Valuing access to biological collections with contingent valuation and cost–benefit analysis

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\textit{(Received 15 April 2014; accepted 3 November 2014)}

Biological collections may be underutilised because of transaction costs incurred in their use. One way to reduce transaction costs and foster greater utilisation of biological collections that could benefit society is through the creation of a virtual central database of biological collections, available online. The objective of this paper is to estimate the benefits of this policy change using a dichotomous choice contingent valuation survey of the primary users of biological collections. Marginal willingness to pay (WTP) for access to a new central database linking collections around Australia was investigated through an annual user fee payment vehicle. The mean WTP of direct users of the proposed program was Australian dollar (A$) 149 per annum (95\% confidence interval of $102–$348). We conducted a cost–benefit analysis of the proposal, showing that the aggregate benefits are likely to outweigh the total costs of setting up and maintaining the database in the longer term. These findings are useful for resource allocation decisions regarding biological collections.

\textbf{Keywords:} value; biological collections; transaction costs; contingent valuation

1. Introduction

Biological collections include materials such as living (e.g. in botanic gardens), nascent (e.g. seed banks, microbes), components (e.g. DNA banks, chemical extracts) and preserved collections (e.g. plant, zoological specimens) in museums and herbaria (Day et al. 2004). Biological collections generate benefits to society in many areas including biosecurity, pharmaceutical research and development, public health and safety, monitoring of environmental change, and traditional taxonomy and systematics (Suarez and Tsutsui 2004). The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is the custodian for a number of important biological collections in Australia. The main collections include (1) Australian National Insect Collection (ANIC), (2) Australian National Wildlife Collection (ANWC), (3) Australian National Fish Collection (ANFC), and (4) Australian National Herbarium (ANH) (Day et al. 2004). These collections have been established over time and cover an extensive range of species. The collections are irreplaceable and hold scientific and heritage values that are not easily measurable in monetary terms.\textsuperscript{1}

However, these resources may not be optimally utilised by the private and public sectors because of various market failures (Bennett and Gillespie 2008). One of these constraints is the presence of high transaction costs incurred in their use.\textsuperscript{2} A transaction cost

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is broadly a cost incurred in making an economic exchange (Williamson 1981; Barzel 1985; Gordon 1994; Coase 1937, 1960; Allen 1991). In this case, it is the cost of participating in the ‘market’ for biological collections. These transaction costs include the time and resources spent searching, waiting, negotiating, applying for permits, filing reports, and administering the paperwork to secure access to biological collections (Wang 2003; McCann et al. 2005). The evidence suggests that the time spent on these activities by researchers could be higher than 10% of their total research time (Productivity Commission 2007). Minimising these transaction costs is vital to maximise the benefits that may flow from biological collections. Furthermore, it has been argued that the benefits provided by collections are ‘undervalued’ by policy-makers, resulting in insufficient resources being allocated for their management (Whiting and Associates 1995; Suarez and Tsutsui 2004).

The existence of transaction costs may inhibit utilisation of biological collections. The question to be investigated in this study is: can the government install policies that reduce the relevant transaction costs to a level that is less than the efficiency benefit improvements that would be generated? One potential policy initiative is the creation of a centralised online database of biological collections (Bennett and Gillespie 2008). This would create wider access to the biodiversity data that currently have limited availability within museums and other institutions. There are several examples internationally of developing the infrastructure required to provide digital access to biological collections. A notable example is the Global Biodiversity Information Facility (GBIF) which was established by governments in 2001 to encourage free and open access to biodiversity data, via the Internet. The GBIF system works through a global network of countries and institutions to promote and facilitate the mobilisation, access, discovery and use of information about biodiversity. Others include the Biological Collection Access Service for Europe (BioCASE), Mammal Network Information System (MaNIS) and Australia’s Virtual Herbarium (AVH) (Beaman, Wieczorek, and Blum 2004).

The evidence shows that Australian collections are moving towards a formal network. The Atlas of Living Australia (ALA 2010) is a national initiative between the CSIRO, about 60 museums, herbaria and other biological collections, the Australian Government and the community. The ALA brings together information on Australian biodiversity, accessible through a single website. The ALA launched its website in 2010 and the database currently contains 152 collections scattered across Australia. There is currently no access and pricing policy associated with the use of the ALA. The objective of the atlas is to provide free and open access to information on biodiversity, via the Internet. However, with decreasing government funding for museums and herbaria, there is a fundamental concern over how such networks and services can be sustained once the initial financial support ends (Scoble 2002). The choice between free access and different charging systems needs to be considered.

An important observation is that biological collections have high public good characteristics. These goods and services are not likely to be supplied by the private sector because of high transaction costs associated with exclusion of users who do not pay. Bennett and Gillespie (2008) indicated that the creation of a virtual network of bio-resources is likely to generate economies of scale in bearing the transaction costs associated with the use of biological collections. They argue that the system will likely reduce transaction costs associated with obtaining access to bio-resources that may currently be limiting the prospects for using the collections. However, there is little information available on the benefits and costs of a virtual network of biological collections. The problem for policymakers is to consider whether the cost of securing the transaction cost reductions (i.e. the
cost of setting up the virtual database of biological collections) is smaller than the associated gains to society. The analysis presented in this paper focuses on the impacts of policy on the users of biological collections. For the majority of these users, improved access to collections probably represents a more efficient way of conducting their work, which should lead to lower costs and improved productivity. Hence this analysis can be framed as evaluating the efficiency of supplying a more accessible public good. Thus the analysis focuses on the willingness to pay (WTP) to reduce transaction costs associated with the use of collections. The contingent valuation (CV) method is an appropriate tool for addressing this objective (McCann et al. 2005). Only if it can be shown that the benefits are greater than the costs to taxpayers of establishing the virtual collection will it be judged socially worthwhile.

