Sustainability and Environmental Valuation

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ABSTRACT: For economists, sustainability and environmental valuation are connected in two ways. At the micro level, proper environmental valuation is required if projects are to be approved and rejected consistently with sustainability requirements. This is cost benefit analysis. At the macro level, many take the view that sustainability requires that national income measurement be modified so as to account for environmental damage. Such natural resource accounting is possible only if environmental damage is valued for incorporation into the economic accounts. The paper reviews the techniques that economists have developed for environmental valuation. In regard to cost benefit analysis and sustainability, it is noted that the technique on which most interest focuses, the Contingent Valuation Method, involves the extension of the domain of consumer demand analysis to include the natural environment. Contributions questioning the appropriateness of this are reviewed, and it is argued that they merit more attention from economists than they have received to date. In regard to natural resource accounting, it is argued that while there is little prospect of it achieving what its proponents claim for it, the modelling that it necessarily implies has the potential to both clarify valuation issues and play an important role in informing the policy process.

KEYWORDS: Sustainability, valuation, environment, contingent valuation, natural resource accounting, optimization.

1. INTRODUCTION

While the definition of sustainability generates debate (see, for example, Pezzey 1992), the basic nature of the idea involved is reasonably clear. The pursuit of sustainability, or sustainable development, involves trying to avoid creating economic problems for future generations arising from current degradation of natural assets. The functions of natural assets in relation to economic activity are:

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1. to provide the basis for resource flows into production
2. to assimilate the waste products arising in production and consumption
3. to provide the basis for flows of services direct to consumption, i.e. amenity services
4. to provide those services which maintain the total global system in a condition to support human life, such as for example the reduction of ultra-violet radiation reaching the earth's surface or the maintenance of the potential for evolutionary change in the biosphere.

The demarcation between the last of these and the other three is not always clear and exact. A concern for biodiversity conservation, for example, relates to 4 and can be regarded also as relating to 1, 2 and 3. However, it appears useful to distinguish 'life support' services from the other three: not all natural asset functions can be captured in terms of flows from a particular natural asset to production and/or consumption across a notional boundary between the economy and the natural environment.

Few would now wish to argue that the management of natural assets can be left entirely to market forces. There are four distinct bases for the position that social action is required to modify the operation of market forces in regard to natural asset management.

First, it is widely recognized that 'market failure' problems are, especially in regard to the environmental asset functions of waste assimilator and amenity service base, the rule rather than the exception. Market failure means that allocative efficiency is not attained. Mainstream environmental economics can be regarded as the study of the causes of and means to correct market failure in regard to environmental assets. We label this the 'Efficiency School': it is well represented in the pages of the *Journal of Environmental Economics and Management*. The elimination of market failure does not, of course, itself ensure distributional justice, which both intra and inter generationally is a major component of the idea of sustainability/sustainable development as expounded in the 'Brundtland Report' (World Commission on Environment and Development, 1987).

The second basis for not leaving things to the market arises directly from this last point. Intratemporal allocative efficiency is consistent with current injustice, and intertemporal allocative efficiency is entirely consistent with current welfare levels exceeding future welfare levels. Hence, market failure correction is not sufficient for sustainability. An explicit position on justice and asset transfers across people and through time is argued to be necessary for sustainability. We label this the 'Equity School': a representative contribution, focusing on intertemporal transfers, is Howarth (1991).

Both of these positions can be located in fairly standard economic concerns for efficiency and distributional justice. A third basis for the conclusion that

matters cannot be left entirely to markets originates in a concern for the integrity of the natural systems where natural assets are located. Sustainability is seen as being about the preservation of such integrity as a necessary condition for levels of future welfare comparable to current levels. Common and Perrings (1992) have argued that consumer sovereignty is not necessarily consistent with the requirements of sustainability thus conceived. To reject consumer sovereignty as the basis for the determination of resource allocation represents a more fundamental departure from standard economic thinking than either of the two positions sketched above. We label this the 'Ecological School'.

The fourth position which would not leave natural asset management entirely to markets also rejects consumer sovereignty. However, this position is not based directly on consideration of the requirements of ecosystem integrity maintenance. It originates in questioning the normative role of consumer sovereignty in resource allocation generally, or in regard to natural assets particularly, on an ethical and/or behavioural basis, rather than an ecologically instrumental basis. We label this the 'Philosophical School', and discuss it in section 4 of the paper.

Each of these positions raises questions of valuation in relation to natural assets. The efficiency school position is that which gives rise to what we call here pseudo market valuation. The other three positions all involve some departure from pseudo market valuation. The equity school notes that efficiency prices are conditional upon current distributional settings, and argues that unless such settings are considered appropriate the prices arising should not guide allocation. The ecological school position is that consumer sovereignty driven outcomes need to be modified by the observance of biophysically specified constraints deriving from system integrity requirements. The philosophical school limits the domain of consumer sovereignty on the basis of ethical and/or psychological considerations: individuals are seen as comprising (at least) two choosing entities, and the consumer entity is regarded as of limited relevance to social choices affecting natural assets.

In terms of the foregoing, the paper is organized as follows. Section 2 reviews the main features of the efficiency school approach, identifying the Contingent Valuation Method, CVM, as that particularly relevant to sustainability issues. Section 3 considers what can be said about the accuracy of CVM. In section 4 we draw upon some of the literature from the philosophical school to raise questions about the appropriateness of the CVM research agenda, and to identify what appear to us to be the critical issues arising. Section 5 discusses environmental valuation in relation to natural resource accounting, noting the existence of two different approaches to the matter. Section 6 offers some conclusions, which mainly relate to a research agenda for providing useful inputs to social decision making on uses of the natural environment. There are two appendices containing more technical material relating to the major issues canvassed in the body of the paper. Appendix 1 sets out the conditions on individual preference orderings which must hold for CVM to be applicable. Appendix 2 provides a

model of economy-environment interconnections, and considers system modelling in relation to valuation and natural resource accounting.

2. MARKET AND PSEUDO MARKET VALUATION

The literature of the efficiency school addressing natural asset valuation is predominantly concerned with ascertaining the valuations of environmental assets and services by individuals. These valuations are generally understood to relate to function 3 above, i.e. to amenity services. However, in some contexts the individual valuation of a particular asset/service may include an element relating to function 4. Thus, for example, the valuation of a species by an individual may reflect both actual or anticipated pleasure from seeing representatives of it and/or knowledge of its existence, and some assessment of the role of the species in maintaining system functioning.

In regard to function 1, nonrenewable resource inputs to production are taken generally to be valued in markets, property rights being well established. The problem of free access in regard to many renewable resource stocks, on the other hand, is widely recognized. This implies that there is no market price for the *in situ* resource stock. A pseudo market price can be derived from the value of the marketed product based on the resource via the production function. This would naturally be done within an optimization framework, with the pseudo price emerging as the shadow price of the resource: see, for example, Ellis and Fisher (1987).

The valuation of assets and associated services in regard to waste assimilation, function 2 in the list above, appears to have received virtually no attention. This may be because of the apparent difficulty of defining a particular relevant asset or associated service flow. It is not, however, the case that waste disposal and its consequences have not been of interest to the efficiency school. There is a substantial literature on valuing the benefits of reduced environmental pollution of various kinds, and the methodologies employed overlap with those employed in the environmental amenity context (to be discussed below).

The valuation of life support services, function 4 in the list above, has received rather little attention. Again, this may be due to the apparent difficulty of identifying a particular distinct natural asset or associated flow. Costanza *et al.* (1989) derive a figure for the 'storm protection value of wetlands' by figuring the increases in property value damages which would result if the buffering wetland area were reduced in size. This 'damage avoidance valuation' approach would appear to have some general applicability to life support services provided by the natural environment; for example, flood protection afforded by tree cover in river catchments.

A variant of this approach is the 'substitute service' approach, according to which a natural asset would be valued at the costs of the inputs required to

provide the same service by means of human production. Repetto *et al.* (1989) use this approach to soil erosion costs in Indonesia. A variant of this approach would be via the cost of replacing an environmental asset rather than substituting for it. On this basis, a particular wetland area, for example, would be valued at the cost of creating a replacement rather than the cost of establishing a fish farm, storm protection facilities etc., etc.

Residual value, damage avoidance and substitute service approaches all involve deriving values for environmental assets from existing market prices, which prices are taken as given and appropriate. They are examples of the class of pseudo market valuation techniques. They are not the techniques on which the efficiency school literature has predominantly focussed, nor have they been used for the environmental function – amenity services, 2 in the list above – on which this literature has mainly focussed.

The efficiency school literature on non-market environmental valuation is now almost entirely about inferring the willingness to pay/accept, WTP/WTA, of individuals for variations in the quantity/quality of environmental 'commodities'.[1] The research agenda involved can be described as the extension to natural assets and associated environmental services of the apparatus of consumer demand theory. It is this theory, and associated technique, which is to be used to make the valuation inferences required on account of the fact that environmental services do not, typically, pass to individuals through markets. Indeed, the way in which environmental services have been classified as commodities has been largely dictated by the requirements of this research agenda, rather than on the basis of biophysical considerations. This has implications for the alignment of valuations generated by pseudo market valuation and information relevant to allocation problems arising in the natural sciences, and the requirements of natural asset managers such as forestry agencies: see, for example, Gregory *et al.* (1989).

