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The concept of environmental function and its valuation

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For a better understanding of the text we would like to provide the reader with the following information. The Figures referred to in the text of Section 1 relate to the concept of environmental function as designed by Hueting. The Figures referred to in the text of Section 2 relate to this concept as – wrongly – used in the *Nature* article of Costanza c.s.¹, *except the text of the last paragraph*. The letters in this paragraph refer to the Figures in the article of Costanza c.s. and without having these Figures at hand it is hardly possible to understand the text. At the time of the publication this *Nature* article was widely distributed and easy to get. Because this is not so today, we replaced the Figures, used in our published article, which have insufficient letters on the axes, by Figures with sufficient letters on the axes, and adapted the text of the last paragraph, using letters which refer to the new Figures.

When reading the last paragraph one should have in mind (1) that we are concerned here with a comparison with National Income figures that do not include consumer surpluses and (2) that the value of environmental functions basically are costs generated by production and consumption; these costs increase from zero (free goods) to an ever increasing level according as production as measured in National Income increases.

Finally one should be aware of the fact that our article had to be limited to two thousand words.

Roefie Hueting and Bart de Boer, August 2007.

Abstract

The concept of environmental function and its valuation methodology were introduced by Hueting (1970, 1974 etc.). The 'services' of functions, without which humans cannot survive, are defined as their possibilities to be used. The value of functions (or their services) is sharply distinguished from the value added by labor, involved in using or 'harvesting' the functions. Estimating the value of functions requires data on the opportunity costs for regaining functions and on preferences for the functions, because functions have no economic value if no alternative has to be sacrificed and if there are no preferences to acquire them. The *Nature* article seems to be in conflict with this approach.

¹ R. Costanza, R. d'Arge, R. de Groot, S. Farber, Monica Grasso, B. Hannon, K. LIMBURG, S. NAEEM, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton and M. van den Belt (1997), *Nature* **387**, 253 - 260

1. Functions and their valuation

The concept of environmental function and its economic valuation methodology were introduced by Hueting (1970, 1974a and 1974b), and supplemented and summarized in numerous articles, e.g. Hueting (1975, 1989, 1992), Hueting et al. (1992, 1995). They are summarized below, briefly and incompletely.

Environmental functions are defined as possible uses of our natural, biophysical surroundings that are useful for humans. Uses can be either passive or direct and practical. The 'services' of environmental functions are defined as their possibilities or potential to be used by humans for whatever end. Some functions can be conceived as consumption goods, others as capital goods.

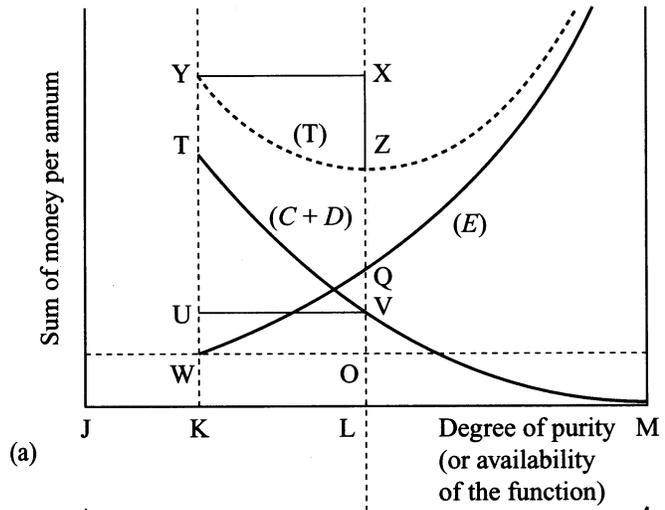
'Producing' is defined, in conformity with standard economics, as 'adding value' (by transforming one 'good' into another to satisfy wants). Value is added by labor. Environmental functions do not produce in the economic sense of the concept, nor are they produced. Economically speaking, a fish in the water is not the same good as a caught fish. The difference is brought about by the value added by labor.

Because we ultimately depend on labor and environmental functions, we stand literally empty handed if we destroy vital functions, unless we find substitutes (e.g. solar for fossil fuels). Most functions of natural ecosystems cannot be substituted.

