although there was general agreement as to the accuracy of the technical content, neither party expressed complete satisfaction with the scenario descriptions.

Under both scenarios, respondents were first read a description of the KNP and KCZ. The description of the area was virtually identical for the major and minor impact scenarios. During the course of this description, they were shown first a map of Australia displaying the location of the KNP and then a map of the KNP showing the location of the KCZ.[4] Using the KNP map, respondents were shown key features of the park, including the South Alligator River and the two proposed mine sites, Coronation Hill and El Sherana, which are located in the KCZ. Respondents were then shown a series of photographs of the area around Coronation Hill, the proposed principal mine site. Three photographs displayed environmental damage from several small open-pit uranium mines dating from the 1950s and from water buffalos which roamed the area under earlier grazing leases. The close proximity (i.e. 250 metres) of the South Alligator River to the proposed Coronation Hill mine was also shown. Respondents were told the area provides important wildlife habitat, particularly in times of drought. They were shown wide angle views of the area around Coronation

[3] These two terms are used to help the reader distinguish the two different scenarios. They are used only in a relative sense and were never conveyed to respondents.

[4] The KCZ was described to respondents in the survey as a particular 'area' or 'zone' separate from but surrounded by the KNP.

Hill. A card exhibited biology text-like pictures of six wildlife species (i.e. orange horseshoe bat, giant cave gecko, rock monitor, Kakadu dunnart, Calaby's mouse, and the partridge pigeon) likely to be affected locally by mining activities. Respondents were told that the area was already used by tourists and that tourism did some environmental harm. They were also informed that the area was important to the Aboriginals who had made claims to it.

The scenario description then turned to the mine itself. Respondents were shown a card describing the mine's operation and effects. They were told that the mine would employ 150 workers for 10 years, that much of it would be underground, and that the mine site itself would occupy about 1 sq. km. Extensive environmental safeguards were described. Respondents were shown two artist's impressions of how the mine site at Coronation Hill would look, including the mine pit, processing plant, waste rock piles, tailings storage pond, and the primary road. They were told that much of the mine area would be restored after mining ceased but that the open pit would remain.[5] Respondents were told that if another mine was allowed in the area (i.e. El Sherana), the environmental safeguards and impacts would be similar to those at Coronation Hill.

The major and minor impact scenarios differ primariy in their depiction of possible impacts outside the KCZ. The major impact scenario included a picture of the wetlands 90 km. downstream from the proposed Coronation Hill site; and respondents were told that there was a small chance of an accident which could 'harm plants and animals that live close to or well away from the mine'. Respondents were also told that there was some possibility that 'the mine could upset the natural balance of Kakadu National Park'. In the minor impact scenario, effects were confined to the KCZ and were centered on the area immediately surrounding the mine.

Two other differences between the scenarios bear mentioning. In the major impact scenario respondents were told about the actual chemicals being used in the mining process; cyanide was specifically mentioned. In the minor impact scenario, reference was made only to 'toxic chemicals'. The major impact scenario also noted that in times of drought there might be water shortage problems for local wildlife due to the mine and that wildlife in the area around the mine would be disturbed and some killed in spite of precautions. The other scenario did not mention the water shortage issue and noted only that wildlife in the local area would be disturbed.

The differences between the two impact scenarios were generally of a qualitative not quantitative nature. The information contained in the two scenarios were largely consistent, the major impact scenario encompassing the minor impact scenario by presenting an expanded and less optimistic view of the possible impacts.

[5] As this aspect seemed important to some respondents, a plan which required complete restoration of the area after mining might have easily resulted in lower estimates. At the time the survey was undertaken, the mining project was deemed economically infeasible if complete restoration was required. The complete restoration issue was later reconsidered by the RAC.

2.2. *General provision context*

The general context in which the good will be provided is an important aspect of a CV survey. At the most general level we sought to avoid respondents placing an artificial importance on preserving the KCZ due to the simple fact they were being interviewed on this issue. First, respondents were asked to express their attitudes on a number of public policy issues. Second, the survey drew the respondent's attention to the fact that the environment is only one of many such issues. Respondents were also asked to name the environmental problems that worried them most. This helped to place the issue of mining the KCZ in the perspective of other environmental issues. Respondents were reminded just before the WTP questions that mining in the KCZ is 'only one of many environmental issues which may cost you money'. At a more specific level, respondents needed to distinguish the KCZ from the larger KNP. This was facilitated by the use of visual aids, which included a map of Australia locating the KNP, This was followed by a map of the KNP with the KCZ and the proposed mine highlighted to accentuate the relative size of the KNP, the KCZ, and the mine.

Another general provision context question which should always be addressed is the appropriate property rights framework, that is, whether the public should be required to pay for obtaining the good or whether the public should receive compensation for giving it up (Hanemann 1991). Closely linked to that question is the issue of whether the good should be valued in a sequence of other public goods and, if so, where in that sequence (Hoehn and Randall 1989). Typically, willingness to accept (WTA) compensation would be the appropriate property right in this case. However, previous mining in the KCZ and the history of creating KNP cloud the picture. In any event, WTA questions are extremely difficult to reliably implement in CV surveys. Carson, Flores, and Hanemann (1992) have shown that willingness to pay obtained for a public good valued alone (i.e. first in a sequence) is less than willingness to accept for the good valued in any order in a sequence. If willingness to pay is the appropriate property right, then it must be considered whether the good in question is part of a larger package contemplated by the agency and, if so, in what sequence the goods in the package would be provided. In this instance, the RAC was looking at three major Australian natural resources issues involving the KCZ, the coastal zone, and the forest estate. The KCZ decision was scheduled to be made first, suggesting that eliciting a WTP value for preserving the KCZ first in the sequence (i.e. alone) was appropriate. Thus, in this case the same operational decision to elicit willingness to pay for preserving the KCZ was indicated. Whether this is the correct measure or merely a lower bound is dependent on the correct property right.