We now provide a very brief overview of the way in which pseudo market valuation typically arises and is dealt with in the economics literature: for a more extended overview, with particular reference to species preservation, see Randall (1986) for example. Consider some proposed development project to be located in and affecting a wilderness area, and social decision making as to whether or not it should proceed. Let B_d be the measure of the value of all of the project outputs, and C_d be the measure of the value of all of the project inputs. Assume that for aggregation to B_d and C_d market prices are satisfactory, and that B_d and C_d are present values (or annuity equivalents). Over and above inputs captured in C_d, going ahead with the project would involve impacts on the wilderness area. Denote the present value of such as EC, for environmental or external cost. Then, the decision rule is to go ahead with the project if

$$B_d - C_d > EC$$

Clearly, the major problems with this Cost Benefit Analysis, CBA, decision rule

are the identification and measurement of the impacts on the wilderness area, and then their valuation and aggregation to arrive at EC, the environmental benefits of not going ahead with the project.

Assuming that the physical impacts involved can be identified and measured, the basic strategy for valuation is as follows. Let x be a vector of ordinary marketed commodities, and q a vector of relevant environmental conditions. Assume that for the affected individuals the utility function U(x,q) exists. It is then possible to use the standard apparatus of demand theory to establish the existence of monetary measures – consumer surplus, compensating variation, equivalent variation etc – of the utility implications of variations in the vector q: see, Johansson (1987), Mitchell and Carson (1989). The research problem for implementation of this approach to social decision making is then the estimation of the sizes of the appropriate monetary measures for affected individuals and their aggregation to obtain total willingness to pay, TWTP, or willingness to accept, TWTA, measures from which EC can be computed. The problem has been brought within the ambit of consumer demand theory by virtue of the assumption that U(x,q) exists.

There are two basic approaches to the estimation of WTP/WTA for individuals, the Indirect and the Direct. Both derive from the fact that markets do not exist for elements of q due to non-excludability and/or non-rivalry. The former involves recovering estimates from the observed behaviour of individuals in regard to marketed commodities, the latter involves asking individuals about their WTP/WTA. The major operational version of the indirect approach is the Travel Cost Method, TCM, in which WTP for use of the area affected by the project would be inferred from costs incurred in visiting it. Another indirect approach, sometimes used in conjunction with TCM, is the Hedonic Pricing Method, where the basic idea is to use market prices of commodities with different bundles of characteristics to value particular, non-marketed, characteristics. The major operational version of the Direct approach is the Contingent Valuation Method, CVM, so called because individuals are asked about their WTP/WTA contingent upon a scenario concerning the affected area.

It is conventional to sub-divide EC into four classes of benefit, or value, to individuals:

Use Value, UV, arises from the individual's planned use of the area, for recreation for example.

Existence Value, EV, arises from knowledge that the area exists and will continue to exist, independently of any actual or prospective use by the individual.

Option Value, OV, relates to willingness to pay to guarantee availability for future use by the individual.

Quasi option value, QOV, relates to willingness to pay to avoid an irreversible

commitment to development now, given the expectation of future growth in knowledge relevant to the implications of development.

Then,

$$EC = UV + EV + OV + QOV = UV + NUV$$

where NUV stands for Non Use Value: the practical difficulties of separating NUV into its three component parts are widely recognized. Note that OV and QOV arise on the basis of incomplete knowledge of future conditions, whereas UV and EV can arise independently of any uncertainty. Note also that the existence for an individual of EV is generally taken to imply some kind of altruism. EV is itself sometimes sub-divided on the basis of the object of the altruism. Randall (1986), for example, distinguishes a philanthropic motive relating to contemporaries from a bequest motive relating to future generations. Randall also considers 'intrinsic' altruism, where "the individual human cares about the well-being of nonhuman components of the ecosystem" (p85).

The TCM can address only the estimation of use values.[2] The CVM can, in principle, address the estimation of all four of the above classes of benefit/value separately. Of these classes of value distinguished in the economics literature, we take it that it is existence value that is particularly, but not solely, relevant to sustainability questions. The major reason for so doing is that the sustainability problem is seen as being essentially about problems of intergenerational equity arising from current impacts on the natural environment. It relates to the state of the environment to be passed on to future others. Of the four classes distinguished above, only existence value aligns directly with this concern. Use and option value relate to use by a current individual. Quasi option value clearly does have some relevance to intergenerational equity. In practical applications of CVM, it will usually, if it exists, be bundled with existence value. Applications of this extended consumer demand theory approach which are generally considered most directly relevant to sustainability issues are those relating to species preservation: Randall (1986) discusses the approach in just that context. An example of such an application is Samples *et al.* (1986), where it was WTP for preservation as such which was investigated by the CVM.

Given all this, we take it that the methodology which is relevant to the application of this variant of pseudo market valuation to sustainability issues is CVM in relation to existence values.

3. THE ACCURACY OF PSEUDO MARKET VALUATION

In the next section of the paper we review some arguments to the effect that it is inappropriate to use CVM to inform environmental decision making. Before doing that we consider the accuracy of CVM when assessed within the conceptual framework from which it has emerged. The question to be addressed here

is as follows: supposing that CVM is appropriate, how well does it perform?

There is a very short answer to this question: nobody knows. The fundamental problem is that there is, special cases apart as noted below, no information on the 'truth' against which CVM outcomes can be tested. Further, it is in the nature of the case that this is not a transitory situation to be remedied by further research. Where environmental 'commodities' to which existence values attach are non-rival and non-exclusive in use, there cannot exist actual markets in which 'true' valuations could be manifest.

Considerable technical virtuosity has been deployed in efforts to assess the accuracy of CVM by other means. Several approaches and arguments have been used. Our assessment of the results arising is that CVM cannot reasonably be regarded as sufficiently reliable for the incorporation of sustainability relevant valuations in project appraisal. We briefly review the main approaches to the accuracy question, with examples, in order to support this assessment.

Mitchell and Carson (1989) review results from a number of studies designed to test for various kinds of bias in CVM responses by comparing them with experimental outcomes. These experiments do not involve environmental existence values, and relate to individual WTP revelation rather than to the aggregate relevant to decision making using the project appraisal methodology outlined above. In their conclusion, Mitchell and Carson pose (p 295) the question: "can CV surveys actually measure values that are sufficiently reliable and valid for use in benefit estimation?" They note (p296) an "emerging consensus … that CV studies are able to measure meaningful values for 'familiar' goods such as local recreational amenities": 'meaningful' is not quantified. In regard to "less familiar goods, such as air quality improvements…", it is recognized that "we cannot test the accuracy of CV surveys against a criterion". Mitchell and Carson express sympathy with those who are sceptical about CV in these contexts, and respond by somewhat changing the rules of the game. In this context, they consider the market model 'inappropriate', and state that:

> in our view, the appropriate model for CV surveys of pure public goods – goods that citizens are least likely to have direct experience in valuing – is the referendum, by which citizens make binding decisions about the provision of public goods. From this perspective, instead of falling short of the relevant market model, well-conducted CV surveys offer significant improvements over actual referenda as a means of measuring consumer preferences (p296).

However well founded this view, we note that if this is to be understood as the basis for the evaluation of CV studies of existence values, then the results cannot be regarded as appropriate for use in CBA.[3] This is clearly important in regard to the uses to be made of the results from CVM studies. If the position stated by Mitchell and Carson is accepted, then CVM results on existence values are not generally going to be valid inputs to CBA exercises. In this event, that method of project appraisal faces a major difficulty where existence values and

sustainability issues are involved. The information required is not available from the technique usually taken to be the relevant one.

Cummings *et al.* (1986) define 'reference operating conditions' which they regard as necessary if an individual CVM response is to be accurate within 50% of the true value of WTP. The first two of the conditions are: understanding of and familiarity with the 'commodity' to be valued; prior valuation and choice experience with respect to consumption levels of the 'commodity'. Clearly, it would be unlikely that these conditions are generally satisfied in respect of existence value 'commodities'.

In some circumstances, CVM results can be compared with outcomes in which actual money transactions take place. Bishop *et al.* (1983) report results relating to permits for geese hunting. The CVM results for permit value ranged from $11 to $101. In an experiment involving actual purchases of permits the price established was $63. Bishop *et al.* comment that "our contingent valuation mechanism seemed to provide meaningful – albeit inaccurate – economic information". The permits are, of course, in the nature of private goods and have little connection with existence values.

An alternative approach is to elicit responses from the same set of individuals in repeat surveys. Evidence that individual valuations are constant across repetitions is taken as evidence for the reliability of CVM. We note that this is a weak test, as any systematic biases in responses will simply be repeated. Loomis (1989) reports repeat survey results for two samples, of visitors and of the general population, in regard to water quality at a Californian lake. The results obtained were mixed according to the precise formulation of the test for constancy, and Loomis concluded that they "support the contention that the contingent valuation method provides reliable estimates" of individuals' WTP. It appears to us that on the basis of the results reported this assessment is overly strong. Loomis notes that one might expect responses to be non-constant if individuals acquire new information as between repetitions of the survey. Samples *et al.* (1986) examined this in relation to species preservation. Statistically significant response differences were found according to the information on which they were based, giving rise to "the fact that information, appropriately selected, can influence the outcome of valuation studies". Clearly, this gives rise to problems for the use of CVM results in project appraisal.

