A Review of Environmental Valuation in Australia

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Australian attempts to value the environment began at least 40 years ago. Since then, environmental protection and natural resource management have become major national issues. But have the methods of valuation kept pace with the importance of the issues that they are meant to resolve? Can environmental and resource values actually be measured? This paper chronicles, reviews, and assesses the valuations of 40 years and more than 100 Australian authors.

1. Introduction

To try to assess our progress in the valuation of environmental goods and services, I recently posed a question to 25 colleagues throughout the country.

Q Name a useful valuation undertaken in Australia?

A Choose one of the following:

(a) the last one you did,
(b) the last one I did,
(c) the last one they did, or
(d) I can't immediately think of one.

The most common answer was (d). If 25 practising resource economists cannot quickly identify a useful Australian valuation, there is a need to assess the status of environmental valuation in Australia, and to decide if we've made any progress at all. The objectives of this paper are therefore to document attempts at valuation, to present an overview of methods, to assess progress, and to suggest areas for further development.

The literature is chronicled in Sections 2, 3 and 4. The methods of valuation are described, illustrated and assessed in these three sections. Australian studies provide the body of this material, but overseas literature is incorporated where necessary to provide specific critiques, or to illustrate particular aspects of the methods. The full procedures to apply each method are detailed in the literature, but enough description is provided here to indicate how to apply each.

The state of the art is then assessed in Sections 5, 6 and 7. The ability of the methods to provide true values is addressed in Section 5. Their ability to provide useful values is addressed in Section 6, and the debate on contingent valuation is reviewed in Section 7. The final discussion of Section 8 attempts to draw the observations together to suggest whether, and how, environmental goods and services might be valued.

2. A Long History of Use and a Wide Range of Methods

Our past attempts at valuation offer, as it were, a set of experiments for a reviewer to observe, record, assess, and then draw together to help future

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I have many acknowledgments of many kinds; to the forests of Great Britain for demonstrating that unpriced values were as important as priced ones; to the forests of Australia for the opportunity to begin to value; to Oregon State University for the chance to develop a method of valuation; to Yale University for two opportunities to teach a course in valuation; to the University of Arizona for the chance to teach a course in the application of values; to Al Worrell for the scholarship that went into the book *Unpriced Values*; to Jack Knetsch for the idea to test contingent valuation with actual money; to students of the University of New England for doing the tests and proving that contingent valuation works; to Dave King for continuing collaboration on hedonic pricing; to the 20th Conference of Economists in Hobart in 1991 for the opportunity to obtain suggestions on a earlier version of this paper; to participants at the 36th Annual Conference of Australian Agricultural Economics in Canberra in 1992 for suggestions on another, earlier version of this paper; and to the patience and help of 25 surveyed colleagues. Robert Young, David Briggs and two anonymous referees commented on an earlier draft of this paper. Their assistance is appreciated too.

Review coordinated by David Briggs.

attempts. Four points immediately stand out from a review of these attempts. First, there has already been a long history of Australian research and applications. In 1955 in the Coleraine area of Victoria, Molnar (1955) valued the damage from soil erosion as a loss in land value. Land values decreased by £1.5 per acre with an increase in erosion of one class unit. In a 1956 benefit-cost analysis of flood mitigation in Launceston, the benefits of each scheme were valued as the costs of damage that were avoided (Munro 1974).[1]

The first review appears to have been published some 25 years ago (Sinden 1967), and reprinted a decade later (in Jones 1977). A comprehensive text on valuation was published some 15 years ago (Sinden and Worrell 1979), and reviews of individual methods (Streeting 1990, and Wilks 1990), and of groups of methods (Armstrong and Lowson 1990, DeLacy 1990, Jubb and Underhill 1990, Rose 1990) have appeared more recently.

Second, a wide range of methods has been applied in Australia. Methods, which can assess benefits and costs in a conceptually-correct manner, are shown in Table 1. The travel-cost method provides a measure of consumers' surplus directly. Hedonic pricing provides estimates of consumers' surplus as the extra price that buyers are willing to pay for an extra unit of a characteristic. Contingent valuation can provide estimates of total benefit or total cost, as well as estimates of consumers' or producers' surplus. The marginal-product method provides increases in revenue from which input costs can be deducted in the usual way to derive net values. The defensive-expenditure method has been used to estimate losses in consumers' surplus, and utility analysis has been used to value all of Hicks' four concepts of consumers' surplus. Benefit transfer is the procedure to apply a value from one situation to another, and to adjust it to meet the characteristics of the new situation. If the method uses a conceptually-correct value from the first situation, it should give a conceptually-correct one in the new application.

Methods which assess partial values are shown in Table 2. None of these methods provide true estimates of surplus, and none can routinely provide estimates of total benefit or total cost. But all have provided useful estimates of minimum or maximum benefit against which cost can be compared, or estimates of minimum or maximum cost against which benefit can be compared.[2] They provide monetary benchmarks against which environmental benefits and costs can be compared. As such, they provide partial values which are helpful information to assist choices and to set the context for choices.[3] The third point is demonstrated by Tables 1 and 2 — contingent valuation is only one of the dozen or so methods that provide information for environmental choices.

Some of the twelve methods in Tables 1 and 2 grade into each other, depending on the way they are applied. For example, the defensive-expenditure method is a rigorous version of the cost-increase technique, and the benefits-transfer method is a rigorous version of the proxy-good technique. Nevertheless, the separation into the two groups of Tables 1 and 2 reflects current practice and seems to reflect current attitudes to the methods and their role. The methods are now reviewed, to illustrate Australian applications of each, and to highlight the strengths and weaknesses of each. The fourth point is thus illustrated - there has been a very large number of Australian attempts to value environmental goods and services.

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[1] Prior to the Hobart presentation of an earlier version of this paper, I told the chairperson that I'd found a valuation undertaken in Tasmania in 1956. She responded, "If we've been doing it in Tasmania for 35 years, why is the rest of Australia still so hesitant about it?" The present paper will show that many valuations have been undertaken since then, in all six states and in at least two territories.

[2] In my experience, all of these methods have provided useful information, and all have been helpful when the methods of Table 1 could not be applied.

[3] An anonymous referee pointed this out.

Table 1: Methods to Estimate Values

	Method	What Can be Valued?	What Data are Required?	Australian Examples
1	Travel cost	Consumers' surplus	Quantities and costs for each visitor group	Recreation, poverty
2	Hedonic pricing	Consumers' surplus, total benefit	Price and characteristics of a good, from many exchanges of the good	Soil conservation, pollution, noise, aesthetics, woodland preservation
3	Contingent valuation	Consumers' surplus, total benefit	Willingness-to-pay responses in surveys	Air pollution, wild-life and habitat pre-servation, life
4	Marginal product	Producers' surplus	Increase in output from increase in input	Water, timber, life, soil conservation
5	Defensive expenditure	Consumers' surplus	Increase in expenditure to maintain welfare	Fishing, rural way of life
6	Utility analysis	Consumers' surplus	Utility functions from each consumer	Recreation, rural way of life, environmental preservation
7	Benefit transfer	Consumers' surplus, total benefit, producers' surplus, total cost	Value in similar case, model to transfer to new case	Fishing

Table 2: Methods to Estimate Partial Values*

	Method	What is Valued?	What Data are Required?	Australian Examples
1a	Cost saving	Minimum value of benefit	Money costs before and after a change	Commuting time, salinity control, open space
1b	Cost increase	Minimum value of benefit, maximum value of cost	Money costs before and after a change	Pollution, city congestion, noise
2	Replacement cost	Range for value of benefit	Actual and likely costs of replacement	Erosion, landscape, wildlife preservation
3	Opportunity cost	Minimum value of benefit	Money income foregone	Leisure time, preser-vation of habitat, land degradation
4	Interpret decisions	Total benefit or cost in particular case	Considerable data on many decisions**	Heritage, wildlife preservation, defence
5	Proxy good	Partial value of benefit or cost	Willingness-to-pay for a proxy good	Pest eradication

* A further method, 'The Last Resort', is presented in Section 5.2 on sensitivity tests.
** Or much insight into a single decision.

3. Methods to Assess Values

Consider first the methods which can provide surplus values, benefit values, or cost values, in a conceptually-correct manner. They can only do so, of course, when the requisite data are available, the necessary analyses are undertaken, the particular assumptions are met, and the usual economic conventions are observed.

3.1 The Travel-cost Method

The travel-cost method is widely used to value the benefits of recreation, and could be used to value the benefits of any good where quantity consumed depends on the costs of travel to acquire it. The method requires data on the costs of travel and the quantities of the good taken per unit time, and rests on two major assumptions. First, travel cost rations the quantity of use like a price. Second, consumers in area i would respond to the level of cost incurred by consumers in area j as if they lived in area j. When these two assumptions are met, a demand curve for the representative recreationist can be derived from the cost and quantity data from all visitors. Consumers' surplus values are estimated from the curve in the usual way.