2.3. *Payment structure*

To obtain a conservative benefit estimate and to maximize the legitimacy of the valuation exercise to the respondent, a WTP question rather than a WTA

question was used to estimate the change in preservation value from not mining the KCZ. Respondents were told that in order to secure the preservation benefits of the KCZ, the public would be expected to pay to replace lost government revenue and park management costs. The payment vehicle used was the reduction in take-home pay or other income of the respondent as a result of increased taxation to set off the loss of tax revenue from the mine, and to provide money to set up the KCZ as part of the KNP and manage it each year.

Because Australian taxes are collected on an individual basis, the survey asked for information about individual willingness to pay. To facilitate comparison to year-by-year estimates of the benefits of mining being developed by the Australian Bureau of Agricultural and Resource Economics, information about annual willingness to pay was elicited.[6]

In retrospect, both of these decisions were problematic. First, there is clear evidence that many respondents based their responses on household income.[7] The conservative assumption is that WTP responses are household, not individual, responses. Second, for goods which look like capital purchases, the interpretation of annual contingent valuation payments is being seen as increasingly difficult. Without a great deal of effort devoted to laying out the payment stream, some respondents may grasp or take seriously only the first year or first few years of payment requests. They may do the latter because they discount additional payments required to purchase the good, or because they believe that the govenment can essentially recontract and change its budget priorities if better opportunities come about. Again, the conservative approach is to treat the payment request as a one-time lump sum.

2.4. *Elicitation method*

We chose the double-bounded, discrete-choice elicitation method (Hanemann *et al.* 1991) for this study. This approach asks a respondent whether she is willing to pay a pre-chosen randomly-assigned amount. If the answer is yes, the respondent is asked whether she is willing to pay a pre-chosen higher amount. If the answer is no, the respondent is asked whether she is willing to pay a pre-chosen lower amount. The discrete choice nature of the question provides respondents with a straightforward option: pay A$$X$ and add the KCZ to KNP or pay nothing and have the KCZ mined. The specification of A$$X$ as the revenue loss to be made up is also consistent with the general prior belief of respondents that the government has indeed estimated the cost of policy options seriously being considered.

[6] It might have been possible to have used loss of net benefits from the mine directly as the motivation for asking for WTP responses; however, this would have likely resulted in a substantial property rights motivated protest response associated with paying a private enterprise not to mine the KCZ.

[7] This observation is based in large part on finding that a non-trivial number of respondents with 'home duties' who reported no income but agreed to pay sizeable amounts. The original RAC estimate was based on 12,261,455 adults rather than 5,420,400 households.

As respondents can only anser 'yes' or 'no', they have little opportunity to bias their answers deliberately in the hope of influencing the survey results.[8] Less burden is placed on respondents because they are not required to determine their exact maximum willingness to pay, rather only whether they are willing to pay at least the amount asked. This is how consumers generally make decisions about the purchase of private goods. The discrete-choice model also tends to be a more realistic and familiar model for the provision of public amenities.

The double-bounded, discrete-choice elicitation method obtains more information about where respondents' WTP amounts lie than does the simple binary discrete choice approach. As a result, the chosen elicitation method obtains substantially more precise estimates than the binary discrete choice method for a given sample size. Like the binary discrete-choice estimator, the information about the extreme tails of the distribution is not gathered. This makes estimates of the mean willingness to pay obtained using this approach quite sensitive to the particular distributional assumption made. Since an initial decision that median willingness to pay would be the principal summary statistic used, this was not seen as a serious problem.

Four sets of dollar amounts were used ([A: 100, 250, 50], [B: 50, 100, 20], [C: 20, 50, 5], and [D: 5, 20, 2]). These amounts were used, to a large extent, in order to facilitate comparison to the likely range of possible benefit estimates from mining the KCZ.

2.5. *Attitudinal, behavioral, and demographic variables*

The KCZ survey instrument contained a number of open-ended and closed-ended questions which elicited attitudinal, behavioral, and demographic information from respondents. The attitudinal questions ranged from general questions on major Australian policy issues to a set of very specific questions on issues concerning national parks and mining. These questions were designed to collect information on the underlying beliefs that Australians hold about natural resource issues. Information was also collected concerning knowledge about KNP, past visits to KNP, desire for a future visit to KNP, and recent visits to national parks and bushland recreation areas. Other questions elicited information about watching nature shows on television, recycling, and membership in environmental organizations. Among the demographic variables elicited were income, age, education, sex, and occupation. Many of these supplemental questions are used in constructing the valuation function estimated in Section 7.

3. Survey pre-test, administration, and sample design

The KCZ survey instrument was extensively pre-tested using experienced interviewers. The pre-text showed the need to modify some parts of the text

[8] As a result respondents who held zero or negative values should say no to any positive amount asked, while respondents with extremely high values should say yes to any of the amounts asked.

which flowed badly, to change some of the skip patterns, and to provide additional cards containing response choices for some questions. A number of minor language changes were made to the KCZ scenarios to improve their understandability. A statement on Aboriginal issues was added as a result of respondent questions during the pre-test. Interviewer screening and training techniques developed for the pre-test were developed further as a result of the pre-test experience.

The Kakadu CV survey was administered in September 1990 throughout Australia by AGB: McNair, one of Australia's major survey research firms. Interviews with 2,034 respondents were completed.[9] The survey was conducted door-to-door with one person interviewed in each selected household. Respondents were selected using a household-based multi-state stratified random sample of persons 18 years or older. Stratification was first done at the state level and then at the metropolitan/non-metropolitan level. Within strata, census enumeration blocks were randomly chosen, with probability proportionate to the population contained in the 1986 Census and households in these blocks physically listed. After household selection, a quota design was used to ensure a sex and age balance for respondents. Respondents were randomly assigned one of eight versions of the questionnaire. Versions contained either a major or minor impact scenario combined with one of four sets of dollar amounts.

