THE ECONOMIC EVALUATION OF ENVIRONMENTAL RESEARCH : A CASE STUDY OF THE SOUTH-EAST FORESTS

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Introduction

The economic evaluation of proposals concerning environmental resources suffers many disbelievers; the economic evaluation of scientific research faces similar resistance. An attempt to undertake the economic evaluation of environmental research can accordingly be expected to receive a degree of scepticism which is some orders of magnitude greater.

There are a variety of reasons for this but an important one is likely to be the perceived impossibility of the task of measuring 'the unmeasurable'. The 'double intangibles' of non-marketed environmental amenities and services plus the uncertain benefits of research are seen to pose an insurmountable measurement problem.

But such challenges are the food of research, and aided by the twin pressures of rapidly tightening budgets and significantly increased pressures for accountability and performance, progress is being made by professional economists in addressing these challenges. This is particularly true in the field of environmental economics, where approaches such as travel cost, contingent valuation and hedonic pricing are relatively well established (see for example Randall; Sorg and Loomis; Loomis and Walsh; Jakobsson and Dragun; Young). Indeed the application of such methods as contingent valuation are required by the US Government in the assessment of proposals for water resource development (US Water Resources Council). The application of these methods in Australia has been less widespread (examples include Bennett; Carter; Sinden).

In the evaluation of research, the need to estimate the value of non market benefits poses similar problems of measurement to those encountered in the economic evaluation of environmental proposals. Hence there appears to be scope for employing approaches such as CVM in the evaluation of research characterised by the generation of non priced outputs (Johnston).

The purpose of this paper is to report on the results to date of a case study evaluation of a research project being conducted by the Division of Wildlife and Ecology. The project concerns the development of a technique to estimate the distribution of flora and fauna in the temperate forests of south eastern Australia. The evaluation includes application of the contingent valuation method. Although the analysis is not yet completed, it is sufficiently well advanced for preliminary results to be of interest and to be exposed to critical review.

Background

In response to the need to undertake research evaluation, specified in the Ministerial Guidelines handed down to CSIRO in 1988, the Institute of Natural Resources and Environment (INRE) in CSIRO engaged the authors to undertake a series of case study evaluations of project research conducted in the Divisions which make up the Institute. The present paper is concerned with the case study nominated by the Division of Wildlife and Ecology (DWE) relating to project research in the temperate forests of south eastern Australia.

The objective of the research is to develop an understanding of the distribution of vegetation communities and forest fauna and of their dynamics in response to logging in the south east temperate forests.

The DWE research commenced in 1979 and is continuing. This case study focuses on the research to date which has primarily been undertaken in the south east forests of NSW. As a result of that research, techniques have been developed which enable the incidence of species to be identified and predicted in a cost effective manner.

The south east forests of New South Wales have for some time been noted for the conflict in resource use between timber production and preservation of plant life and habitat. One outcome of the DWE research will be the generation of information which will assist in the resolution of that conflict by allowing a more informed debate to take place about the benefits of preservation compared with the more easily measured benefits of logging. A second anticipated outcome is improved forest management, and forest management practices in NSW have already been influenced by the research findings to data.

Analytical Approach

Following what is now a well established tradition in the evaluation of publicly funded activities, a benefit cost approach was adopted (see Sugden and Williams; Mishan; Pearce). There are of course a number of issues associated with the application of benefit cost analysis which are still being debated in the economics profession, including choice of discount rate, the related social opportunity cost of public funds, and the extent to which BCA should address questions of equity as well as efficiency (for recent discussion see Lind, Young).

In addition, the non market characteristics of many environmental resources and the uncertainties associated with the impact of research further stoke the fires of the measurement debate. Indeed the theoretical problems are probably far outweighed by the data problems.

Despite this, encouraging progress has been made in reducing the magnitude of a number of critical problems, particularly those occurring in relation to environmental resources. Reference hs already been made to techniques developed to address the problem of measuring non priced goods and services and the point has been made that the contingent valuation method (CVM) in particular offers potential for addressing similar problems in the evaluation of research.