A number of studies have compared CVM results with corresponding TCM results, with the idea that convergence demonstrates reliability. Actually, of course, it demonstrates only convergence unless it is taken as given that one result is known to be reliable. The implicit assumption in most of these studies would appear to be that the TCM result is the more reliable, and that some validity is conferred on the CVM result if it is 'close' to the TCM result. It should be noted that in so far as TCM can address only use values, this approach can assess the reliability of CVM only in regard to use values. An example of a study of this genre is Hanley (1989), where on the basis of a CVM figure of 181,250 and a

TCM figure of 160,744 (pounds Sterling) for aggregate annual consumers surplus, it is stated that: "This might seem to indicate that the two methods do produce similar outcomes." Actually, Hanley gives, in Table 8, TCM results ranging from, according to the functional form used in the visits demand equation, 73,948 to 1,497,858. According to standard statistical tests there is no basis for discrimination between the 160,744 result 'preferred' by Hanley and the upper limit of this range. The CVM figure of 181,250 could equally well, that is, be compared with a TCM figure of 1,497,858. The basis given by Hanley for preferring the TCM figure of 160,744 is that the 1,497,858 figure "seems inconsistent with other travel cost work on UK sites". Hanley is unusual in that he reports the range of results that makes this comment possible, and also in that he discusses his results in terms of the aggregates which are relevant to decision making rather than in terms of individual consumer surpluses.[4]

This is important in that if CVM, or TCM, results are to be used in project appraisal, it is necessary to aggregate the estimated individual valuations. Clearly, over and above any potential for error at the level of individuals, there is large potential for error in the aggregation procedure. Most fundamentally, it is often not clear at the level of principle what the relevant population for sampling is. In practice, even if the relevant population is agreed, it is not necessarily the case that it is sampled in its entirety. Consider species preservation for example. Presumably, for a project in one country, the relevant population is that of the world, though of course in many countries individual WTP might, in fact, be vanishingly small. But suppose we consider a conservation area threatened by development in Australia and we know that in all countries except it and the USA average individual WTP is, in fact, zero. For reasons of expediency, a CVM is confined to a sample of Australians, for whom average individual WTP is found to be x. Since the population of the USA is some thirteen times that of Australia, if average individual WTP there is x/10, aggregation over only Australian individuals will give less than 50% of true preservation benefits. We also note here that there is often some ambiguity as to whether CVM responses should be interpreted as on behalf of an individual or a household. Clearly, to the extent that errors arise in this respect, aggregation has the potential to introduce large errors into the project appraisal relevant result.

The potential magnitude of aggregation problems in a CBA context is illustrated in Common and McKenney (1992), where Monte Carlo methods are used with a simple hedonic travel cost model to simulate outcomes in regard to a decision on whether a unique timber stand should be felled. The simulation is constructed so that the usual problems attending estimation of the parameters of visitor participation equations are absent. The construction allows for errors in the estimation of the numbers of visitors, and is such that the correct CBA decision is that the stand should not be harvested. The simulations show that decision making is very sensitive to errors in population size estimation. For

example, across 50 replications of the simulation, an error of 10% in the estimation of the size of the population for one of the two sites considered leads to 50 incorrect decision outcomes.

Overall, then, we judge that CVM results on existence values are not at all reliable. We have noted that definitive tests for accuracy are impossible, so that it is judgement, rather than statistical testing, that is involved.

4. THE APPROPRIATENESS OF PSEUDO MARKET VALUATION

In this section of the paper we briefly review the nature of a number of contributions to the literature which have raised questions about the model of human behaviour which is the basis for the pseudo market valuation approach reviewed in the previous section. These contributions are representative of what we called the philosophical school in section one above.

Sagoff (1988) attacks the approach to environmental decision making based on neoclassical economics, i.e. that involving pseudo market valuation and CBA. He argues that in regard to the making of 'hard' decisions, which include decisions about the environment, individuals act as 'citizens' rather than 'consumers'. The distinction is put as follows:

> As a citizen, I am concerned with the public interest, rather than my own interest; with the good of the community rather than simply the well-being of my family. … As a consumer … I concern myself with personal or self-regarding wants and interests;I pursue the goals I have as an individual. I put aside the community-regarding values I take seriously as a citizen, and I look out for Number One instead (Sagoff, 1988, p8).

In the citizen role the individual considers the benefits of a proposal to the nation as a whole. This involves consideration of sentimental, historical, ideological, cultural, aesthetic and ethical values. Thus, the "individual as a self-interested consumer opposes himself as a moral agent and concerned citizen" (p67). Sagoff refers to this consumer/citizen dichotomy as 'the conflict within us'.

Sagoff sees environmental decision making problems as falling within the provenance of what he calls 'social regulation' and therefore matters for citizens rather than consumers. Social regulation is to be guided by 'ethical rationality' which emphasizes the need for highly informed deliberation rather than choice on the basis of given, and likely poorly informed, preferences. It follows that in such contexts aggregated individual willingness to pay is an inappropriate measure of 'worth', and that decision making is to involve a process of political representation and majority voting. The role for economics is largely limited to that of cost effectiveness analysis, i.e. determining the least costly means to the accomplishment of goals set on the basis of ethical and moral arguments and emerging from the political process. Economics would have some role in goal setting in so far as the costs of alternative goals will have some implications for

the desirability of those goals. In relation to the issues addressed in this paper, it is Sagoff's view that it is a 'category mistake' to expect individuals to behave as consumers rather than citizens in regard to hard decisions such as environmental protection. The question is whether the observable needs of the political process for information on individuals' views on environmental matters, over and above those capable of being expressed through the processes themselves, are properly addressed in the context of individuals as citizens or of individuals as consumers. The pseudo market valuation approach assumes that the answer is 'consumers': Sagoff asserts that it is 'citizens'.

Some economists have taken positions similar to that of Sagoff in that the standard representation of the individual in terms of a single preference ordering is seen as inadequate. Thus, for example, according to Sen:

> purely economic man is indeed close to being a social moron. Economic theory has been much preoccupied with this rational fool decked out in the glory of his one all-purpose preference ordering … we need a more elaborate structure (Sen, 1977, p336).

In this paper, Sen refers to the work of Harsanyi (1955), where a distinction is made between an individual's ethical and subjective preferences. Harsanyi, commenting on then emerging trends, notes that:

> our individual utility concept has come logically nearer to a social welfare concept. Owing to a greater awareness of the importance of external economies and diseconomies of consumption in our society, each individual's utility function is now regarded as dependent not only on this particular individual's economic (and noneconomic) conditions but also on the economic (and other) conditions of all other individuals in the community (Harsanyi, 1955, p315).

He considers taking this further by viewing the individual as having an individual social welfare function, ISWF, as well as a utility function. In order to maintain a clear distinction here, Harsanyi requires the ISWF to express what the "individual prefers (or rather would prefer) on the basis of impersonal social considerations alone" and the utility function to "express what he actually prefers, whether on the basis of his personal interests or on any other basis" (1955, p 315). The first set of preferences are 'ethical', the second 'subjective'. For Harsanyi, the ethical preferences

> express what can only in a qualified sense be called his 'preferences': they will, by definition express what he prefers only in those possibly rare moments when he forces a special impartial and impersonal attitude upon himself (p 315).

It is argued that this impersonality requirement will be satisfied if preferences are expressed from behind a, what would now be described as Rawlsian, 'veil of ignorance'.

This dual self envisaged by Harsanyi clearly has affinities with the consumer/citizen duality espoused by Sagoff. In regard to the claim by Harsanyi that the ISWF self, Sagoff's citizen, will only be manifest in 'rare moments', it is interesting to note the work of Maslow in the field of behavioural psychology. In Maslow (1954) it is suggested that human needs satisfaction proceeds from the material through the social to the moral. The last are also referred to as self-actualizing needs, and it is argued that they are self-perpetuating so that there is in respect of them non-satiation. On this view self-actualization, addressing moral needs, would await the satisfaction of the lower order needs, consistently with Harsanyi's view of only rare references to the ISWF. However, in later work, Maslow (1968) modified this view somewhat. In this work self-actualization is not

> some far off distant goal at the end of a long series of steps, but is present as a possibility all the time, even when the lower needs are still operating (Lutz and Lux, 1988, p16).

This view is closer to that of Sagoff, in that higher and lower needs are presenting themselves to the individual simultaneously. There is a continuous interplay between lower and higher needs (Maslow), ethical and subjective preferences (Harsanyi), and citizen and consumer (Sagoff). It would not be expected that the boundaries involved in these distinctions would be the same for all individuals, given different experiences in terms of social conditioning as well as genetic endowments, nor constant over time for a given individual, given changing circumstances. This does not render the distinctions useless, of course. On the contrary:

> the dual self conception is what economics needs in order to break out of its overly narrow and distorted image of what people are and how they operate (Lutz and Lux, 1988, p18).