Interviewers received extensive training by attending one of 14 full-day training sessions held in different locations throughout Australia. The training emphasized the use of visual aids, the need for neutrality, and the nature of the quota selection. The survey instrument took on average a little over 30 minutes to complete. Interviewers made at least three calls back (at least two of which were in the evening or on weekends) in an effort obtain a completed interview. A 62% response rate was achieved. Those not interviewed were divided primarily into refusals and failures to contact, with the latter category being larger. The survey firm randomly selected 12% of the completed questionnaires and independently verified that all of these interviews had actually taken place. An interviewer debriefing after the survey suggested that the survey had gone well and had been taken seriously by respondents.

4. Estimation of median WTP

Asking each respondent two discrete choice questions defines an interval estimate of their willingness to pay (WTP): a respondent's WTP could be categorized as being less than the smaller amount asked, between the two amounts, or greater than the larger amount. For our sample, the WTP responses can be shown to lie in one of the following intervals based on the dollar amounts randomly assigned to the respondent and depending on the pattern of the for and against responses to the valuation questions: A: $0–2,

[9] A separate sample of 502 interviews conducted solely in the Northern Territory was also obtained at the same time using similar procedures. This sample is discussed in a later section.

\$2–5, \$5–20, \$20–∞; B: \$0–5, \$5–20, \$20–50, \$50–∞; C: \$0–20, \$20–50, \$50–100, \$100–∞; D: \$0–50, \$50–100, \$100–250, \$250–∞.

This type of information on willingness to pay can be analyzed using survival analysis techniques appropriate for interval-censored data (Nelson 1982). A survival function is defined as one minus the cumulative distribution function at a particular point. In our case, the estimated survival function will trace out the percentage of the population willing to pay particular dollar amounts. The general log likelihood function for interval censored survival data can be written as

$$\ln L = \sum_i \ln\left[\Phi\left(\frac{\eta_{ij} - \mu}{\sigma}\right) - \Phi\left(\frac{\eta_{ij-1} - \mu}{\sigma}\right)\right]$$

where the i_{ih} unit's functioning (e.g. where the respondent is willing to pay the amount asked about) is inspected j independent times to check for failure (e.g. not being willing to pay the amount inquired about). This suggests two possibilities; either the unit failed in the interval between the last two inspection times $[\eta_{ij-1}, \eta_{ij}]$ or the unit is still responding positively at the last inspection time, in which case the observation is considered censored at η_{ij}.[10] The location and scale associated with the underlying density function, $\Phi(\cdot)$ are given by μ and σ. It is possible to fit this likelihood function directly using a variation of the Kaplan-Meier nonparametric approach proposed by Peto (1973) and Turnbull (1976) or to fit it assuming a particular parameteric distribution for $\Phi(\cdot)$.

A large number of parametric survival distributions are available, and the most frequently used is the Weibull distribution. In our case, the Weibull has the advantage of being the simplest two-parameter survival distribution which allows for the possibility of an increasing, decreasing, or constant price elasticity. This distribution is fairly flexible and is capable of approximating a large number of other distributions, including that of the normal and exponential. The Weibull distribution has two parameters, a location parameter (α) and a scale parameter (β).[11] Using the accelerated life representation of the Weibull distribution, the survival function can be written as

$$S(y) = 1 - F(y) = \exp\left[-\exp\left(\frac{y - \alpha}{\beta}\right)\right]$$

The median willingness to pay of respondents of our sample is estimated using both the Turnbull nonparametric approach and a parametric approach

[10] In our analysis, we make the usual assumption found in the statistics literature that the response to the second question is not influenced by the response to the first question. This is unlikely to be strictly true and usually a downward bias (insignificant in our case) is observed relative to and analysis based on the first WTP response. Cameron and Quiggan (forthcoming) and Alberini *et al.* (1994) present models which allow for imperfect correlation between the two responses using this study's data as an example.

[11] Most statistics of interest can be written as a function of these two parameters. For instance, the general formula for the willingness to pay of the pth percentile of the distribution is given by $WTP_p = \exp(\alpha)[-\ln(1-p)]^{\beta}$.

TABLE 1
Turnbull nonparametric estimation results

Interval		*Minor scenario*		*Major Scenario*	
Lower bound	*Upper bound*	*Probability of being greater than the upper bound*	*Change in density*	*Probability of being greater than the upper bound*	*Change in density*
$-\infty$	2	0.706	0.294	0.788	0.212
2	5	0.680	0.026	0.780	0.008
5	20	0.628	0.052	0.716	0.064
20	50	0.563	0.064	0.650	0.066
50	100	0.488	0.075	0.580	0.070
100	250	0.377	0.111	0.382	0.198
250	∞	0	0.377	0	0.382

based on Weibull distribution. The nonparametric approach only imposes the restriction that the estimate of the survival function is (weakly) monotonically declining in price and imposes a self-consistency property when there are multiple or overlapping estimates for a particular interval. It should also be noted that the nonparametric estimator allows for the possibility of negative WTP amounts which parametric survival estimators generally do not. This is especially important for the Northern Territories sample considered later. While distribution-free, the nonparametric method has the drawback that it only provides estimates of a fraction of the distribution which falls into particular intervals defined by the dollar thresholds used. The estimates for the major and minor impact scenarios are displayed in Table 1.

Note that this nonparametric approach does not provide any point estimates. For this we turn to the parametric approach which can provide point estimates for statistics such as the median and mean, as well as easily handling covariate analysis which is presented in Section 7. The drawback of the parametric approach is that some statistics, the mean in particular, are often quite sensitive to the particular distributional assumption made. Table 2 displays the non-parametric estimate of the interval where the median falls, as well as the Weibull based estimate of the median and its 95% confidence interval.[12] Figure 1

[12] While we restrict our attention here to Weibull distribution, other common distribution assumptions such as the log-normal and log-logistic result in similar estimates for median willingness to pay for the two scenarios. These distributions provide for fairly similar fits over the range of the dollar thresholds used. However, those distributions imply radically different estimates for the mean because they imply quite different behavior for the tail of the distribution. A lower-bound estimate for the mean can be obtained using the non-parametric interval estimates and placing all of the probability mass in each interval at the lower end-point of that interval. Doing this for the minor impact scenario yields an estimate of A$110.69. Werner (1994) provides an extensive discussion of the econometric issues involved in estimating mean willingness to pay from this dataset emphasizing the treatment of possible zero WTP responses.