The travel-cost method originated in the United States of America (USA) in the 1930s in a letter from Hotelling to the National Parks Service (Prewitt 1949). The first major application was by Clawson in 1959. Then followed the Australian adaptations by Ferguson and Greig (1973) in the forests of the Grampians of Victoria, and Ulph and Reynolds (1978) in the Warrumbungles National Park of New South Wales (NSW). In the mid 1970s, the NSW government perceived the need to assess recreation benefits in Colo Shire and commissioned a travel-cost study (Sinden 1978a) to do so. Subsequently, Bennett and Thomas (1982) explored ways to include the costs of time as a travel cost. Hundloe, Vanclay and Carter (1987) used the method to estimate the consumers' surplus for visits to the region of the Great Barrier Reef and for visits to the coral sites themselves. More recently, the benefits from day-use recreation and camping recreation along the Ovens and King Rivers in northeastern Victoria were valued in this way (Sinden 1990a). The broader role of the method is demonstrated by Thampapillai's (1982) application to value the benefits of poverty reduction through changes in the costs of travel to find employment.

The policy relevance of the travel-cost values is demonstrated by recent applications of this established method. Pitt (1992) estimated the net benefits of recreation as scenic, unpolluted beaches in NSW and so demonstrated the worth of activities to maintain them. Knapman and Stanley (1991) estimated the annual recreational benefit from visits to Kakadu National Park. They then derived estimates of the loss in visitor numbers if mining proceeded, and estimates of the net benefit from mining. In a direct application to the policy issue, they explored the trade-offs of reductions in recreation value for increases in mining profits. The Resource Assessment Commission (1992) estimated the recreation value of all the southeastern forests which are classified as part of the National Estate, and the value if only 50 per cent of the forests remained so classified. The difference is the loss in recreation value if half of the forests were logged. The inclusion of unpriced values in a benefit-cost analysis can sometimes drastically alter the ranking of alternatives, as Jenkins (1993) demonstrated when travel-cost values for beach recreation were included in an analysis of alternatives for protection of the Adelaide coastline.

The necessary data are derived from actual expenditures by actual visitors and so, ceteris paribus, the method promises true estimates of value. This advantage is however associated with some inflexibility. The demand curves are usually derived by regression of quantity of use on travel cost, and on other relevant variables, in an existing situation. Applications to new situations require regression models which capture the variables which change from the existing to the new situations. These variables are often hard to define and measure — simply because they must capture new situations. Tisdell (1977) addresses another difficulty, namely

the problem of recreation valuation when substitute sites are available, and Ward and Loomis (1986) provide a useful overview of the theory and conceptual basis of the method.

Overall, the method seems well suited to ex post estimation of consumers' surplus values for goods and services for which quantities taken depend on the costs of travel to acquire them. It also seems well suited to ex ante estimation where new situations correspond closely to existing situations. But, it may lack the flexibility of other methods to adapt to *ex ante* valuations in new cases.

3.2 Hedonic Pricing

Hedonic pricing is a technique to value a characteristic of a good from the market price of the good. Price per unit is regressed on the characteristics of the good, and the implicit marginal value of a unit of the characteristic of interest is derived from the parameters of the regression. The cost of 'producing' the characteristic can then be compared to this value. Early applications in the USA included estimation of the implicit values of characteristics of automobiles - presumably to see whether the possible increase in purchase price exceeded the cost of adding the accessory.

As a simple illustration, consider two houses A and B. House A is adjacent to a public park, but otherwise they have identical characteristics. A higher price for A is attributed to the benefits from nearness to the park. In hedonic pricing, this appealing relationship between price and characteristic is modelled through regression analysis of observations of many exchanges of the good in question. As another illustration, consider agricultural land. The difference in price between parcels can be due to differences in productivity and in other factors, such as environmental amenity. Thompson and Cook (1978) report a difference of $225 per hectare between parcels inside the Eppalock Catchment Soil Conservation Project and parcels outside. The difference was attributed as $175 to productivity and $50 to amenity — hence a value for the visual and other environmental benefits of soil conservation.

The hedonic-pricing principle underlay Abelson's (1979a) suggestions for valuation of the costs of aircraft noise from the prices of Sydney houses under the flight path. Soon after, he presented an analysis of data on 1400 properties in Sydney to relate market prices to valuations by the Valuer General's Department, and to characteristics of the land and house (Abelson 1979b). The most important determinants were size and shape of the house block. But the environmental factors of quality of view and noise were also significant. A one unit increase in aircraft noise on the Noise Exposure Forecast index decreased land values in Marrickville by six per cent.

In a policy-oriented comparison of the social costs of transport options in Melbourne, Andrews, Lacey and Moriarty (1981) set the cost of noise to houses on particularly-busy roads at six per cent of the value of comparable houses in quiet areas. In doing so, they applied basic research on the valuation of noise by the Bureau of Transport Economics (1977) for Marrickville in Sydney. The Roads and Traffic Authority of NSW (1990) now routinely assess the benefits of noise reduction as a proportion of the value of affected houses — indicating the development and acceptance of hedonic principles for valuations for this particular environmental problem.

Coelli, Lloyd-Smith, Morrison and Thomas (1991) used hedonic pricing to value the benefits of a water-supply pipeline to properties in the wheatbelt of Western Australia. The benefit was valued as the increase in property value, and was then entered into a benefit-cost analysis of the pipeline scheme. Maintenance of tree cover on grazing properties can provide amenity to the local community and preserve biodiversity. But, at the same time it can constrain farm income. This trade-off was valued by Reynolds (1978) through the change in the value of farm land following a change in tree cover. The broader issues of the associated land-use choices, which flow from these hedonic valuations of wood-

land, were reviewed by Reynolds and Sinden (1979).

In an active land market in localities where erosion is obvious, the benefits of soil conservation are likely to be captured in the increased value of conserved farmland. King and Sinden (1988) established this relationship in Manilla Shire in the wheat-sheep zone of NSW, and then estimated the marginal implicit prices of soil conservation. These values were then used to define the kinds of land and land market in which large and small increases in land value are likely. The underlying hedonic equation is a regression of the price of the good or property on its characteristics. To develop the method, King and Sinden (1994) estimated sets of simultaneous equations, and a set of sequential equations to model the influence of buyer, seller, market conditions and market processes on price — as well as the influence of the usual characteristics on price. Buyers in the Manilla farm land market valued soil conservation more highly, and property size less highly, than sellers.

Mattinson and Morrison (1985) explored the difficulties with the method, and demonstrated the care that must be used to interpret the values obtained. Algae in rivers can cause aesthetic and olfactory pollution that can affect the environment of neighbouring houses. However, they found that house values were unaffected by nearby algal pollution — a result that could be interpreted in several ways. Algae may have been a negligible nuisance, participants in the house market may have lacked knowledge of the problem, or there may have been a quick solution in prospect.

Hedonic pricing rests on data from actual market exchanges, and so promises true estimates of value. But equally, true values require a competitive market from which to collect the data. The difficulties, that arise when the competitive conditions are not fully met, are explored in Willis and Foster (1983). They may be summarised as the following requirements for effective application of the method. Participants in the market must be able to observe the levels of the particular characteristic, to adjust their sale and offer prices to those levels, and then interact in a competitive manner. Another problem is the bias in values when future levels of a characteristic are ignored, and Abelson and Markandya (1985) discuss this difficulty.

3.3 Contingent Valuation

Responses to the question "what is the maximum you are willing to pay?", should provide estimates of total benefit from which consumers' surplus values can be derived. This appealing notion is the basis of contingent valuation, the method where valuation is contingent on modelling a market in a questionnaire. Contingent valuation has been used in Australia for at least two decades, by many kinds of agencies and organisations, to value many kinds of outcome, and the accuracy of the results has been tested at least 17 times.

Throsby (1982) estimated the willingness of residents of Mildura to pay for an arts centre in the town. The Australian Environment Council (1982) reported a survey of willingness to pay for pollution control and cleaner air. Also in that year, Bennett (1982) valued the continued existence of a specific ecosystem on the south coast of NSW. The unpriced benefits and costs of amalgamation of local government areas were assessed by Musgrave, Conner, Gregory, Sinden and Wright (1983). Residents in areas of contentious amalgamations were asked their willingness to pay to prevent the unwelcome effects and also to ensure the welcome effects of amalgamation.

Bennett (1984a) assessed willingness to pay for the benefits of bushfire prevention in National Parks, while Majid, Sinden and Randall (1984) investigated the value of adding increments to National Parks. Ekanayake (1985a) estimated the changes in recreation benefit with increasing distance from the recreation site. Carter (1987) valued the consumers' surplus from visits to coral sections of the Great Barrier Reef, with a question phrased to assure respondents that the amount paid would be used in management of the reef. Hundloe (1990) measured the value of visits to the reef as a whole.

Young and Carter (1990) applied the method to value the benefits of research, while Stone (1991) estimated the value of preserving Barmah wetlands. Dumsday, Jakobsson and Ransome (1991) smoothed a range of individual values to give a single set of overall valuations, and then applied the set to a statewide valuation of rivers in Victoria. Walpole (1991) valued the benefits of naturalness of the environment to those who recreate in the environment, at sites along the Ovens and King Rivers in northern Victoria. Hector (1992) used the method to value the benefits of agricultural information services that are presently provided free of charge. In a balanced perspective, Lockwood and Tracy (1993) assessed the willingness of Victorians to pay to preserve the heritage values in cattle grazing and to preserve the native vegetation of the Bogong High Plains.