Etzioni (1988) also rejects the single 'self' represented as a single set of preferences, which is the foundation of the standard economic approach to the understanding of human behaviour, and to normative prescription. He focuses on conflicts between a morally committed self and a pleasure maximizing self, arguing that "people's behaviour is systematically and significantly affected by moral factors that cannot be reduced to considerations of personal gain" (Etzioni, 1988, p22). It follows that there are for an individual (at least) two distinct sources of value. Etzioni characterizes his approach as one of codetermination: "people do not seek to maximize their pleasure, but to balance the service of two major purposes – to advance their well-being and to act morally" (p 83).

Boulding (1969) has noted the relevance for observed human behaviour of what he calls the 'heroic ethic', to be distinguished from altruism which he

considered to be more readily accommodated within the conventional economic view of an individual. Boulding regards recognition of this as necessary to explain (voluntary) military service, and some religious behaviour. In Boulding's view:

> man requires both heroic and economic elements in his institutions, in his learning processes and in his decision making, and the problem of maintaining them in proper balance and tension is one of the major problems of motivation, both of the individual person and of societies (Boulding, 1969, p10).

We also note here that it has long been recognized that on the standard view of the individual as solely a maximizer of utility it is difficult to explain participation in democratic voting exercises. For example, Downs (1957) drew attention to the fact that the probability of casting a decisive vote is so small that a 'consumer' would not vote, even if the costs involved were small, and sought to explain voting on the basis of "each citizen's realization that democracy cannot function unless many people vote" (p274).

Margolis (1982) develops a model of dual rational choice in which individuals are seen to pursue (i) self-interested activities (where altruism is not ruled out), and (ii) activities that benefit some larger collectivity of which they are part, independently of any personal benefits arising. The two are linked by an allocation rule based on equalization of utilities at the margin. Margolis uses Darwinian survival considerations to place restrictions on the roles for self and group interests for individuals. Individuals who are purely group-interested would be vulnerable to the activities of self-interested individuals within their group. On the other hand, a group comprising solely self-interested individuals would be vulnerable to other groups where some group interest was the norm, with implications for individual members of the group. Margolis also discusses altruism, to which we return below.

The foregoing is a sampling of a literature which demonstrates that Sagoff is by no means unique in questioning the conception of a unified self with a single preference ordering that underpins mainstream economic analysis generally. Clearly, the issue is important for the appreciation of the use of CVM studies, and consideration of alternatives, in relation to non-use environmental valuation. We next note some other issues, logically distinct from, but of relevance to an interest in, the dual (or multiple) self hypothesis. Some of these have been raised in the literature in a general way, some are specific to consideration of the appropriateness of the pseudo market approach to environmental valuation.

The pseudo market approach depends on acceptance of consumer sovereignty as the foundational normative criterion. Sagoff (1988) rejects consumer sovereignty in the area of hard environmental decision making. Most economists accept it unreservedly, and the standard approach to environmental valuation is but one example of efforts to extend the domain of the technical apparatus developed on its basis. However, it has been questioned at the general level, a

notable recent example being the work of Penz (1986). There are four main bases for the critique:

1. individuals may be inadequately informed as to the consequences for themselves of the alternatives they face
2. individuals may be insufficiently deliberative in assessing the consequences of alternative choices
3. individuals may lack self-knowledge in the sense that they cannot properly relate the consequences of alternative choices to their preferences
4. individuals' preferences may not reflect their true interests due to 'preference shaping' arising from socialization processes and advertising

Clearly, 1 here is likely to be relevant in the context of consideration of the consequences for the individual of alternative states of the environment. The problem of knowledge is not avoided by the introduction of a citizen self additional to a consumer self, and the question of deliberation has already been raised above. However, it appears to be at least implicit in Sagoff's position that proper recognition of the citizen role would work to increase citizen deliberation and knowledge.

Economics does not insist that the individual as consumer is purely and narrowly selfish; altruism, toward other human individual humans, in various forms is admitted (see Collard, 1978, for a useful overview). As noted above, some form of altruism is generally regarded as necessary for the existence of existence benefits. However, both generally and in regard to such benefits, problems arise in dealing with altruism within the standard conception of the individual. For example, participatory altruism is defined as a situation where satisfaction is derived from an act of giving in and of itself (Margolis, 1982). This is closely related to the 'warm inner glow' idea introduced by Andreoni (1990). Kahneman and Knetsch (1992a, 1992b) have attempted to use this idea to explain the embedding phenomenon often observed in CVM studies of non-use values.[5] Their paper has evoked strong reactions from CV practitioners: see, for example, Smith (1992). We note that if participatory altruism is at work when individuals respond to WTP questions in CVM studies, it would, in terms of the response that it is intended to elicit, be likely to produce some upward bias. This would be the case to the extent that individuals respond with their WTP for the subject of inquiry plus their WTP for the purchase of a 'warm inner glow'.

So-called 'deep-ecology' would attribute 'intrinsic value' to non-human biological entities, claiming that they have value independently of any human interest in them. We find it difficult to see how value can exist independently of a valuer, and it seems more reasonable to regard claims for such intrinsic value as claims that altruism be extended to embrace non-humans.[6] The operational force of this claim for intrinsic value would appear to be that it provides a basis

for species conservation, even where the species in question is neither useful in production nor a source of pleasure to humans. The concern of those who argue for this kind of intrinsic value would appear to be that if, on the contrary, species are accorded value only in so far as they are useful or give pleasure, then even species now so valued may come not to be deemed worthy of preservation as technology provides substitutes for their services.

Goodin (1991) seeks to develop a 'moderately deep' green theory of value. He suggests that ultimately "what is especially valuable about the products of natural processes is that they are the products of something *larger* than ourselves" (p 69, italics in the original). Norton (1986) arrives by a different route at what appears to be, operationally, an essentially similar position. According to Norton: "each species should be accorded substantial value and … when a species has particular, identified uses, the values derived from those uses should be added to that original, general value" (p132). The general value arises from interdependencies between species, which are poorly understood. For both Goodin and Norton, as we understand them, species are to be valued not simply on the basis of production requirements and consumer preferences, but in recognition of the processes which support them and humans. In Appendix 2 we suggest that Norton's 'original, general value' for each species can, in principle, be identified within a constrained optimization framework where species interdependencies are explicitly accounted for. Equally, it would appear that the operational force of intrinsic value as suggested above could be achieved alternatively, within a standard anthropocentric and utilitarian framework, by recognition of species interdependencies in relation to the life support system for humans, where humans cannot definitely know which interdependencies are critical and which are not: see Common and Norton (1992).

In a paper on 'Sustainability and the Problem of Valuation', Page (1991) notes that "from the perspective of evolutionary biology", "we can say that the concept of an individual human being becomes less 'individuated'" (p61). Page is referring here to the fact that related human beings share common genes, and cites the work of Dawkins (1978). While some of the conclusions and speculations arising in sociobiology are controversial, it seems clear that we are genetically programmed to be social animals, rather than purely selfish individuals. Dawkins discusses altruism from this perspective. Page argues that studies of non-human primate groups support the observation that "society creates the individual, the individual does not create society" (p61), and suggests that a response to emerging knowledge in these fields should involve "a search for a value theory which does not rely foundationally on the *predefined (exogenous) individual*" (p62, italics in the original). We draw the lesson that there is some biological basis for the individual as citizen: cultural conditioning would operate on this genetic base.

Some of those who have entertained the dual-self hypothesis have considered whether the dual utilities are reducible to one: see Etzioni (1988), Lutz and Lux

(1988), Margolis (1982), and Collard (1978). The consensus here would appear to be that while some forms of morally committed behaviour are explainable in terms of 'consumer' maximizing behaviour, given due allowance for altruism, there remains a significant component of behaviour that cannot be so explained.

Standard economics, which underpins CVM and CBA, does assume reducibility. An alternative terminology would be to say that it assumes commensurability. In the context of the particular concerns of this paper, environmental valuation in relation to sustainability, the application of standard economics requires, as noted above, that for the individual there exists a utility function that has as arguments both ordinary marketed commodities and states of the natural environment. It assumes, that is, that for the individual these things are everywhere commensurable.

What is involved here is, as far as we can ascertain, an assumption. As far as we are aware, economists have not tested for the existence of utility functions with vectors x and q as arguments. This is a curious and important lacuna in the environmental economics literature. The assumption that U(x,q) exists is crucial to the whole of the elaborate methodologies for environmental valuation that economists have developed over the last three decades. The validity of the assumption has been widely questioned, and is not self-evidently compelling: the conditions for the existence of the required utility function are set out in Appendix 1. Yet, to repeat, the matter does not appear to have been put to the test. The existence of U(x,q) has been adopted as part of the maintained hypothesis without any explicit empirical justification.

This is important because, as noted in the previous section here, there is generally no external reference against which to evaluate CVM results. Over the domain of marketed commodities, a lack of interest in testing for the existence of a utility function could be defended by appeal to the methodological position of Friedman (1953), which is adopted by many economists. According to this position, the validity of assumptions embodied in the maintained hypothesis need be of no interest, does not require direct testing, so long as the predictions to which they lead are accurate. For marketed commodities, it could be argued, a utility function can be assumed, and demand functions estimated and used to generate predictions testable against independently derived observational data. For environmental 'commodities' there is, generally, no independent observational data against which estimated WTP/WTA measures can evaluated for accuracy.[7] Hence, and particularly if the inferences are to be used as inputs to social decision making, there is required some attention to the validity of assumptions used as maintained hypothesis.

