

TWO PERSPECTIVES ON ECONOMY AND NATURE: A REVIEW

V. Kerry Smith, *Estimating Economic Values for Nature: Methods for Nonmarket Valuation*, Edward Elgar, Cheltenham, 1996.

Kimio Uno, *Environmental Options: Accounting for Sustainability*, Kluwer Academic Publishers, Dordrecht, 1995.

The books reviewed here offer two quite different perspectives on incorporating measures of the services of environmental resources into economic models. Smith's work applies microeconomic theory to estimate the economic value associated with specific resources and uses—such as the value of a sport fishery, recreational use of a wilderness area, or the value of clean air in a given community. The emphasis is on the demand side, typically for a single sector. From the standpoint of the level of aggregation, Uno's work is at the other end of the spectrum. He applies a national level input–output framework to analyze the role of natural resources over several recent decades in a case study of Japan—including an evaluation of the extent to which accounting for environmental degradation reduces estimates of GNP.

It is perhaps remarkable that two recent books in the same field could appear to intersect so little. Smith does not happen to report on any work done on macro-accounting issues *per se* (though a preliminary estimate is presented for the environmental costs of the U.S. agriculture sector). Uno briefly mentions and dismisses several of the microeconomic valuation approaches as being inconsistent with the transactions basis of the system of national accounts. However, it is apparent that the primary weak element in Uno's application—estimation of his term "DZ" or environmental degradation—is necessarily best approached by the very methods Smith describes. Why then do these two books not intersect? One reason is that each book comes from a very different tradition. Accordingly this review begins with a somewhat selective overview of the history of thought in this field before turning to a focus on the books themselves.

The economic issues associated with environmental and natural resources are the same allocative and distributive issues that arise with any resource. However, in many cases the services of environmental resources are not marketed. Some of these services, such as recreational fishing or hunting, have the theoretical private good characteristics of excludability and divisibility. Nonetheless, public ownership is common in most of North America due to the unique history and evolution of property rights on this continent. By contrast, in Norway and much of Europe fee fisheries are the common allocative mechanism. Other natural

Note: The author would like to thank Lars Osberg for helpful comments on earlier drafts. As usual the author has sole responsibility for any errors or misinterpretation.

resource services have the economic properties of public goods such as nonexcludability—it may be too costly or difficult to exclude users for markets to exist (an example is access to clean air). In an important paper published in 1967, John Krutilla argued that many of the indirect services of fish and wildlife resources and natural environments (wilderness areas, seashores, etc.) are also public goods to the extent that individuals place value on just knowing that some resources are viable or healthy (so-called “existence value”) or value knowing that these resources will be available for future generations (“bequest value”). These types of indirect uses have come to be called passive uses (Arrow *et al.*, 1993). The potential mix of observable *in situ* direct use services as well as passive use associated with any given resource has important implications for the analysis of these types of problems—for example the set of feasible methods and the definition of the extent of the relevant markets.

A key implication of the public good properties of natural and environmental resources is that markets will fail to exist for their services, or where they do exist, may undervalue or overvalue a given use due to externalities. The resulting problems of valuation and accounting have attracted the attention of many economists working both within essentially microeconomic (“nonmarket valuation”) and macroeconomic (for example, “green accounting”) frameworks. To a large extent the work in this field has been motivated by public policy issues, and can be classified into two broad categories: the evaluation and design of alternative allocative mechanisms vs. the effort to identify the welfare implications of any given allocation. An example of the first category is the very large literature on the economic organization of air resources—the comparison of various command and control regulatory approaches to tax or subsidy incentives to the establishment of limited markets in pollution rights, etc. The second category includes the evaluation of specific projects or policies.

