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Some Procedures for Determining their
Economic Value**

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Ecosystem Services – A Re-examination of Some Procedures for Determining their Economic Value

ABSTRACT

The importance of taking account of the total economic value of ecosystems is stressed and the possible reasons why the Millennium Ecosystem Assessment (2005) emphasised the importance of ecosystem services for biodiversity conservation is discussed. It is suggested that the Millennium Ecosystem Assessment does not give enough attention to the disservices association with some ecosystems nor to the comparisons of the value of alternative ecosystems. Reasons why it is important to estimate the total economic value of ecosystems are outlined. It is argued that the economic valuation of ecosystems is of little value unless it compares the economic value of alternative ecosystems or forms of land use. Most published economic valuations of ecosystems fail to do this or only do it to a very limited extent. The cost of replacing ecosystem services if an ecosystem is lost is sometimes used to value its services. In most cases (but not all cases), this tends to over value the loss. This is illustrated using some simple graphs. There is also the further complication that if one type of ecosystem is replaced by another form of land or aquatic use, some ecosystem services may continue to be supplied, possibly in reduced quantities or qualities. In such cases, assuming that the pre-existing services are totally lost and need to be replaced completely overstates the economic value lost, or in other words, the value of retaining an existing ecosystem.

Keywords: biodiversity conservation, cost of replacement method of valuation, economic valuation of ecosystems, ecosystem services, Millennium Ecosystem Assessment, total economic valuation.

JEL Classifications: Q01, Q51, Q57.

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1. Introduction

The existence of organisms depends on the nature of their environments and (except less so for primary producers) relies heavily on the presence of other organisms, other species and so on. This is particularly so of species present in environments that are unmanaged or little managed by humans and which are high in the food chain. Conserving such species may require the preservation of their whole web of ecological dependence and interdependence. This is likely to necessitate the conservation of complete (or only slightly altered) ecosystems. An ecosystem has been defined as “a community of organisms, interacting with one another, plus the environment in which they live and with which they also interact as a pond, a forest” (Delbridge, 1981). Losses of ecosystems or their dramatic alterations are significant sources of biodiversity loss. This is probably why the Millennium Ecosystem Assessment (2005) (which is concerned primarily with biodiversity change) places most emphasis on the conservation of ecosystems.

In this article, I'll first of all outline some of the points made in the Millennium Ecosystem Assessment (2005) and critically assess these. Subsequently, I'll discuss the economic valuation of ecosystems and raise some issues needing to be resolved, such as all the services provided by a particular ecosystem may not all be lost when it is replaced by another one. The economic value of the particular ecosystem should not be assessed in isolation but should be considered in relation to alternative ecosystems or forms of land use

2. Some Points Raised in the Millennium Ecosystem Assessment about Ecosystem Services

The Millennium Ecosystem Assessment (2005, pp. 33-37) lists several services which are provided by ecosystems and supplies notes about trends in their enhancement or degradation. These services have been classified into four categories.

1. Provisioning services

2. Regulating services

3. Cultural services

4. Supporting services

Provisioning services cover mainly material benefits to human-beings (for example, provision of food and fibre), regulating services encompass environmental services that are of value to humans, cultural services include spiritual and religious values and supporting services include such services as nutrient and water recycling. This list of services (together with examples) is presented in Table 1. While this classification brings attention to ecosystem services that are likely to be valued, the assessment does not give much attention to their comparative value. Furthermore, the report makes no mention of disservices to human beings which are associated with some ecosystems. For example, some ecosystems provide breeding grounds for pests. For example, mosquitos breed in swamps and transmit malaria. Protected areas often harbour wild animals which attack the crops and domesticated animals located near such areas. Some ecosystems are a source of fires which cause economic damage, and economic losses are associated with damaging floods associated with unregulated river systems. Furthermore, some unmanaged ecosystems hinder transport and communication. Therefore, it needs also to be recognised that ecosystems can generate negative effects which human beings try to limit by engineering and other means. Usually, both benefits and costs to human beings are associated with particular ecosystems and changes to these. It could therefore, be claimed that the Millennium Ecosystem Assessment is not very balanced because it focusses mainly on the benefits from such systems.

Table 1 Types of services provided by ecosystems according to the Millennium Ecosystem Assessment (2005)

Category of service	Examples
1. Provisioning services	Food/fibre; genetic resources; biochemical, natural medicines and pharmaceuticals; ornamental resources; fresh water
2. Regulating services	Air quality regulation; climate regulation; water regulation; erosion regulation; water purification and waste treatment; disease regulation; pollination; natural hazard regulation.
3. Cultural services	Cultural diversity; spiritual and religious values; knowledge systems; educational values; inspiration; aesthetic values; social relations; sense of place; cultural heritage values; recreation and ecotourism.
4. Supporting services	Soil formation; photosynthesis; primary production; nutrient cycling; water cycling.

