Staff Paper

Valuing Biodiversity
Issues and Illustrative Example
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Issues and Illustrative Example

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INTRODUCTION

An important element of natural landscapes is the biodiversity they harbor. People value biodiversity because of the services it provides, e.g. aesthetics (Barbier et al., McNeely). As natural landscapes are converted for human development, biodiversity services are lost. Economists are focusing attention on biodiversity issues because an efficient level of biodiversity may not be provided by market forces (Randall 1986). Markets may underprovide biodiversity because of its public-good aspects of non-rivalness and non-exclusion (Cornes and Sandler). For example, several people can enjoy biodiversity services at the same time when they observe migrating birds, and individuals cannot be excluded from enjoying the benefits biodiversity provides because birds are highly mobile and cannot be restricted to controlled areas.

Valuation of biodiversity is a first step toward an efficient allocation of resources to biodiversity preservation. In order to value biodiversity three issues need to be addressed: first, the definition of biodiversity, second, the biodiversity measure, and third, an appropriate valuation method and its application to the specific valuation problem. This paper addresses these three issues and provides an illustration of a valuation study applied to bird diversity.

Existing valuation studies related to biodiversity tend to focus on irreversibility (Barbier et al., Pearce and Moran). Irreversibility occurs when species go extinct or ecosystems are permanently destroyed. It is misguided, however, to focus attention on the study of biodiversity only once ecosystems or species are threatened. Biodiversity decreases not only when species are irretrievably lost, but also when land-use decisions involve a local loss of species that are not threatened with extinction. Over time, population numbers of species may decline to a threshold level low enough to pose a threat to further existence of the species. If the value of biodiversity enters into land-use decisions before species reach the threshold, individual species may not become threatened to warrant the special attention they currently receive.

Often, valuation studies of protected areas are included in the biodiversity valuation literature (Pearce and Moran). It is not clear to which extent the studies are actually capturing the value of biodiversity. For example, the willingness to pay for travel to a national park is not necessarily equivalent to the value of biodiversity it contains. Similarly, the willingness to preserve an endangered species is not necessarily an appropriate marginal valuation of biodiversity.

The species diversity valued in the example described in this paper is not limited to rare, threatened, or endangered species. Because of the high degree of uncertainty and irreversibility when species become extinct the economic approach to analyzing biodiversity is perhaps most easily justified where species extinction is not an issue. Furthermore, the biodiversity valuation in the example is not tied to a specific location and not limited to a single species. These characteristics make this type of value appropriate for benefit transfers (Pearce and Moran).

DEFINITION

Biodiversity can be defined as genetic diversity, ecosystem diversity, and species diversity. Genetic diversity is the variation in genetic material, ecosystem diversity, the variability in the ecological complexes which form habitat for species, and species diversity, the variability across species (McNeely, Pearce and Moran, Reid and Miller).

It is important that the definition of biodiversity is relevant. In some instances valuation of biodiversity may be conducted by estimating the costs of alternative means to generate biodiversity's services, e.g. pollution absorption by installing filters. However, generally, biodiversity valuation involves eliciting willingness to pay (WTP) or willingness to accept (WTA) compensation for levels of biodiversity from a sample of a target population. In that case, meaningful estimates for WTP or WTA can only be obtained if the respondents understand the definition of biodiversity and perceive changes in biodiversity as specified by the researcher. The definition of biodiversity must also be relevant for the policy issue to be analyzed. For example, if the purpose is to study the effect of pollution on biodiversity and the main effects are an alteration of genetic material, defining biodiversity at the species level is inappropriate. Thus, the first step in meaningful biodiversity valuation is defining biodiversity appropriately.

MEASUREMENT

Once the appropriate definition of biodiversity has been determined a measure must be chosen or constructed. The measurement problem will be illustrated for species diversity. In the past, species richness, the number of species in a given area, was generally used as a biodiversity measure (Williams et al.). However, when population distributions are of interest to the researcher, abundance information is needed for the individual species (Magurran). More recently, researchers have attached weights to species based on their relative position in a classification system. Williams et al., for example, incorporate genealogical relationships between species.