In this context, the BCA approach has been readily adopted for ex-post analysis of research (for examples see Marsden et al; Edwards and Freebairn; Lindner and Jarrett). However for ex ante analysis, some modifications to the conventional formula are needed (see Davis et al.; Lindner), and the evaluation framework used in the series of case study evaluations of research being undertaken for INRE is based on the following extended BCA formula:

$$E(NPV) = \Sigma_t \Sigma_i (p_i . a_{it} . B_{it} - C_t)(1+r)^{-t}$$

where: $E(NPV)$ = expected net present value of the streams of benefits less costs;

p_i = probability of success of research and development in generating the ith benefit

a_{it} = level of adoption/diffusion of ith benefit in year t;

B_{it} = value of ith benefit in year t;

C_t = value of R&D costs in year t;

r = social rate of discount;

i = type of benefit (if more than one from the R&D), or region/state, or community group.

In the case of the south east forests research the particular problem is to obtain a measure of the benefits.

It is clear that the benefits of the research are not amenable to ready measurement by market based variables. To obtain estimates of the value of these benefits, it was necessary to approach the perceived beneficiaries of the research. The beneficiaries fall into two categories viz the community at large, and the users of the research output - the resource managers, in this case the Forestry Commission of NSW.

For present purposes we will restrict our attention to the approach adopted to obtain estimates of the value of the research to the ultimate beneficiaries, the community.

The CVM is a survey based approach, whereby a hypothetical market is created for the unpriced good or service being evaluated and respondents are asked to provide estimates of their maximum willingness to pay, WTP, (and/or minimum

compensation which would be accepted, WTA) to achieve (or avoid) the associated change in welfare, (see Cummings et al; Pearce and Markyanda). An advantage of the CVM approach for use in BCA is that the value estimates generated can be 'interpreted directly as observations of the appropriate compensating values of economic surplus' (Randall).

A number of potential sources of bias have been attributed to CVM responses, and the validity of such estimates has been questioned (see for example Bishop et al.; Cummings et al.). A number of recent studies have addressed this issue and specific sources of response bias have been tested, (see for example Boyle and Bishop; Sinden; Smith et al.). Many of the results, but not all have either indicated an absence of significant bias or have led to the introduction of refinements to the procedures used. Needless to say these efforts are continuing, and further progress can be expected and indeed hoped for because the technique does not yet appear to have passed the laugh test among policy makers in Australia.

The current state of play has been well described by Randall:

'The consensus among professionals has gradually shifted from the skeptical -- "Ask a hypothetical question and you get a hypothetical answer" -- to the cautiously optimistic ... .Optimism is engendered by empirical studies that have shown CVM results are consistent with actual choice behavior, systematically related to demographic characteristics and the availability of substitutes and complements, and consistent with the results of hedonic and travel cost studies'.

Randall does however identify 'some persistent anomalies in CVM data sets' including the sensitivity of CVM values to the payment method nominated to respondents (Boyle et al.); significant divergence between WTP and WTA (Knetsch and Sinden); and the appearance of zero valuations for desired commodities in WTP formats. Randall concludes that:

'while some of the old questions concerning CVM are yet to be resolved, innovations in the CVM research program continue apace.....these developments will tend to enhance the potential of CVM to generate reliable benefits data'.

In the interim, CVM is the only technique available to measure non use and most non market valued benefits of research. On the basis of work to date we would argue that the application of CVM will provide estimates which at least in order of magnitude terms do have validity for policy guidance.

Data

To apply the CVM, a mail questionnaire survey of the community was conducted. The CVM scenario was designed in as realistic a manner as possible and respondents were asked to

estimate the increase in welfare they would receive in terms of their willingness to pay to have the scenario implemented. The scenario presented in the questionnaire involved CSIRO undertaking research to provide information to allow improved management decisions about the location and size of conservation reserves. The contingency on which the estimated value is based is that if the research was not undertaken then the improved management would not be achieved and there would be a risk of loss of habitat, and plant and wildlife.

The questionnaire was sent to a randomly selected sample of 1031 people registered on the Commonwealth Electoral Roll. The sample was stratified such that a random sub sample of 400 was drawn from the Eden-Monaro Electoral Division, which is the area in which the research is primarily concentrated, and the remaining sub samples were drawn equally from the other 50 NSW Electoral Divisions and the 2 ACT Divisions.

Within each of the geographic strata, the sample was further stratified by splitting each sub sample in two for the purpose of comparing two alternative methods of payment - one based on WTP to a special research fund directly from income, and the other on WTP to the same fund via increased taxes.