The versatility of the method, and the importance of magnitudes, are well illustrated in the assessment of net benefits of hatchery activities to maintain trout stocks in the streams of New England (Kelly and Bright 1992). Costs of the activities were immediate and well documented. Benefits to anglers were estimated by a willingness-to-pay question, and their minimum estimate of benefit exceeded costs by an order of magnitude.

In addition, there have been applications with non-money measures of value. Sinden and Smith (1975) compared the benefits of eucalypt and pine habitat for recreation through questions on willingness to spend time in travel. Sinden, Koczanowski and Sniekers (1982) assessed landholder preference between eucalypt and pine for several purposes, through willingness to travel for several agricultural purposes.

The debates on the method in general, on the structure of contingent value questions, and on the procedures for asking them, have been lively. The journals are replete with tests of contingent valuation under conditions of different information, discrete choice versus open-ended questions, different starting points, and different aggregation procedures.[4] These tests have provided improvements in the ways to ask the question, such as Bennett's (1987) comparison of direct question and the Smith auction, and Bennett's (1983) procedures to identify overstaters and understaters of willingness to pay. Further tests are, of course, needed, and Blamey and Common (1993) highlight the problems of valuation of public goods and environmental services.

The wide range of applications, with many detailed studies, has provided the opportunity for many writers to assess the potential of contingent valuation. The usefulness of contingent values depends on the truthfulness, and hence accuracy, of the responses from each subject. In the context of valuation of benefits from continued existence of nature reserves, Bennett (1984b) assesses the potential for inaccuracies from strategic behaviour, hypothetical bias, payment-mode bias and the need for separability of benefits. Sappideen (1993) discusses the potential problems of starting-point bias and payment-vehicle bias, as well as strategic bias in his attempt to value the benefits of preserving the Sale wetlands. Direct questioning is obviously subject to such biases while the other methods are not. But after reviewing ways to minimise and test for bias, Bennett concluded that careful contingent valuation is capable of providing reasonable estimates of benefits. Rose (1990) also addressed the problem of bias, and identified the many factors which limit the accuracy of responses to willingness-to-pay questions. He concluded that the procedures can be designed to limit the bias, but the method must be applied with subtlety and without a mechanistic approach. In their attempt to value natural bushland in Brisbane, Windle and Cramb (1993) discovered that respondents used cues in the questionnaire to determine these values. Nevertheless, they concluded, the method demonstrated that

[4] This lively debate is a healthy manifestation of our success in the development of valuation methods. But potential users, who are diligent enough to study the debate, often regard it as an expression of our failure. They become converts only when they study cases where contingent values have been elicited, and the values have then been used in the kinds of decision they presently face.

local residents did value the area and were willing to pay to maintain it.

The Resource Assessment Commission undertook recently two contingent value surveys. The first aimed to assess the value to all Australians of preservation of the conservation zone around Kakadu National Park (Imber, Stevenson and Wilks 1991). The second was designed to value the benefits of preserving the forests of south-east NSW and east Gippsland in Victoria that had been listed by the Australian Heritage Commission as part of the National Estate (Streeting and Hamilton 1991). The second was designed to avoid the pitfalls of the first, but as Bennett and Carter (1993) demonstrate, local validation tests were still required to justify the values derived. More importantly for the longer term prospects for contingent valuation, they urge that the limits of the method be clearly defined to promote more-relevant application, and point out that greater use of the user-pays principle will facilitate applications for policy purposes.

The role of the method is well summarised in Blamey's (1991a, pp.7-10) assessment of the statistical models which underlie estimates of willingness to pay, and the way the estimates depend on particular utility functions. "The development and use of the CV method has been particularly useful in bringing arguments for preservation of wilderness areas onto the same footing as the arguments for exploitation of these areas that the developers have been employing for years - the appeal to monetary return". This sort of role is well illustrated in the application to the valuation of benefits from forest preservation on Fraser Island by Hundloe, McDonald, Blamey, Wilson and Carter (1990).

Economic valuation of amenity resources, such as natural areas, is a growth area in Australia. The main valuation method has been contingent valuation, and Lockwood and DeLacy (1992) address the challenges with the method in their book *Valuing natural areas: applications and problems of the contingent valuation method.* This book includes a new Australian application by Rogers (1992) on old growth forest, and an assessment of the difficulties in integrating results from contingent valuation results into decision making (Glyde 1992). From his first-hand experience, Glyde concludes that ministers and senior bureaucrats must be informed of its complexities, and the use of hypothetical questions must be justified — all in a simple, five minute presentation.

A thorough review of the method and it's procedures is provided by Mitchell and Carson (1989). As the more detailed discussion of Section 7 shows, contingent valuation can provide reliable values if the questions follow economic theory and fit their problem context, and if subjects are co-operative. The validity of the value responses should however be checked.

3.4 Marginal-product Method

In a competitive market, the value of an increase in an input can be assessed as the value of the associated increase in output. More rigorously, the marginal product of an input is calculated as the additional output from use of one more unit of an input. The revenue from the additional output, or marginal revenue product, is calculated as the marginal product times the price per unit of output. The producers' surplus is then calculated as the marginal revenue product minus the cost of the unit of input.

The method requires the estimation of production functions to relate the change in inputs to the change in outputs. The potential of the technique is demonstrated by Long's (1987) application to value of water used in agriculture in western regions of the USA for each of several years, several activities and several states. A series of Australian studies, starting perhaps with Flinn and Musgrave (1967) and Flinn (1969), have used the same concepts in the same ways to value water.

The basic principles have been long and widely applied to value land and water as inputs to production. For example, thirty years ago Molnar (1965) estimated the cost of land degradation as the loss in

agricultural output. His productive units were the shires that covered a large proportion of Victoria. Tisdell (1985) reviewed attempts to value shelterbelts through the associated increases in agricultural production, and Yapp (1989) summarised the results of many examples that demonstrate loss of agricultural production due to the degradation of the land. In a similar way, the benefits of lower noise levels in factories have been valued at the higher output through less absenteeism (Bennett and Murray 1991).

At it's simplest, this method can be interpreted as the increase in money revenue due to an environmentally-related activity. Both Lothian (1984) and Touche Ross Services (1984) demonstrate that a national park on Kangaroo Island will add value to the local tourism industry. While not necessarily an economic-surplus value, this kind of benefit is always useful information to assist policy choices. At it's most complex, the method can involve modelling the inter-related impacts of an environmental effect in a general equilibrium framework. For example, Godden (1992) used the ORANI model to compare the direct and indirect impacts of an enhanced greenhouse effect on agricultural output.

The estimation and interpretation of marginal products is a standard application of production theory. As such, the principles are well established. But the applications require detailed data from competitive markets and robust statistical functions to relate changes in inputs to changes in an output. Such data seem unlikely to be available outside the agricultural or household sector.

3.5 Defensive-expenditure Method

A household may choose, or be forced, to increase expenditure to defend the level of environmental quality that presently enters its utility function. This increase in expenditure is an estimate of the loss in surplus due to a potential environmental change, measured as the Hicksian quantity-equivalent variation. This relatively-straighforward concept requires careful application because the costs must defend the initial level of utility from the initial level of environmental quality and both of these levels will often be hard to specify.

Both Neutze (1965) and Gillen (1974) applied the method to value the unpriced costs of city life. The disadvantages of traffic congestion in Sydney were assessed by Neutze as the increase in traffic costs in Sydney relative to Wagga Wagga. Gillen argued that the value of the extra unpriced costs of city life is the extra wage obtained in the city — an increase must be obtained otherwise people wouldn't move to the city. He then estimated this increase in wages to the marginal mover, interpreted it as the increase in unpriced costs, and included it in his early exposition of natural resource accounting. The benefits of recreational fishing on the Ovens River in Victoria were also estimated with this method (Sinden 1990a). If these particular recreational opportunities were unavailable at the current levels of their characteristics, a yearly increase of $1300 per angler is required to provide each angler with the same level of fishing enjoyment.

Conceptually, the expenditure must hold the utility constant at the pre-change level. Empirically, the estimation must allow for complementary and substitute activities, and ensure separability of goods in the utility function. These requirements lead to complex survey and estimation procedures. Smith (1991b) offers an authoritative and rigorous review of the theory and these requirements for its effective application. The surplus value could be the increase in expenditure to defend the existing level of utility — without specifying how that utility is obtained. Or it could be the increase in expenditure to maintain the existing level of utility from specified goods or specified environmental services. As Smith demonstrates, if private goods and environmental services are perfect substitutes, the two values are conceptually identical, and so should also be empirically identical. Sinden (1991) explored the application of the method, and showed that the level of substitutability needs to be clearly identified in data collection.

The method is closely related to the cost-saving and cost-increase methods, which are described in Sec-

tion 4. The specification of before-and-after scenarios, with their before-and-after levels of utility, offers more rigour and the possibility of estimating conceptually-correct values. But this specification requires a certain subtlety and a certain statistical precision — as well as many tests of the necessary questionnaire. Nevertheless, Smith's theoretical exposition should promote use of this interesting method.