Some of the earliest applications of microeconomic and welfare economic tools in this area derive from the role of the U.S. federal government in water resources development and the need for economic evaluation of projects. For example, the Flood Control Act of 1936 and much of the water project funding legislation thereafter specifically required projects to pass a benefit–cost efficiency test. Recreational use was among the first nonmarket uses to be examined and provides an example of how dramatically the applications have evolved in terms of the scope of resource services being evaluated (as well as in the sophistication of the methods). The earliest and somewhat crude recreation valuation efforts (relying on unit values from marketed recreation uses) generally weighed in on the project justification side—for example, including the benefits of flat-water recreation in the evaluation of dam and reservoir systems. Eventually recreation also began to enter as an opportunity cost. (For example, the evaluation of foregone whitewater recreational use in Krutilla and Fisher’s (1975) evaluation of a proposed dam in the Hells Canyon of the Snake River.) Expanding the potential scope of these types of inquiries, recent evaluations include proposals to remove dams. The direct and passive use values associated with the Elwah River’s anadromous fishery were found to exceed the value of hydroelectric generation (Loomis, 1996), and the dam is slated for removal. Similar analyses are being undertaken for existing large hydroelectric dams on the Snake River.

The range of potential policy issues and applications is, of course, far broader than outdoor recreation and includes a wide range of fish, wildlife and other natural resources. By way of example, recent policy issues in the Northern Rockies include purchase of wildlife habitat (elk winter range), pricing of access and hunting permits, establishment of instream flow rights for fisheries, development of air pollution standards, and recovery of endangered species (wolves, spotted owls, grizzly bear, bison). The absence of established data sets is common in work on these issues. Due to market failure there may or may not be relevant transactions data or established business statistics series. Accordingly the development and implementation of population surveys is an important feature of much of the work in environmental economics.

The level of interest and activity in this field essentially parallels the increased awareness of society at large in environmental issues beginning in the late 1960s and early 1970s. For example, in the U.S., the associated environmental legislation during this period—the Clean Air Act, the Clean Water Act, etc.—led to efforts to quantify the benefits and costs of these activities. This increase in interest was, of course, worldwide. For example in Norway the Samlet Plan attempted to quantify the tradeoff of hydroelectric development and other natural resource services. In the U.S. another major impetus to development of this field was the passage of legislation relating to toxic wastes, including the CERCLA (or Superfund Act) in December 1980. An important part of CERCLA establishes liability for damages for injuries to natural resources resulting from the release of hazardous substances. Since many of the potentially injured natural resources provide nonmarket services, CERCLA has focused attention on how these resources should be valued. Since 1986 Congress has directed the Department of Interior to develop regulations specifying economic methods for implementing natural resource damage assessments, which have been challenged in court by industry and environmental groups. The Exxon Valdez oil spill in March 1989, while not a CERCLA case, was the first very large case where nonmarket valuation methods were used to establish a large share of the economic damages (Carson *et al.*, 1992). Relatedly, this case led to a continuing lively debate over the validity of these methods. The development of federal guidelines on economic methods for these types of cases continues and includes the promulgation of regulations by the National Oceanic and Atmospheric Administration (NOAA) to implement the Oil Spill Act of 1990. Texts on the application of economics in this area include Kopp and Smith (1993) and Ward and Duffield (1992).

The net result of the plethora of policy issues and related research in the last several decades is that the field of natural resource and environmental economics is now one of the major fields in the profession. The Association of Environmental and Resource Economists was formed in 1978 and currently numbers about 800 members. It is also symptomatic of the attention being given to this field that both of the books under review are publications in series—one being the “New Horizons in Environmental Economics” series from Edward Elgar and the other the “Economy and Environment” series from Kluwer (Smith and Uno, respectively).

With regard to methods, on the microeconomic side, two broad classes of approaches have been developed for valuing nonmarket resources. One group of

models are the so-called “revealed preference” approaches which rely on observed behavior in related markets. As noted, recreational use was an early focus of attempts to value nonmarket services. One revealed preference approach is the travel cost model, first suggested by Hotelling (1949). The basic idea is that utilizing the services of a typical outdoor recreation site requires a visit to the site. Access to the site itself may be free or may entail only a nominal fee, but there are costs associated with travel to the site. The observed variation in use with these spatially varying travel costs (depending on where the visitor lives) can be used to infer a tradeoff of site use and access price. The earliest models, in the late 1950s, were estimated on visitation data aggregated by distance from the site (so-called zonal models). A more recent approach is based on individual level data in a discrete choice/random utility framework first developed in the transportation literature (McFadden, 1973). Both types of models have their limitations; the zonal model handles substitution poorly while the discrete choice model provides little information on changes in overall participation levels. The discrete choice models have the most potential for describing the welfare implications of changes in resource quality (such as improvements in water quality, etc. that might benefit a recreational fishery) and have been the focus of much recent research, particularly in the context of natural resource damage litigation. Nonetheless, the data collection and econometric problems in developing robust estimates from these types of models are formidable (McFadden, 1996).