TABLE 2
Australian sample median willingness to pay estimates

	Nonparametric estimate of median interval	*Weibull median estimate (95% confidence interval)*
Major impact scenario	A$100–A$250	A$143.26 (110.31–186.02)
Minor impact scenario	A$50–A$100	A$80.32 (60.65–106.37)

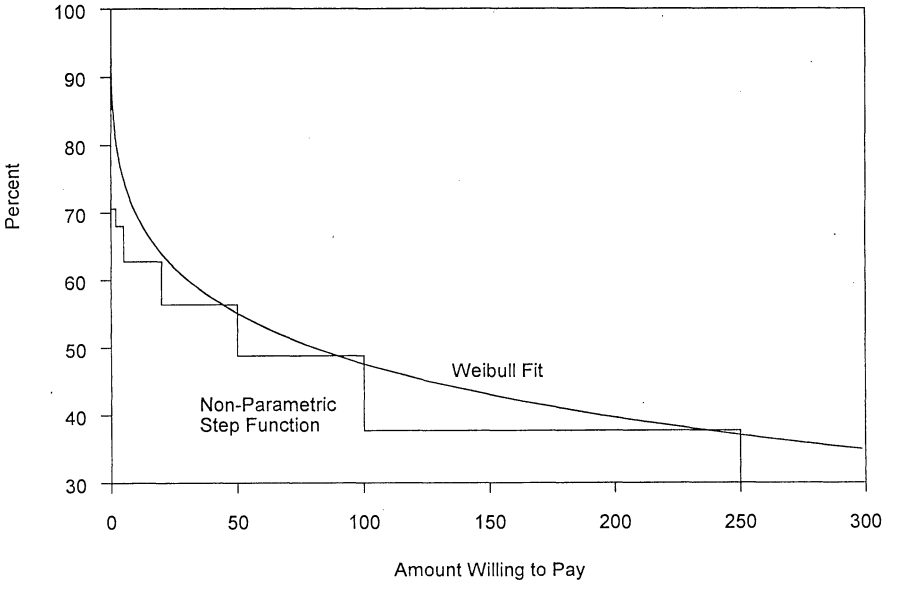

FIG. 1. Minor impact scenario

compares the smooth Weibull parametric fit to the nonparametric step function for the minor impact scenario. A good fit for the parametric model is indicated when its estimated survival curve just touches the top of each step of the nonparametric step function. Visual inspection suggests quite a good fit except for very small dollar amounts.

It is possible to test whether the major and minor impact scenarios resulted in different WTP distributions. By comparing the log-likelihood of the Turnbull estimator using the complete data set to the sum of the log-likelihoods from fitting this estimator to the separate major and minor impact scenario subsamples. The resulting test statistic, 27.20, is distributed as a $\chi^2_{(6)}$ variate under the null hypothesis that the two distributions are identical. This test

TABLE 3
Test of scenario difference in Weibull model

Parameter	*Estimate*	*t-statistic*
Scale	2.932	27.89
Location	5.439	38.75
Major	0.673	3.47

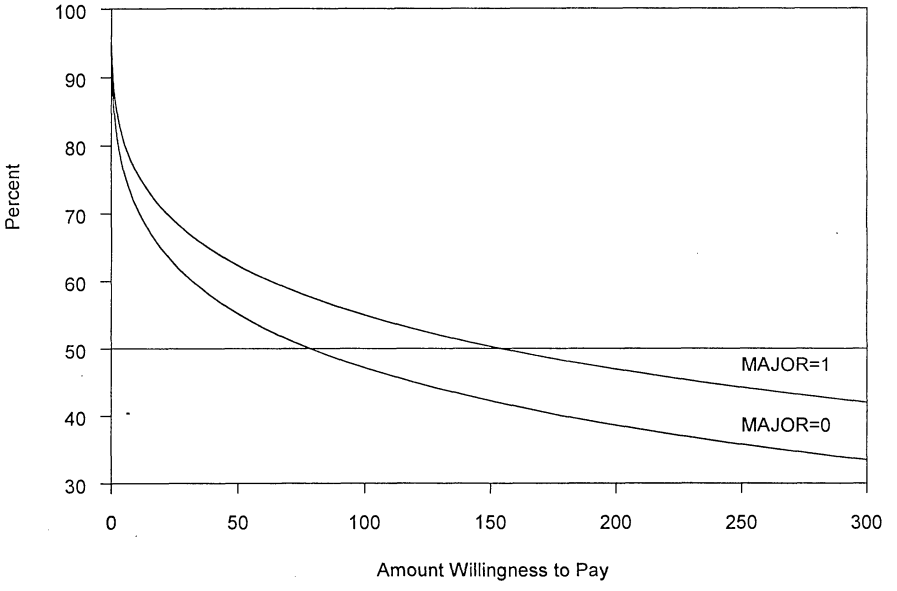

FIG. 2. Willingness to pay for preserving KCZ

indicates a clear rejection of the null hypothesis of no difference between willingness to pay under the two scenarios at $p < 0.01$.

Whether the major and minor impact scenarios share the same location parameter in the parametric Weibull model may be tested by parameterizing the location coefficient to include a dummy variable for the major impact treatment. The results from this estimation are displayed in Table 3. The coefficient on the major impact treatment dummy has a t-statistic of 3.47. This also provides clear evidence for rejecting, at the $p < 0.01$ level, that the major and minor impact scenarios were valued equivalently by the Australian public. This difference can be seen graphically in Fig. 2 which plots the estimated Weibull survival curves for the major and minor impact scenarios.