The objective of this paper is thus to conduct an empirical study to estimate the value of a policy change related to the establishment of a virtual database of biological collections. The paper presents an empirical analysis of WTP for the creation and access to a virtual database of biological collections using the CV methodology. The CV used was a single dichotomous choice (DC) format, with an open-ended (OE) follow-up question. This paper provides an addition to the CV literature by applying the method to a different type of good for which it has previously not been applied. Specifically, we apply the CV method for the measurement of transaction costs (McCann et al. 2005; Zhengchao, Liu, and Wang 2012). The target respondents for the CV study were individual users within firms, institutions, departments or organisations that use biological collections. This offers an interesting setting for comparing aggregate WTP against the costs of providing the good. The results show a potential efficiency gain that is not currently realised due to transaction costs. Many of these costs are hidden and hence the need to apply the CV as a means of estimating the value of those hidden transaction costs (Wang 2003; Liu and Shen 2006; McCann et al. 2005).

To the best of our knowledge, there has been few valuation studies conducted to estimate the benefits derived from biological collections. A study by Whiting and Associates (1995) estimated the economic value of scientific collections in Canada using the ‘past expenditures’ approach. The authors estimated an average annual capitalised value of approximately $14 million for the fish collection and $3 million for the bark beetle collection. Using the method of ‘avoided costs’, Suarez and Tsutsui (2004) estimated that the National Museum of Entomology Collections in the United States (US) generated benefits in excess of US$1 million in 2002. Mwebaze and Bennett (2012) used a combined travel-cost and CV methodology to estimate the benefits derived from botanic gardens. The CV component of the study produced an estimated mean WTP value of $3–$5 per person per trip for access to botanic gardens. In these published studies, the resources themselves have been the subject of valuation but not access to collections. It is the non-market value for access to information and collections that is of concern in this paper.

The policy option being evaluated in this study is the creation of a central online database of national biological collections. The database would provide primary records of biological collections while leaving control of the collections with the custodial institutions. The intent here is not to estimate the value of biological collections, rather it is the value of the virtual interface that improves access to the resource that is being estimated. There is an extensive literature describing the economic value of information generally (e.g. Stigler 1961; Bellin 1993; Van Wegen and De Hoog 1996; Laxminarayan and Macauley 2012). There have been a number of approaches to measuring the value of access to information. These include econometric modelling, extrapolations based on surveys of producers and users, estimates based on agency costs, and consumer’s WTP, and
estimates of elasticities and multipliers (e.g. PIRA 2000; Dekkers et al. 2006; te Velde 2009; DotEcon 2006; ACIL Tasman 2008; Houghton 2011). What these example studies reveal is that the economic value can be high, often far outweighing the costs of provision. However, despite our best efforts, we were unable to find specific studies estimating the values of different information systems for biological collections. This paper is intended to fill this gap in the literature.

The remainder of the paper is structured into the following sections. The next section describes the value estimation methodology used and the survey instrument developed for the study. The main CV results are reported and discussed in Section 3. Section 4 reports a partial cost–benefit analysis (CBA) of establishing a virtual database of biological collections. Section 5 provides a discussion and concludes the paper.

2. Methods

2.1. Contingent valuation method

The CV method is a survey-based approach to the valuation of non-market goods, in which the user is asked (in various ways in differing versions of the method) how much they would be WTP for an environmental good (Mitchell and Carson 1989; Bateman et al. 2002; Champ, Boyle, and Brown 2003; Carson and Hanemann 2005; Alberini and Khan 2006; Carson 2011). Over the past decades, the CV method emerged as one of the primary tools for modelling and understanding the WTP for public goods. The foundation of the CV method lies in welfare economics and it is commonly used to evaluate benefits associated with government intervention aiming to correct market failures and to set priorities among competing public policies (Mitchell and Carson 1989). The technique has great flexibility which can allow for the valuation of a wide range of non-market goods (Freeman, Herriges, and Kling 2014). The CV method is the dominant technique used to estimate the value of cultural heritage public goods such as museums, monuments, cultural venues, art galleries and other cultural assets (e.g. Scarpa, Sirchia, and Bravi 1997; Santagata and Signorello 2000; Navrud and Ready 2002; Provins et al. 2008). Additionally, the CV method measures benefits and costs in the same units so that the results can be used in a CBA (OECD 2002; Boardman et al. 2006; Pearce, Atkinson, and Mourato 2006).

The CV employed in this study was a single round DC CV format. The DC CV requires respondents to accept or reject a proposal. In a typical DC CV question, a respondent is asked whether he or she would vote in favour of a government policy or a new product or service (e.g. virtual database of biological collections), given a specified cost to be borne by themselves. In choosing whether to respond with ‘yes’ or ‘no’ to the DC question, we assume, based on utility maximisation, that respondents will choose options that are likely to offer higher utility. Consider a situation where the respondent is offered an increase in the good (from \( q_0 \) to \( q_1 \)) at an additional cost ($\( c \)), the respondent will reply with a ‘yes’ only if his/ her utility level in the presence of the proposed change and cost exceeds the utility level in its absence (Haab and McConnell 2002). The respondent answers yes with probability:

\[
\Pr(\text{yes}) = \Pr\{v(p, q_1, y - c, s) + \varepsilon \geq v(p, q_0, y, s) + \varepsilon\}
\]

where \( v \) is the indirect utility function for the individual, \( p \) is the price of market goods, \( y \) is income, \( c \) is compensating surplus, \( s \) represents respondents characteristics and \( \varepsilon \) is the
random component of choice. A complete technical discussion of these issues can be found in Haab and McConnell (2002), Champ, Boyle, and Brown (2003), Carson and Hanemann (2005), Hanley and Barbier (2009) or Freeman, Herriges, and Kling (2014).