Source: Based on Millennium Ecosystem Assessment (2005, Table 2.2, pp. 33-37)

The Millennium Ecosystem Assessment does not provide much guidance on the economic valuation of ecosystems nor does it make substantial concrete suggestions on how ecosystems might be optimally managed, changed or conserved. If alternative ecosystems or forms of land use are possible, it does not indicate how the best alternative should be chosen. It is true that the Millennium Biodiversity Assessment (2005, Table 5.1, pp. 78-80) lists goals and targets which it considers to be desirable, but these seem to be opinion-based or consensus-based

3. The Importance of Determining the Total Economic Values of Ecosystems

It is often believed by members of the public that only those uses of land (and other resources) providing income have economic value. The income received from using these resources is counted as a part of gross national production. This, however, overlooks the fact that many desired services are provided by land (and aquatic areas) yield no income or little income. This is because some of their services are unpriced or under-priced. For example, wetlands may appear to some people as wastelands and of no economic value. However, they may be breeding grounds for fish, a refuge for significant birdlife, cleanse water of pollutants and provide protection against coastal surges.

It follows that the actual private income received from a parcel of land or a portion of the biosphere is usually not a measure of its **total economic value**. Ideally, in considering whether to replace an unmanaged ecosystem (say a forest) with a managed ecosystem (for example, farming of a particular kind or tree plantations) account should be taken of the comparative total economic value of the alternatives. This is likely to reduce a possible bias in replacing natural or unmanaged ecosystems by managed ones.

Note that measuring the total economic value of natural ecosystems is of little practical significance in itself. Its main purpose would appear to be to drive home the point that such ecosystems have greater economic value than is commonly perceived. From a practical point of view, it is very important to compare the total or social economic value of possible alternative ecosystems or land and aquatic uses in an area. This involves social cost-benefit analysis. The form of land use or pattern of land use yielding the highest social net benefit will be optimal from an economics standpoint.

In principle, this procedure will enable an optimal local or regional pattern of land use to be determined. However, it may not enable a global optimum to be obtained because it is based on partial analysis. The whole may be greater than the parts because of the complexity of environmental and ecological systems (Simon, 1962). Nevertheless, consideration of the total economic value of alternative uses (non-uses) of the biosphere would seem to be a step forward.

In the rest of this article, I'll mention some economic valuations of ecosystems which have been published and outline some issues involving the economic valuation of ecosystems that require more attention, particularly from comparative point of view.

4. Some Published Economic Valuations of Ecosystems

One of the earliest estimates of the annual value of ecosystem services was published by Costanza *et al.* in 1997. This estimate, not surprisingly, turned out to be higher than global gross product. From their estimates, it seems that the total annual value of the flow of services from croplands and rangelands is a lot less than that from natural or little managed biomes, such as those in marine areas. Costanza *et al.* (1997) estimated that the annual value of the world's ecosystem services in 1994 was about US\$33 trillion. Ninan (forthcoming) adjusted this figure for inflation. The adjusted figure amounted to US\$50 trillion in 2011. Thus, the estimated global annual economic value of services supplied by ecosystems is huge. However, the incomes obtained from ecosystems are lower than their total economic value, especially in the case of natural or little managed ecosystems because many of these services are not marketed or only partly marketed.

Dayuan Xue and Clem Tisdell (2001) estimated the value of ecological services from Changbaishan Mountain Biosphere Reserve in Northeast China. This article valued the ecological services generated by this reserve at 10 times its economic value should it be used for regular timber production.

The categories of ecological functions for which numerical estimates of their economic value were made are shown in Table 2. Estimates were mostly based on the cost of replacing these ecological functions by engineering and other human-produced solutions. No specific values could be estimated for the value of genetic diversity protected by the reserve.

Table 4.2 Categories of ecological functions and their valuation methods.

Function category	Function indicator	Valuation methods	Calculation path
Water conservancy	Reducing surface runoff	Alternative cost	Water amount x actual cost of reservoir's construction
Soil protection	Controlling erosion	Opportunity cost	Avoided eroding land area x opportunity production per unit area
CO ₂ fixation	Reducing greenhouse effect	Production cost	Amount of fixed CO ₂ x afforestation cost
Nutrient cycling	Accumulating nutrients	Alternative cost and market price	Maintained nutrient amount x market price of fertilizer
Pollutant absorption	Absorbing SO ₂	Alternative cost	SO ₂ amount x engineering control cost
Disease and pest control	Avoiding diseases and pests	Alternative costs	Forest area x chemical control cost

Source: Xue and Tisdell (2001, p.473)

Some of the economic values generated by this biosphere reserve are not included in the calculations by Xue and Tisdell (2001). Changbaishan Mountain Biodiversity Reserve is, for example, used for ecotourism. Xue *et al.* (2000) used the travel cost method to estimate its economic value for this purpose. This value is considerable and is likely to increase with the increasing involvement of Chinese in domestic tourism.