We have conducted an experiment concerning the existence of U(x,q) using as subjects a small sample of economics students: details are given in Blamey and Common (1992). When asked to make pairwise choices involving combinations of ordinary commodities and environmental states, 84% gave responses consistent with the existence of a utility function. On the other hand, when asked

whether decisions involving species preservation should be made by comparing the costs of preservation with the aggregate of individuals' willingness to pay for preservation, 79% responded 'no'. Also, when asked for comments in an open-ended way, 40% of those responding did so in such a way as suggest that they found it difficult to treat species preservation and ordinary commodities commensurably. The results are, then, mixed. This is clearly an area requiring further investigation.

Approaching matters somewhat differently, the position taken by Sagoff can be stated as a hypothesis and a variant hypothesis. The Sagoff hypothesis is: with regard to their non-use relationships with the natural environment, individuals consider questions arising in citizen, as opposed to consumer, mode. The variant Sagoff hypothesis is: if asked questions about their non-use relationships with the natural environment, individuals consider that they *shoul*d respond as citizens rather than consumers. We note that it is likely to be difficult to test these as competing hypotheses, but that both have implications for the conduct of, and interpretation of the results from, CV surveys conducted on the basis of the assumption that individuals respond as consumers.

Sagoff (1988, p50-51) reports a classroom experience which he regards as providing evidence consistent with his position. We have conducted a small scale survey, designed to generate evidence bearing upon the hypotheses stated above: details are reported in Blamey and Common (1992). 67 economics students, who had not previously been taught anything about pseudo market valuation, were presented with a scenario according to which an area rich in biodiversity was threatened by a tourist development, and where conservation would require that the land be purchased from the current owners. They were then asked to choose from two options. Option A involved the establishment of a commission of inquiry as to the merits of conservation, and the purchase of the land by the government if the commission reported in favour of conservation. Under this option, government purchase would involve reduced government expenditure elsewhere. Option B involved a conservation organization opening a subscription to raise the money to buy the land. Whether or not the land went to tourist development would then depend on success in raising sufficient money by subscriptions from individuals. 70% of the students chose option A. We take this as, limited, evidence consistent with the Sagoff hypothesis for at least some individuals. It may also, or alternatively, be consistent with the variant Sagoff hypothesis.

It does not appear that any of the philosophical school positions reviewed above would support the proposition that citizens' views on impacts of projects on the natural environment should not be sought by interview or questionnaire. Rather, the operative point appears to be, generally, that those views should not be sought and analysed solely within the conceptual framework of neoclassical economics, and, particularly, that they should not be sought from individuals construed solely as consumers. Indeed, it would appear that it is entirely

consistent with the position of Sagoff, for example, that there is an important role for surveys of citizens' views. We noted above the view of Harsanyi that an individual's 'ethical' preferences are likely to come to the fore "only in those possibly rare moments when he forces a special impartial and impersonal attitude upon himself". Participation in an interview, or the act of completing a questionnaire, could be one way of prompting the reflection and deliberation associated with such 'rare moments'.

If it is accepted that individuals consider questions about their non-use relationships with the natural environment as matters to be considered by them as citizens, rather than consumers, a further question arises. Do citizens have preferences that can be used to inform social decision making that go beyond the capability to provide answers to either/or type referendum questions? That is, is there any prospect of eliciting from individual citizens preference information that could be used to determine relative social values? This is an important question, as democratic political processes appear to require this kind of information. While the precise role of CBA in actual social decision making on environmental issues is frequently unclear, it is very often the case that it is felt necessary to have some kind of TCM/CVM exercise conducted. A proposal that development projects with adverse environmental implications be approved/rejected on the basis of a yes/no referendum question would appear not to meet the needs of the political process in many democratic nations.

In Australia, for example, the federal government established, in 1989, the Resource Assessment Commission, the RAC, to advise it on matters concerning alternative uses of the natural environment. Referenda on alternative uses of the natural environment have not been used in Australia. The legislation requires the RAC in conducting an inquiry to take account of the alternative uses of a resource and the "environmental, cultural, social, industry, economic and other values involved in those uses". It is made explicit that 'use' is to cover both conservation and development, and the legislation lays down policy principles according to which competing claims are to be resolved. One of these is that:

> Resource use decisions should seek to optimise the net benefits to the community from the nation's resources, having regard to efficiency of resource use, environmental considerations, economic and ecological sustainability, ecosystem integrity and sustainability, the sustainability of any development, and an equitable distribution of the return on resources.

In an early statement on procedures, the RAC chairperson stated that "we will constantly need to address the problem of how to ascribe sensible values to the intangible or non-marketed benefits of natural resources". In both of the RAC inquiries which have so far been completed, CVM was used, though in neither case do the results arising appear to have greatly influenced the report submitted to government. The point is that we take the RAC to be representative in considering it necessary to attempt to assess relative social values.

More generally, consider the Safe Minimum Standard, SMS, approach. This has been proposed (Bishop 1978, and see also Randall 1986) as an alternative to the CBA approach to social decision making where irreversible sustainability relevant effects, such as species extinction, are in prospect. On this approach, the decision should go against the project unless the social costs of not proceeding with it are unacceptably large. Essentially, as compared with the CBA approach, this poses the valuation question in a different way. It appears to us that the SMS requires that it is individual citizens, rather than consumers, that are to be the judges of cost acceptability. If SMS is adopted, it remains to determine in particular instances whether or not the cost of not proceeding with a project is or is not socially unacceptable. Proponents of SMS do not apparently have it in mind that each project simply be decided upon by a yes/no referendum on the question "should it go ahead?" Such an approach would likely not meet the requirements of the political system. A politically feasible version of SMS would, it would appear, have to involve some assessment of the costs and benefits of decisions on projects, and policies. It would not eliminate an interest in citizen's preferences going beyond those expressed in the election of representatives or participation in yes/no referenda.

The point being made here is that if individuals relate to sustainability issues as citizens, rather than consumers, then the question arises as to whether they have, in that role, preference orderings that can be revealed and used to inform social decision making. This question was addressed very broadly, together with the Sagoff hypotheses, in the student survey referred to above: see Blamey and Common (1992) for details. *After* selecting option A or B, respondents were confronted with a cost of conservation and asked if they thought it should be borne. For those who selected A, citizens, the cost was specified in terms of a reduction in government expenditure on education. For those selecting B, consumers, it was in terms of a monetary contribution to the conservation organization. For both sub-groups, three levels of costs were offered. For citizen respondents, the proportion willing to meet the cost fell as it increased. For consumer respondents it did not.

Clearly, this is an area in which more evidence is needed. This need exists even if there is no interest in exploring the possibility of using citizen responses in social decision making processes, unless it is also proposed that CVM and CBA be abandoned. If some CVM subjects are responding as citizens, or are giving responses that are conditioned by the belief that they should view the matters under consideration as citizens, then this has implications for the interpretation of CVM results obtained according to standard methods where respondents are treated as consumers. These implications are discussed in Blamey and Common (1992). Here we consider one aspect of the matter only, which could be regarded as providing some, indirect, evidence for the Sagoff hypotheses.

A problem which has been raised in regard to the use of CVM responses in CBA of projects with environmental impacts is the disparity between the size of

inferred WTP and inferred WTA. As set out by Knetsch (1990), the problem is that WTA is generally found to be much larger than WTP in respect of the same environmental 'commodity'. The divergence should not, it is generally understood, be as large as in commonly estimated. The issue has been discussed in the literature within the framework of the CVM respondent as consumer, i.e. within the context of consumer demand analysis and utility theory. For respondents to existence value questions in citizen mode, we suggest that the 'every citizen has a price' phenomenon may well be operative and do much to explain the observed disparities. If an individual regards an environmental asset as the property of the citizenry of which he is a member, then moral considerations may asymmetrically affect his responses to WTP/WTA questions seeking to elicit a consumer response. Requested to pay as a consumer, the citizen will likely find the question inappropriate but not wildly inappropriate. Thus, one might strongly believe that the relief of poverty is properly a matter for collective social action, yet not refuse a request for a donation to a private charity. On the other hand, a request to accept a payment to one's self in return for giving up what is regarded as a truly collective asset would jar greatly – one is being asked to accept a bribe to act immorally. Consider the question: how much would you need to be paid to accept the complete abolition of all welfare payments to the poor? There is no doubt some, non-infinite but large, answer to this question for most people, i.e. some price at which prospective consumer gain is sufficient to compensate for abandonment of citizen responsibilities. Further, presumably few would accept the proposition that the answers to such a question by individuals should be relevant, by way of a comparison of the aggregate of such answers with the savings in government expenditure, to a decision on whether or not government should make welfare payments. If individuals regard questions relating to the existence of environmental assets as falling within the domain of citizen rather than consumer choice, then one might expect that CVM responses on WTA would be higher than on WTP.