Two other general revealed preference approaches to valuing nonmarket resources are hedonic pricing and the factor income approach. In hedonic pricing, implicit prices are estimated for individual attributes of a market commodity. For example residential property prices may vary systematically with an environmental attribute of interest—such as proximity to a lake. An early application was an analysis of the relationship of housing prices to air pollution levels in St. Louis (Ridker and Henning, 1967). Rosen (1974) was the first to develop a rigorous theoretical basis for these types of models. The factor income approach can be used when the resource at issue is an input to a production process that has as an output a marketed commodity. For example, markets generally do not exist for water withdrawals from Western rivers, but given a model of the production technology for irrigated agriculture and market prices for crops, it is possible to estimate demand functions for the water input.

The other broad class of nonmarket valuation methods are the stated preference approaches—surveys simply ask individuals about the values they place on, for example, their recreational experience. Although this idea goes back to Ciria-Wantrup (1952), the first well-known application was by Davis (1963) who studied the value of hunting and other recreation in Maine. One specific approach has come to be known as contingent valuation—individuals are asked to state their valuation of a given resource contingent on their acceptance of a given hypothetical payment situation. For example, an individual about to enter a park could be asked if she would still have chosen to make this trip if the access fee was, say, \$25 higher than the current fee—yes or no.

The design and implementation of these types of studies requires the development of a plausible and realistic payment vehicle and an appropriate range of bids. A standard reference is Mitchell and Carson (1989). This approach has been

very widely applied. (Richard Carson maintains a bibliography that now numbers into several thousand studies.) The approach has been subject to a court test in a challenge to the 1986 DOI CERCLA regulations [*Ohio v. DOI*, 880 F.2d 432,474 (D.C. Circuit 1989)]. Additionally, in 1992 NOAA appointed a distinguished panel (including several Nobel laureates in economics) to evaluate the approach in the context of implementing the Oil Pollution Act of 1990. In both instances the method has been judged to be a useful tool for valuation in the context of litigation. For example, the NOAA panel concluded that: “contingent valuation studies can produce estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive-use values” (Arrow *et al.*, 1993 at 4610). This is not to imply that the development of these methods or the debate on their appropriateness is over [for example, see Diamond and Hausman (1994); and Hanemann (1994)].

Recent studies have also paired stated preference and actual cash transactions in experiments to validate or calibrate contingent valuation estimates. The seminal paper on this topic, Bishop and Heberlein (1979) examined actual cash bids and hypothetical bids for a private good—goose hunting permits on a Wisconsin wildlife refuge. There has been less work on public goods where the most plausible payment vehicles are referendums or voluntary contributions (Seip and Strand (1992); Duffield and Patterson (1992); Champ *et al.*, 1997). A related recent and innovative area of work are models that combine stated preference and revealed preference data sets [Cameron (1992); Louviere (1996)].

The book by Smith (a collection of 32 of his essays and articles written between 1973 and 1993), is a welcome and timely addition to this tradition. Taken together the papers are representative of the rapid development of the field over the last several decades—a development in which Smith himself has played a leading role. While most of this work has in some way been focused on a given empirical application or policy, the central theme in almost all of the papers is on advances in economic methods.

Indicative of this focus, Smith chose to organize his papers along methodological lines. After an introductory section of “overview” essays, the first substantive section is a collection of papers on the revealed preference methods or “indirect methods as detective work” as Smith titles it. This includes a large group of papers on travel cost models, hedonic models, and household production models. The second and smaller group of papers is on the stated preference approaches—“direct methods as listening to ‘data.’” A final section groups several papers addressing what Smith considers the “new horizons” in environmental economics. While the range of methods and issues in this collection is quite broad, there are some common themes that connect many of the papers. Smith has long had an interest in the issue of defining the extent of the market (his paper number 13 on the spatial extent of the travel market was published in 1980)—the same kind of problem common to market organization and antitrust applications. In a more recent paper that evaluates the plaintiff and defendant positions in a natural resource damage case (the Eagle Mine in Colorado), he correctly identifies this same issue as a major factor explaining differences in the two sides’ evaluation of the economic damages. Many of the papers focus on econometric and modeling issues, for example, use of a Poisson model for modeling household production (first published in 1993).