The choice of biodiversity measure will depend on the exact research topic, underlying assumptions, and value judgments. If it is believed that biodiversity conservation efforts should focus on conserving as many species as possible, species richness is the biodiversity measure to use. If the goal is a stable ecosystem and this requires a maximum number of species that are distinct from one another, a measure that captures distinctiveness is required.

The type of biodiversity measure chosen can affect decision-making. For example, if a biodiversity ranking is the criterion for determining which of a number of alternative sites to select for protected status, choosing one biodiversity measure over all others can affect the final site selection.

VALUATION

Biodiversity is valued for the services it provides. The different services make a contribution to the total value of biodiversity. The major categories are use values and non-use values (Pearce). Within the use category, direct use, indirect use, and option value can be distinguished. Direct use values relate to biodiversity services such as aesthetics and outdoor recreation. For example, bird watchers derive direct use values from a birding trip when they enjoy a variety of different bird species in their natural setting. Indirect use values of biodiversity for bird watchers would be, for example, the satisfaction they get from watching a birding video and listening to a presentation on bird diversity at a birding site. Option value is the value of the resource associated with preserving the option of using it in the future. Birders have option value, for example, if they are willing to contribute toward preserving a birding area so that they may be able to visit it in the future.

Bequest and existence values are non-use values. Biodiversity's bequest value is the value of biodiversity services to be passed on to future generations and existence value the value of knowing that biodiversity exists without any intention of deriving use values (Randall 1986). Quasi-option value arises when lack of information exists about future benefits where species may be lost irreversibly (Randall 1986). The quasi-option value of biodiversity may make up a large part of total value when species face extinction.

Revealed and stated preference models have been developed to analyze non-market goods, such as biodiversity. Contingent valuation appears to be the only non-market valuation technique that can address non-use values. When non-use values are likely to be large, the contingent valuation method is more appropriate than the travel cost method or hedonic approaches.[1]

[1] For a survey of non-market valuation approaches see Hoehn and Krieger, Freeman, Carson.

IRREVERSIBILITY AND UNCERTAINTY

The analysis so far implicitly suggested that biodiversity can be analyzed deterministically. However, examples are abundant where this assumption is likely to be violated. Some economists and many non-economists feel uneasy about using the economic approach to analyzing biodiversity because of the many things that are not known about genes, species, ecosystems and their interdependencies and because of the irreversible effect of species loss (Ehrenfeld, Norton, Randall 1988, Hanemann, Swaney and Olson).

Economic theory provides some tools to deal with issues of uncertainty and irreversibility. Uncertainty can be incorporated into biodiversity analysis by attaching probabilities to different possible outcomes and assuming certain risk preferences for utility-maximizing individuals. The problem becomes more difficult if the probabilities are not known. Sensitivity analysis can reveal the variation in biodiversity values when different assumptions about uncertain data are made.

The probability of extinction or survival becomes an important element in the analysis of biodiversity where extinction of species is important (Solow et al., Solow and Polasky). It is not clear, however, how extinction probabilities are to be determined. Solow et al. give an illustrative example where they assign decreasing probability to endangered, vulnerable, indeterminate, and other species.

Biodiversity valuation research where extinction of species is important cannot necessarily use the same approach that is applicable in the case where extinction of species is not an issue. Option value and quasi-option value can be very large for species threatened with extinction. A valuation approach that focuses on use values, e.g. the travel cost method, could considerably undervalue the total value of biodiversity that includes species threatened with extinction.

One way to incorporate possible extinction of species in valuation of biodiversity is to include a variable for rare, threatened, and endangered species in a contingent valuation model. A positive relationship between WTP and these variables indicates respondents' willingness to pay a premium for those species.

AN EXAMPLE: THE VALUE OF BIRD DIVERSITY

The following section illustrates how issues raised in the preceding section have been resolved for a bird-diversity valuation project. The pilot study is currently in progress at Michigan State University.