A useful feature of this study is that it provides economic values for alternative land use, namely that of conserving the reserve as now or alternatively opening it up for regular timber production. Its value for regular timber production is assumed to be equal to the average profit from timber production in China as a whole. Thus a net benefit transfer method was used. But this value might in fact be higher or lower in this reserve than in China as a whole. Furthermore, even with regular timber production, some ecological values (services) may still exist, albeit at reduced level. These values will be greater if low impact logging or similar is practised.

5. More Attention Needs to be Given to Some Comparative Issues Involved in Ecosystem Valuation

Some of the methods used for the economic valuation of services provided by ecosystems are not very reliable measures of economic value. This is, for example, true of the cost of replacement method which has been used by Xue and Tisdell (2001) and by others. Use of this method can overstate the value of services provided by an ecosystem. This can be illustrated by some examples.

In Figure 1, x_n , represents the annual volume of water provided by an ecosystem, and line DEF indicates the extra value that human beings put on the supply of this water. In total, they value this total supply by an amount equivalent to the hatched area. The cost of supplying this water by alternative means (e.g. by a dam or pipeline from elsewhere) is shown by the line MC and its supply is supposed to cost ¥OM per unit. Therefore, the total cost of supplying x_n of water will be equal to the dotted area plus the hatched area. Thus, the economic value of this water will be over stated by an amount equal to the dotted area because the loss in economic value if all water supplies disappear due to a change in the ecosystem will be equivalent to the area of the hatched quadrilateral. A further problem is that when the ecosystem is changed, not all water supplies may be lost. For example, supplies may be reduced to x_r annually. In that case, the total loss in the economic value of this water service will be equal to the area of quadrilateral GHFE.

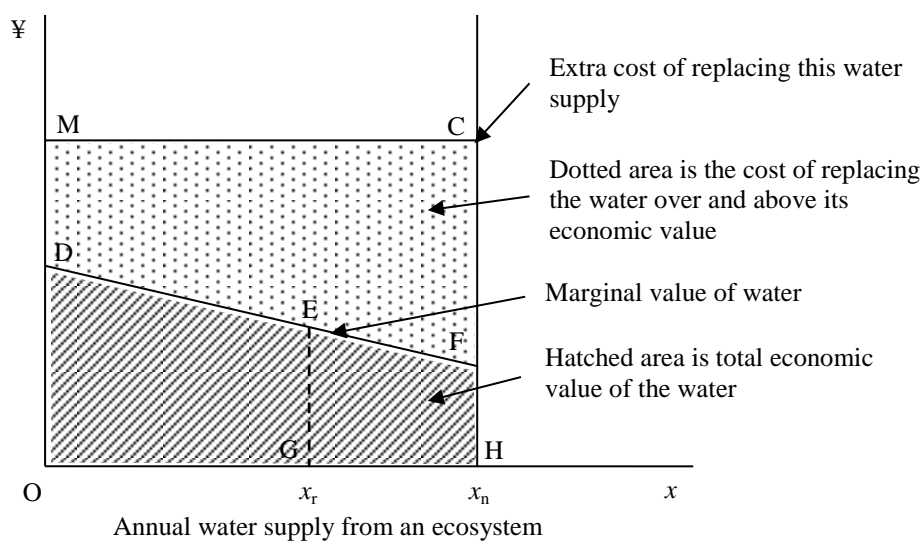


Figure 1 An illustration that the cost of replacement of an ecological service can overstate its economic value. In this case, the economic cost of replacing the water supply exceeds the economic value of the water supply

In some instances, also an ecological service is not fully demanded. In the case illustrated in Figure 2, the extra value placed on water is shown by line DNF. Even if the water supply is free, a maximum quantity of water of x_2 is demanded. The supply $x_n - x_2$ of water from this ecosystem has no economic value. If line MNC represents the per unit cost of replacing this water, it will be optimal to only replace x_1 of the water if all the water supply from the area is lost. When the ecosystem disappears, this will result in an economic loss of an amount equal to the area of rectangle OGNM (the cost of supplying water by alternative means) plus a stemming loss equivalent to the area of triangle GFN. This is a lower economic loss than would be incurred by replacing the whole water supply x_n . This estimate of replacement costs will overestimate the economic burden of losing all the water supplies (provided by the ecosystem) by an amount equivalent to the dotted area in Figure 2.