Perhaps because of his long-term involvement with the field, Smith has occasionally been asked (or inspired) to write about the big picture of where the field has been and where it is going. Excellent examples of this writing are in both the extensive preface (about 15 pages and in excess of 50 citations) and in his previously unpublished essay "Resource Evaluation at a Crossroad." One of Smith's themes is the transition from the historic benefit-cost project evaluation focus of the field to the current work that provides evaluation of regulatory and resource management policies characterized by uncertainty, a broader set of services and broader geographic scale. Both in the preface and in his last four "new horizons" papers Smith identifies what he believes are some of the key remaining issues in the field. One of these is the valuation of passive use (or "nonuse" as it was earlier termed). Since only stated preference methods can be used to value these services, Smith suggests the need for validation through experiments, calibration and surveys to provide "open data" that can be evaluated by both sides in a controversy. Another issue is how to more efficiently and reliably generalize existing estimates and studies to new situations ("benefit transfer"). Smith has also identified the potential for important insights from third party evaluation of the competing sides in natural resource damage assessment cases. His analysis of the Eagle Mine case in Colorado (published in 1989) to this reviewer's knowledge was the first such publication. Given the tremendous resources and considerable talent put in by both sides in many of these cases, there is the potential to learn a great deal from these comparative studies. A fourth area that Smith highlights is environmental costing—in part the quantification of externalities. He provides a specific paper in his collection focused on the implications of this issue in agriculture, but also mentions the general importance of these types of studies, for example in the electric utility sector.

Smith also was the first to introduce "meta-analysis." This collection includes several such papers, one an econometric analysis of the variation in recreation benefit estimates (first published in 1990) and another an evaluation of 25 years of research in hedonic models of air pollution. Smith has undertaken a similar analysis (not in this collection) of contingent valuation studies (Smith and Osborne, 1996). With regard to stated preference methods, the collection does include a paper on what is likely the first application of focus group methods in the development of contingent valuation instruments (a 1988 paper). This is now a standard element in most stated preference applications.

As with any collection consisting mostly of previously published papers, it is worth examining the possible justification. A potential limitation of the collected works of any single individual is that it is a bit serendipitous as to how completely the field is covered. As it happens, this collection does not include papers on global issues or biodiversity or any of a number of other major environmental issues. Nonetheless, in this reviewer's opinion, this collection provides a unique and valuable complement to other book-length texts in this field that are primarily focused on providing an overview of methods. For example, Braden and Kolstad (1991); Freeman (1993); and Mitchell and Carson (1989) come to mind as good overviews of methods. What the Smith collection provides is a different commodity—in large part a set of case studies that take one through the entire analytical and empirical process of theory, empirical methods, data, and findings. In

short, for those who are unfamiliar with the field Smith's collection is a valuable resource. For those who are already involved in this field and possibly already familiar with much of Smith's work, the several lengthy previously unpublished essays are recommended reading. This is a chance to think about "the big picture" with regard to methods and focus contemplated in a careful and insightful way.

In the same general period that the microeconomic issues in this field were beginning to be explored, economists were also examining the implications of nonmarket services for macroeconomic measures of growth and well-being. An early paper in this area that raised awareness of alternative measures of the benefits of economic growth was Boulding's (1970) "Fun and Games with the Gross National Product." Nordhaus and Tobin (1972) undertook some of the seminal quantitative work in this area. However, it is not as obvious that this line of work has to date made a real difference in welfare measures and policy—for example in the way GNP is defined and measured.

The book by Uno is in the "macro" tradition and sets out on a very ambitious agenda: "This study aims at constructing a systematic statistical framework concerning environment, technology, economy, and society and carrying out a series of analyses regarding the impact of human activities on the environment." (at xi.) The author views his work as providing three contributions: (1) an early attempt at implementing (and expanding on) the System for Integrated Environment and Economic Accounting (SEEA) proposed by the United Nations; (2) to develop measures of "green GNP"; and (3) to introduce the Japanese experience in environment-related fields. Uno points out that Japan offers an interesting case study for the application of his methods in that "it compresses industrial expansion and urbanization in a short time span of 40 years or so which is fully captured by various statistics" (at xiii).