These two tests strongly suggest that respondents valued the two different impact scenarios differently, with median willingness to pay being substantially larger for the major impact scenario. This evidence refutes Kahneman's

TABLE 4
NT sample median WTP estimates

	Nonparametric estimate of median interval	*Weibull estimate median (95% confidence interval)*
Major impact scenario	A$20–A$50	A$35.28 (19.92–62.50)
Minor impact scenario	A$20–A$50	A$33.61 (19.26–58.65)

supposition (Kahneman 1986; Kahneman and Knetsch 1992) that respondents are incapable of distinguishing between different levels of a potentially symbolic good and supports Smith's (1992) position that Kahneman's empirical results are not likely to generalize to CV surveys which devote substantial effort to laying out in careful detail the characteristics of the good respondents are being offered.[13]

5. Northern Territories sample

A separate sample was taken of 502 households in the Northern Territories (NT) where the KNP is located.[14] The same type of median estimate for this sample as those provided in the previous section may be obtained. These estimates are presented in Table 4.

These estimates display several interesting characteristics. First, they are much lower than the estimates for the Australian sample presented in Table 2. Second, in contrast to Table 2, there appears to be little or no difference between the estimates for the major and minor impact scenarios. Third, a close look at the interval estimates based on the nonparametric approach suggests that the WTP responses are much more concentrated in the extremes and appear to be somewhat bimodal. As a result, the (unconditional) Weibull distribution does not appear to be a particularly good fit for the NT subsamples.

None of these findings are surprising. In contrast to other areas of Australia, many NT respondents are likely to perceive direct benefits from mining in the KCZ. Thus, the lower values for the NT sample were not unexpected. Also, in contrast to the rest of Australia, NT residents were likely to have been exposed

[13] While space considerations prevent us from further discussion of this issue, it was a key area of concern in the NOAA Blue Ribbon Panel's deliberations on contingent valuation. Carson and Mitchell (1993, forthcoming) discuss this issue at length making specific reference to this and other split sample tests which demonstrate the sensitivity of respondents to the scope of the good being valued.

[14] The sample was taken because less than 1% of the Australian population lives in the sparsely populated Northern Territories. Therefore, a random sample of the Australian population would not have included enough observations to draw any reliable inferences about the willingness to pay values of the region where the mine would be located. Indeed, only sixteen out of 2,034 respondents in the Australian sample are from the Northern Territories.

to substantial information about the possible effects of mining in the KCZ. As a result, many NT residents had probably formed their own views about the risk to KNP from possible mining. Those views were unlikely to be altered by the particular version of the KCZ scenario received, since most of the information in the two scenarios was identical and the rest of the information was not directly contradictory. The key differences between the two interest groups' views about the risk to KNP from mining had been well publicized in the NT. Many of the most vocal proponents and opponents of mining often came from the NT and the proponents had the public support of the NT government.

An interesting question is whether the NT sample's lower median estimates are due to fundamentally different preferences or whether those preferences, after conditioning on the values of observable covariates, are similar to respondents elsewhere in Australia. In particular, is the extreme, almost bimodal response pattern in the NT sample explained by the differences in covariate values? This isssue is taken up in the next section.

6. Valuation function

In this section we estimate a valuation function, first for the Australian sample and then for the combined Australian and NT samples. The estimation of such a function serves several purposes. It will allow us to perform a test of construct validity by determining whether the willingness-to-pay responses are systematically related to covariates which theory suggests should be predictors. It will also allow us to compare formally in a statistical sense valuation functions estimated from the Australian sample and the combined Australian and NT samples.

6.1. *Weibull model with covariates*

To see how the Weibull distribution works in practice with covariates, let WTP_p be the estimated amount that the pth percentile respondent with the covariate vector X is willing to pay. Given our Weibull distributed assumption, WTP_p can be expressed as

$$WTP_p = \exp(\alpha + \gamma X)[-\ln(p)]^{\beta}$$

where γ is the vector of parameters associated with the covariate vector.

For example, assume that α equals 5.439 and β equals 2.932, and that the major impact scenario dummy is the only covariate and its γ equals 0.673 (i.e. the parameter estimates in Table 2). To find the estimate of the willingness to pay of the median ($p = 0.5$) respondent in the major = 1 subsample

$$\exp(5.439 + 0.673 * \text{major} = 1)[-\log(0.5)]^{2.932} = 154.06$$

Additional covariates can easily be added (e.g. $\gamma_1 X_1 + \gamma_2 X_2$) and the sense in which these covariates allow the univariate Weibull location parameter to be generalized is now easily seen.

6.2. *Valuation function predictor variables*

A valuation function predicts a respondent's willingness to pay as a function of financial resources (Y), tastes (T) for the good, and treatment variables such as the characteristics (C) of the particular goods being sold: $WTP = f(Y, T, C)$.

Financial resources are most often defined as either disposable income or wealth. Both are proxied in most studies by a standard survey measure of income. We have already noted that there are problems with this variable for some respondents, particularly those with home duties or who are retired.[15] Because income is such an important variable from an economic perspective, we will drop those observations from this analysis which appear to have substantial measurement problems with the income variable.

Tastes for the good are generally proxied by variables related to the use of the resource demographic variables and attitude variables (see Table 5 below). The first group of these variables considered involves the use and potential use of Kakadu and other national parks. From past studies of parks (e.g. Carson *et al.* 1992), we expect WVKAK, likely to visit Kakadu in the future, to predict higher willingness to pay amounts. Two other possibilities in this group are: VKAK, a past visit to Kakadu, and VPARKS, a recent visit to a national park or bushland recreation area. VKAK will be a good predictor if past visits to Kakadu are good predictor of future visits to Kakadu,[16] or if a visit to Kakadu increases concern about mining the KCZ. VPARKS may be a good predictor of general concern for parks and incorporates a recent activity dimension that the two Kakadu specific variables do not.