3.6 Utility-analysis Method

The term 'contingent valuation' has come to mean the estimation of values with willingness-to-pay questions. Another kind of valuation method is also contingent on the simulation of markets and can also provide estimates of surplus — but the method is not termed 'contingent valuation' in the literature. The utility-analysis method rests on estimation of multi-attribute utility functions, calculation of indifference maps from the functions, and derivation of surplus values from the maps. Sinden's (1974) work in this area was improved by Findlater and Sinden (1982), assessed by Kennedy (1980), and improved further and assessed by Bennett and Smith (1985). When applied with the Bennett-and-Smith improvements, it can provide estimates of consumers' surplus for any of the several concepts of surplus.

Sanderson (1974) used the method to estimate the compensation required to balance the loss in surplus due to crowding of recreation sites, to maintain the original pre-crowding level of utility. Land-use decisions often involve the sale of land to the government. When farmers are offered a sum equivalent to their earnings, they often refuse to sell, indicating the existence of unpriced benefits such as the rural way of life. Liesch and Sinden (1976) valued the rural way of life with these methods, after protracted but unsuccessful attempts with contingent valuation. In an application to value recreation, Sinden (1978b) estimated consumer surplus values for each of the four Hicksian concepts (quantity-equivalent variation, price-equivalent variation, price-compensating variation, and quantity-compensating variation) for a recreational activity.

In an innovative application of Lancaster's characteristics theory through utility functions, Greig (1983) modelled recreation behaviour to derive recreation values. Demand curves, for changes in characteristics of a ski area, were estimated from utility functions and budget distributions, to give the change in value. In a recent overseas application, Cameron (1992) used the method to combine travel-cost data and contingent-valuation data to estimate recreation values.

While the method requires intensive and lengthy interviews with each subject, it can provide values in situations where contingent valuation fails. The intensive nature of the interviews may in fact suit situations where just a few subjects need to be surveyed. For example, Thampapillai (1985) investigated a choice between habitat preservation and extraction of minerals for a specific tract of land. The few key decision makers were interviewed to obtain their indifference curves and their marginal rates of substitution to value the trade-offs between preservation and income. Thampapillai (1982) had earlier shown how to apply the method to derive a demand curve to value reductions in absolute poverty for decision makers who allocate resources to such programmes.

3.7 Benefit-transfer Method

The accumulation of studies which value a particular kind of benefit, like recreation, creates the opportunity to transfer benefit values from an original study(ies) in one area to a new study in a new location. This traditional application of regression models has become known as the benefit-transfer method (Walsh, Johnson and McKean 1992). Krupnick (1993) reviews the opportunities for the method and argues that some kinds of benefit (improvements in health, economic assets, and environmental assets) are more amenable for transfer than others.

A formal procedure is required to provide useful estimates of value for new areas, and the following steps have been suggested.

(a) Collect the existing studies which have estimated values, and which have fully described the physical, social and economic variables of their situations.

(b) Pool the data from these studies and estimate a regression, over all the studies, to relate the benefit values to the set of explanatory variables.

(c) Insert the levels of the variables for the new situation in the preferred regression, and estimate the required benefit value for this situation.

At this stage, there may be sufficient Australian studies to apply this method for recreation benefits and the benefits of preservation. In an application in Victoria, Read Sturgess and Associates (1992) used the regression models estimated for recreation on the Ovens and King Rivers (Sinden 1990a) to derive benefit values for similar kinds of recreation on similar, nearby rivers. The situations and variables were similar in the original and new study areas. So, if the original values were appropriate estimates of surplus or total benefit, the values for the new areas should be too.

The method is a formalised and more rigorous version of the proxy-good method which is described below. It applies standard concepts of information transfer and regression analysis to a cross-section of data (or studies). Thus it is susceptible to all the statistical challenges of specification and estimation. But if successful, it avoids all the problems involved with collection of primary data.

4. Methods to Estimate Partial Values

The methods of Section 3 can all provide estimates of value for specific concepts of consumers' and producers' surplus. The methods of Section 4 can all provide estimates of total benefit, total cost, or maximum or minimum estimates of benefit and cost. These kinds of partial value can all assist decisions, and the methods to provide them are now reviewed.

4.1 Cost-saving (and Cost-increase) Method

The introduction of new technology or a new consumption opportunity may lower costs to consumers. The costs saved measure the minimum value of the benefit derived from the actual levels of consumption, because the new thing would still be used if the cost-saving benefits were higher. Similarly, costs incurred to continue consumption of some good or service measure the minimum value of the benefit so derived.

An early application of the cost-saving method was Munro's 1956 valuation of the benefits of flood mitigation in Launceston as the damage avoided if mitigation were undertaken (Munro 1974). Informal valuations with the cost-increase method have, of course, been going on for years — as demonstrated in the Australian Golden Book, *Harry the Hairy-Nosed Wombat* (Morris 1970). To preserve a wombat habitat on a prospective road line, the engineers assessed the increase in costs and made their decision to change the route (unnumbered pages): "... There'll be a long curve and that will make the road a little longer ..."

The engineers had informally assessed the benefit of preservation to exceed the increase in costs of the longer road.

The method was applied by Greig and Devonshire (1981) to value the benefits of salinity control by retaining woodland. The benefits were costs that households would save by not having to adapt to more saline water. The cost-saving method was promoted by Sappideen (1989) to value benefits of other soil conservation programmes which reduce salinity. The cost data for savings in damage to public property and utilities, and reductions in maintenance costs of domestic water supply, could

be derived from shire records. Yapp and Sinden (1992) report valuations where cost-savings, as reduced damage to silos and transport infrastructure, were used as estimates of off-site benefits of soil conservation.

In a similar way, Bennett and Murray (1991) set the benefit of better hearing as the reduction in compensation paid to those who suffer noise-induced hearing loss in the workplace. The compensation does not measure the utility of hearing, or the disutility of the loss. But savings in compensation payouts, through less workplace noise, do provide firms with important information on the benefits and costs of introducing new practices. Carefully applied they could measure defensive expenditures to maintain an environmental quality.

A traditional method to value time is to multiply time saved in travel by cost per hour of travel to give the cost saving. Actual, simulated or experimental data for the time saving are multiplied by the travel cost for each travel mode. The time savings are calculated, as Hensher and Truong (1985) illustrated for five Australian cities, and then inserted into benefit-cost analyses of alternative transport proposals.

The temporary loss of open space or parkland, due to some short-term alternative use, can be valued as the costs saved in the short-term use. For example, if highway construction uses such open space as a temporary storage for materials, the maximum-acceptable cost of renting a replacement storage area is an estimate of the value of this use of the open space and park (Enersol Consulting Engineers 1989, from Beder, undated).

The cost-increase version of the method has also been widely used. For example, water can become contaminated when effluent is dumped into a river. Downstream communities may be forced to obtain water elsewhere, or increase costs of treatment to maintain water quality. Young (1992) estimates that existing levels of salinity in major rivers in Australia increase household costs by $2 per person per week. An overview of the increases in costs to agriculture, households, industry and government due to land degradation is provided by Sinden, Sutas and Yapp (1990). Such costs have been useful in drawing attention to the problem, but they are not true changes in net benefit because output levels (and utility) vary along with costs.

Ease of application and usefulness of the value information make this an attractive method. But the value information is useful, only as long as its minimum or maximum nature is recognised. The method would be rigorous if the full surplus changes were measured, and the before-and-after utility levels were held constant — as they are in the defensive-expenditure method. But as with all methods in Section 4, careful use will provide information that can be used in the appropriate manner.

4.2 Replacement-cost Method

The replacement-cost method provides a range for the estimate of a benefit. The minimum value is the lowest cost that would be actually incurred to replace the good or service that provides the benefit. The maximum value is the maximum that would be actually incurred. Barter (1986) related costs of restoring damaged roads, bridges, and railways to the kinds of degradation that caused the damage. Yapp (1989) summarised a range of such cases where local government authorities expend money to replace bridges and roads after degradation-related damage.

Laws governing open-cut mining sometimes require that the soil and vegetation is restored at the end of the operation. On this basis, Park and Thampapillai (1989) and Thampapillai (1988) estimate costs of restoring woodland after open-cut coal mining in the Hunter Valley. The legislative requirement necessitates outlays up to $233 000 per hectare. Davidson (1989) applied the same method in the same place to address the same problem. The costs of restoring pasture through land forming, seeding, and pasture establishment were some $800 per hectare. The benefits, valued as the sale price of restored land, were some $500 per hectare.

The net social loss to the community from the requirements to restore the land was $300 per hectare.

The consumers' surplus from urban parkland is difficult to assess, particularly when consumption of the service depends mainly on non-monetary factors. A city park may provide many recreation opportunities for families in adjacent high-rise developments, but the quantity they consume will likely depend more on preferences for activities and the available facilities, than on money costs of acquiring the park services. In such cases, the travel-cost method and hedonic pricing cannot be applied but the cost of replacing the parkland can. Accordingly, Enersol Consulting Engineers (1989) assess the value of parkland permanently lost to the Sydney Harbour Tunnel at its replacement value.

