ON THE ECONOMIC VALUATION OF ECOSYSTEM SERVICES

by

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On the Economic Valuation of Ecosystem Services[1]

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Abstract

A recent publication in *Nature* suggests that the economic value of global ecosystem services is between $16 trillion and $54 trillion, with an average of $33 trillion. This far exceeds the aggregate Gross World Product ($18 trillion). It is argued herein that the foregoing estimate is based on methodological assumptions that are seriously flawed. The use of willingness-to-pay survey data for estimating values in the absence of market prices is problematic, as is well-known. But the conclusion that ecosystem services are worth more than gross world product (GWP) is internally inconsistent. An hypothetical general equilibrium GWP incorporating monetized ecosystem services within a 'virtual' market must reflect not only hypothetical payments by the rest of the economy for ecosystem services (i.e. *to* ecosystems, or their proxies) but also payments *by* ecosystems for economic services such as protection and rehabilitation. In other words, the economic *value* of ecosystem services in a steady state equilibrium must be exactly equal to the *cost* of maintaining the relevant ecosystems in a steady state. These costs would surely be only a few percent of GWP.

Background

A recent multi-author book has effectively summarized both the philosophical issues underlying the valuation problem, and many of the specifics of ecosystem services [Daily (ed) 1997]. As was inevitable, some authors are more quantitative than others and the assumptions made in quantification vary from author to author. An heroic effort to produce a set of methodologically consistent totals in monetary terms has also been published recently in *Nature* [Costanza *et al* 1997].

It is appropriate for me to say here that I accept the utilitarian, human-oriented value systems adopted by the authors. Nor am I uncomfortable with their qualitative conclusions that environmental services have been and are still grossly undervalued in many private transactions and government decisions. Yet, though I am in general agreement with the results, at least in qualitative terms, I am thoroughly uncomfortable with the quantitative results of the economic anyalysis, which applies standard partial equilibrium economic logic to a situation where it cannot be applied. The long list of caveats in the paper is not taken seriously enough. I suspect that those whose economic interests are served by setting "growth" ahead of environmental protection will find both the analysis and the results thoroughly unconvincing, which is unfortunate.

The model used by Costanza *et al* for valuation is, at first glance, a logical extension of the intersecting supply-demand curves of neoclassical marginalist analysis (see *Figure 1a* of their paper). To be absolutely clear, the "demand" curve represents the composite demand of a large group of consumers with different individual preferences and different willingness to pay for the commodity or service. Some are willing to pay more than others; more consumers are willing to pay as the price falls. Meanwhile the supply curve represents the availability of the commodity or service as the price rises. The higher the price, the greater the supply because more and more producers enter the market. The three economic measures of value adopted by the authors (in order of preference) were (1) consumer surplus plus producer surplus, (2) producer surplus (net rent) and (3) price times quantity. All three measures, however, depend on price estimates, many of which depend on "willingness-to-pay" survey data and all of which are explicitly at the margin. This raises questions about the legitimacy of extrapolation.

I discuss the price issue in the next section. A more fundamental problem, arising from the "partial equilibrium" treatment, is discussed subsequently.

Marginal prices and extrapolation

The first problem concerns imputed prices for ecosystem services and the legitimacy of multiplying marginal prices by quantities. It is questionable whether "willingness to pay" is a legitimate artifice in the absence of real market prices. It makes sense in an imaginary static world of educated consumers facing an array of goods and services with known characteristics. It is much less justifiable in a dynamic world of extremely incomplete and contaminated information, where most people literally don't know what to think about problems they have never had to face.

A brief digression is needed. WTP is clearly justifiable in a model world of rational utility maximizers where the consumers all have fixed preference orderings (which are consciously known and immediately applicable to every situation) and behave with perfect rationality.[2] But this is obviously unrealistic. Fixed and immutable preferences are rare and exceptional. While there are people with unchangeable views on almost every side of every issue, the same people who are totally committed to support or opposition to abortion (or firearms, or marijuana, or ...) are likely to be very fuzzy and unsure on most other issues. To paraphrase Abraham Lincoln, everybody has some definite preference orderings, and some people have a definite preference order that encompasses a lot of things, but nobody has a definite preference ordering that is both unchangeable and comprehensive. The truth is that most people don't know what they think about most things, most of the time. Were it otherwise, there would be no need or demand for editorials, debates, lawyers with oratorical skills, juries, public hearings, public relations, "spin doctors", advertising or politics.