The DC CV data were analysed using a logistic regression model to estimate the maximum WTP (Haab and McConnell 2002). The logistic model assumes that in the population the latent true WTP variable follows a logistic distribution. The logistic model is specified as follows

\[
\ln \left( \frac{\Pr(\text{yes} | i)}{1 - \Pr(\text{yes} | i)} \right) = \beta_0 - \beta_1 \cdot c_i + \sum_{m=1}^{m} \beta_{2m} X_{2m} + \epsilon_i
\]

(2)

where \( c_i \) is the annual user cost ($) the \( i \)th respondent was asked to pay, \( X \) is an \( m \)-dimensional vector of institutional variables, \( \epsilon_i \) is the error term assumed to be independently and identically distributed with mean zero and the \( \beta \)'s are the coefficients to be estimated.

The expected WTP was calculated from the estimated logit model. The expected WTP was calculated using the formula developed by Hanemann (1984) for a WTP distribution truncated at zero in the left-hand side to prevent negative WTP values from being predicted:

\[
E(\text{WTP}) = \frac{\ln(1 + \exp(\beta_0))}{\beta_1}
\]

(3)

where \( \beta_1 \) is the slope of WTP function plotted against cost and \( \beta_0 \) is the value of the constant (Carson and Hanemann 2005).

The OE WTP response was analysed using a Tobit regression model, since the data are censored at zero (Haab and McConnell 2002). A more thorough description of the Tobit model can be found in standard econometric texts (Wooldridge 2002; Greene 2011).

CV studies use different payment vehicles depending on the nature of the good or service being evaluated. Examples of payment vehicles used in other studies investigating the value of information include user fees, licence fees, royalties and other cost recovery charges (Scoble 2002; Houghton 2011). Payments may be specified as a one-off lump sum, yearly, monthly, daily or a per use/visit amount (Carson and Louviere 2011). Annual payments tend to be appropriate for goods that are provided continually (Bateman et al. 2002). The payment vehicle chosen for the CV application was an annual subscription fee to purchase access to the new central database. It is assumed that a continuous service will be provided, which cannot be purchased and paid for in a single payment. The WTP values were therefore elicited as annual fees over the useful life of the proposed virtual database ($\times \text{per year}$).

Face-to-face interviews offer the most scope for detailed questions but are costly. They were also ruled out in this study because the primary users of biological collections are geographically widely dispersed so that it would not be possible to reach a large number of users within the timeframe and budget of the project. Hence an Internet-based survey was used to implement the CV questionnaire. A number of pre-testing rounds were conducted with representatives of institutions currently using collections in order to check for clarity of the questions and to establish the range of the bid amounts used for the DC question (Cooper 1993). The questionnaire was revised accordingly before it was administered in the final survey.

We constructed a sampling frame using lists of current users of Australian biological collections provided by custodians of the different collections. An additional list was
obtained from a user needs report for the ALA which provided detailed information on a wide range of users of biodiversity data in Australia (Tann, Kelly, and Flemons 2008). The sampling frame comprised people working for the Australian Federal and State Government departments, non-governmental organisations, private consultancies, research and teaching institutions and other groups. The respondents to the CV survey were current researchers who would be responsible for paying the costs that they were being asked to consider. The CV survey was designed to target managers or staff with the authority to make purchase decisions in order to ensure consequentiality in the policy scenario (Carson and Groves 2007).

Australia’s biological collections are used both domestically and internationally. However, international users were excluded from the sample on the basis of the investment being made by Australian tax payers. This study took only the national costs and benefits into account, rather than any international impacts. It is noted that the decision to exclude international users from the sample implies that the estimate of WTP reported in this study is likely to be understated. Also, the objective of the sampling strategy employed in this study was to maximise the total number of respondents in the survey. Email invitations were sent out to all potential respondents drawn from the accessible list of users. We have no definite check on how representative the sample is. However, our sampling frame is a close match to the population. This makes the assumption of the sample being representative plausible.

The questionnaire consisted of two CV questions one in the DC format with a follow-up OE question to establish maximum WTP. These followed a number of questions about the respondent’s use of collections. The DC question used seven different (Australian) dollar cost amounts ($50, $100, $150, $200, $250, $300 and $400 per annum), of which one was randomly assigned to each respondent. The DC format was preferred because it is incentive compatible, is a relatively easy question for the respondent to answer, is similar to how a real market works and is also an easy question to use in an Internet survey (Loomis 1990; Carson and Groves 2007; Hanley and Barbier 2009; Freeman, Herriges, and Kling 2014). The combined questioning strategy used in this study generates more information (discrete and continuous) and allows comparison of WTP values derived from single-bounded DC formats with those from the OE question. The text of the CV question reads as follows:

Please consider the following scenario: Suppose that the government were to invest funds to develop infrastructure (e.g. server, internet portals etc) to bring together all national biological collections into a central database, available online. This would result in lower search costs for collection users. However, it might require the introduction of a ‘user fee’ to maintain the new database in the long-term. Suppose that collection users were asked to contribute funds for this new central database of collections through user fees.