In an attempt to overcome potential response bias in favour of the south east forests in NSW, the context of the WTP response was broadened by initially seeking estimates for similar research in all native forests of Australia, and respondents were then asked to divide the initial total WTP between native forests excluding the south east forests of NSW and the latter.

The overall response rate, following a reminder, was 30% which was regarded as adequate for this type of approach. The overall representativeness of the sample respondents was checked by comparing socio-economic characteristics of respondents against those of the NSW/ACT populations.

For the benefit cost analysis, benefits from the research are also likely to accrue to forest and natural resource managers in other states and to the Australian community outside the Electoral Divisions covered by the survey. However in the first instance, attention was focused on the value of benefits to the community in the Electoral Divisions surveyed.

Non R&D costs of implementing the research output plus the opportunity cost of logging foregone as a result of any conservation measures introduced should be deducted from the expected value of the benefits. At the time of drafting this paper, we did not yet have estimates of these implementation costs, and hence the estimates of expected benefits will be overstated. We do not however anticipate that the degree of error resulting will be such as to alter greatly the relative orders of magnitude obtained for the estimates of the benefits.

Cost estimates of the R&D on an annual basis for the relevant time period were obtained from DWE scientists. Allowance was made for overhead costs as well as direct salary and other costs. Values of unity were assigned to 'p' (probability of success of R&D) and 'a' (adoption level) because it has been assumed that the WTP estimates were given in the knowledge that there was some risk of 'p' < 1, and of 'a' < 100%. Clearly there is scope for sensitivity analysis in respect of the 'p' and 'a' values. This is particularly the case for the value of 'a' since the questionnaire does not explicitly state that the implementation of the research output by forest managers is not a certainty.

Results of Survey

A slightly higher proportion of the initial sample receiving the questionnaire with the increased tax payment vehicle responded (33%), compared to the corresponding rate for the direct payment vehicle (27%). Of the former, 63% indicated a positive non zero WTP, whilst for the latter group the proportion was 66%.

The annual average WTP amount to a fund specially established for research into the existing native forests in Australia across the two groups was estimated to be $17.79 per respondent per annum with a confidence interval at the 95% level of $14.27 to $21.31.

When asked to distribute the stated WTP amount between four forest regions in which the research could be undertaken, the respondents gave % shares which were averaged. The mean % shares are shown in Table 1.

TABLE 1 Distribution of WTP Amounts by Region and Electoral Division

	Eden-Monaro Electoral Div. %	Other Electoral Div. %
South-west Tasmania	22.2	21.7
South-east NSW	29.5	26.2
North Queensland	23.0	23.7
Other	25.3	28.4

For the south east forests of NSW, the annual average WTP for 'research to provide information to allow improved management decisions as to the location and size of conservation reserves' was estimated to be $4.23 per respondent per annum. Estimates of mean and range by Electoral Division and payment vehicle are shown in Table 2.

TABLE 2 Annual Average and Range of WTP Amounts per Respondent by Electoral Division and Payment Vehicle

	Direct Payment		Extra Tax		Total	
	Mean $	Range $	Mean $	Range $	Mean $	Range $
Eden-Monaro	1.64	0-25	3.25	0-125	4.13	0-125
Other	1.52	0-50	3.54	0-104	4.30	0-104
Total	1.57	0-50	3.43	0-125	4.23	0-125

Inspection of the data in Table 2 suggests that payment vehicle bias is present, confirming the earlier results of Boyle et al. However if allowance is made for the fact that direct payments are made from 'after tax' dollars whilst the increased tax amounts are 'before tax' dollars, then the extent of bias would appear to be relatively minor.

The results which follow are based on the aggregation of WTP estimates across payment vehicle strata without adjusting for any difference in value between 'before tax' and 'after tax' dollars.

In aggregating sample data to population data in the relevant Electoral Divisions, the assumption was made that the non respondents in the sample have similar characteristics to the sample respondents. Accordingly, the group of respondents is taken to be a representative sample of the population from which they have been drawn. This means in effect that non respondents have been assigned the mean value of the respondents. The weighting of the response data to derive population aggregates was done by aggregating each strata or sub sample to its respective population level. The estimated aggregate WTP amount for the population in the relevant Electoral Divisions was $15,738,554 per annum, with a confidence interval of $11,123,277 to $20,353,831.