In short, preferences as applied ecosystem services are evidently mutable and changeable. Part of the reason is that even if people could state clear preferences for outcomes, it is seldom clear what policies or practices result in what outcomes. There are two sources of uncertainty. One is scientific uncertainty. There are situations where even the most advanced science is unable to make clear unambiguous predictions. (For instance, what ecological impacts would result from climate warming?) The other source of uncertainty is in the knowledge dissemination system. Not everyone has the educational background to understand the science. Most people do not keep abreast of the latest developments. (Very few people read every word of *Nature* or *Science*, and even fewer read *Ecological Economics*.) To make matters worse, the popular media thrive on conflict, or the appearance of conflict, so that exponents of idiosyncratic views receive disproportionate media coverage. The net result is that information is heavily contaminated with disinformation and misinformation.

In short, I think WTP is too blunt an instrument for practical application to such complex issues as climate warming. By way of illustration, consider the range of valuations given by different studies applied to a much more straightforward question: the relative damage potential of specified pollutants and toxic substances (*Table 1*). If very sophisticated analysts working independently cannot achieve more consensus on such a well-formulated question, how can we attach any credibility to WTP as applied to more complex issues?

Table I: Estimates of relative damage potential of specified pollutants & toxic substances

Source		**1993 dollars per metric ton**				
Marginal damage estimate [(a)]		***CO***	***VOC & CO***	***NO_X***	***SO_x***	***Particulates***
[Repetto *et al* 1996] p.24		0.8	1148	661	758	2509
[Repetto 1990]				199	552	2209
[Elkins & Russel 1985]			1148		1151	2764
[BPA 198?]	West of Cascades			678	2761	1181
	East of Cascades			53	310	128
[US-EC undated] [(b)]	Knoxville				42	2523
	Four Corners				4	230
NY State Externalities Study [(c)]	Rural I			645	501	2291
	Rural II			696	523	3136
	Suburban			645	573	5514
	Urban			788	859	31363
Northern State Power [Banzhaf 1995]	Urban	1.2		226	99	3385
	Rural	0.2		18	12	467
	Metropolitan fringe	0.8		60	51	1605
EPRI [Koomey 1990] [(d)]	Rural PA/WV			108	745	
	Suburban NY				1971	
NPC [Wang *et al* 1994]	Las Vegas Valley			169		1092
	Outside			138		154
Environmental Load Index [(e)] ***[Steen 1993]***		***CO*** 35.5	***PAH*** 64350	***NO_X*** 28.6	***SO_x*** 13.1	***Particulates*** 1.0
		CO_2 11.7	***Ethylene*** 129.7	***N_2O*** 926.8	***BOD*** 0.26	***COD*** 0.21

(a) Marginal Damage Estimates here are all shown in Repetto *et al* 1996, pp. 23-24 Tables 2.1 and 2.2. The original units (1987 dollars) have been converted to 1993 dollars using a conversion factor of .786 1993$ per 1987$.
(b) Coal fired plants.
(c) Central estimates for Natural Gas Combination Cycle facility.
(d) Best estimate.
(e) Original units for the Environmental Load Index were 1993 ECUs per kg. These have been converted to 1993 dollars per metric ton using a conversion factor of 1.32 dollars per ECU.

Apart from the utility of WTP, it is a classic problem for environmentalists that short term benefits tend to dictate actions and resource allocations that are environmentally suboptimal, or even disastrous, in the long run. The best known example is the fact that, for any realistic discount rate assumption, cutting (or burning) rain forest in the Amazon to create grazing land for cattle is typically preferable on a cost-benefit basis — *even if the land is destroyed thereby* — to sustainable long-term use of the forest based on its natural products. This has prompted a lot of heartburn over the use of discounting and the choice of discount rates in various circumstances.

If the preference for short-term exploitation *vis a vis* conservation is at all generalizable, it implies that the marginal present value of the natural system, relative to its most profitable "economic" use, is often negative. This is a datum, not an opinion. There is a tendency to try to get around it by arguing that discounting is inappropriate, or that the "market" rate is too high for a "social" purpose. But the market rate of interest is also a datum. Though I have some sympathy with the argument that there should be different discount rates for different situations, it will surely be regarded as specious by anyone whose direct economic interest is threatened.

The analogy with stock market valuation is instructive. The market valuation of a stock almost invariably rises with every announcement of a major layoff of employees. In effect, the market is saying that employees, at the margin, are simply a cost providing no corresponding benefit to the firm. But of course, if all the employees were laid off, the firm could not operate, and it's stock would then be valued at the net current market value of physical assets (land, buildings, cash and receivables, plus scrap value of equipment, less debt). If all firms did this, those assets would be worthless.