Q8. Would your department, organisation or institution be willing to pay an **annual subscription fee** of ..... $X ..... to purchase access to the new central database?  

□ Yes—Q9.  □ No.—Q9/Q10.

Q9. What is the most that you would be prepared to pay every year, through a subscription fee, to purchase access to this new database? $ 

Additional questions were included in the survey to determine the user’s experiences and perceptions of Australian biological collections, as well as expenditures associated
with their use of Australian biological collections. These questions focused on respondents understanding of the resource being valued and the specific change in the provision of the resource they were being asked to consider. The Internet survey was conducted over a 3-month period from September 2010 through to November 2010. During this period, 300 primary users of Australian biological collections were invited to fill out the online survey. With a response rate of approximately 50%, a total of 142 primary users of biological collections were surveyed.

3. Results and discussion

3.1. Descriptive statistics

Table 1 shows the identity of the responding primary users of biological collections in the survey. Figure 1 shows the most commonly used collections among the sampled users. Respondents were queried about their reasons for using a collection. The main stated reasons were for taxonomic identification, preparation of a book/journal article, research and teaching (Figure 2). The survey also asked respondents to identify the main problems encountered in using biological collections. A summary of the responses may suggest the need for a central database of biological collections, to be available via the Internet (Figure 3). Finally, the respondents were asked to rank the importance of biological collections to their current work: a total of 85 respondents considered the collections to be essential; 42 stated that the collections are very important; 15 reported that collections are moderately important and there were no respondents reporting that the collections are not important at all in their current work. Thus the contribution of biological collections was beneficial.

3.2. Results from payment principle question

In addition to the DC question, a follow-up OE valuation question was included to establish the respondent’s maximum WTP (Bateman et al. 2002). If the response to the OE question was a zero WTP, then the respondent was asked to indicate the main reason for this choice. Overall, 85 respondents (60%), out of 142 indicated that they would be willing to contribute fees to access the central database of biological collections while 57 respondents (40%) answered negatively to the DC payment question (Table 2).

Table 1. Responding primary users of Australian biological collections.

| Organisation                  | Frequency |
|-------------------------------|-----------|
| Federal, State or Local Government | 35        |
| University/schools            | 32        |
| Museums/herbaria              | 12        |
| Research institute            | 9         |
| Other                         | 5         |
| Private consultancy           | 2         |
| Non-governmental organisation | 2         |
| Military/police               | 1         |
| Total                         | 142       |
Following standard practice in CV studies, the respondents were asked follow-up questions to screen for 'protest zeros'. Individuals giving a zero WTP were asked to indicate the main reason for not being willing to contribute for the proposed change. Respondents who objected to user fees or stated that the government should cover the costs were classified as protest zeros and excluded from the final WTP analysis (Bateman

Figure 1. Which biological collections have you used over the past 12 months?

Figure 2. Main reasons for using a biological collection.
et al. 2002). Respondents who provided reasons of an economic nature, such as uncertainty in using the collections, not being able to afford to pay or not having to pay for existing databases were considered as true zeros. Overall, the protest rate was relatively low, with a total of 14 protest bids.

The most important reason (with 44%) for not being willing to pay anything was that the use of the collections is limited, uncertain or intermittent. Some respondents stated that their use was sporadic and unpredictable, and that they would still have to pay for other costs to access the collections once they determine what material is being held. This

Table 2. Distribution of responses to the DC WTP question.

| Bids (A$) | Number | Accepting the bids | % Yes | Rejecting the bids | % No |
|-----------|--------|--------------------|-------|--------------------|------|
| 50        | 23     | 17                 | 0.74  | 6                  | 0.26 |
| 100       | 21     | 14                 | 0.67  | 7                  | 0.33 |
| 150       | 17     | 10                 | 0.59  | 7                  | 0.41 |
| 200       | 23     | 13                 | 0.57  | 10                 | 0.43 |
| 250       | 17     | 9                  | 0.53  | 8                  | 0.47 |
| 300       | 20     | 12                 | 0.60  | 8                  | 0.40 |
| 400       | 21     | 10                 | 0.48  | 11                 | 0.52 |
| Total     | 142    | 85                 |       | 57                 |      |

Note: Our CV data are generally ‘well behaved’, meaning the value of $F_j$ (% no) tends to rise every time the cost increases. Except the response to the price of $300 violates the monotonicity assumption for standard distribution. Responses to the two neighbouring prices of $250 and $300 need to be merged together to ensure the monotonicity property (see also Hanley and Barbier 2009, 51; Haab and McConnell 2002, 77).
is indicative of a wider issue of uncertainty associated with the use of biological collections (Whiting and Associates 1995). It also implies that a ‘per use/visit’ payment vehicle and not the ‘annual fee’ may be the best payment structure for the proposed virtual database of biological collections.

3.3. WTP estimation

A number of statistical methods were used to analyse the CV data in this study. The DC data-set was analysed using a logistic regression model while the OE data was analysed using a Tobit model to estimate the mean WTP (Haab and McConnell 2002). Table 2 gives a summary of the basic data-set derived from the single-bounded DC valuation question for the survey. It shows the number of respondents who accepted and rejected each bid. The pattern of the responses indicates diminishing levels of support as the cost of the policy increases.