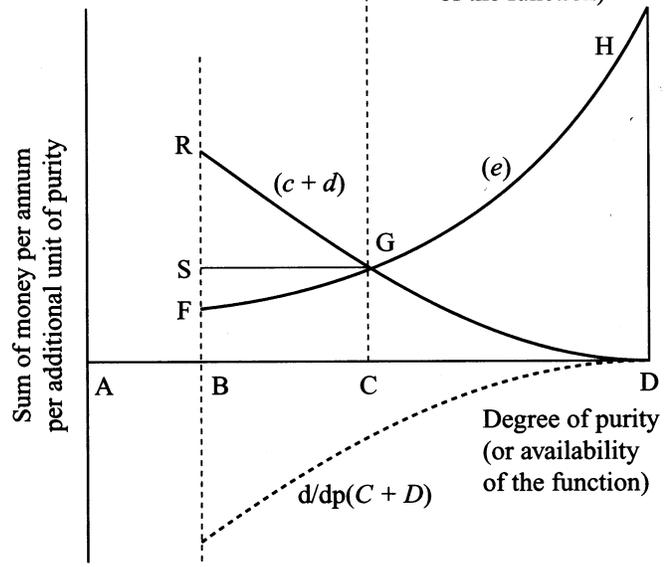
As soon as the use of a function is at the expense of another (or the same) function, or threatens to be so in the future, there is competition of functions. Competing functions are economic goods, because they fully meet the definition of scarcity. Functions have been changed from free goods with an economic value zero into scarce goods with a ever higher positive value. This increase in value is basically an increase in scarcity (costs).

For the valuation of functions, the construction of both a supply and a demand curve is indispensable. If there are no opportunity costs or no preferences, the economic value of a good equals zero. Supply curves reflect the costs of all kind of measures needed to restore and conserve functions: opportunity costs. They can always be constructed, except for irreversible actual losses. Demand curves can only very partially be constructed with the aid of data on expenditures on compensatory measures that replace a function, on financial damage etc. (revealed preferences), and willingness-to-pay techniques (see Figure 1).

Consequently, for finding shadow prices for functions, it is necessary to make assumptions about (individual and social) preferences, in CBA's and green accounting. Thus the assumption that we want to use vital functions sustainably can yield Sustainable National Income (with the aid of a comparative-static model) (see Figure 2).



(a)



(b)

Figure 1 *Costs of elimination and revealed preferences for an environmental function: (a) total curves; (b) marginal curves. (E) = elimination costs, (C+D = compensation and (financial) damage costs, (e) = marginal elimination costs, (c+d) = marginal compensation and damage costs. Taken from Hueting (1974a)*

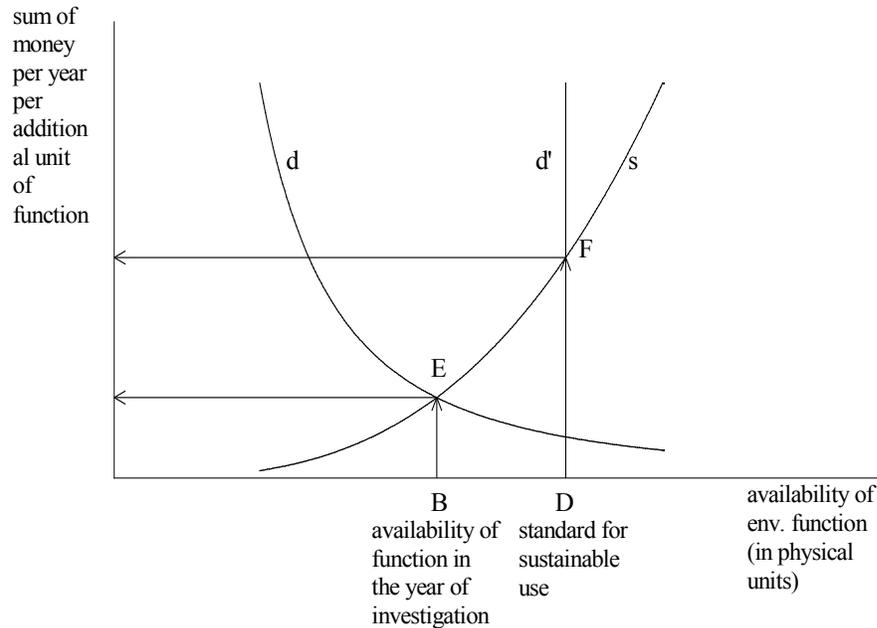


Figure 2. *Translation of costs in physical units into costs in monetary units: s=supply curve or marginal elimination cost curve; d=incomplete demand curve or marginal benefit curve based on individual preferences (revealed from expenditures on compensation of functions, and so on; d'='demand curve' based on assumed preferences for sustainability; BD=distance that must be bridged in order to arrive at sustainable use of environmental functions; area BEFD=total costs of the loss functions, expressed in money; the arrows indicate the way via which the loss of environmental functions recorded in physical units is translated into monetary units. The availability of the function (B) does not need to coincide with the level following from intersection point (E)*