Any intelligent critic will immediately respond by saying that of course there is an optimum employment level for firms, greater than zero, but less than the current level. We can say much the same thing about the environment: there is probably an optimal amount of rain forest, or of wetlands, or of biodiversity. But the stock market does not know (cannot know) where this optimum is, or how to find it. Yet if it attaches negative value to the marginal increment now, why should it not do so again when employment is half, or a tenth, the present level?

The attempt to calculate environmental benefits in absolute terms (rather than in net present value terms) is laudable, and perhaps necessary to avoid the pitfall of negative net present values. But extrapolation of partial equilibrium estimates from the margin to the whole is also problematic for other reasons. The nature of the difficulty becomes clearer (I hope) in the next section.

The model

As Costanza *et al* duly acknowledge, the standard equilibrium supply-demand model applies to a case where a commodity is both produced and consumed by humans. The demand and supply curves reflect possible allocations of resources: income on one side, labor and capital on the other side. There is a closed (but implicit) cycle of monetary flows. Producers and consumers belong to the same economic system. Consumer income is derived from producers wages. The explicit balance between supply and demand of the produced commodity is only part of the story. In the real economy there is also an implicit balance between supply and demand of other goods and services —resulting in budgetary constraints — including labor and capital. This is what is meant by "general equilibrium".

Because of budgetary constraints, which correspond to limitations on output and the availability of factors of production, neither demand nor supply curves can go to infinity in the real economy. The demand curve, even for an absolute necessity, remains finite: the maximum price any consumer will pay cannot exceed the total income of the richest consumer (e.g. Bill Gates). Similarly, the price of a produced good cannot fall to zero, because wages (and capital costs) must be paid.

Costanza *et al* have introduced two deceptively simple conceptual devices (in their *Figure 1b*) that are intended to introduce ecological realism. They are: (1) vertical demand and supply curves to reflect supposedly infinite willingness to pay for absolute necessities on the one hand and limited supplies at any price on the other hand, and (2) the notion of a monetary "producer surplus" to a natural system. The problem with a vertical demand function (device #1) is that consumers in a real economic system cannot pay more money than they actually receive as income from wages and dividends or interest. So the demand curve for humans must be finite after all. Only the supply curve can be vertical, meaning that supply remains finite regardless of price or willingness to pay.

The problem with device #2 is that nature itself cannot enjoy a producer surplus in monetary terms. Only the human owners (if any) of natural systems can extract a monetary rent. Presumably where private ownership is already a fact, they do so. Where it is possible but not actual (as with common land) this change of status would reduce the extent of the "tragedy of the commons". But, of course, most ecosystem services are inherently indivisible and thus public goods. This is why they are not "sectors" in the current economy.

For purposes of analysis, however, let us suppose that this difficulty were magically waived. Let us assume, in the spirit of a *gedanken* experiment, that a new set of sectors is introduced to the economic system to provide "ecosystem services" of the kind described in exhaustively in the book cited earlier [Daily 1997]. Like any private business, we assume for purposes of argument that these new sectors have the ability to withhold the services they currently provide free, so as to demand (and maximize) appropriate economic rents in competition with labor and capital. Based on the arguments outlined in the *Nature* article, this rent is assumed to be $33 trillion.

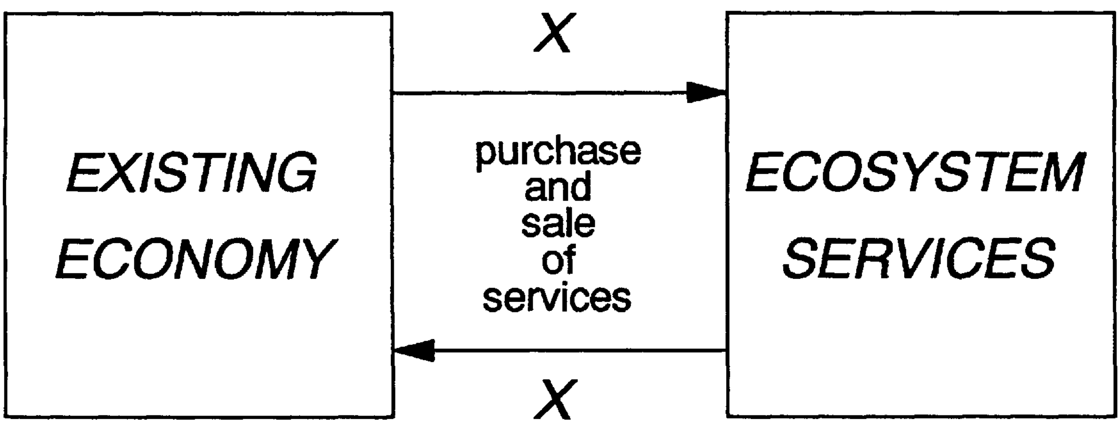

Figure 1: Monetary flows in an equilibrium exchange economy

Note, however, that in an *equilibrium* exchange economy money must flow in both directions between the old economy and the new sectors. The situation is pictured schematically in *Figure 1*. Let us assume that the gross world product in the existing exchange economy is Y and that the annual monetary payments for ecosystem services are X. Then, we have