Table 3 reports the results of the full logistic model. The model is significant, has strong explanatory power and several variables have the expected signs and are significant determinants of choice. The probability of acceptance to the WTP question is significantly (and negatively) related to the bid cost. This implies that the user’s WTP for a new virtual database of biological collections is sensitive to the cost of provision to the user. The coefficient on the number of employees (a proxy for the size of the user) is positive and statistically significant ($P \leq 0.05$), as larger entities are able to pay more. However, this result should be treated with a bit of caution. The distribution of the number of employees is skewed because some organisational users have thousands of employees while others may have relatively few (range of 1–6500 persons). Of the demographic variables, only age and education were significantly related to WTP. Age is negatively related to WTP while education has a positive effect on WTP (Table 3).

The mean WTP estimates were calculated using Equation (3) and the confidence intervals were produced using the Krinsky and Robb (1986) simulation technique using 1000 draws (Park, Loomis, and Creel 1991). The mean WTP and 95% confidence intervals are reported in Table 4. The users’ mean WTP estimated via the logit model is approximately A$149 per year. The median WTP calculated using the approach of

| Variables            | Coefficients/se | $t$-value |
|----------------------|-----------------|-----------|
| Constant             | $-0.5847 (0.8295)^{**}$ | $-2.47$ |
| Bid cost             | $-0.0069 (0.0035)^{**}$ | $-2.67$ |
| No. of employees     | $0.1541 (0.1498)^{**}$ | $2.93^{*}$ |
| Importance           | $0.3327 (0.4465)$ | $0.75$ |
| Education            | $0.1592 (0.3059)^{**}$ | $2.00$ |
| Age                  | $-0.0343 (0.0161)^{**}$ | $-2.14$ |
| Gender               | $0.7831 (0.4227)$ | $1.85$ |
| Log-likelihood       | $-94.05$        |           |
| Chi-2 statistic      | 67.77           |           |
| Pseudo $R$-squared   | 0.64            |           |
| No. of obs.          | 128             |           |

Note: Coefficients are reported with robust standard errors in parentheses; $t$-values; $^{**}P \leq 0.05; ^{* * *}P \leq 0.01$. 

Table 3. Logistic model estimates of WTP.
Hanemann (1984, 1989) is $85 per year. It should be noted that the mean WTP is the correct measure to use from the perspective of economic efficiency. As long as the mean WTP outweighs the cost per user, the decision-maker can apply the Hicks–Kaldor compensation principle to conclude that the policy should be adopted (Boardman et al. 2006). Therefore, the mean WTP estimate of $149 per year was used as the basis for calculating the total WTP for use in the CBA conducted in this study.

Figure 4 shows the distribution of responses to the OE WTP question. The results are consistent with the hypothesis that the proportion of respondents who would be prepared to pay a given amount decreases with an increase in the cost of the good. Table 4 reports summary statistics for the OE WTP question. The skewness and kurtosis measures indicate that the distribution of the OE WTP response is positively skewed. The mean WTP recovered from a Tobit model is approximately A$133 per annum. As can be seen, the OE mean WTP value is close to the single-bounded DC mean value (DC/OE ratio is 1.12). Further, the confidence intervals of the two point estimates overlap each other, conservatively indicating that there is no statistically significant difference between these two values.

Table 4. Mean WTP values obtained from the logistic and open-ended WTP models ($A).

|                           | Logistic model | Open-ended WTP model |
|---------------------------|----------------|----------------------|
| Mean WTP                  | $148.93        | $132.64              |
| 95% confidence intervals  | $102.18—$347.71| $81.38—$183.89       |
| Standard error            | —              | $26.15               |
| Median                    | $84.74         | $100                 |
| Min—max values            | $−∞$ to $+∞$   | $0—$1000             |
| Skewness                  | —              | 1.87                 |
| Kurtosis                  | —              | 5.88                 |
| Sample (n)                | 128            | 128                  |

Note: The OE mean WTP value was estimated with a Tobit regression model.

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Figure 4. Distribution of responses to the open-ended WTP question.

Source: CV survey.
WTP estimates (Schenker and Gentleman 2001; Wolfe and Hanley 2002). There is an extensive literature describing the relationship between DC and OE responses, and thus will not be elaborated much further in this paper. There is some consensus that the OE questions produce lower estimates of WTP than the DC questions (e.g. Welsh and Poe 1998; Blamey, Bennett, and Morrison 1999; Boyle et al. 1996; Brown et al. 1996; Venkatachalam 2004).

However, it should be noted that the OE responses are not automatically anchoring-free, as the DC question (with a specified bid level) was asked first. The presence of anchoring was tested empirically by regressing the OE WTP value on the bid used in the previous stage of the questionnaire. This linear regression showed that the coefficient estimate of the bid price was not statistically different from zero ($t$-value = 0.5). Inspection of the data-set further indicates that the percentage of cases in which the stated WTP was equal (censored) to the posed bid was 17% on average. Hence, our OE data-set does not appear to exhibit a serious anchoring problem.

### 3.4. Results from the expenditure approach

The study also asked respondents if they had incurred any expenditures associated with their use of biological collections. The majority of the users spent nothing while others had spent considerable amounts. Approximately 61% of the respondents did not report any expenditure while the remainder (39%) of respondents incurred various costs in using biological collections. A few users who incurred no expenditures indicated a personal and professional time cost associated with their use of the collection. Those who spent funds indicated costs that ranged from A$20 to A$50,000 per year. Most expenditure varied between $1000 and $8000 per annum. These costs are summarised in Table 5.