The complexity inherent in the replacement-cost method is illustrated by the exchange between Drynan (1986) and Lipsett and Dann (1983). The latter had suggested that the minerals in a tonne of grain would cost the grower $18 to replace, that the lost minerals must be replaced, and that growers currently sell grain at less than the true costs of growing it. Drynan questions the particular monetary values and their bases. But more importantly, he points out that in a competitive market either soil mining and soil enhancement could be optimal. Further, the possibilities for substitution between soil minerals and other inputs in place A, and between output in places A and B, affect the way replacement cost is determined. These same possibilities for substitution could also permit output to be maintained in the long term even with a loss of minerals. For these reasons, an estimate from the replacement-cost method can never be more than one end of the range for a benefit or cost.

4.3 Opportunity-cost Method

Opportunity cost is, of course, the true social cost of a project, programme or policy. Estimation of the opportunity cost of environmental programmes is never easy, but the potential usefulness of the estimate can often justify the attempt.

Instead of estimating the benefits from preservation of the coloured sands at Cooloola in Queensland, Fitzgibbons and Hendriks (1970) estimated the opportunity costs of preservation as the loss in mining income. These costs do not, of course, measure the value of benefits of preservation but they do provide a benchmark or threshold against which the benefits can be compared. Referring to the demand for beach sands output and to the situations where there would be no economic gain from mining, they state (p.72) "...If the elasticity is less than 1.83, then from a national viewpoint our interests would not be served by mining Cooloola if it were in the middle of a rubbish tip rather than around rainforest..."

The Eastern Barred Bandicoot is now an endangered species. An extinct species can never be replaced, but the true social costs of programmes to reduce the probability of extinction can be estimated and used to develop conservation policies. Crosthwaite and McMahon (1992) demonstrate how to estimate and use such costs. Standard procedures of benefit-cost analysis were used to estimate the present value of the costs of breeding programmes to reduce the expected probability of extinction by known amounts. The key trade-offs were then presented in simple terms such as, are you willing to pay $950,000 to reduce the probability of extinction from 0.7 to 0.3? The bandicoot is not valued as such, but information on the true social costs of reducing extinction is provided.

Eucalypt dieback in New England has demonstrably increased farm incomes (Sinden and Jones 1985), and so preservation of existing woodland will impose demonstrable opportunity costs on the farm community.[5] Nadolny (1991) has defined the benefits to be gained from preservation of this

[5] Another, earlier version of this paper, which was presented at the 1992 AAES conference in Canberra, included several anecdotes on the difficulties in presenting these arguments on eucalypt-dieback to environmental groups. It suffices to note here that Nadolny (1991), at least, has appreciated the significance of the opportunity-cost concept and the magnitudes of the costs themselves.

woodland and has explicitly set them against these monetary opportunity costs.

Hitchens, Thampapillai and Sinden (1978) estimated the opportunity costs of limiting agriculture to achieve environmental goals in the use of crown land. Yapp and Sinden (1987) made preliminary estimates of the opportunity costs of land degradation in NSW on a statewide basis.[6] They continued these valuations in Sinden and Yapp (1993), where they estimated that degradation in the wheat-sheep zone of NSW is associated with a loss of at least $31 in gross income per hectare. Hall and Hyberg (1991) also examined the effect of degradation as the opportunity costs of lost agricultural production. The reduction in output averaged some 23 per cent per property, although there was a wide confidence interval around this figure. In a similar fashion, Syaukat, Pandey and Sinden (1993) estimated the loss in income, as present value per mm of soil saved, when cropping practices change to conserve the soil.

An important question concerning cuts in emissions of greenhouse gases is — how great are the costs likely to be? Unable to identify the benefits of reducing emissions, let alone value them, the Industry Commission (1991a) estimated the costs to the national economy in terms of economic output forgone to meet target reductions in emissions. While the actual cost would depend on the target and mechanisms to achieve it, this opportunity cost is useful information for policy decisions. As an example, they estimated that a 40 per cent reduction in greenhouse emissions in Australia would reduce net domestic product by 1.5 per cent.

Road congestion reduces output due to time delays to road transport and commuters. In a review of the social benefits of rail transport, the Industry Commission (1991b) argue that increased rail travel will save road congestion and so save congestion costs. Luck and Martin (1988) estimate the total costs of road congestion at some $2000m per year, from the reduction in output due to delays.

The potential increase in true community welfare, from decisions based on opportunity cost information, lies largely in the clarity with which the fundamental questions can be framed. If sand mining were resumed on Fraser Island, recreation and preservation benefits would be reduced. Bennett (1991, p.13) poses a clear opportunity-cost question as follows: "Are the $200 million benefits of sand mining worth the reduction in recreation and preservation benefits that would result?"

The question is more important than the answer.

A conflict between allocation of a West Australian forest to woodchips or to preservation centred on an area of 100,000 ha. The Forestry and Timber Bureau (1975) estimated that preservation of the natural ecosystems would reduce the net benefit for woodchips from $8.3 to $7.7m. Is preservation of this area worth the loss of $0.6m? The opportunity-cost question presents the key information from an economic assessment in a way to help decisions.

The concept of the Safe Minimum Standard, as the maximin criterion, is a useful way to present opportunity-cost information. In this context, Rogers and Sinden (1993) estimate the opportunity cost of preserving old-growth native forest as the lost income from logging. They then determine whether specific populations believe that this loss in income is a greater cost than the the loss of species habitat.

The calculation of opportunity-cost values can require considerable care. For example, logging in eucalypt forests may be reduced or constrained to achieve an environmental objective. Galapitage (1991), building on work by Opie and Thomson (1978), showed that net present values with and without the constraints must be calculated under the same conditions. Yet reductions in logging, or rescheduling of logging activities to meet a constraint, may require a different set or combination

[6] In my survey of 25 colleagues, no-one could remember who was the junior author of this paper.

of inputs. He calculated the optimal mix and quantity of inputs for several scenarios, and valued both water and timber outputs, for a particular forest area in Victoria. Unconstrained optimisation gave a site value of $70m net present value. If logging were prohibited on steep slopes to maintain the quality of water run off, the loss in net present value was $12.9m. If logging were further constrained to maintain certain landscapes, this opportunity cost would rise to $15.3m.

The calculation of opportunity cost should ensure that like is compared to like. In the case of preservation of native forest, for example, the preservation alternative should provide the same timber output as the logging alternative. To recognise this, Rogers (1992) calculated the opportunity cost of preservation of old growth forests as the lost income from that forest plus the net cost of establishment of eucalypt plantations elsewhere to maintain timber output to the community.

The notion of an opportunity cost as a loss in income seems to be readily and widely understood. In many land-use evaluations, opportunity costs can be estimated with some confidence, but benefits to society can only be approximated or guessed. In these cases, evaluations could well be restricted to careful assessments of opportunity cost.

4.4 Interpret Decisions

Rational decisions, based on a net benefit criterion, imply benefits and costs, and the interpret-decisions method attempts to derive those implicit values. The method has been much discussed in Australia but appears to have been successfully applied only twice anywhere in the world.

Cannegieter (1964) valued the contribution of the Ord River Scheme to defence at £45m because a previous government decision had allocated £45m to the Queensland sugar industry to support it for mainly strategic reasons. Musgrave and Lewis (1965) reviewed the difficulties in drawing such a conclusion from a single decision. Bowen (1964 and 1965) and Laing (1964) also helped to clarify the relevance of this estimate. But in a well-balanced caveat, Bowen (1964, p.394) heralded the next 25 years of work on valuation:

> *the discussion here is a beginning and not an end. In attempting to assess the benefits of the Ord, we have tried to discuss the fundamental assumptions as well as methods of computation.*

Loane and Gould (1986) discuss the possibility of this kind of valuation for a few purchases of land for national parks in Victoria, and Sinden and Mackay (1979) observe a single case and suggest that wombats are worth $30,000.

Helliwell (1967) in England and Gupta and Foster in Massachusetts (1975) were both able to analyse many actual decisions and so circumvent the many, obvious difficulties in interpretation of a single or a few decisions. They used government decisions to spend money to buy and preserve land, and they related the expenditure to the characteristics of the land. They then estimated the values implicit in the characteristics of the land. These two studies showed how to generalise the particular, and then apply general values to specific cases. The paucity of applications like these two studies is surprising, in view of the implied values in every choice, and the firm foundations of the method (Kort 1968, and Weisbrod 1968).

Fowler (1980) combined the opportunity-cost and interpret-decisions methods to value the benefits from property preservation — as implied in heritage legislation. The Australian Heritage Commission Act 1975 restricts the activities of owners of listed properties and so imposes costs on them. The owners of the 20 listed properties in Armidale in NSW incurred, on average, an extra $10,200 in building and renovation costs because of the Act. If the Commission explicitly considered the heritage benefits and this sort of cost in their listing, then the benefits of heritage are worth at least $10,200 per property.

Attempts to model and interpret future decisions have varied from direct experiments to intensive survey methods. In a key overseas application, Hauer and Greenough (1982) offered money to subway passengers to increase their travel time by delaying their departures. The payments which were required to obtain the delay were presumably a measure of the minimum value of time. This revealed-preference approach to decisions, and their interpretation, follows on from innovative work in London by Hoinville and Berthoud (1970). Their method, which simulated choices subject to budget constraints, was applied by Wildermuth (1976) to compare urban transport alternatives in Perth.