5. VALUATION AND NATURAL RESOURCE ACCOUNTING

There is a widespread view that modifications to national income accounting procedures are crucial to the pursuit of sustainability. A representative statement of this view is to be found in Repetto *et al.* (1989), where it is claimed that:

> A country could exhaust its mineral resources, cut down its forests, erode its soils, pollute its aquifers, and hunt its wildlife to extinction, but measured income would not be affected as these assets disappeared.

Here, 'measured income' is national income figured on existing accounting conventions as Gross Domestic Product, GDP. According to Repetto *et al.*

> politicians, journalists and even sophisticated economists in official agencies

> continue to use GDP growth as the prime measure of economic performance

and

> only if the basic measures of economic performance … are brought into conformity with a valid definition of income will economic policies be influenced toward sustainability.

The call here is for a revision to national income accounting practices such that what is measured is sustainable income. In this context, sustainable income is taken to be the maximum aggregate consumption possible during a period, such that the society has the same wealth at the end of the period as at the start of it. Wealth is the total value of society's assets, including both assets produced by economic activity, capital equipment of all kinds, and natural assets. We will here call the measure of sustainable income Proper Net Domestic Product, PNDP. The position of which Repetto *et al.* are representative, which is taken by many in the green movement and implicitly endorsed by some economists, is that the availability of PNDP data is necessary and sufficient for the attainment of sustainability. Natural resource accounting is the means by which PNDP data would be produced.

Common and Norton (1992) argue that there are several reasons for rejecting the claims made for natural resource accounting. Here we focus on the valuation problems which any attempt to measure PNDP necessarily entail. Two approaches to sustainability-modified national income accounting can be distinguished in the literature. The distinction relates directly to the approach taken to valuation. One group of contributors come at the question from essentially a national income statistician's perspective and background. A second group take an approach based in economic theory.

National income accounting statistician-type interest in adjusting GDP data to reflect concerns which would now appear under the sustainability rubric predates the widespread use of that terminology. However, the emergence of widespread interest in sustainability, or sustainable development, in the 1980's provided a major stimulus to work on environmentally adjusted national income accounts.

This has been reflected in numerous recent publications and workshops. Official statistical agencies' activities (UNSO, IMF, OECD, World Bank, national government agencies) have thus far been restricted to discussions of proposals for construction of a PNDP measure, together with some physical data generation (see e.g. Peskin with Lutz, 1990). PNDP type series have been constructed by some academic researchers; see Repetto *et al.* (1989) for Indonesia, and Young (1990) for Australia, for examples.[8] Two useful points of entry to the literature on proposals emanating from official agencies are Bartelmus *et al.* (1989) and a 'preliminary draft', on 'General Concepts', for an *SNA Handbook on Integrated Environmental and Economic Accounting*, United Nations (1990). The former provides a fairly brief description of the basic

strategy envisaged, which involves, in relation to existing SNA procedures, two new sets of accounts. In the first, which deals with flows of goods and services, flows relating to expenditures on environmental protection, 'defensive expenditures', are separated out from all other flows to final demand. A measure of 'Environmentally Adjusted GDP' is then derived by subtracting defensive expenditures from GDP. The second new set of accounts consists of opening and closing balance sheets for natural resources and environmental assets, together with two tables linking these in terms of physical and unit value changes over the period. 'Environmental Cost' is defined as the difference between the value totals for the opening and closing balance sheets, and subtracted from Environmentally Adjusted GDP to give 'Sustainable GDP'. Then, 'Sustainable NDP', our PNDP, is derived by subtracting the depreciation of man-made capital stocks.

There is, in these two publications, some discussion of the valuation problems arising where market prices are not available. It is clear that in such cases what is envisaged is, in the terminology of this paper, pseudo market valuation. While it is acknowledged that this would give rise to many conceptual, practical and accounting problems, the issues raised in earlier sections of this paper are not explicitly addressed. There is no reason to suppose that the set of market and pseudo market prices to be used would be internally consistent. Nor is there any reason to suppose that they would be the prices appropriate to a sustainability objective. The sustainability problem is essentially a dynamic problem, so that the appropriate prices would reflect current and future relative scarcities: see Appendix 2. The limited ability of pseudo market prices to do this is recognized:

> The dynamic processes within the natural environment are not taken into account. The picture of the natural environment is therefore limited to a description of the natural environment at different points in time and to an analysis of the status differences (United Nations, 1990, p77)

We now turn to the economic theory based approach. Given that the sustainability problem is essentially dynamic, the relevant theory is capital theory. Within this framework, a number of contributions have addressed the problem of valuation consistent with sustainability. Here we focus on the contribution of Mäler (1991), where a model of economy-environment interconnections is used to elucidate a precise conception of sustainability and to explore the question of the definition and measurement of PNDP, which in Mäler's terminology is NWM for net welfare measure.[9] Mäler (1991) showed that PNDP as a measure of sustainable income can be defined and measured using the shadow, or imputed, prices that emerge from a dynamic optimization problem. He showed that a necessary condition for sustainability is that the value of the total capital stock, including natural assets, be non-declining *when aggregation over man-made and natural assets uses the proper shadow prices everywhere.* Mäler also related his NWM measure to a standard accounting measure of

national income, and set out the adjustments necessary to go from the latter to the former. In regard to the netting out of defensive expenditures, Mäler found that this should not be done, contrary to the practice often advocated on the basis of the national income statistician's approach to the problem discussed above.

The capital theoretic approach to the measurement of PNDP yields unambiguous accounting conventions together with a complete, internally consistent, and appropriate set of prices for use with those conventions to produce a valid measure of PNDP. We argued above that this is precisely what the national income statisticians' approach does not do. However, this advance is bought at a price. The conventions and prices are model dependent and vary with model specification in regard to both the objective function and the constraint set. What is measured, that is, is PNDP for the model, not any actual, economy-environment system. The relevance of the model measured PNDP to the actual economy-environment system depends upon the extent to which the model approximates to actuality. Equally, the extent to which it would be appropriate to use the shadow prices derived from the optimization to set the prices to be faced by agents in an actual economy would be dependent on the extent to which the model structure reflects actuality. A key feature of the sustainability problem is lack of knowledge about the true nature of economy-environment interactions. One of the few things that we can be reasonably certain about is that any given model is a poor representation of the relevant reality. Common and Norton (1992) argue the need for physical monitoring programmes to improve understanding of the nature of constraint sets. While the argument there is developed in the particular context of biodiversity conservation, it is of general applicability. Recognising ignorance about system functioning also has implications for CVM and related pseudo market valuation techniques: see Appendix 2.

The theory driven approach to natural resource accounting does produce internally consistent valuations from a given optimization problem. However, since the 'correct' way to specify the problem is unknown and unknowable, it would produce PNDP measures for models rather than economies. These measures would of themselves be of very limited use in addressing sustainability problems. We do not draw from this the conclusion that such modelling activities should be abandoned. On the contrary, we consider that they should be encouraged to develop as empirical, rather than purely analytical, exercises. However, such empirical exercises should not be seen as being for the purpose of producing PNDP numbers, or total asset value figures. Rather, the essential point should be seen as using constrained optimization modelling to explore the implications of alternative model specifications, in terms of both that which is to be maximized and the constraint set, with a view to informing policy debate. It may be, for example, that some natural asset valuations emerging would be relatively insensitive to plausible variations in constraint set specification, while others would prove very sensitive. Such information could be useful for setting directions for scientific research intended to improve understanding of the sustainability problem. Again, some valuations might prove very sensitive to

social welfare function variations, thus focusing political debate. Clearly, however, this is in the nature of a long term research agenda and the prospects for results of direct and obvious use to the political process, which ultimately determines how the economy-environment system is managed, lie well into the future.

6. CONCLUSIONS: FUTURE RESEARCH DIRECTIONS

In this paper we have identified the dominant form of sustainability relevant pseudo market valuation as the use of the CVM to estimate the non-use values of environmental assets for incorporation in CBA. We have noted that while this involves the assumption that individuals have utility functions defined over arguments which comprise both ordinary commodities and 'environmental commodities', this assumption does not appear to have been subjected to any empirical research. On the other hand, there exist many contributions to the literature which contend that individuals cannot be adequately understood within the single utility function framework. A number of these contributions relate this specifically to the question of social decision making on 'projects' with environmental impacts. We have, in this context, noted especially Sagoff's distinction between the individual as consumer and as citizen, and his contention that it is the second of these selves which is relevant to such social decision making. This is also relevant to proposals for revised national income accounting procedures which involve the use of pseudo market prices.

It is in the nature of the case that we cannot claim that any firm positive conclusions are warranted. We do consider that the material reviewed in this paper adds weight to the view that the extant approach to pseudo market valuations and their use is likely based on weak foundations. We do think that it has been established that there is a case for new directions of research in regard to environmental valuation and its use in social decision making. We now briefly indicate what we think those directions are.

First, there is a need to investigate directly whether the utility functions required for the standard approach can reasonably be assumed to exist.