The framework presented by Uno is an expansion of input-output analysis to include "environment, material flow, and lifestyle." His starting point is the conventional system of national accounts (SNA). After several introductory chapters, the main part of the book is a discussion of sectors for which national level statistics are available and which are environmentally significant. This includes chapters on energy demand and supply, transportation, pollution prevention investment, and environment-related R&D. The bulk of the book is taken up with fairly straight-forward descriptions of these sectors and often extensive data tables. For example, Chapter 6 on pollution investment is about 55 pages long and includes 42 pages of tables. One twenty page table reports investment by type of equipment (seven types of air pollution equipment, etc.) by industrial sector for 1970, 1975, 1980, 1985, and 1990. There is very little analysis or summary of most of this data—not even discussion of simple aggregate trends. The motivation for presenting this level of detail in the data presented is not obvious. One of the latter sections of the book is entitled "Natural Environment and Economy." This section consists of a chapter on land use (which is almost entirely descriptive) providing tabular material on land allocation by broad use category in Japan and a chapter on "Resource Endowment and International Linkages." The latter summarizes data (including imports and exports) for wood products, energy resources, and metals.

Only in the last two chapters (Part V Measuring Quality of Environment) does Uno offer some analysis and insights. Chapter 11 is characterized by Uno as a “controversial chapter which examines the relation between the quality of life and environment” (at xiii). He begins with a review of the early literature in this area including the well-known papers by Dennison (1971); and Nordhaus and Tobin (1972) and goes on to provide an interesting discussion of the development of a net national welfare measure by the Economic Council of Japan. Uno then presents some empirical measures using primarily the Nordhaus–Tobin adjustments (leisure time, loss due to urbanization, and environmental pollution, etc.) and reports a time series by five-year interval for Japan 1955–90. The cost of environmental degradation is estimated based on the costs of control to achieve 1955 levels of pollution. Of course this may understate or overstate the real cost of pollution damages. The relevant tables, which are extensive, are clearly presented and understandable. However, Uno never summarizes or interprets his results and only offers tersely at the end: “in lieu of a conclusion” that the “‘misuse’ of national account data has turned out to be a ‘proper use’ by the development of various data sets covering social, economic, and environmental spheres and, more importantly, by the development of SNA itself” (at 338).

In Chapter 12 (Social, Economic, and Environmental Data Set) Uno specifies the framework he is working from, referencing a background paper [Bartelmus, Stahmer and van Tongeren (1991)] to the earlier mentioned UN environmental accounting framework. Essentially Uno’s goal is identifying “sustainable” net domestic product (SNDP) by subtracting depletion or degradation of environmental assets (DZ) in economic activities. As Uno correctly observes, “the crux of the problem lies in estimating the term DZ” (at 347). The theoretical measure he chooses for DZ (as in his chapter 11) is treatment costs—which is very different from what Smith would advocate: a welfare measure of damages which would include foregone consumer surplus. Noting that “the conceptual framework is one thing, and empirical feasibility is another,” Uno presents an empirical model for application to Japan as a case study. The model is modified to reflect limitations in the availability of statistical data. He includes some separately-reported physical measures for certain quality of life indicators (such as average floor space and number of units for housing capital). This analysis he does carry to the end and reports estimated damage amounts equal to 8.6 percent of GDP in 1970 and 1.5 percent in 1990.

Uno is pragmatic in his conclusions and notes some of the limitations of his analysis. While his measure of environmental damages includes some air pollutants (SO₂, soot and dust, and automobile exhaust) and industrial and household waste and water pollutants, other pollutants and impacts on the environment are not included: “noise, vibration, odor, heat island, acid rain, global climate change, loss of ozone layer, etc.” and “endangered species, soil erosion, loss of scenic beauty, damage to historical sites, etc.” (at 391). In summary, he notes that one remaining fundamental question is “whether the statistical system such as the one presented here, or any indicator derived from it, will by itself suggest the road leading to sustainable development.” He concludes: “Apparently, the answer is no.” (at 392.) In his view the limitations of the framework presented include

the problem of measuring quality of life (as distinct from income and consumption), the uncertainty associated with projecting technology, and the need for international linkage in environmental accounts. Unless the impact of Japan's consumption and production activities on resource-producing countries is part of the analysis "the whole exercise will be in vain" (at 393).