The monetary figures from the method will only indicate true values if the decisions themselves have been rational and maximised welfare. Even so, these values only indicate the economic trade-offs that decision makers have been willing to make in the past, and so the method can only offer partial indications of values for current and future decisions.

Political decisions are, however, not always accurate reflections of welfare, as measured by economic surpluses. Indeed, the public choice literature argues that the incentives which motivate politicians rarely reflect these values. Politically-revealed preferences are therefore likely to be poor indicators of environmental values, and so this method is likely to provide poor estimates of value.

Acceptance of the relevance of the method is to recognise the irrelevance of valuation.[7] The method implies that political decisions maximise welfare, and so are efficient. It follows that application of this method to derive surplus values, for policy advice to assist decisions, is unnecessary. There is no need for policy advice, no need to value anything, and no need for economic analysis.

The interpretation of decisions is clearly a difficult process, and the interpretation of a single decision may yield little information to apply to current choices. But the interpretation of a large number of decisions about a single kind of environmental choice, after Helliwell, Gupta and Foster, or Fowler, seems a sufficiently promising method to justify further research. At the very least, it will demonstrate the values implicit in past decisions.

4.5 Value Proxy Goods

There is an underlying premise in this method — the value of an environmental good or service can be taken as the value of a proxy or substitute. Consider the case of the Big Tree at Guildford, near Castlemaine in Victoria. This river red gum is classified by the National Trust but is close to power lines which present a fire risk. The State Electricity Commission recently spent $8600 to shift a power pole to reduce this risk, and so use of this figure for the benefit of similar, or substitute, trees is appealing. But at best, $8600 is a minimum estimate of the benefits of preserving this tree. More importantly, there is a broader issue in using this figure for the benefit of a proxy good, or close substitute. Is the benefit of second object B of similar characteristics, in similar circumstances to a similar community, likely to be similar to the benefit of an original object A?

Expenditure on viewing or learning about wildlife is sometimes taken as a minimum estimate of the benefit of knowing that wildlife still exists. Thampapillai (1991) suggests that the benefits of flood mitigation can sometimes be approximated by charitable donations for flood relief. Johnston (1982) explores the possibility that willingness to pay for cans of fly repellent can be taken as a proxy for benefits of a research programme to eradicate flies.

Governments produce and sell many goods and services including water, road space, and recreation opportunities. Occasionally, they charge and this administered price has sometimes been used as a

[7] An anonymous referee provided this important Randian insight.

measure of benefit or cost. In this case, the administered market situation is taken as a proxy for the competitive market situation. For example, O'Shaughnessy and Jayasuriya (1987) take the benefit of water to be the price for which the Melbourne Metropolitan Board of Works sold it. The difficulties in this procedure concern the degree to which the administered price reflects true benefit, the marginality or otherwise of the quantities produced and exchanged, and, of course, the extent to which consumers can express their preferences for the good. In terms of information for a decision, the issues concern whether use of an administered price as a benefit value for the water is better than use of no value at all, and this choice often reduces to a judgement by the analyst and decision maker.

The usefulness of the method depends, of course, on the availability of a good substitute and the availability of a value for it. Even then, this method is fraught with conceptual problems concerning the degree of substitutability. Nevertheless, the analyst should be able to identify whether the proxy value is an underestimate (or even a minimum value), or an overestimate (or even maximum value), and treat it as such.

5. Do the Methods Provide True Values?

In the last 40 years, there has been a substantial growth in the number of valuations, and the kinds of valuation method in use in Australia. There has also been a large number of Australian valuations, and at least 100 authors have been involved. Nevertheless, maturity, growth, diversity, and number are only partial indicators of progress, so some assessment of the state of the art seems appropriate, even though such an assessment may be restricted, superficial — or both.

An overall assessment of valuation must rest on two criteria — the reliability of the values obtained, and the degree to which they improve the information for choices. The truthfulness of the values obtained, in the sense of predictors of behaviour, is explored here in Section 5. The role of the information in choices is assessed in Section 6, and the debate surrounding information from contingent valuation is assessed in Section 7.

5.1 The Predictive Test

Of the seven methods to derive values (Table 1), only contingent valuation is always based on hypothetical responses and hypothetical exchanges of goods and services. With the exception of utility analysis, which has a more restricted use, the other methods rest on data from actual exchanges. Thus contingent valuation requires the closest scrutiny for the reliability of its values. In this context, a true or reliable value is taken to be a value which would arise if there were a competitive market for the particular good or service. The value would then be a predictor of, or a result of, economically-rational choices.

There appear to be some 20 tests of predictive ability worldwide, of which 17 are reported in Sinden (1988). In each of these 17, students completed a survey which included a standard, hypothetical, willingness-to-pay-question. The students were then asked to donate actual money for the same, local, environmental purpose as in the question. In 16 tests, there was no statistical difference between the mean donation and the mean hypothetical willingness-to-pay. In the 17th, the actual mean payment exceeded the mean hypothetical one. Contingent values successfully predicted actual values in 16 of these 17 tests.[8] In this set of tests, the small absolute sums involved ($1 to $20) were relatively large to their donors. Students are ideal subjects because they know all about playing strategic games with questionnaires, and most had already taken courses in public economics and so knew all about free riding.

[8] Authors are probably the worst judges of their best papers, but the 17 tests of the predictive ability of contingent values (in Sinden 1988) surely make a contribution to the valuation literature. Nevertheless, this paper seems to have been largely ignored in the literature. Even Smith (1991a) ignored it, in his address to the 35th Annual Conference of Australian Agricultural Economics Society on the valuation of environmental amenities.

The other three tests were undertaken by Bishop and Heberlein (1979) in Wisconsin and Bohm (1972) in Sweden. In the former, divergences of up to 60 per cent between actual and hypothetical values were reported. In the latter, there was no statistical difference between actual and hypothetical means.

In a review of predictive tests, Smith (1991a) argued that some forms of contingent valuation do provide consistent and plausible values for some types of environmental resources. His earlier conclusion (Smith 1990) is also relevant — contingent values are systematically related to the types of resource being assessed, and the assumptions of the valuation study. Braden and Kolstad (1991) expand on this conclusion in the context of contingent valuation and the whole set of techniques to estimate values. The methods now in widespread use provide reasonable estimates of values of environmental goods and services, but more importantly, they do so with regularity and consistency.

5.2 The Sensitivity Test

The steps in a sensitivity test are (a) estimation of the likely range for a particular variable, (b) calculation of net benefits for this range, (c) determination of the levels for the variable for which the choice in unaffected (or insensitive), and then (d) interpretation of this level and range to help the choice between alternatives. For example, the opportunity costs of damming the Franklin River, in Tasmania, would have included foregone wilderness recreation, foregone general recreation, lost forest habitat and lost aboriginal sites. Saddler, Bennett, Reynolds and Smith (1980) did not estimate the value of these lost benefits as such. Rather, they determined what their minimum value would have to be so that the net benefits of preservation just exceeded the net benefits from construction of the dam. The same procedure was followed by Young and Mues (1993) to calculate a threshold value for the benefits of the natural environment of the Barmah-Millewa forest. These values ranged between $62 000 and $1 204 000 per year, depending on the water management strategy.

The valuation of mining and preservation at Coronation Hill demonstrated several of the issues involved in employing sensitivity tests in choices which involve important unpriced values. According to the Australian Bureau of Agricultural and Resource Economics (1990), the net present value of mining at Coronation Hill is $82 million at eight per cent over 12 years. The basic estimate of the benefit of preserving the area was derived by contingent valuation (Imber, Stevenson and Wilks 1991) and was $647 million per year or a present value of $5 876 million (also at eight per cent for 12 years). The two sensitivity-test questions can now be posed. What is the likely range of the net present value for preservation? Does the net present value of mining exceed the minimum estimate of the net present value from preservation?

The public and private debate which followed release of these values for Coronation Hill ranged from the immorality of measuring environmental values to the statistical difficulties of value estimation. But any reasonable minimum estimate of the benefit of preservation, derived from Imber, Stevenson and Wilks, must surely exceed $82 million by an order of magnitude. In any case, the order of magnitude by which the preservation benefit exceeds $82m was surely the issue, not the well-known difficulties of contingent valuation that were reviewed by Australian Bureau of Agricultural and Resource Economics (1991). The Tasman Institute (Moran 1991) and the Institute of Public Affairs (Brunton 1991) also emphasised these other difficulties at the expense of the key sensitivity-test issue.

When a particular item of data is missing or hard to calculate, a sensitivity analysis can be structured to calculate a break-even value for a particular variable. Streeting and Hamilton (1991) used this procedure to treat the unpriced benefits of preserving the National Estate forests of south-eastern Australia in their benefit-cost analysis of cessation of logging. The benefits they could value included cost savings in forest operations and mill activities. The costs they could assess comprised the forgone sawlog and pulpwood income and the economic

cost of unemployment. The main missing data were the benefits of preservation. At a four per cent discount rate and with the assessable benefits and costs, the net present value of preservation was -$14.7m. The required break-even value is now the level of the preservation benefit at which the net present value becomes $0, and the level is clearly $14.7m. If the community or its decision makers believe these benefits are worth more than $14.7m, the forests should be preserved. Otherwise they should be logged.