General Remarks

The pilot study on bird diversity uses in-person interviews with members of the American Birding Association (ABA) to elicit willingness to pay for bird diversity. A 1994 ABA membership survey reveals that the average ABA member is 53 years old, has an average family income of $60,000, and is highly educated with 43% possessing a Master's or Doctoral Degree (ABA 1995b). ABA members tend to be knowledgeable about birds. 29% lead birding trips or tours, 19% write about birds or birding, 11% teach birding classes and many more are active in their local birding club, take field trips with their local birding club, and/or participate in bird counts or research projects (Butcher).

Birding can be done anywhere where there are birds, in the backyard, parks, wood lots, along the lakeshore. Some sites, such as migration points for birds, are particularly attractive to birders because a large number of bird species can be seen in large concentrations. Many sites that are popular with birders make bird checklists available to visitors. The information provided is typically a list of bird species by season with a code attached which designates abundance. Endangered species may be identified specifically.

Definition

For the purposes of the study biodiversity is defined as species diversity. This definition is relevant for the targeted population as well as the policy issue. Pretests have shown that birders distinguish avian life primarily at the species level (pretest). Publications targeted at bird species may be grouped by families but the major focus is on species (Jones, Kitching, Wauer).

The study will present respondents with five alternative hypothetical birding sites. The description of each birding site takes the form of a bird chart. The focus will be on the spring season (March-May) which was identified as the prime birding season by participants in pretests (pretest). Each bird species receives one of five abundance codes (abundant, common, uncommon, occasional, rare). These codes will correspond to probability ranges of a competent birder identifying the bird species on a weekend of birding during peak migration time.

Measurement

There are a number of possible ways to construct a biodiversity measure with the information given above. The easiest measure to construct is species richness. This measure only requires counting the number of species. Pretests indicate that birders value bird species equally, unless they are rare (see the section on Irreversibility below). However, the number of birds listed on a bird chart for a particular site are not certain to be found at anyone time. Economic theory offers the expected utility framework to deal with uncertainty. Use values of bird diversity will then depend on the expected number of bird species at the site. Pretests have shown that birders like to go to birding sites where they are likely to find a lot of birds (pretest). This indicates that the expected utility framework is appropriate.

Probability ranges will be associated with the abundance codes typically used in bird charts. This type of information is not generally provided to birders.[2] An alternative measure of biodiversity will thus be the number of bird species in each of the five abundance categories.

Valuation

The non-market valuation model for this pilot study is contingent valuation. Non-use values associated with bird diversity can be potentially large and contingent valuation is the only method that can estimate those values. Birders are expected to have high use values since observing birds is the key activity for birders. Non-use values may also be substantial. A survey of participants in a Christmas bird count revealed that on average a birder spends $62 per year on membership in conservation organizations (Wiedner and Kerlinger). Part of the membership fee reveals the member's WTP for conservation efforts which may be an expression of non-use value.

In order to avoid biased results from contingent valuation studies, it is important that respondents are familiar with the good to be valued. ABA members are experienced birders (only 4% are beginners) and can be expected to understand the concepts used in the study (ABA 1995a).

It is also important to have a realistic valuation scenario and a value elicitation procedure that is modeled on real-world decision-making situations, such as voting or shopping for market goods. Asking referendum questions, yes or no, for WTP or WTA puts respondents in a familiar situation and requires a fairly simple task (Freeman). The referendum format has the added benefit of reducing strategic behavior in respondents (Hoehn and Randall).

Thus, survey respondents will be presented with a scenario that asks them whether they would be willing to pay a stated amount to have an area, for which a bird chart is presented, managed for bird diversity rather than

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2 For a bird chart which does provide probability ranges see Supplement to Winging It, 7(12) (ABA1995a).

lose it to commercial development. The question is repeated for a total of five sites. The respondents are asked to view the questions as true alternatives, i.e. the respondents would be expected to pay for only one of the five sites. Presentation of the five alternatives will be randomized to avoid an order effect.