Demograpic variables which are often used as indicators of taste include age, education, sex, place of residence, and engaging in environmentally supportive activities. Of these, age has been found to be the most consistent predictor and is usually negatively related to willingness to pay for environmental amenities. Education is usually positively related but it is often difficult to get age, income, and education all to be significant in a regression equation and so we will not include education in our valuation function. Being female is sometimes positively related to willingness to pay for environmental amenities but generally not significantly so and that is the case here. With respect to environmentally supportive activities, there are four possible variables: recycling; purchasing environmentally friendly products; ENVTV, watching environmental programs on television; and CONMEM, membership in a conservation organization. Because of the high percentage who say that they recycle or buy environmentally friendly products, we create a new variable, ENVCON, which

[15] Any future RAC survey should collect household as well as individual income and make additional inquiries of respondents expressing very low incomes. Additional work also needs to be done on imputing missing income variables. Typically, the major government statistical agency responsible for collecting income information from the population from regular surveys will have substantially built up expertise in performing this imputation.

[16] This is unlikely since the distance of KNP from population centers suggests very infrequent visits; 12% of the population indicate they visited Kakadu whereas 60% indicate that they would like to visit Kakadu.

TABLE 5
Variable definitions

RECPARKS (Q10) measures agreement by respondent that the greatest value of national parks and nature preserves is in recreational activities such as bushwalking, camping, or just taking photographs. Higher values indicate greater agreement. (Q10–Q18) are all measured on a 5 point scale with 1 = strongly disagree and 5 = strongly disagree

JOBS (Q11) measures how important the respondent feels jobs are in making natural resource (forest and mineral) decisions. Higher values indicate jobs are an important factor

LOWRISK (Q12) measures acceptance of low risk mining activities. Higher values indicate greater acceptance

PRESERVE (Q13) measures how much respondent agrees that native wildlife and plants should be preserved even if never seen by the respondent. Higher values indicate stronger agreement

FUTURE (Q14) is a measure which indicates that the needs of future generations are important in deciding how to use Australia's natural resources. Higher values indicate greater agreement

ABORIGINAL (Q15) is a measure of how much importance of Kakadu to Aboriginals should be taken into account as a factor in making decisions concerning Kakadu. Higher values indicate that this factor should be taken into account

FINBEN (Q16) measures the importance of financial benefits in making natural resource decisions. Higher values indicate greater importance

MINEPARKS (Q17) measures how strongly the respondent feels that mining within national parks reduces the value of the parks. Higher values indicate mining reduces the value of parks

MOREPARKS (Q18) measures how strongly the respondent feels more national parks should be created from state forests. Higher values indicate respondents favor more parks

ENVCON is a measure of being an environmentally minded consumer. This indicator equals 1 if both Q21 and Q22 equal 1 (respondent recycles and buys environmentally friendly products) and 0 otherwise

ENVTV (Q23) is an indicator which equals 1 if the respondent watches environmental TV frequently

CONMEM (Q24) is an indicator which equals 1 if the respondent is a member of a conservation group

VPARKS is an indicator of whether the respondent has visited a national park or bushland recreation area in last 12 months. It is taken from Q4 and equals 1 if they have visited one

VKAK is an indicator that the respondent has visited KNP. It takes on a value of 1 if Q5c equals 1

WVKAK is an indicator that the respondent would like to visit KNP. It equals 1 if Q7 equals 1

AGE is the respondent's age

INCOME (Q28) is the respondent's reported yearly income in thousands of dollars

MAJOR is an indicator which is true if respondent received the major impact version of KCZ questionnaire

NTSTATE is an indicator that respondent lives in the Northern Territory. The indicator variable takes on a value of 1 if true. Most but not all of the respondents for whom this indicator is true are from the NT sample

NTMAJOR is an indicator variable which is the product of MAJOR*NTSTATE

equals one if the respondent both recycles and purchases environmentally friendly products and zero otherwise.

The RAC survey has a rich set of variables, particularly the Q10–18 series.[17] Several of these directly relate to national parks, RECPARKS, PRESERVE, ABORIGINAL, MINEPARKS, and MOREPARKS. One question, LOWRISK, deals with acceptability of low level risks from mining development. Two questions deal with the perception of mining benefits, JOBS and FINBEN. A third variable, FUTURE, deals with the current generation using natural resources versus the future generation. There is also a general environment-development tradeoff question, Q2, which we will use due to its high correlation with the more specific attitude variables.

The final set of variables to be considered includes which scenario the respondent was randomly assigned, whether the respondent lives in the Northern Territory, and an interaction between living in the Northern Territory and receiving the major impact scenario. These variables are MAJOR, NTSTATE, and NTMAJOR, respectively. All are dummy variables which take on the value of one if the condition is true and zero otherwise. The complete set of variables considered in the estimation of the valuation function is defined in Table 5.[18]

6.3. *Obtaining a clean data set*

There are two steps which usually are taken before a reliable valuation function is estimated from a CV survey data set. The first is to locate the small number of respondents who appear to have given inconsistent and possibly random responses to the WTP questions and/or the key predictor variables. They may be identified either by visual inspection or by the use of statistical techniques to identify such observations. The second is to deal with the income variable, which almost always creates difficulty since the information for it is missing for a number of respondents and erroneous for others. The usual problems with the income variable are exacerbated in this study because it was asked of the individual and is likely to be inappropriate for many of those retired or with home duties. For these respondents, individual income is not a good measure of available wealth.

To deal with these two issues, 207 observations (out of 2,034 respondents in the Australian sample) were dropped from the estimation for failure to meet the consistency checks described below. The seven consistency checks per-

[17] These questions are worded so that there is no consistent direction with respect to the KCZ of agreeing or disagreeing with the statement made. These variables will be entered into the regression equation as a single continuous variable rather than a series of dummy variables. The additional variance created by adding four dummy variables will typically outweigh the bias introduced by treating the ordinal variable as a continuous one (Carson 1983).