2. Some comments on the *Nature* article

On the face of it, it looks as if the authors of the *Nature* article used supply and demand curve analyses for their estimates, in line with Section 1. But the supply curve in diagram 1B is not a supply curve, and it is not clear what the 1A supply curve represents. Also their demand curve is probably not appropriate in either figure.

Fig.1B supply curve is almost perpendicular to the abscissa, thus intersecting it. This means that the services of the function (see Section 1) can be supplied without costs up to the perpendicular. This conflicts with economic theory and environmental fact.

It conflicts with economic theory because, as Figure 1B shows, the authors are valuing free goods with a value above zero, which is by definition impossible; opportunity costs cannot overlap the abscissa (see Section 1).

Fig.1B conflicts with fact because nowhere on our planet is there any place where ecosystem services (see Section 1) are not threatened. Both actual and anticipated use involve opportunity costs (forgone alternatives). The availability of environmental functions depends on biophysical processes: life support systems. These systems are today being disturbed to such a degree that the availability of vital functions is jeopardized worldwide, risking the possibilities of future generations to fulfil their needs. Research shows that the opportunity costs of restoring and safeguarding those systems and functions are very high indeed. A rough estimate by Tinbergen and Hueting (1991) arrives at 50 % of World Income.

Such opportunity costs are not reflected on the curve in 1B. Therefore this curve cannot be a supply curve in the economic sense and cannot be used for economic valuation of environmental functions. Figure 1B tells us only that the price of each quantity of function greater than indicated by the perpendicular would approach infinite; the (near) perpendicular does not supply a function or its services. Their text (page 257, first column), states: "...to the extent that ecosystems cannot be increased or decreased by actions of the economic system, their supply curves are more nearly vertical..". We agree that ecosystems, as a result of millions of years of evolution, cannot be increased by human action. But they certainly can be - and are - decreased by human production and consumption.

As stated before, ecosystems can be maintained and restored by human actions, if no irreversible losses have been caused: by doing certain things and refraining from others. It looks as if the authors realize that irreplaceable functions cannot be supplied. However, it is possible to formulate measures (what has to be done and what has to be refrained from) in order to safeguard irreplaceable ecosystems, and to estimate opportunity costs. This yields an elimination cost or supply curve as described in Section 1: the less risks one wishes to take, the higher the costs.

The authors write that the demand curve is mainly derived from willingness-to-pay inquiries. We agree with the drawbacks mentioned: lack of information about the significance of ecosystems leading to underestimates. Other drawbacks to this technique make it questionable whether this approach can yield reliable figures for vital global functions (Hueting, 1989, 1992).

Quite apart from this, we question the way in which the authors seem to use this approach. For example, p. 255 reads: "..... if ecological services provided a \$50 increment to the timber productivity, the beneficiaries of this service should be willing to pay up to \$50 for it". We understand that this means that if, for example, a hectare of forest has a yearly increment in cubic metres of wood that would yield \$50 on the market, the beneficiaries should be willing to pay \$50 for this service. So the yearly services of an

ecosystem are basically valued by their potential market revenues. Valuing environmental functions by their potential market revenues is also used elsewhere (e.g. De Groot, 1992)

However, market prices reflect the sum of the values added involved in harvesting the services of the function, such as wood, and not the costs of maintaining the environmental service function up to a desired degree (see Section 1). Value added by labor and the value of functions are completely different. Consequently the authors demand curve cannot be a demand curve for functions. Ecosystem functions are not valued at all.

For vital functions of ecosystems, valuation is based on an alleged producer surplus, as shown in 1B. However, as stated above, the 1B "supply curve" cannot be a supply curve in the economic sense. This makes any comparison with a producer surplus on a market impossible. There cannot be a producer surplus without opportunity costs, that is: without producers.