Second, the Sagoff hypotheses require further examination. Do individuals respond to CVM non-use value questions as citizens rather than consumers? Do they think that they should? If the answer to either of these questions is 'yes', how does that affect their responses to questions posed on the assumption that their only response mode is as consumer, and what are the implications arising for the interpretation of aggregate WTP/WTA estimates based on their responses?

Third, if individuals relate to aspects of the natural environment as citizens rather than consumers, do they have citizen preference orderings that can be used to inform social decision making in relation to sustainability relevant policy questions? If such preference orderings exist, can means be devised to interrogate citizens that will reveal useful information on those orderings?

In the paper we have given some indications of how one might start to think about trying to answer some of these questions. There is much in the existing CVM related literature that is also relevant, of course. Many of the problems that attend attempts to interrogate individuals as consumers will also attend attempts to interrogate them as citizens. The problem of informational conditioning is as relevant to a citizen as to a consumer, for example. The point is not that, if research confirms it as appropriate, a switch from seeking sustainability relevant valuations from individuals as consumers to individuals as citizens will solve all problems. It is that it would then put those problems in a more appropriate context.

The central problem with natural resource accounting as the measurement of PNDP, or sustainable income, is valuation. Aggregation requires relative prices. If these are to be relevant and consistent they are necessarily derived from an optimization problem, so that the measure of PNDP arising relates to a model rather than an economy. An essential feature of the sustainability problem is that the reality to be modelled is both complex and largely unknown. An approach to PNDP measurement which does not involve modelling, using market and pseudo market prices, has little to offer as there is no reason to suppose that such prices will, generally, be either consistent or relevant. We conclude that the availability of PNDP figures would, in the foreseeable future, do little to promote sustainability. We do, however, see economy-environment modelling as an important route to improved understanding of the implications for human interests of economy-environment linkages. A pluralistic programme of such modelling could improve understanding of management options and inform public debate and the policy process. It would generate demands for the availability of systematic and comprehensive physical data relating to economy-environment linkages. It could also both draw upon and inform a programme of research into individual preferences.

APPENDIX 1: UTILITY FUNCTION EXISTENCE CONDITIONS

As noted in section 2, CVM, and related methods for the elicitation of WTP/WTA for environmental commodities, requires that for the individual there exists a utility function which has as arguments ordinary marketed commodities and states of the natural environment. Here we will assume that the latter comprise only arguments which take the value one or zero according to whether a corresponding species exists or not. Denote a vector of ordinary commodities by x and of species existence indicators by s. Then the assumption required for pseudo market valuation is that U(x,s) exists. The conditions on preferences which are necessary for the utility function to exist are discussed in demand theory texts: see, for example, Deaton and Muellbauer (1980, p26-30), whose treatment we follow here. Let the alternatives to be considered by the consumer be bundles Q_i, where

Q_1 Q_2.....Q_n

x_{11} x_{21}.....x_{n1}

x_{12} x_{22}.....x_{n2}

. . ..

. . ..

x_{1m} x_{2m}.....x_{nm}

s_{11} s_{21}.....s_{n1}

s_{12} s_{22}.....s_{n2}

. . ..

. . ..

s_{1p} s_{2p}.....s_{np}

The condition, or axiom, of Completeness is that for any Q_i and Q_j

Either Q_iPQ_j

Or Q_jPQ_i

Or Q_jIQ_i

where P stands for 'is preferred to' and I represents a relationship of indifference. This condition requires that the individual be able to compare *all* bundles in such manner as to be able to make a definite statement as to a preference/indifference relation.

The axiom of Transitivity is that

If Q_iPQ_j and Q_jPQ_k then Q_iPQ_k

These two axioms, together with the trivial axiom of Reflexivity, define a preference ordering. To go from a preference ordering to a utility function there is required the fourth axiom of Continuity. This is that for Q_i,

the set $A(Q_i)$ = $\{Q|Q \geq Q_i\}$

and the set $B(Q_i)$ = $\{Q|Q_i \geq Q\}$

are closed sets

This axiom rules out discontinuities in the preference ordering. An example of a discontinuous preference ordering is the Lexicographic. An ordering is lexicographic if Q_i is preferred to Q_j because it contains more of, say, food than Q_j, irrespective of what else Q_i and Q_j contain, and so on. Bundles are ordered as with words in a dictionary, in which case a complete set of indifference relations does not exist.

These four axioms are sufficient for the representation of a preference ordering by a utility function. Two further axioms are required to yield the 'well-behaved' utility functions usually employed in pseudo market valuation, but we will ignore these here: see Deaton and Muellbauer (1980).

APPENDIX 2: MODELS AND SHADOW PRICES

Here we consider a model which is an extended version of that of Mäler (1991), in that whereas his contained just one biotic population it contains two. This extension makes it possible to discuss matters appertaining to biodiversity and species interdependencies. We also modify Mäler's treatment by working with discrete rather than continuous time. We do not seek to re-establish Mäler's results for the modified model, but take them as given for it. The purpose is rather to use the analysis to illustrate the connection between valuation and constrained optimization, and to discuss the limitations of the capital theoretic approach to the measurement of PNDP. A useful account of the methods of constrained optimization in relation to natural resources and economic analysis is Conrad and Clark (1987).

Consider, then, the following illustrative dynamic optimization problem:

$$Max \quad \sum_{0}^{T} U(X_t, L_{Lt}, R_{3t}, R_{1t}) d^t : d = (1 + r)^{-1} \qquad (1)$$

subject to

$$\begin{aligned}
R_{1t+1} &= R_{1t} + G_1(R_{1t}, R_{2t}, R_{3t}) - Y_{1t} \\
Y_{1t} &= F_1(L_{1t}, R_{1t}) \\
R_{2t+1} &= R_{2t} + G_2(R_{1t}, R_{2t}, R_{3t}) \\
R_{3t+1} &= R_{3t} + G_3(R_{3t}) + Y_{3t} \\
R_{4t+1} &= R_{4t} - Y_{4t} \\
R_{5t+1} &= R_{5t} + Y_{5t} - \delta R_{5t} \\
Y_{6t} &= F_6(L_{6t}, R_{5t}, Y_{1t}, Y_{4t}, R_{3t}, Y_{7t}) \qquad (2) \\
Y_{7t} &= h(Y_{4t}) \\
Y_{3t} &= Y_{7t} - Y_{8t} \\
Y_{8t} &= F_8(L_{8t}, Y_{9t}) \\
X_t &= Y_{6t} - Y_{5t} - Y_{9t} \\
L_{Lt} &= L - L_{1t} - L_{6t} - L_{8t}
\end{aligned}$$

Here, R_1 and R_2 are interacting populations, both affected by the stock of pollution, R_3. R_1 is harvested, R_2 is not. The pollution stock decays by natural processes, $G_3(R_3)$, and is subject to net additions, Y_3, which are the difference between emissions, Y_7, and cleanup, Y_8. Emissions are a function of the use of the nonrenewable resource, R_4, in production. Cleanup activity uses labour, L_8, and produced output, Y_9. R_5 is man-made capital, used to produce output, Y_6. The other arguments in the production function are labour, L_6, the renewable resource harvest, Y_1, the extracted nonrenewable resource Y_4, the pollution stock, R_3, and emissions, Y_7. Output is allocated as between consumption, X, investment, Y_5, and cleanup activity, Y_9. Leisure, L_L, is the time invariant endowment of time, L, less its uses in harvesting the renewable resource, L_1, production, L_6, and cleaning up pollution, L_8. Equations (2) comprise the constraint set. In the objective function, equation (1), $U(X_t,L_{Lt},R_{3t},R_{1t})$ is to be understood as an instantaneous utility function reflecting the preferences of the representative household. Note that the arguments of the utility function are: consumption, leisure, pollution, and the size of the population R_1. The representative household has no direct interest in R_2 or R_4: R_2 is not an input to production. The whole problem is to be understood as that facing a planner seeking to determine the time paths for the control variables which will maximize the discounted sum of instantaneous utilities, where d is the discount factor used by the planner.

The Lagrangian for this problem is

$$\sum_{0}^{T} U\,(X_t,L_{Lt},R_{3t}R_{1t})\,d^t$$

$$-p_{1t}[G_1(R_{1t},R_{2t},R_{3t})-Y_{1t}+R_{1t}-R_{1t+1}]$$

$$-p_{2t}[G_2(R_{1t},R_{2t},R_{3t})+R_{2t}-R_{2t+1}]$$

$$-p_{3t}[G_3(R_{3t})+Y_{3t}+R_{3t}-R_{3t+1}]$$

$$-p_{4t}[R_{4t}-Y_{4t}-R_{4t+1}]$$

$$-p_{5t}[R_{5t}+Y_{5t}-\delta R_{5t}-R_{5t+1}]$$

$$-q_{1t}[F_1(L_{1t},R_{1t})-Y_{1t}]$$

$$-q_{6t}[F_6(L_{6t},R_{5t},Y_{1t},Y_{4t},R_{3t},Y_{7t})-Y_{6t}]$$

$$-q_{7t}[h(Y_{4t})-Y_{7t}]$$

$$-q_{3t}[Y_{7t}-Y_{8t}-Y_{3t}]$$

$$-q_{8t}[F_8(L_{8t},Y_{9t})-Y_{8t}]$$

$$-q_{Xt}[Y_{6t}-Y_{5t}-Y_{9t}-X_t]$$

$$-q_{Lt}[L-L_{1t}-L_{6t}-L_{8t}-L_{Lt}]$$

where p's and q's are Lagrangian multipliers. These give the payoff in terms of the maximized value of the objective function of relaxations of the corresponding constraints. They thus value the constraints and have the interpretation of, shadow, prices. The necessary conditions for the maximization of (1) subject to (2) are found by differentiating the Lagrangian with respect to its arguments. These conditions can be solved for time paths for the control variables and the shadow prices. The important point here is that although only X_t, L_{Lt}, R_{3t} and R_{1t} appear in the utility function, the solution for the dynamic optimization problem attaches shadow prices to all of the constraints, and thereby to all of variables appearing in the constraint set (2).