[18] Missing values for INCOME were imputed by using the mean value of observed Q28 responses by employment classification Q29a. A very small number of missing values for the Q10–18 series were also imputed.

formed tended to reduce estimated median willingness to pay for the KCZ by about 30% and shrink estimated confidence intervals.[19] Checks 1, 2, and 3 drop a small number of observations (just over 1% of the sample) whose WTP responses are completely inconsistent with the key attitudinal variables. Checks 4 and 5 drop a small number of observations for which income is large and likely in error. Checks 6 and 7 largely drop observations for whom individual income is not a good measure of the financial resources available to that respondent to pay for preserving the KCZ. A large majority of the observations dropped (over 75%) are for this reason. A description of these consistency checks and the number of observations failing to meet each, for both the Australian and NT samples, is contained in Appendix 1.

6.4. *Results for the Australian sample*

Our preferred valuation function for the Australian sample is displayed in Table 5 in the columns marked 'AU'. The most striking feature of this table is the large number of statistically significant variables. The scenario treatment indicator variable, MAJOR, is positive and significant. INCOME and AGE are significant and of the expected signs. Of the main attitudinal variables only two, PRESERVE, which attempts to get at pure existence motivations, and FUTURE, which attempts to get at current versus future use of the resource, were not significant at the 0.10 level in the model displayed in Table 6 using likelihood ratio tests.[20] ENVCON is of the expected sign and significant, and VPARKS is of the expected sign and is significant in the combined sample and close to significant in the Australian sample. WVKAK is not significant and can be rejected as being needed in the valuation function in Table 6 using likelihood ratio tests, as can be VKAK, ENVTV, and CONMEM.[21]

The valuation function for the Australian sample in Table 6 predicts large differences in willingness to pay for different respondents. Take a respondent assigned to the minor impact scenario who had a set of covariate values which should indicate a low willingness to pay for the KCZ (RECPARKS = 2, JOBS = 5, LOWRISK = 5, ABORIGINAL = 2, FINBEN = 5, MINEPARKS = 2, Q18 = 2, ENVCON = 0, VPARKS = 0, Age = 65, and INCOME = 20). Using the valuation function we calculate the estimated median willingness to pay of a respondent with those characteristics to be $0.27. Now take a respondent also assigned to the minor impact scenario with a set of covariate values which should indicate a high willingness to pay for the KCZ

[19] Note that it is possible that an observation violates more than one of these consistency checks. The checks were performed sequentially so that an observation failing more than one consistency check is classified as failing the highest consistency check not met.

[20] Both of these variables have positive coefficients and are generally statistically significant in valuation function specifications with a smaller number of variables.

[21] WVKAK, which is positively correlated with VPARKS, has a positive sign and is generally significant in specifications with fewer variables. VKAK tends to have a negative sign. ENVTV and CONMEM have the expected positive signs.

TABLE 6
Weibull valuation functions for cleaned Australian and combined samples

	Parameters		*Asy t-statistic*		*p-values*		*Means*	
Variable	*Au*	*Au & NT*	*Au*	*Au & NT*	*Au*	*Au & NT*	*Au*	*Au & NT*
Scale	2.168	2.190	27.79	32.36	0.000	0.000	—	—
Location	5.054	4.793	8.46	8.93	0.000	0.000	—	—
RECPARKS	0.148	0.201	1.95	3.18	0.051	0.001	3.689	3.641
JOBS	−0.426	−0.433	−6.22	−6.97	0.000	0.000	2.592	2.616
LOWRISK	−0.576	−0.599	−8.14	−9.18	0.000	0.000	2.790	2.877
ABORIGINAL	0.138	0.241	2.12	4.18	0.034	0.000	3.570	3.467
FINBEN	−0.568	−0.612	−7.65	−9.12	0.000	0.000	2.915	2.921
MINEPARKS	0.708	0.718	10.59	12.09	0.000	0.000	3.643	3.502
MOREPARKS	0.279	0.240	4.19	4.06	0.000	0.000	3.864	3.851
ENVCON	0.464	0.401	2.86	2.74	0.004	0.006	0.545	0.512
VPARKS	0.250	0.333	1.46	2.04	0.144	0.041	0.723	0.746
AGE	−0.024	−0.022	−4.93	−5.05	0.000	0.000	42.968	41.910
INCOME	0.013	0.012	2.49	2.68	0.013	0.007	21.514	22.040
MAJOR	0.402	0.373	2.54	2.44	0.011	0.015	0.502	0.500
NTMAJOR	—	−1.059	—	−4.26	—	0.000	—	0.104

N is 1,827 for the Australian (Au) sample and 2,296 for the combined (Au & NT) sample. Log likelihood for the model reported for the Australian sample is −1,527.865, while the log likelihood for a model with no covariates is −2,020.955. Log likelihood for the model reported for the combined sample is −1,884.823, while the log likelihood for a model with no covariates is −2,568.494.

(RECPARKS = 5, JOBS = 3, LOWRISK = 2, ABORIGINAL = 5, FINBEN = 3, MINEPARKS = 4, Q18 = 4, ENVCON = 1, VPARKS = 1, Age = 40, INCOME = 60). Using the valuation function we estimate median willingness to pay to a respondent with these characteristics to be $418.84.

Three variables, LOWRISK, FINBEN, and MINEPARKS, are primarily responsible for the very large differences in willingness to pay between respondents. That is because they have large coefficients, in an absolute value sense, and have a reasonable amount of dispersion. The largest effect is from MINEPARKS, which indicates the degree to which the respondent agrees with a statement which says that parks are greatly devalued by development activities such as mining within their borders. One can get a shift of over one hundred dollars by changing the value of MINEPARKS from 1 to 5. This result helps provide some interpretation of what many people are buying in the KCZ survey; the integrity of one of their major national parks. FINBEN measures a belief that the most important aspect of natural resources like mineral deposits are the financial benefits for Australia. Respondents who strongly agreed with this statement are much less likely to be willing to pay very much to add the KCZ to KNP. LOWRISK measures the respondent's position towards projects with a low risk of environmental damage. Respondents who think low risk mining development projects should proceed are willing to pay substantially less to add the KCZ to KNP than those who do not think that very low risk mining projects should proceed.