The use of this break-even test has been formalised into another method to assess partial values.[9] The method is aptly called 'The Last Resort'. Even if all the methods of valuation fail, or data are available for none of them, a decision maker will still have to choose between alternatives. A simple, but systematic, representation of the benefits and costs should increase the rationality of the decision. Suppose a land-use change would impose net costs of $2m on society and the main benefit is preservation of a natural area. Instead of assuming that the benefits do or do not exceed these costs, a simple question could be posed to the decision maker: "Do you think preservation of this area is worth $2m or more to society?"

The presentation of information in this way may sometimes allow decisions to be made without formal valuation of the unpriced benefits or costs. Jenkins (1993) estimated the costs of depressing a railway line to reduce noise to residents of Caulfield to be $13.8m. The benefits of lower noise would accrue to 130 residents, and so the cost is $106 000 per person. The analysts argued that the benefits were not worth $106 000 per head, and the project did not proceed.

Data are always difficult to obtain but careful use of the methods of valuation, supported by equally-careful use of sensitivity tests, can sometimes provide broad policy conclusions. Young (1992) used changes in agricultural output to measure the on-site and off-site costs of soil erosion, and changes in land value and in costs to households to measure the costs of salinity. He then applied these values to adjust gross national product in an application of natural resource accounting for rural resources. He considerably improved on an earlier, more limited, attempt to adjust natural resource accounts to include a full set of goods and services of the forest (Sinden and Aitken 1980). After noting that only 5.7 per cent of the Australian workforce is employed in the renewable-resource sectors, Young concluded that adjustments for these sectors are not likely to change the conventional indicators of national economic performance sufficiently to change policiy decisions. This conclusion proved robust over a wide range of changes in the value data.

Sensitivity tests do not help to assess whether values are true, and they should not be used to avoid valuation or to substitute for valuation methods. They still require judgement by analyst or decision maker to select minimum or maximum values for a particular unpriced benefit. So they are not useful when the unpriced value is completely unknown.

6. Do the Methods Provide Useful Values?

Progress in valuation could be assessed by the ability of the methods to provide values which are useful for choices, rather than by the ability of the methods to provide true values. Values can help decisions in many ways, as Greig (1977) discusses for the travel-cost method. The obvious role is instrumental, where values are directly used to determine choices. The other, equally-important, role is conceptual, where values are used to promote an understanding of problems and situations.

These two roles provide two different criteria against which to assess the success of valuation, but they are clearly inter-related and separated only in time. The difficulty of identifying decisions,

[9] Both Michael Read and Neil Sturgess, of Read Sturgess and Associates, pointed out the role for this de-facto method. They coined the apt label, "The Last Resort".

which follow valuation and analysis, is not peculiar to environmental problems. In agricultural policy for example, the steady accumulation of evidence against marketing boards has slowly been translated into industry reform — even though no individual analysis may have led to the reform.[10] With these caveats, progress in the instrumental and conceptual roles is now discussed.

6.1 To Assist Choice

Government decisions appear to have been based on valuations, and on what the values indicated, in at least four major decisions. The Commonwealth and Queensland Governments banned drilling on the Great Barrier Reef shortly after Cochrane, Fitzgibbons and Hendriks (1971) showed that drilling contributed between - $13m and + $170m to economic welfare — surely a small present-value contribution. The research by Saddler, Bennett, Reynolds and Smith (1980) did not make an explicit valuation of the wilderness benefit of preserving the Franklin River. But it did provide a sensitivity test with a threshold value. If the benefits of preservation were deemed higher than this threshold, preservation is preferable to hydro-electric development. These results directly influenced government to preserve the natural river environment (Kellow 1989).

The Western Australian Government has just abandoned a proposal to extend a water supply pipeline to farms in the wheatbelt. A recent benefit-cost analysis, with its hedonic valuation of pipeline benefits, confirmed the result of an earlier contingent valuation which showed that the line would reduce welfare (Coelli, Lloyd-Smith, Morrison and Thomas 1991). In Queensland, the government followed Hundloe (1990) and Bennett (1991) to ban logging on Fraser Island.[11]

The Australian Government recently ruled against mining at Coronation Hill in the conservation zone of Kakadu National Park. The stated reasons for preservation concerned preservation of sacred areas of the Jawoyn people, although a struggle for political leadership was occurring at the time of the decision. Nevertheless, the net benefits for preservation (from Imber, Stevenson and Wilks 1991) were higher than the net benefits for mining (from the Australian Bureau of Agricultural Resource Economics 1990).

In addition to these major, one-off decisions, some Government agencies have developed their own guidelines, as for example the Roads and Traffic Authority of NSW (1990). The existence of such guidelines suggests that some agencies actually apply the values they derive and actually base choices on these applications.

6.2 To Assist Understanding

In the longer term, individual valuations and benefit-cost analyses may be more useful in assisting general understanding than in assisting a given choice. In this context, values and analyses help to focus discussion, define issues, formulate problems, provide orientation, provide a framework for thought, expose fallacious arguments, and raise the general level of debate over particular issues. In addition, values will help to show who benefits and who pays.

Estimates of environmental values have several roles in a decision, one of which is to focus discussion. Numbers can always promote debate, but reliable numbers can sometimes improve the quality of debate. But further, the concepts which underly the numbers can also concentrate and direct arguments in useful ways. Irrespective of the problems in estimating the preservation value of the Kakadu Conservation Zone, the work of the Resource Assessment Commission has focussed discussion on the nature of the economic benefits of preservation and whether they exceed the costs.

[10] David Briggs provided this example.

[11] An anonymous referee provided this information.

In their assessments of contingent valuation, both Imber (1991) and Blamey (1991b) emphasize the way in which their work helped to raise the level of debate on environmental issues. The former concluded (p.20) that the study of preserving the Kakadu conservation zone "helped raise the level of environmental debate. Environmental opportunity costs are now widely recognised". The latter concluded (p.27) that "non-market values are now generally recognised as valid components of welfare, with the consequence that most controversy now concerns the accuracy of the estimates rather than whether such values are worthy of consideration at all".[12]

Dumsday and Oram's (1990) estimation of the opportunity costs of degradation emphasised the framework of biophysical-economic inter-relationships in land uses, and the biophysical causes of degradation. The opportunity costs of proposals to change land uses to reduce salinity demonstrated to farmers, engineers and biologists the true economic costs of their proposals and the ways in which the components of the system interacted.

The benefits of river recreation were estimated by Sinden (1990a) and the importance of the natural environment to the value of river recreation was demonstrated by Walpole (1991). These demonstrations of the possibility of valuation, and the quantitive importance of the environment, have proved as important as the money values themselves. Apart from an application in a related follow-up study (Read Sturgess and Associates 1992), the values have never been used. Yet the studies have encouraged the recognition by river managers of recreation as a legitimate use, have encouraged other government agencies to value and include external costs in decisions, and have encouraged a shift in management priorities toward recreation and toward improvements in the naturalness of recreation environments.

The importance of valuations to understanding is summarised in Thorne's (1992, p.1) appraisal of pasture establishment to control salinity in the Riverina.

> *... in the present economic downturn, the economic impact of establishing these pastures needs to be appraised. This appraisal can provide supporting data for extension work with landholders....*

Tourism and pastoralism interact in the Flinders Range of South Australia. In places, tourism brings business, employment and income for pastoralists. In others, tourists create costs through littering, opening gates, and frightening stock. Delforce, Sinden and Young (1986a) compared the net revenue from pastoralism with the contingent value from tourism in this area. But the real usefulness of this comparative valuation came from Young's simpler but more detailed revision of the study (Delforce, Sinden and Young 1986b). The greater detail on tourist preferences, pastoralist opinions, options for management, willingness to pay by sites, individual categories of cost, and quantities of use, provided more information than the comparative values alone. These extra data widened the audience, broadened the relevance of the values themselves, and assisted general readers to understand both the interaction between tourists and pastoralists and the possible solutions to the problem.

A whole sequence of studies sought to determine the level of community support for soil conservation in NSW (Sinden 1987, Dragovich 1990 and 1991, and Yapp, Young and Sinden 1991). The central feature of all these studies was the contingent-value question — what is the maximum extra amount you are willing to pay per loaf of bread if all the extra goes to control soil erosion? Instrumentally, the particular values may not have assisted any particular decision. But conceptually, the orders of magnitude, with the similarity of numbers across many situations, have helped to

[12] To my mind, the general recognition that every action has an opportunity cost, and the widespread appreciation that preservation benefits have worthy economic values, are very significant improvements in the level of debate. They are improvements that would seem to justify any valuation study.

frame broad budget decisions and to expose fallacious arguments against funding conservation programmes.

7. The Case of Contingent Valuation

Contingent valuation is clearly not the only method to assess net benefits. Yet contingent valuation has attracted more attention than any other method.[13] These debates arose because of the public exposure of preservation values derived in the Coronation Hill study (Imber, Stevenson and Wilks 1991), the flexibility of the method, and its widespread potential use. The view of some economists is well summarised by Harrison (1993) in the context of environmental inquiries in Queensland. Given the present status of the method in Australia, only courageous economists would stake their reputations on the method in an inquiry. A more detailed assessment of this method therefore seems appropriate, as does the introduction of some overseas experience.