$$Z = Y + 2X$$

where Z is the revised gross world product, taking into account the new service sectors. The factor 2 arises from the fact that, in equilibrium, each dollar paid *to* the ecosystem service sector must be matched by another dollar paid *by* the sector. So if X is the aggregate monetary payment for the services of ecosystems, there must be an equal payment of X in the reverse direction, also for goods and/or services provided by the conventional economy. (We ignore the possibility of payments between subsectors within the new sector). Based on the numerical values $Y = \$18$ trillion and $X = \$33$ trillion, the value of Z becomes $84 trillion and the "ecological" share of that total is X/Z or about 0.39.

This calculation will seem reasonable, at first sight, to many ecologists. But it leaves a very big question unanswered, namely: what does the new "eco-sector" do with its money? There are only two possibilities. Either it must buy goods and services from the conventional economy, or it must buy assets. But, by assumption, the total payment must add up to $33 trillion. Yet the eco-sector clearly has no need for manufactured products, with the possible exception of fences to keep humans out. Quite possibly it would buy other services to ensure protection of habitats from interference — i.e. defense — as wealthy humans do. Some ecosystems might buy habitat renovation services.

But the point of the argument should be obvious by now. The economic value of ecosystem services in a steady-state general equilibrium exchange economy cannot exceed the economic value of the goods and services it buys to maintain itself. (If it did, the eco-sector would have to use the surplus funds to *expand* its territory — buy buying land, water rights, etc. But in this case the ecological-economic system would not be in a steady-state equilibrium). In other words, the *value* of the aggregate services of the ecosphere to humans, in equilibrium, must be exactly equal to the *cost* of maintaining the various components of that system in a sustainable steady state.

How much would this cost be?

Here it is important to bear in mind that the advanced industrial countries have actually come close to stabilizing the natural ecosystems within their geographic borders. Air and water pollution have been significantly reduced, and the total cost of this "cleanup" effort has not exceeded a few percent of GDP (some of which has been inefficiently spent). The problems that remain unsolved are mostly in developing countries or in the "global public goods" category, especially global warming, and over-fishing of the oceans.

In most cases, the cost of maintaining stability by preventing further human encroachment on natural terrestrial systems such as tropical rainforests and allowing marine systems to recover from overfishing would be very small, or even negligible in terms of GWP. The environmental organizations have not the resources to buy up and protect the remaining rain forests of the world, but the governments of the countries in question could do so at very modest one-time cost. (Instead of which they are selling the remaining forests to wealthy and unscrupulous mining and timber companies for relatively trivial sums.) Even the most pessimistic estimates of the "cost" of stabilizing climate by accelerating the phaseout of fossil fuels are in the range of $1 trillion or so, and that would be spread over the next century (i.e. as a very small constraint on economic growth).[3]

This is not the place to calculate the continuing economic costs of permanent eco-system stabilization. However I believe that a few hundreds of billions of dollars (spent wisely) would accomplish most of the needed one-time repair and cleanup costs for old messes (such as strip mines). Another few hundred billions would suffice to purchase most of the remaining wilderness land in the world and finance permanent protection as habitats for non-human species. Maintenance costs and waste treatment would cost no more than a few percent of the conventional GNP thereafter. (Even this seems to be too much for most governments and business interests to accept readily, but that is another issue.)

Apart from my quantitative point of disagreement with the numbers in the *Nature* article, I think it is worthwhile to re-emphasize the enormous difference between the results of a partial-equilibrium calculation, in some cases, *vis à vis* a general equilibrium calculation. The partial equilibrium approach is inherently local; it cannot be extrapolated safely to global scale. For this reason the production function approach initiated by the World Bank to estimate the value of natural capital, despite its flaws, seems more promising [World Bank 1995; Sarageldin 1995].

In any case, a cost estimate for the human services to ecosystems in a steady-state equilibrium exchange market is the key to estimating the value of ecosystem services to humans. I think it is an obvious next step for research.

Endnotes

1. Much of the material in this commentary is from a forthcoming book.

2. This is, in fact, the standard economic utility maximization model as it is usually formulated.

3. I happen to think those estimates are grossly exaggerated, but that is another question.

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