The expenditure estimates were converted to an ‘average per-user level’, in order to draw comparisons with the WTP estimate obtained through the CV method. The total expenditures were divided by the total number of responses in the survey to get an average per-user cost (Table 5). As can be seen, the average annual expenditure value per user was about A$500 in 2010. There is sharp increase in ‘other’ costs in 2010, which is difficult to explain. However, we were unable to obtain detailed information on expenditures and user/organisational size to explain the increase. While this might limit the usefulness of the data, it gives an appreciation of the current level of expenditures on collections.

Further, the WTP values obtained using the CV method is smaller than the expenditure amounts incurred by primary users of biological collections. This result could be interpreted as respondents being willing to pay less than what they estimated to be their current expenditures, which is another form of anchoring whereby the respondents refer

| Items                  | 2006 | 2007 | 2008 | 2009 | 2010 |
|------------------------|------|------|------|------|------|
| Charges for accessions | 552  | 600  | 1800 | 9000 | 2500 |
| Transport costs        | 17,500 | 20,500 | 32,700 | 35,830 | 45,872 |
| Other costs            | 1800  | 3925 | 5280 | 6280 | 22,825 |
| Total expenditures     | 19,852 | 25,025 | 39,780 | 51,110 | 71,197 |
| Average cost per user  | 140  | 176  | 280  | 360  | 501  |

*Source*: Survey of primary users. Note the number of responses to the expenditure question is 142.
to the amount they would save if there was a virtual database of collections. The expenditure figures also provide an external validity test for the CV estimates (Champ, Boyle, and Brown 2003).

4. Cost–benefit analysis

The next logical step in this paper is to compare the total costs of setting up (and maintaining) a centralised database of biological collections with the total benefits generated by the proposed system. This section sets out a preliminary CBA for the proposed virtual database of biological collections. The report by Bennett and Gillespie (2008) identified the key elements of a CBA for a virtual repository centre for bio-resources. Another study by Houghton (2011) developed a framework for estimating the costs and benefits of providing access to public information. This CBA follows the framework outlined in these two studies. The possible benefits and costs are as follows:

Benefits:

(1) Increased probability of the development of new products with associated producer and consumer surplus benefits. This would be reflected in an increased value of biological collections themselves through increased derived demand.
(2) Reduced transaction costs and increased efficiency gains.
(3) Reduced costs in the preservation of biological collections and provision of verified biological collections for research and development (R&D).
(4) Provision of a home for biological collections at risk of being lost after the original research is completed.

Costs:

(1) Capital and operating costs associated with providing improved access, including Internet portal, staff and central infrastructure.
(2) Capital and operating costs associated with improved level of maintenance for dispersed repository operations.

This study provides an estimate for benefit (2), and costs (1) and (2). Benefits (1), (3) and (4) are beyond the scope of this analysis. As such, the CBA conducted here is partial only. It should be stated that this CBA relies heavily on information from the ALA project to show the magnitude of benefits and costs of the proposal. Note that the majority of respondents in our survey comprised existing users of the ALA system. The timing of the CV exercise was fortunate for this reason – the CV survey collection was completed before the ALA website became fully established in 2010. This implies that there was not much overlap and potential confounding of the associated WTP/benefits between the before and after responses.

The costs of the proposed database were relatively less difficult to estimate than benefits. They include establishment and ongoing (annualised) costs. Table 6 gives a breakdown of the costs of the ALA project over the period 2009–2012. There are 11 distinct outputs (or phases) and associated costs to the project. The total spending in setting up (and maintaining) the ALA database was, on average, A$15.7 million per annum. This average cost figure was subsequently applied in the CBA. The average establishment costs and the running costs of the virtual database appear to be relatively high. However, a large component of these costs would be one-off establishment costs incurred in the
early years. The ongoing annual costs of maintaining the database would be substantially lower in the future years.

The sample CV WTP estimates can be used to draw inferences about the potential total net value of the virtual database of biological collections. However, this is a challenging task given the difficulty in predicting how many people might use the database in any one year. An important source of proxy indicators of use is website statistics (Houghton 2011). Table 7 gives some performance statistics for the ALA project for the year 2011/2012. As can be seen, the average monthly number of distinct users of the system is significantly high compared to the target. Figure 5 shows a clear upward trend in the monthly number of total visits during the period 2010–2014. Using a log-linear regression model, the trend growth rate in usage of the ALA system was estimated to be 6.5% per month (or 78% per annum). However, while these statistics show some useful impacts there are limitations in trying to use extrapolations.4 For this CBA application, we have used a more conservative trend growth rate of 25% per annum of the initial user population in order to project the flow of future benefits.

By the construction of the WTP question, the mean WTP estimate in this study needs to be multiplied by the number of ‘organisations’ which pay the annual subscription fee –

### Table 6. Breakdown of projected costs of the ALA project by output (2009–2012).

| Costs (A$)                          | 2009–2010 | 2010–2011 | 2011–2012 |
|-------------------------------------|-----------|-----------|-----------|
| Output 1: Project Office            | 1,834,642 | 2,318,336 | 1,981,379 |
| Output 2: Collection Data Management| 2,089,898 | 3,880,638 | 2,601,890 |
| Output 3: Rich Data Stores          | 946,100   | 2,823,599 | 1,404,896 |
| Output 4: Australian National Checklists | 4,178,735 | 2,863,883 | 398,944   |
| Output 5: Geospatial Data Management| 579,310   | 891,900   | 234,021   |
| Output 6: Data Integration          | 1,280,540 | 1,980,692 | 1,456,844 |
| Output 7: Data Dissemination        | 573,680   | 1,320,640 | 1,172,240 |
| Output 8: International Engagement  | 174,476   | 170,534   | 177,468   |
| Output 9: Governance                | 65,000    | 15,000    | 15,000    |
| Output 10: Network Infrastructure   | 143,200   | 396,000   | 310,000   |
| Output 11: Populating the Atlas     | 4,842,000 | 4,197,500 | –         |
| Total costs                         | $16,707,581 | $20,858,722 | 9,752,682 |

Note: Figures taken from the ALA (2010) Business Plan. The ALA is a 5-year project which has been organised into 11 outputs or phases.