Overlooking the different probabilities associated with viewing different bird species in a study of bird watchers' valuation of bird diversity would be a serious analytical flaw. Birders frequent spring migration points because of the large number of species and the high probability of identifying them (pretest). The expected utility framework incorporates probabilities and WTP for expected biodiversity can be estimated.

A problem arises when probabilities are not available and cannot be calculated from the available data. Population distributions can still be incorporated if some abundance information is available. For example, bird lists compiled for different birding sites typically offer an abundance code for each bird species at the site. This information can be used to determine whether birders care about species distribution across categories and how much.

It will be tested whether WTP for bird diversity can be explained by the expected number of bird species at the site or alternatively the number of bird species in the different abundance categories. A nested structure of model specifications will be developed. The unrestricted model, where every bird species has its own coefficient, will not be estimated because with the limited number of observations this pilot study would run out of degrees of freedom. There will be two restricted models, the model with a separate coefficient for the abundance categories and the model with a single coefficient for the expected number of bird species. The restrictions can be tested using an LM test which only requires the restricted estimates.

If birders care about bird diversity, the expected number of bird species will be positively related to WTP. It can be expected that the WTP for bird diversity is positively related to the number of species in the common and uncommon categories. The relationship may be insignificant for the occasional and rare categories or at least the coefficients on these categories will be smaller. The coefficient sign for the abundant category should be positive. However, if the category contains a lot of species that have become accustomed to human contact, e.g. crows, robins, the coefficient may be small and may be insignificant.

It can be expected that birders' willingness to pay for bird diversity is higher when the development option for the proposed bird diversity management area would make the extinction of species more likely. This translates into a higher willingness to pay for rare species. This research incorporates this element of irreversibility by asking respondents to check off those bird species they consider rare in Michigan. The number of rare species at the birding site will become a separate variable in the analysis. It is expected that the sign of the coefficient on the "number of rare species" variable will be positive and significant as birders are willing to pay a premium for rare species.

SUMMARY

This paper investigates conceptual issues in biodiversity valuation. They can be broken down into definitional, measurement, and valuation problems. Possible definitions of biodiversity are genetic, species, and ecosystem variability. Further analysis focuses on the species level. The dominant measure of species diversity used to be species richness, the number of species. More recently different weights attached to different species has led to a multitude of different measures of species diversity. A widespread problem encountered in biodiversity measurement is the fact that data necessary for the construction of the biodiversity indicator is often not available.

Biodiversity is valued for the services it provides. Values can be identified as direct use, indirect use, option, quasi-option, bequest and existence values. Valuation of species diversity requires a non-market valuation method because biodiversity is not traded in markets. Contingent valuation is the only method that can measure non-use values. Issues of irreversibility and uncertainty require special treatment.

Definition, measurement, and valuation of biodiversity is illustrated with currently ongoing research on the use of the contingent valuation technique to value bird diversity. The study focuses on American Birding Association members' valuation of bird diversity. Species and abundance information readily available for many possible birding sites is the basis for the description of the contingent valuation scenario. Uncertainty of bird encounters is incorporated in the study by calculating the expected number of birds. Since probabilities are not typically provided in bird charts, it is tested whether abundance categories can serve as substitutes for probability ranges.

Biodiversity research on species to date has tended to focus on species extinction. However, typically, species are driven to the brink of extinction by more or less gradual loss in habitat. Therefore, it is appropriate to study biodiversity issues in a broader context when species extinction is not the primary issue. The research example presented here also facilitates benefit transfers as the scope extends beyond the single species level and is not bound to a specific location. Furthermore, if it can be shown that abundance categories can be used to explain willingness to pay for biodiversity, compilation of this type of information for more sites and other species should be encouraged because categorical abundance information is easier to compile than actual population counts. If abundance categories are not a good substitute for expected number of birds, research into construction of probability ranges and their use should be encouraged to provide necessary input for biodiversity valuation.

BIBLIOGRAPHY

American Birding Association. "A Field Guide to the Major Field Trips." *Winging It* 7(12): 1995a.

American Birding Association. "ABA Survey of Members - 1994." Colorado Springs, CO: American Birding Association, 1995b.