Uno has undertaken a challenging and important problem. The study is well-documented and the author succeeds in providing a good introduction to Japan as a case history in pollution control investment. However, the book seems unfinished. Very few conclusions are offered and the analysis seems minimal compared to the richness of the data. The study is also limited by the author's choice to define what is relevant to environment and economy by what is readily available in conventional national economic statistical series and by spending an inordinate amount of time presenting this data. The book would be improved if the theoretical framework was presented early on, perhaps with a better review of the recent extensive literature in this area. Much of the data could be moved to an appendix. Nonetheless, beyond these editorial problems, the analysis that is presented is thoughtful and the conclusions are honest and pragmatic.

As already noted, these two books barely intersect. The key element in Uno's application, the DZ or environmental degradation measure, is estimated only in a limited way and then using treatment costs as a measure of damages avoided, but this problem is best approached by the methods Smith describes. In addition to the empirical measure chosen, there is the problem of identifying the appropriate theoretical construct. In his introductory essay Smith comments on the specific problem of air pollution emissions as an example of the need to view environmental resources as assets and to identify the effect of a given residual's impacts on the full range of the asset's services. The conventional Pigouvian direct interaction framework (which Uno implicitly adopts) shifts the focus from the resource to the activity involved in using them. Uno is Pigouvian in focusing on the externalities associated with a given activity, such as energy conversion, rather than on the environmental asset being impacted. This may systematically lead to understating impacts on a given environmental resource because other activities and services of this resource may be impacted in addition to the activity at issue. For example with regard to the atmosphere, carbon dioxide influences global climate regulation and chlorofluorocarbons affect the ozone layer, but neither of these pollutants is an important static source of externalities.

Both authors point to measures of environmental degradation as an important area for further research. In the context of global issues and environmental costing, Smith comments on the need to move from the historic project-level and partial equilibrium focus to one which acknowledges the presence of general equilibrium linkages inside and outside of markets. The last paper in Smith's collection in fact presents a preliminary estimate of the costs of environmental degradation on a national scale—but only for a single sector (agriculture). This paper is a valuable contribution that addresses many of the empirical and conceptual issues of aggregating the existing micro-level valuation work with measures of changes in environmental services. An important part of the problem is developing the ecological link between a given economic activity and these services. Relatedly, one of Uno's main conclusions is that: "The most important role

the framework can play would be to promote an interaction between in-depth study on the one hand and the comprehensive framework on the other. It is also essential to stimulate discussion between the natural sciences, social sciences and technology spheres. This is more easily said than done. But this is exactly what needs to be done today.” (at 393.)

In fact the research agenda Uno describes is at least in part reflected in the goals of a relatively new association of economists (formed in 1987), the International Society for Ecological Economics (ISEE). This association has provided an arena where the two problem areas described in the books under review are intersecting. As a generalization, this group moves beyond the mainstream economic efficiency-based analysis (represented by both Smith and Uno) to include long-term sustainability as a goal. Implicitly, intergenerational equity becomes a dominant criteria. Among other work, there have been several studies that address the same “green accounting” issue that Uno examines—and that come to different conclusions for the United States. This may be due to a difference in the two countries. It may also be due in part to moving closer to measuring change in terms of economic welfare (as opposed to output or just market-priced consumption) and by including more comprehensive measures of environmental damages. Several recent studies of this issue include Daly and Cobb, 1989; Cobb and Cobb, 1994; and Max-Neef, 1995. Some of these authors find a leveling of welfare since 1970 while GNP has continued to increase. A recent issue (August, 1995) of the society’s journal, *Ecological Economics*, focused on the problem of ecosystem valuation and included a number of papers stemming from the Ecosystem Valuation Forum sponsored by the U.S. Environmental Protection Agency in 1991–92. The paper by Bockstael *et al.* (1995) provides a specific example of ecological economic modeling and ecosystem valuation applied to the Patuxent River watershed in Maryland. Several papers in this volume address fundamental conceptual issues, including the relationship of economic efficiency and sustainability (e.g. Woodward and Bishop, 1995). These papers provide a perspective on a microeconomic and ecological economic foundation for addressing the kind of problems that Uno tries to address.