For other functions the economic value is said to equal the sum of producer and consumer surplus (excluding the cost of production: p. 257, column 1). A consumer surplus is the amount of money people are willing to pay beyond the price of a good. It is the difference between the total utility of a good and the product of quantity and price (as the criterion of marginal utility). There are several objections to using this concept as a basis for valuing functions, especially on a world scale.

First, at the macro level, a consumer surplus has little or no significance, because all available production factors have been used on that level. People might be willing to pay more for the total amount of goods (including environmental functions) available, but they are unable to do so.

Second, unavoidable choices are almost always between quality and quantity (availability) of functions and goods produced. The intra-marginal utility of goods produced also approaches infinity, just like that of functions. After all, it includes the utility of medical care that saves the life of a child; the first slice of bread; and the first sip of water. A sincere comparison should either include or exclude consumer surplus with both categories of goods (this is one of the four reasons why the comparison with GNP on p.259 is incorrect).

Third, consumer surpluses are very difficult to measure, if at all.

It follows from the above that the total economic value of functions does not equal the sum of producer and consumer surplus. Total utility (surface BCGR in Figure 1b) includes also the surface BCGS in Figure 1b. It also follows that any practical economic analysis, (e.g., cost-benefit, or green national accounting), should use either price times quantity (BCGS) as the value of functions or, according to some authors (e.g. R.Hueting) surface BCGF, both Figure 1b. That is, of course, under the — questionable — assumption that curve (c+d) reflects the preferences completely; see Figure 2 for the situation with assumed preferences for environmental sustainability.

References

De Groot, R., 1992. Functions of nature. Evaluation of nature as a tool in planning, management and decision-making. Wolters-Noordhof.

Hueting, R., 1970. Functions of nature: Should nature be quantified? *Economisch-Statistische Berichten*, 21 January (in Dutch). Also in Hueting, R., 1970. What is nature worth to us? A collection of articles from the years 1967-1970 (in Dutch).

Hueting, R., 1974a. *New Scarcity and Economic Growth*. Dutch edition: Agon Elsevier. English edition: North-Holland Publishing Company, Amsterdam, New York, Oxford, 1980.

Hueting, R., 1974b. A Statistical System for Estimating the Deterioration of the Human Environment. Paper prepared for the Symposium of the International Association for Statistics in Physical Sciences (IASPS) at Harvard University, August 10-20, 1971. In: *Statistical and Mathematical Aspects of Pollution Problems*. John W. Pratt (ed.). Marcel Dekker Inc., New York.

Hueting, R., 1975. Environmental Deterioration, Economic Growth and National Income. Paper prepared for the 14th General Conference of the International Association for Research in Income and Wealth (IARIW) at Aulanko (Finland), August 18-23, 1975.

Hueting, R., 1989. Correcting National Income for Environmental Losses: Towards a Practical Solution. In: Y. Ahmad, S. El Serafy, E. Lutz (eds.), *Environmental Accounting for Sustainable Development*. The World Bank, Washington, D.C.

Hueting, R., 1992. The Economic Functions of the Environment. In: *Real-Life Economics*. P. Ekins and M. Max-Neef (eds.). Routledge, London and New York.

Hueting, R., Bosch, P., and de Boer, B., 1992. Methodology for the Calculation of Sustainable National Income. *Statistics Netherlands, Statistical Essays, M44*, SDU/Publishers, 's-Gravenhage. Also published as WWF International report, Gland, Switzerland.

Hueting, R., de Boer, B., Bosch, P. and van Soest J.P., 1995. Estimating Sustainable National Income. In: W. van Dieren (ed.), *Taking Nature into Account*, Springer Verlag New York.

Tinbergen, J. and Hueting, R., 1991. GNP and Market Prices: Wrong Signals for Sustainable Economic Success that Mask Environmental Destruction. In: R. Goodland,

H. Daly, S. El Sarafy and B. von Droste (eds.), *Environmentally Sustainable Economic Development: Building on Brundtland*. United Nations Educational, Scientific and Cultural Organization, Paris. Also in: R. Goodland et al. (eds.), 1992. *Population, Technology and Lifestyle. The Transition to Sustainability*. Island Press, Washington, D.C.; and in: R. Goodland et al. (eds.). *Environmentally Sustainable Economic Development Building on Brundtland*. Environment Working Paper No 46, The World Bank, Washington, D.C., 1991.

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