Specifically, consider the population which is R_2. It is not an argument of the utility function, nor is it an input to any productive activity. However, the constrained optimization problem does assign a value, or shadow price, to it, which reflects its role in the functioning of the total system in relation to the arguments which do appear in the utility function and/or production functions. Think of R_1 as fish and R_2 as plankton. Fish are harvested and used to produce for consumption, which households value. Households also value the existence of fish independently of its contribution to consumption. Households do not directly value plankton, nor is plankton an input to production. However, the constrained optimization problem assigns value to plankton, reflecting the fact that R_2 is an argument in $G_1(\cdot)$ – fish eat plankton. In this sense, the value so assigned to plankton is instrumental within the utilitarian framework.

However, the instrumentality is indirect and arises from interdependencies within the natural system that humans exploit. Thus, value so assigned appears to offer an alternative basis for the intrinsic valuation argued for by some deep ecologists (see section 5 above), without the need to step outside of an anthropocentric and utilitarian framework. Note also the relevance to the position of Norton (1986), referred to in section 5 above, that the value to be accorded a species should consist of value derived from identified human uses plus some original general value. The dynamic optimization framework appears to offer, in principle, the means of identifying and measuring Norton's original general value, again within an anthropocentric and utilitarian framework.

Within that framework, this formulation of a dynamic optimization problem picks up a purely instrumental concern for biodiversity. This is in as much as R_1 and R_2, their inter-relationships, and the implications arising for human interests as represented by (1) are in the constraint set. Actually, this would be true even if R_1 did not appear as an argument in $U(\cdot)$, given that the harvest on this population is an input to production for consumption. However, if the equation for R_2 did not appear in the constraint set, and the R_2 argument did not appear in $G_1(\cdot)$, then the problem would not involve an instrumental concern for biodiversity. Economic models of economy-environment linkages frequently include only those natural resources which are themselves inputs to production, or feature as utility function arguments.

Now consider CVM. Suppose that the state of the world is as given by (2), and that all households have identical preferences which are as given at (1). In this context consider a household asked about its WTP for the preservation of the species which is R_2. Clearly, only if the household knows that (2) describes the state of the world will it give a WTP corresponding to p_2. Suppose instead that the household is ignorant of the state of the world. Then its response to a WTP question could be expected to be conditioned by, among other things, whether it has any awareness of its ignorance. If it is aware of its ignorance, its response would further depend on its attitude to such ignorance and its imagined implications. The household could be unaware of and/or indifferent to its ignorance, presumably implying a stated WTP of zero. The household could be aware of its ignorance and of the possible implications of that ignorance in relation to its interests. In this case its WTP response would depend, among other things, on its attitude toward risk and uncertainty. A positive WTP response would certainly not be ruled out. However, such a response would be in the nature of a WTP for insurance rather than a valuation of the species.

To include in the problem formulation a non-instrumental concern for biodiversity, the instantaneous utility function could be written as

$$U_t = U(X_t, L_{lt}, R_{3t}, R_{1t}, R_{2t}) \qquad (3)$$

or

$$U_t = U(X_t, L_{lt}, R_{3t}, D\{R_{1t}, R_{2t}\}) \qquad (4)$$

where $D\{\bullet\}$ is some measure of biodiversity, such as that proposed by Weitzman (1991), for example, or as:

$$U_t = U(X_t, L_{lt}, R_{3t}, R_{1t}, R_{2t}, D\{R_{1t}, R_{2t}\}) \qquad (5)$$

where there is a concern for the absolute size of biotic populations as well as biodiversity.

Note that each of (1), (3), (4) and (5) would imply, for a given specification of (2) in terms of functional forms and parameter values, different shadow prices everywhere, a different specification of PNDP, and a different value for PNDP at t=0. Valuation and PNDP measurement on this approach are, that is, model dependent. Unless, it is assumed that there can be consensus on the specification of the instantaneous utility function, or more generally an objective function, there is, even assuming that the constraint set specification is taken as given and correct, no prospect of a unique measure of PNDP. What this approach would measure is PNDP for a model, not PNDP for an actual economy. And, the nature of the adjustments to conventionally assessed NDP seen as required would also be model dependent.

Consider now the constraint set. Suppose first that (2) is 'correct' in the sense that there are just two renewable resources, one pollution stock, etc., etc. Then, the shadow prices and the measure of PNDP will vary with the particular

functional forms and parameter values used in a particular formulation of the model. Only if those used in modelling are the 'correct' ones will measured PNDP be 'correct'. Of course, (2), or some extended version thereof, is not going to be correct even in terms of general structural specification. In (2) itself there is an obvious 'error' in that natural processes and/or cleanup activity make the pollutant vanish with no implications elsewhere in the system. The structural specification, that is, violates the law of conservation of mass. This is fairly typical in economic modelling. Generally, the point is that on this approach valuations and PNDP measurement are model dependent in regard to the constraint set, as well as in regard to the objective function. One of the few things we can be sure about is that we do not know the true model to use in this approach to valuation and PNDP measurement. Numerous models have been specified in the literature. Common and Norton (1992) consider, in relation to the biodiversity conservation problem, a variant of that used here where there are many interacting populations and threshold effects are allowed for. See also, for examples: Common and Perrings (1992), O'Connor (1991), Perrings (1987), Pezzey (1992).

NOTES

[1] We use the term 'individual' to refer to consumption agents. As elsewhere in economics, there can in the environmental valuation context be ambiguity as to whether the individual or the household is the appropriate consumption unit. This ambiguity can give rise to substantial empirical problems, especially in regard to aggregation, in applications of methodologies for pseudo market valuation.

[2] This statement describes the current consensus among economists. A referee has drawn attention to a recent paper, Larson (1992), in which it is claimed that TCM can, in some circumstances, be used to estimate non-use, as well as use, values.

[3] In the light of the discussion in the next section of the paper of Sagoff's consumer/citizen distinction, we should note here that it does not appear that any significance should be attached to the use of these terms in this quotation. Certainly, Sagoff is not cited in Mitchell and Carson's bibliography. However, we should note that in their, brief, discussion of the 'political market' (un-defined) as "a more appropriate analogue for CV surveys that value public goods" (p91-94), Mitchell and Carson (1989) state that: "The strict application of a private goods market ignores any but self-interested consumption behaviour and therefore downplays the 'public-regardingness' behind existence values" (p93). We should also note here that the use of referenda type bid elicitation methods is consistent with treating the private goods market as the model for CVM.

[4] We should note explicitly that TCM does offer an advantage over CVM in regard to accuracy assessment, where both are applicable. In the case of TCM it is not true that there is no external criteria for such assessment. In order to calculate consumers surplus via TCM it is necessary to fit to the visitation data a trip generating, or visits demand, equation. This equation can be, and routinely is, subjected to the standard tests for goodness of fit, statistical significance of estimated parameter values etc. Typically, R

squared is rather low. Also, an equation estimated for data for one year could, for example, be used to predict visits for another year. This is rarely done, it would appear.

[5] Embedding is the phenomenon arising "when the same good is assigned a lower value if WTP for it is inferred from WTP for a more inclusive good rather than if the particular good is evaluated on its own" (Kahneman and Knetsch, 1992a, p58).

[6] A referee raised the question as to whether one can be 'altruistic' except in regard to an entity which values its own good. If non-human entities are to be regarded as themselves incapable of valuation – the position we consider reasonable – then it might be better to call altruism extended to them paternalism, or some politically correct variant thereof. Thus, it is not inconsistent to regard one's dog as incapable of valuation and to care about its welfare. The welfare involved is, of course, one's own understanding of what is good for the dog.

[7] But, with respect to TCM, see footnote 3.

[8] It should be noted that Daly and Cobb (1989) have produced a series for an 'index of sustainable economic welfare' for the USA. By, for example, incorporating adjustments to reflect changes in the distribution of income this seeks to go beyond what is usually understood by a proper measure of national income, to provide a measure of performance according to Daly and Cobb's view of the appropriate social welfare function. The index is constructed by a series of *ad hoc* adjustments to a conventional national income accounting measure for consumption.

[9] Hartwick (1990), notably, has explored similar issues within the same capital theoretic framework. Mäler (1991) provides references to other important contributions within this framework. Faber and Proops (1991) also argued that any attempt to measure PNDP must be based within an inter-temporal optimization exercise, but took a somewhat different approach to modelling the economy-environment linkages and to capital theory.

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