6.5. *Combined sample*

Next, we turn to a comparison between the Australian sample valuation function and the combined Northern Territory and Australian valuation function which is also presented in Table 6 in the columns labeled 'Au & NT'. The parameters in the two valuation functions are generally quite similar. In many instances the differences between the coefficients are so small as to be trivial, sometimes occurring in the second or third decimal place. The largest difference in coefficient values is on ABORIGINAL. Here the combined sample has a larger coefficient. The other noticeable differences are on the two park recreation variables. RECPARKS and VPARKS, where the combined sample also reacts somewhat more positively in terms of their willingness to pay responses for these two covariates. The increase in these parameters is largely compensated by a small decrease in the location parameter.

All in all, the coefficients in these two models are quite close considering that over 25% more observations were added from a sample which holds substantially lower willingness to pay values. In conjunction with finding that a separate NTSTATE variable has no additional explanatory power once an NTMAJOR interaction term is included, this suggests that those interviewed in the NT responded in the same basic manner as the rest of the Australian sample did

for the minor impact scenario once differences in responses to attitude and demographic variables are taken into account.[22]

7. Policy conclusions

A conservative estimate of the benefits of preserving the KCZ by adding it to KNP is obtained by multiplying the median WTP amount for the minor impact scenario by the number of 1990 Australian households (5,420,400). This results in an estimate of the value for preserving the KCZ of A$435m. This compares to A$102m estimated as the net present value of the proposed Coronation Hill mine to Australia at a 5% discount rate by the Australian Bureau of Agricultural and Resource Economics (RAC 1991a).[23] Thus, from a standard welfare economic perspective, social welfare could be improved by preserving the KCZ by incorporating it immediately into KNP rather than mining it first.

As an interesting postscript to this analysis, the government decided to preserve the KCZ rather than mine it, but publicly stated its chief reason as aboriginal concerns. The RAC Kakadu Commissioners, rather than making a definite recommendation (RAC 1991a) to the Prime Minister, spelled out several options for the KCZ. They never adopted the benefit-cost analysis suggested by this comparison of mining *versus* preservation. This may be due in part to the Commissioners making a major modification to the proposed mine plan whereby complete rather than partial restoration was required in all of their options allowing mining to go forward. It may also have been in part due to the vehemence of the attacks by critics of the study.[24] Much of this criticism appears to be analogous to arguments concerning non-market valuation and contingent valuation later put forward by Exxon in the United States. The US National Oceanic and Atmospheric Administration's Blue Ribbon Panel Report (Arrow *et al.* 1993) rejected most of these arguments stating that contingent valuation, when properly conducted, can reliably estimate passive use of values. Perhaps this finding will also have implications for greater acceptance of contingent valuation in major policy discussions outside the US.

[22] The NTSTATE variable proportionately changes all of the WTP estimates for NTSTATE respondents. With the exception of the coefficient on ABORIGINAL which is much larger for NTSTATE residents, none of the other coefficients on the covariates either individually or as a group are significantly different at the 10% level between NT residents and residents of the rest of Australia using likelihood ratio tests.

[23] Alternative assumptions such as treating the willingness to pay amounts as individual rather than household or multiple year rather than one-time payments substantially increases the estimate. There is also evidence that respondents took into account some of the benefits of mining when making their decision. This factor also likely reduced the benefit estimate to an unknown extent. These three assumptions all deserve further study due to the magnitude of the potential impact they can have on the final estimate.

[24] These critiques by Ron Brunton, Alan Moran, and John Stone, along with a response by Richard Carson are contained in RAC (1991b).

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APPENDIX

Consistency check definitions

Check 1: If JOBS = 5, LOWRISK = 5, FINBEN = 5, and MINEPARKS = 5, then drop. This is an inconsistent set of responses to key predictors of willingness to pay and probably indicates that respondents simply picked the last category without listening to the questions. (Fifteen respondents dropped [12 Au; 3 NT].)

Check 2: If JOBS = 1, LOWRISK = 1, FINBEN = 1, and MINEPARKS = 1, then drop. This is an inconsistent set of responses to key predictors of willingness to pay and probably indicates that respondents simply picked the first category without listening to the questions. (Nine respondents dropped [7 Au; 2 NT].) Note that Checks 1 and 2 tend to be offsetting in terms of changes to WTP estimates.

Check 3: If (JOBS + LOWRISK + FINBEN) > 10 and (MINEPARKS + MOREPARKS) < 6 and income < \$30,000 and WTP falls into interval [100–∞], [100–250], or [250–∞], then drop. This check drops respondents with a contradictory response pattern on attitude questions coupled with low income levels and high WTP intervals. This check lowers WTP estimates. (Seven respondents dropped [7 Au; 0 NT].)

Check 4: If income > \$50,000 and age < 30, then drop. Unlikely high income for age. (Eighteen respondents dropped [12 Au; 5 NT].)

Check 5: If income > \$50,000 and occupation code > 6 then drop. Unlikely high income for occupations. (Nine respondents dropped [8 Au; 1 NT].)

Check 6: If income < \$5,000 and interval [100–∞] or [250–∞], then drop. Drops respondents falling into lowest income class who may have no direct income, who give a willingness to pay response falling in an unbounded interval above \$100. About half of the respondents dropped by this check are employed, so their having an income between \$0 and \$5,000 seems implausible; and the other half of the respondents are unemployed or students who might have other sources of income. This check lowers willingness to pay estimates. (Fifty-seven respondents dropped [47 Au; 10 NT].)

Check 7: If Q29a (employment classification) indicates retired or home duties and income < \$30,000 and WTP falls in interval [100–∞], [100–250], or [250–∞], then drop. This check drops respondents without visible job income who seem to be willing to pay considerable amounts. These two employment categories are known for having high variance and often unreliable income responses. As a sizeable percent of the respondents are likely to give valid willingness to pay responses because they have considerable income from working spouse or retirement savings. This check lowers the willingness to pay estimates. (One hundred and twenty-five respondents dropped [113 Au; 12 NT].)