Following the suggestion of Loomis that a more conservative stance may be appropriate with regard to the assumption about non respondents, and that it may alternatively be assumed that non respondents WTP is zero, the estimates were recalculated. On this basis, the aggregate WTP amount was estimated to be $4,030,046 per annum for the population in the relevant Electoral Divisions.

For respondents who received the tax payment questionnaire, some 42 respondents were unwilling to pay any extra amount and hence were assigned a zero value for purposes of estimating an annual WTP amount. However these respondents did indicate that they would be willing to redirect an amount of current income tax to a special research fund. Not

unexpectedly, the average annual WTP amount for this group was greater than for the other two groups, being estimated at $5.56 per respondent. This result does perhaps give a clearer indication of payment vehicle response bias and gives some justification for treating this group as respondents with zero values.

Benefit Cost Analysis

The average annual WTP value of $4.23 per respondent and the corresponding aggregate population value of $15.7M per annum as a measure of the benefits expected from the DWE research, together with the data on R&D costs for the period 1979-80 to 1988-89, formed the data base for the BCA. An alternative set of benefits estimates based on the assumption that non respondents assign a zero WTP value, yielding the aggregate population value of $4.0M per annum referred to above, was used to derive a second set of BCA estimates.

Three scenarios were selected for determining the stream of benefits. In the first, it was assumed that the benefit span would be concurrent with the ten year time span already covered by the research undertaken to date. On this basis it is assumed that respondents would have been willing to pay their stated annual amounts to the special fund beginning in 1979-80 and ending after ten years. The results for this scenario are shown in Table 3.

TABLE 3 Benefit Cost Analysis - Ten Year Time Horizon for Benefits

Non Respondents WTP:	Mean Sample Value		Zero Value	
Discount Rate:	5%	10%	5%	10%
PVC $M	3.4	5.2	3.4	5.2
PVB $M	190.4	238.3	48.8	61.0
NPV $M	187.0	233.1	45.4	55.8
PVB/PVC	56.5	45.7	14.5	11.7

A second scenario is based on the assumption that the community would be willing to pay only until the present research was completed - a period expected to end in 1990-91. In this scenario the time span of the benefits was accordingly projected to be three years. Results are presented in Table 4.

TABLE 4 Benefit Cost Analysis - Three Year Time Horizon for Benefits

Non Respondents WTP:	Mean Sample Value		Zero Value	
Discount Rate:	5%	10%	5%	10%
PVC $M	3.4	5.2	3.4	5.2
PVB $M	42.9	39.1	11.0	10.0
NPV $M	39.5	33.9	7.6	4.8
PVB/PVC	12.7	7.5	3.3	1.9

The final scenario is based on the assumption that the benefits extend to the year 2049-50, a proxy for perpetuity. The results are presented in Table 5.

TABLE 5 Benefit Cost Analysis - Sixty Year Time Horizon for Benefits

Non Respondents WTP:	Mean Sample Value		Zero Value	
Discount Rate:	5%	10%	5%	10%
PVC $M	3.4	5.2	3.4	5.2
PVB $M	299.5	157.0	76.7	40.2
NPV $M	296.1	151.8	73.3	35.0
PVB/PVC	88.9	30.1	22.8	7.7

The results of the BCA suggest that on the basis of the community survey responses of WTP, the research on the south east temperate forests being conducted by the DWE in CSIRO is highly valued.

Discussion

The results of the community survey and the associated benefit cost analyses indicate that a substantial value is placed by the community on research likely to lead to improved forestry management including conservation of important habitat areas.

Although some implementation costs were not included in the analyses, the fact that the data encompass only NSW and the ACT suggests that the estimates of benefits may be understated rather than the reverse.

The fact that the CVM methodology is still being refined is not in our view a sufficient reason to dismiss the results as being invalid. Every effort has been made to maintain the integrity of the responses, and there is no indication that the results are less than plausible.

Finally it seems likely that the community values embodied in these results may not be reflected in management regimes currently being practised in Australian native forests. To that extent, there will be potential for forest managers to support to a greater degree the areas of forest research concerned with conservation reserves.

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