7.1 Application

We seem to limit our use of contingent valuation to the relatively straight forward question, how much are you willing to pay? The flexibility of the method could well be applied to develop trade-off games, and budget allocation games to model and interpret behaviour. These methods have been explored in Ekanayake (1985b), O'Hanlon and Sinden (1978) and Sinden (1990b). Sinden and Worrell (1979) remains a comprehensive review of the problems and potential of these games. The flexibility of contingent-value questions could also be extended by integrating the techniques of decision theory and contingent valuation to pose questions in terms of relative utilities (Sinden and Windsor 1981).

The usual kind of contingent-value question is "what is the maximum you are willing to pay to obtain X?". Alternatively, the question can be phrased as "what is the minimum you are willing to accept for the loss of Y?". This version applies when a good is given up and compensation is required to leave the individual at the initial level of utility. Armstrong and Lowson (1990) use the term "route bidding", for this version in the context of planning corridors for power-lines in Victoria. Property owners are asked how much they would require to sell a right of way on their land for a corridor. The bids for each corridor are summed, and the route with the lowest bid would normally be preferred.

Hicks (1943) demonstrated the conceptual differences between willingness to pay and willingness to accept. But this disparity was not generally recognised in valuations until Knetsch's series of demonstrations in the 1980s to show that there were substantial empirical differences between the versions (see, for example, Knetsch and Sinden 1984, and Knetsch and Sinden 1987). The choice between them turns on issues of actual endowments, perceptions of endowments, reference points, perceptions of reference points, changes in consumption, perceptions of changes, and prospects. The choice is between four measures of consumers' surplus, as Hicks had demonstrated 50 years ago.

7.2 Interpretation

Contingent valuation in Australia is at a critical stage of public scrutiny. Accordingly, the analyst must be able to demonstrate that (a) the dollar numbers are primarily attempts by respondents to value the environmental good or service in money terms (and so the values have meaning), (b) the values are true estimates of worth, and (c) the values can play an instrumental or conceptual role in decisions.

[13] In an application of contingent valuation to value characteristics of lamb, Mullen and Wohlgenant (1991) estimated willingness to pay for changes in fat level, and area of red meat. Consumers were not willing to pay more for desirable attributes, but they were willing to accept discounts for less - indicating a role for contingent valuation in providing policy content to studies of attitudes.

A strong test of whether values have meaning, for the first necessary demonstration, would compare stated willingness to pay to another measure(s) of benefit or utility. In studies of recreation, elicited money values are often compared to some general measure of enjoyment such as willingness to travel extra distance or even qualitative rankings of recreation sites. In Sinden (1990a) for example, the elicited contingent values varied directly with these other proxies for benefit. Another test, suggested by ABARE (1991), would compare stated willingness to pay to income. The lack of a relationship between stated money values and income would suggest the survey responses are not primarily attempts to value a good or service in monetary terms. In this context, the Resource Assessment Commission (Imber *et al.* 1991) was unable to relate its contingent values for the preservation of the Kakadu conservation zone to respondent income — but a short time later Carson (1991) confirmed this relationship from the same data.

In their discussion of the state of contingent valuation, Bennett and Carter (1991) conclude that the next step with the method must be validation testing. An important part of this validation will be tests of relationships between the money values and their meaning. Sinden and Worrell (1979) list the range of validation tests for such purposes, from the strongest, prediction test, through internal consistency, comparison of results between methods, to the weakest content check. Pitt (1993) used the internal-consistency test to compare elicited willingness-to-pay values for dune protection with source of income, location of residence, and length at that location.

Consider, now, the second necessary demonstration — that the values are true estimates of economic worth. The predictive test is also a strong test of whether contingent values are true estimates of worth. Twenty tests of predictive ability were reported in Section 5.1. They indicated that elicited values for willingness to pay can predict amounts actually paid when subjects are co-operative and well informed.

The adaptability of contingent valuation, and the usefulness of the values so derived, were illustrated by Bennett (1992) in a case-study context. He observed that many studies have sought to check bias in contingent values, and then summarised the viewpoints of the practitioners of the method. If respondents are given full information on the goals of the study and on the benefit or cost being valued, they do attempt in good faith to provide accurate answers to the willingness-to-pay question.

The third necessary demonstration is the ability of contingent values to play an instrumental or conceptual role. Some evidence on their instrumental role has been provided, but there is more. The trends to natural vegetation to stabilise river banks and to enhance river-recreation sites in northern Victoria have followed the valuations of the natural environment in Walpole (1991). Four intensive contingent valuations (Dragovich 1990, 1991, Sinden 1987 and Yapp, Young and Sinden, 1991) all gave consistent values for the benefits from soil conservation. Because of this accumulated weight of evidence, these results were used to address broad questions about the size of budgets for soil conservation.

Evidence that contingent valuations have contributed to assist understanding has been cited in Section 6.2. Further evidence is provided by the newspaper reports and discussions on environmental worth versus economic worth, on the meaning of values, and on the concepts of opportunity cost, as for example *The Daily Telegraph Mirror* (4/12/90, p.31), *The Sydney Morning Herald* (19/9/90, p.3, and 19/12/90, p.4), and *Financial Review* (21/12/90, p.35).

8. Conclusions

Has there been sufficient progress in valuation in Australia to justify the routine valuation of unpriced benefits and costs? The rich history of reported valuations together with the 100 and more people who have undertaken them, provide important resources for potential valuers to draw on. The crucial role of unpriced values in many decisions,

and the ready accessibility of these resources, suggests that valuation should always be explored as a standard part of any analysis.

The potential for converting exploration to discovery, or for actually deriving useful values, depends partly on the available data and partly on the available methods.[14] The wide variety of tested methods has been well illustrated in Australia. Over 20 years ago, Nairn (1971) stood up at the Second Conference of Economist's and "sought ... sympathy" for a set of values for eight unpriced outcomes. The outcomes ranged from road deaths to noise and severance of vehicular access. He had used the replacement-cost, cost-saving, marginal-product, contingent-valuation and proxy-good methods to derive his values. The potential role of the wide range of methods was also well recognised by Hundloe, McDonald, Ware and Wilks (1986) in their study of the use of benefit-cost analysis to improve techniques of environmental impact assessment. The authors clearly demonstrate that complete measurement of benefits requires hedonic pricing, travel-cost, opportunity-cost, cost-saving, marginal-product, replacement cost, defensive-expenditure, and contingent-valuation methods.[15]

Engineers, as well as economists, have contributed to this extensive valuation literature, starting perhaps with Munro's (1956) application of the cost-saving method to value the benefits of flood mitigation. O'Brien and Roy (1971) presented a system for multi-objective management of natural resources. Their approach rested on the concepts of production-possibility curves and indifference maps, and their goals were to reduce conflicts, to promote these particular concepts, and to promote ways to value resource goods and services.

In an assessment of the remaining issues in valuation, Sinden (1993) identified an asymmetry between professions in their attitude to valuation. In comparisons of transport alternatives for example, engineers regularly incorporate values for pain and suffering from accidents. But in assessments of the benefits of preservation, economists usually stop at the assessment of the costs of species extinction. Is the disutility of pain and suffering that much easier to estimate than the disutility of loss of a species? Is it easier to generate useful information for decisions on accidents than for decisions on preservation?

The estimation of values for market goods seems to raise relatively few objections from professionals in other disciplines or from those who make decisions, despite the distortion and unrepresentativeness of many market prices. But the estimation of values for unpriced goods and services usually meets several objections. One particular criticism is the application of anthropocentric concepts to ecocentric systems. Humans are, of course, making the decisions so use of anthropocentric concepts is inevitable — and perhaps all that is feasible. But just as importantly, society pursues several goals including both improvements in economic welfare and improvements in environmental quality. Valuations assess worth on the first of these goals and not the second. Anthropocentric values can only be used to assess choices on the anthropocentric goal of economic welfare. Thus values may be the predictors of choice on the first, but should be replaced by other concepts and measurements for the second.

Valuations provide a means of explicitly accounting for factors which are otherwise overlooked, implicitly valued, and often wrongly valued by decision makers and resource managers. Any relevant information will help account for these factors even if the information is a partial value. In this

[14] The potential for deriving useful values also depends on several other less-easily defined factors. "These (Australian) applications demonstrate what is required for valuation - a touch of artistry, a grasp of magnitudes, an insight into economic principles, and a bit of luck." This concluding sentence in Sinden (1992) seems appropriate as a footnote to the present paper.

[15] They also showed how to fill the conceptual gaps of environmental impact assessment with the rich diversity of valuation concepts and methods.

context, the methods to estimate partial values may prove just as useful as those to estimate surplus values *per se*.

After some thought, my 25 survey colleagues did nominate several useful surveys, all of which have been cited above. But collectively, they emphasised the aggregate role of all this work. More important than any individual study is the total body of knowledge and experience which now allows valuation to be routinely attempted — as for example the valuations of noise by the Roads and Traffic Authority (1990 and 1993). More important too, are the insights to be drawn from the total body of valuations of particular resources. In a review of values derived from many studies of land and water resources, Young (1991) concluded that the consistency of values across the body of valuations was far more important than the warts of individual studies.

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