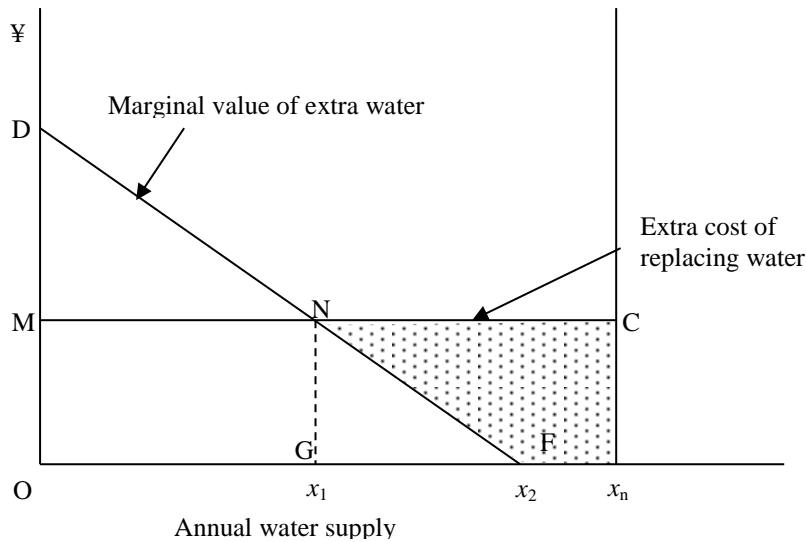


Figure 2 Another case in which the cost of replacement method can overstate the economic value of an ecological service. The dotted area represents the excess of the cost of replacing water compared to its economic value.

Of course, there are some situations in which the cost of replacement would be an accurate measure of an ecological service. Such a case is illustrated in Figure 3. There line DF represents the extra value of water from the ecosystem and MC is the per unit cost of supplying it by other means. A cost equivalent to the dotted area will be incurred if the ecosystem disappears and **all** water supply is lost. However, this may not be so. If x_1 of water continues to be supplied by the changed ecosystem, then the additional cost incurred as a result of the changed ecosystem is equivalent to the area of rectangle **GHCN** **not** the area of rectangle **OHCM**. This shows the complexity of the problem, and the need to do comparative analysis.

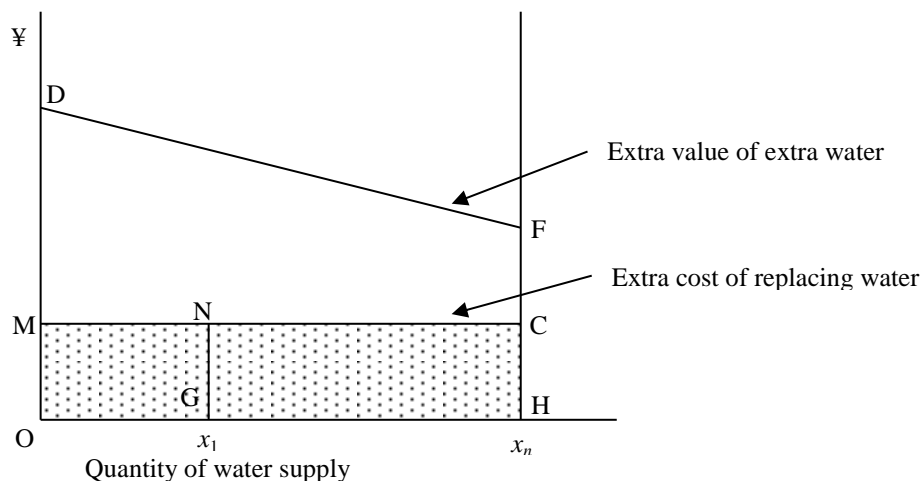


Figure 3 An illustration that the cost of replacement method can sometimes provide an accurate measure of economic value of an ecosystem. However, whether it does so depends on what services are provided by the changed ecosystem. In the case shown, the cost of replacing lost water is less than its economic value.

6. Concluding Comments

It is important to complete economic valuations of ecosystems because some ecosystems which appear at first sight to have little economic value in fact have a high economic value when their unpriced and under-priced services are taken into account. These valuations have significant implications for the optimal use of terrestrial and marine areas. However, methods for economic valuation of alternative ecosystems need further development. This was illustrated by showing that the application of the cost of replacement method of valuing ecological services associated with an ecosystem can provide misleading estimates of the economic value of these services.

However, the science of evaluating ecosystems is relatively new and undoubtedly progress will be made in improving methods of economic valuation of ecosystems. The study of ecosystem services is very popular at present. The Millennium Ecosystem Assessment (2005) probably helped to increase interest in this subject and just recently (2012), Elsevier launched a new journal entitled *Ecosystem Services*. There is considerable scope for advancing our

knowledge of this subject and for devising practical methods for determining the optimal use of land and marine areas, taking into account the value of ecological services.

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