### Table 7. Performance statistics for the ALA database for the year 2011/2012.

|                         | 2011–2012 |
|-------------------------|-----------|
| Total number of distinct users per month | 21,600    |
| Total number of visits per month            | 35,300    |
| Average monthly number of distinct Australian users | 16,660    |
| Average monthly number of distinct overseas users | 13,600    |

Note: Statistics derived from CSIRO Annual Report (2012). Academic users are defined as those coming from IP addresses assigned to Australian schools, colleges or universities. Government users are defined as those coming from IP addresses assigned to Australian Government addresses. These appear to be the major target groups for the ALA services.
and not the total number of ‘individual’ users. To deal with the uncertainty relating to which number of organisations to employ in the CBA, the following approach was taken: the CV WTP estimate of benefit was multiplied by a specific number of organisations so as to generate a benefit/cost ratio (BCR) of one in all the scenarios evaluated. This allows us to test the sensitivity of the results to the choice of this key parameter. A simplifying assumption is that the WTP value is constant over the useful life of the project.

A timeframe was then constructed for the analysis, to allow the identification of when costs and benefits occur in the CBA. The time horizon chosen for this (partial) CBA is 20 years. This is based on the average longevity of other existing networks of biological collections. The establishment costs ($15.7M) are assumed to be incurred from year 1 to year 10 only. Thereafter, the ongoing annual costs of running the system are significantly reduced. The annual benefits in year 1 are set to zero, with benefits beginning to flow from year 2 through to year 20. The final parameter for the CBA is the discount rate, for which a range of values (3%, 7% and 10%) were used to test the sensitivity of the results to the choice of this parameter. To show the assumptions underlying the calculation of the net present value (NPV) more clearly, the flows of costs and benefits and the effect of discounting are presented in Table 8.

The results of the CBA are presented in Table 9. Given the assumptions made in the base-case analysis, the number of organisations necessary to finance the virtual database of collections is approximately 559. If the discount rate is changed from 7% to 3% and 10%, then the required number of contributing organisations also changes to 346 and 792, respectively. Table 9 also shows the results if the CV WTP estimate for the virtual database of collections is reduced by one-half over the lifetime of the project (from A$149 in year 1 to A$74.5 in year 2 onwards). In this case, the number of organisations required to maintain a BCR of 1 increases to 1118. Clearly, the magnitude of the benefit estimate has a large impact on the population size required to ensure that the policy is economically justified. The number of potential users of the proposed system is difficult...
to ascertain but is estimated to be approximately 1000 (which would yield a positive NPV greater than $87M and a BCR greater than 2:1). Hence the aggregate benefits are more likely to exceed the total costs of setting up and maintaining the database in the longer term.

Table 8. Full discounted annual costs and benefits of proposed virtual database of collections.

| Year | Discount factors | Annual benefits ($M) | Discounted benefits ($M) | Annual costs ($M) | Discounted costs ($M) |
|------|------------------|----------------------|--------------------------|------------------|----------------------|
| Year 1 | 0.9346 | 0.000 | 0.000 | 15.773 | 14.741 |
| Year 2 | 0.8734 | 0.083 | 0.073 | 15.773 | 13.777 |
| Year 3 | 0.8163 | 0.1256 | 0.102 | 15.773 | 12.875 |
| Year 4 | 0.7629 | 0.187 | 0.143 | 15.773 | 12.033 |
| Year 5 | 0.7130 | 0.281 | 0.200 | 15.773 | 11.246 |
| Year 6 | 0.6663 | 0.422 | 0.281 | 15.773 | 10.510 |
| Year 7 | 0.6227 | 0.632 | 0.394 | 15.773 | 9.823 |
| Year 8 | 0.5820 | 0.949 | 0.552 | 15.773 | 9.180 |
| Year 9 | 0.5439 | 1.423 | 0.774 | 15.773 | 8.579 |
| Year 10 | 0.5083 | 2.135 | 1.085 | 15.773 | 8.018 |
| Year 11 | 0.4751 | 3.202 | 1.521 |
| Year 12 | 0.4440 | 4.803 | 2.133 |
| Year 13 | 0.4150 | 7.204 | 2.989 |
| Year 14 | 0.3878 | 10.80 | 4.191 |
| Year 15 | 0.3624 | 16.210 | 5.875 |
| Year 16 | 0.3387 | 24.315 | 8.236 |
| Year 17 | 0.3166 | 36.472 | 11.546 |
| Year 18 | 0.2959 | 54.708 | 16.186 |
| Year 19 | 0.2765 | 82.062 | 22.691 |
| Year 20 | 0.2584 | 123.093 | 31.810 |
| PV | | | | 110.782 | 110.782 |
| BCR | | | | | 1.00 |

Note: All values rounded to the nearest million dollars (A$1 M). Benefits calculated using CV estimates obtained in this study. Costs taken from the ALA Business Plan (2011).