Barbier, E.B., J.C. Burgess, and C. Folke. *Paradise Lost?* Earthscan Publications Ltd.: London, 1994.

Butcher, G. "Demographics of ABA Members." *Winging It* 7(4):April, 1995.

Carson, R.T. "Constructed Markets." In: Braden, J.B., and C.D. Kolstad, eds. *Measuring the Demand for Environmental Quality*. Elsevier Science Publishers: North-Holland, 1991.

Cornes, R., and T. Sandler. "The Theory of Externalities, Public Goods, and Club Goods." Cambridge University Press: Cambridge, 1986.

Ehrenfeld, D. "Why Put a Value on Biodiversity?" In: Wilson, E.O., eds. *Biodiversity*. National Academy Press: Washington, D.C., 1988.

Freeman III, A.M. *The Measurement of Environmental and Resource Values. Theory and Methods*. Resources for the Future: Washington, D.C., 1993.

Hanemann, W.M. "Economics and the Preservation of Biodiversity." In: Wilson, E.O., eds. *Biodiversity*. National Academy Press: Washington, D.C., 1988.

Hoehn, J.P., A. Randall. "A Satisfactory Benefit Cost Indicator from Contingent Valuation." *Journal of Environmental Economics and Management* 14:226-247, 1987.

Hoehn, J.P., D. Krieger. "Methods for Valuing Environmental Change." Staffpaper. Department of Agricultural Economics, Michigan State University, East Lansing, Michigan. October, 1988.

Jones, J.O. "Where the Birds Are." William Morrow and Company, Inc.: New York, 1990.

Kitching, J. *Birdwatchers Guide to Wildlife Sanctuaries*. Arco Publishing Co.: New York, 1976.

Magurran, E. *Ecological Diversity and Its Measurement.* Princeton University Press, 1988.

McNeely, J. *Economics and Biological Diversity: Developing and Using Economic Incentives to Conserve Bilogical Resources.* Gland, Switzerland: IUCN, 1988.

Norton, B. "Commodity, Amenity, and Morality." In: Wilson, E.O., eds. *Biodiversity.* National Academy Press: Washington, D.C., 1988.

Pearce, D.W. *Economic Values and the Natural World.* 1993.

Pearce, D.W. and D. Moran. *The Economic Value of Biodiversity.* Earthscan Publications, LTD, 1994.

Randall, A. "What Mainstream Economists Have to Say About the Value of Biodiversity." In: Wilson, E.O., eds. *Biodiversity.* National Academy Press: Washington, D.C., 1988.

Randall, A. "A Total Value Framework for Benefit Estimation." In: Peterson, G.L. et al. *Valuing Wildlife Resources in Alaska.* Westview Press: Boulder, San Francisco, Oxford, 87-111, 1992.

Reid, W.V., K.R. Miller. *Keeping Options Alive. The Scientific Basis for Conserving Biodiversity.* World Resources Institute, 1989.

Solow, A., S. Polasky, and J. Broadus. "On the Measurement of Biological Diversity." *Journal of Environmental Economics and Management* 24 (1):60-68, 1993.

Solow, A.R. and S. Polasky. "Measuring Biological Diversity." *Environmental and Ecological Statistics* 1:95-107, 1994.

Swaney, J.A., and P.I. Olson. "The Economics of Biodiversity: Lives and Lifestyles." *Journal of Economic Issues* 26(1):1-25, March, 1992.

Wauer, R.H. *The Visitor's Guide to the Birds of the Rocky Mountain National Parks.* John Muir Publications: Santa Fe, New Mexico, 1993.

Wiedner, D. and P. Kerlinger. "Economics of Birding: A National Survey of Active Birders." *American Birds* 44 (2):209-213, Summer, 1990.

Williams, P.H., R.I. Vane-Wright and C.J. Humphries. "Measuring Biodiversity for Choosing Conservation Areas." In: LaSalle, J. and I.D. Gauld, eds. *Hymenoptera and Biodiversity*. CAB International, 1993.