A recent article in *Nature* (Costanza *et al.*, 1997, hereafter Costanza) provides an estimate of the annual value of the world’s ecosystem services and natural capital. By contrast with Uno’s SNA-constrained definition of environmental services, these authors identify the annual value of services for a matrix of 17 categories of environmental services (e.g. climate regulation, water supply, erosion control, nutrient cycling, waste treatment, etc.) and 16 marine and terrestrial biomes (open ocean, coastal, forest, grasslands, etc.). Uno’s definition of natural and environmental resources is limited to the substantial natural resource-based market sectors including energy, minerals, forestry and agriculture. Nonmarket resources (which leave no trace in the SNA) are excluded. The Costanza paper draws on an extensive literature including ecological and economic studies. The authors conclude that the annual value of these services is US\$16–54 trillion, with a point estimate of \$33 trillion. This is about 1.8 times larger than the global gross national product estimated to be around \$18 trillion per year. The authors acknowledge the many conceptual and empirical problems inherent in such an estimate, but suggest that their estimate is probably a minimum value. (Among

other issues, the study uses a partial equilibrium framework.) The main point of the study is that ecosystem services provide an important portion of the total contribution to human welfare on this planet. The policy implication is that “we must begin to give the natural capital stock that produces these services adequate weight in the decision-making process” (at 259). One of the 17 ecosystem services categories, climate regulation, has in fact been the subject of numerous recent global studies, some of which come to a similar policy conclusion.

It is not straightforward to compare the Costanza estimates with Uno’s. Uno’s measures are primarily annual environmental control costs as a proxy for annual environmental degradation by industrial sector for Japan. Costanza’s are global estimates of annual contributions of ecosystem services—not how much these services are diminished in a given year. Nonetheless, some limited insights can be gained by comparison. The global estimates show waste treatment (the only specific service for which Uno reports even partial measures) as accounting for only a relatively small amount (about 7 percent) of the total value of global ecosystem services. Needless to say it would be interesting to see an analysis that examined impacts on the other 16 categories, including, as Uno suggests, the exported impacts.

The Costanza estimates also provide an interesting perspective on the relative significance of different ecosystem services. Recreation services, which historically have been a major focus within the field of nonmarket valuation (e.g. Smith, reviewed here), accounts for only 2.5 percent of total value. Most of this work has additionally been focused historically on the so-called consumptive uses (hunting and fishing) as opposed to nonconsumptive uses such as driving for pleasure, bird watching, and wildlife viewing and photography. Of course the optimal allocation of research effort would not follow the share of annual contribution, but would also take account of what is at risk and current impacts.

The conclusion of this review is (no surprise) that there are lots of interesting things remaining to work on in the field of environmental economics. Smith’s collection is an impressive set of papers that provides a solid foundation of past research and a valuable perspective on the future. Methodologically, the field has made tremendous progress in the development of several powerful and general tools for nonmarket valuation—in particular, the random utility travel cost models and contingent valuation. A remaining problem for the travel cost models is that models cannot deal consistently with decisions over both the choice set and participation. Estimates are usually not very robust to changes in model specification. The core problem for contingent valuation is reliability. There is an obvious need to develop procedures and accumulate sufficient experience for these approaches to be generally acceptable to the mainstream of the profession. The author of this review concurs with Smith that the problems of nonuse value, benefit transfer and environmental costing are leading topics on the future research agenda. An important extension of the environmental costing issue is the integration of microeconomic methods and data sets into evaluation of macroeconomic issues. Here the book by Uno is a bit of a disappointment, largely due to his SNA-constrained definition of natural and environmental services. Obviously one should move cautiously from the precision afforded by market transactions and double-entry accounting. However, perhaps the biggest set of

remaining issues concern sustainability—including depletion of our descendants' natural heritage and long-term damage to ecosystems. For these topics, precision may only come at the price of irrelevance. The step from Uno to Smith is made by accepting the economic relevance of nonmarket exchanges. The next step, the ecological economics step, is into an even more complex realm—a realm where the future-blindness of discounting and efficiency analysis is recognized. The challenge is in combining the theoretical rigour characterized by both Smith and Uno's work with the admittedly rough and ready (one might say heroic) scope of the Costanza paper.

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