Table 9: Base-case and sensitivity analysis for establishing a virtual database of collections.

| Discount rate | BCR | No. of organisations |
|---------------|-----|----------------------|
| Base-case assumptions | | |
| Base case | 7% | 1.00 | 559 |
| High | 10% | 1.00 | 792 |
| Low | 3% | 1.00 | 346 |
| WTP reduces by one-half (benefit = A$74.5) | | |
| Discount rate | BCR | No. of organisations |
| Base case | 7% | 1.00 | 1118 |
| High | 10% | 1.00 | 1584 |
| Low | 3% | 1.00 | 692 |

Note: Analysis performed using Crystal Ball software (Decisioneering, Inc).
5. Conclusions

Our main concern in this study was that biological collections may be underutilised and undervalued because of high transaction costs that they involve now. This paper reports on a CV exercise conducted to estimate the value of those hidden transaction costs. The DC format of the CV was used, with an OE WTP follow-up question. The mean WTP of the direct users of the proposed program was approximately A$149 per annum (with a 95% confidence interval of A$102–A$348 per year). The modelling results indicate that the user’s attitudes towards payment for the proposed central database of biological collections are sensitive to the cost of provision. The study also asked users about their current expenditures on biological collections. The usefulness of these data is somewhat limited; particularly because it was not possible to obtain detailed information about user and organisational size. However, the data give an appreciation of the current level of expenditures on biological collections. Data on expenditure figures incurred in using collections provide an external validity test for the CV estimates. The CV WTP estimates are smaller than the expenditure amounts incurred by primary users of the collections. This result might be interpreted as respondents being willing to pay less than what they estimated to be their current expenditures, which is a form of anchoring whereby the respondents refer to the amount they would save if there was a virtual database of biological collections.

However, there are other aspects which might also cause underutilisation of biological collections. Even if transaction costs can be reduced by establishing virtual networks, the overall value of the collections might still be underestimated because values such as option values of the biological material that can be conserved are not included. Also, it is unlikely that there will be zero transaction costs after the establishment of the virtual networks of collections. There will still be some transaction costs incurred in using a virtual database. For example, the database could be used to identify the location of source material. However, if the user still needs direct access to the material, then some transaction costs would be incurred. Furthermore, it is questionable if the information would be complete once the collections are accessible in a virtual network. The level of specimen detail desired by users may be inadequate or incomplete for a given collection. Therefore, while we expect that there will be benefits from a virtual database of biological collections, it is unlikely to satisfy all of the users’ needs.

This paper also assessed the costs and benefits of implementing the virtual database of biological collections. The results indicate potentially high costs for implementing the virtual network of biological collections. However, these costs would be one-off establishment costs, even though they may be as high as the initial gains for the users. The social worth of the investment depends on the longevity and the potential number of organisations and users who pay for the virtual network of collections. The results presented in this paper indicate that the aggregate benefits are likely to outweigh the total costs of setting up (and maintaining) the virtual database in the longer term.

One aspect which was overlooked in this analysis is the distribution of benefits and costs associated with the use of collections. This study excluded international users from the CV exercise. However, it seems likely that international users potentially benefit more from the development of an online database of collections and the reduced transaction costs. Australian collections are used not only by Australians but also by international researchers from around the world (for example, there were 13,600 overseas users of the ALA database in 2012). Similarly, Australian researchers use collections housed and maintained by other countries. The benefits derived from Australian collections,
therefore, do not all remain in Australia; some benefits are ‘exported’. If we could add these wider benefits that are more difficult to measure, the NPV and BCR reported in this paper would increase and the case for the virtual database of collections is stronger. Nonetheless, it is hoped that the information generated from this study will help support the future management of biological collections.

Acknowledgements
We acknowledge the contributions of Judy West and Jim Croft, both from the Australian National Botanic Gardens. We would like to thank the management of the Atlas of Living Australia (ALA) project for helping to facilitate the survey of users of biological collections. We are especially grateful to Donald Hobern and Rob Palmer for helping to distribute the CV questionnaire amongst the current users of Australia’s biological collections.

Funding
This study was funded by the Australian Government Department of the Environment, through the Commonwealth Environment Research Facilities (CERF) project. The work was conducted by the Environmental Economics Research Hub (EERH), with support from the Taxonomy Research and Information Network (TRIN).

Supplemental data
Supplemental data for this article can be accessed here.

Notes
1. Biological collections have the property of being expensive to develop and maintain. It would be difficult and costly to collect again many of the species represented in museums and herbaria. Scoble (2002) estimated that a single specimen cost over $1300 to collect, catalogue, prepare and describe.
2. For example, Suarez and Tsutsui (2004) estimated that a typical research trip from the US to Argentina last about a month and cost over $5000 for airfare, car rental, food and accommodation and collecting biological materials.
3. For more details, interested readers should visit http://www.ala.org.au/.
4. For example, one can assume that the total number of users is 16,600 × 12 per year. The problem with this assumption is that there are most likely repeated users throughout the year. Table 6 reports the number of distinct users ‘per month’ but it does not guarantee that the ‘yearly’ (16,600 × 12) users will be distinct. We thank the reviewer for this observation.
5. For example, the European Natural History Specimen Information Network (ENHSIN) project was funded by the EU for 3 years (2000–2003). The ENHSIN project was then expanded into another EU funded project, BioCASE, which was supported over 4 years. Total EU support for collections infrastructure in seven EU countries amounted to €5.63 million in 2002 (Scoble 2002). The database is still available and accessible by users after nearly 14 years (see http://www.biocase.org/index.shtml).
6. A discount rate of 7% was used in the base-case calculation because rates between 3% and 10% are typically used by government departments in Australia (see Harrison 2010).

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