2 Valuing ecosystem services

Benefits, values, space and time

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2.1 Introduction

A growing body of evidence suggests that in the twenty-first century we will face a number of pressing and interrelated problems, including large-scale conversion of ecosystems and the subsequent loss of biodiversity (Millennium Ecosystem Assessment, 2005); increasing poverty and water scarcity (Rosegrant *et al*., 2003); potentially dangerous alteration in the climate system (Schneider, 2001; Mastrandrea and Schneider, 2004); and global fisheries collapse (Myers and Worm, 2003). These problems are occurring on an unprecedented scale and are inherently connected to growing societal demands. The mitigation of these problems requires a deeper comprehension of the environmental infrastructure upon which human existence and welfare depends (Schroter *et al*., 2005; Sachs and Reid, 2006).

The concepts of ecosystem services and 'natural capital' have recently been developed to make explicit this connection between human welfare and ecological sustainability for policy, development and conservation initiatives (Daily, 1997; Millennium Ecosystem Assessment, 2005). Recent efforts have shown that incorporating ecosystem services into land use decisions typically favours conservation activities or sustainable management over the conversion of intact ecosystems (Balmford *et al*., 2002; Turner *et al*., 2003). Although much ecosystem service research is still at an early stage, systematic approaches to measuring, modelling and mapping of ecosystem services, governance analysis and valuation are needed urgently. In order to make progress in these areas it must be transparent what is being considered an ecosystem service versus other concepts in the literature, such as ecosystem processes, functions, goods and benefits. This delineation is of particular import to any valuation exercises that might accompany ecosystem service research. There are important economic concepts that need to be made transparent for meaningful estimates to be made. These concepts include the distinction between prices and values, and acknowledgment that values are context specific – meaning they change across space and time. This chapter discusses these issues with the aim of informing valuation exercises from an economic perspective.

2.2 Services versus benefits

In 2005 the Millennium Ecosystem Assessment (MA) defined a framework for relating ecosystem services to the larger scientific and policy communities. It proved to be an important development and excellent heuristic. The MA divided ecosystem services into a few very understandable categories – supporting services, regulating services, provisioning services and cultural services. This in turn makes the classification scheme readily accessible as a heuristic to decision-makers and non-scientists. The MA delivered a broad definition (by design) of ecosystem services as 'the benefits humans obtain from ecosystems'. However, this definition has not been shown to be operational for all research purposes (Boyd and Banzhaf, 2007; Wallace, 2007; Fisher and Turner, 2008; Maeler *et al*., 2008), and efforts have been made to more carefully classify and understand ecosystem services to make their analysis more operational (see Fisher *et al*., 2009 for review).

We have argued elsewhere (Fisher and Turner, 2008; Fisher *et al*., 2009) that a simpler delineation of intermediate services, final services and benefits is more useful for valuation. There are multiple relationships between ecosystem processes and human benefits (see Boyd and Banzhaf, 2007 for a description of the benefit-dependence aspect of ecosystem services), but what is important for valuation exercises is that you value the endpoints that have a direct effect on human welfare – in economics these are considered through the use of the term 'benefits'. Both intermediate and final services are ecological phenomena (as opposed to things like cultural fulfilment). The term 'intermediate services' here is similar to the MA's 'supporting services', and these intermediate services combine in complex ways to provide final services, which have direct effects on human welfare. Benefits, which include things like wood, food and cultural aspects and recreation, are related but different to the services that provide them. For example, water regulation and drinking water are not the same thing. Benefits also typically require other forms of capital to affect human welfare. For example, clean drinking water for consumption is a *benefit* of the final service of water provision. In turn, water provision by an ecosystem is a function of the intermediate services, including nutrient cycling and soil retention. The end benefit typically requires some built capital to be realized, whether it is a well or an urban water distribution system.

In this scheme we avoid the double counting flaws acknowledged in earlier ecosystem service valuation exercises. This is not the case for the MA classification, which could lead to double counting the value of some ecosystem services. For example, in the MA, nutrient cycling is a supporting service, water flow regulation is a regulating service, and recreation is a cultural service. However, if you were a decision-maker contemplating the conversion of a wetland, and you utilized a cost–benefit analysis including these three services, you would commit the error of double counting. This is because nutrient cycling and water regulation both help to provide the same service under consideration, providing usable water. The MA's recreation service is actually a human benefit of that water pro-

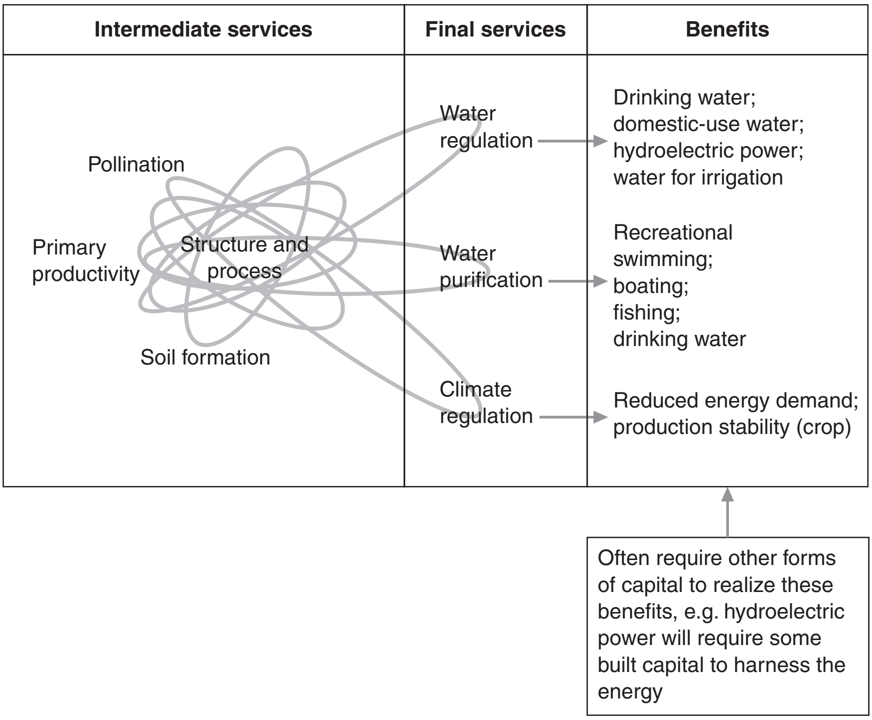

Figure 2.1 Conceptual delineation between ecosystem services and the benefits derived from them (source: Fisher *et al.* 2009).

vision. An analogy is that when buying a live chicken you do not pay for the price of a full chicken, plus the price of two legs, two wings, head, neck and other body parts, you simply pay the price of a whole chicken.

Figure 2.1 provides a conceptual example of our schema, where complex ecosystem processes and functions give rise to ecosystem services (final and intermediate), which then interface with direct human usage and provide benefits. Again, some benefits require other forms of capital in order to be realized. For example, hydroelectric power requires water provision and regulation from ecosystems, but also requires dams and transmission infrastructure.

This line of argument, however, is not meant to imply that intermediate services have no value. Without a sufficient configuration of structure and processes, ecosystems will not function (or will function less well) and will not provide the diverse range of final services and benefits that they could potentially deliver (Turner, 1999; Gren *et al*., 1994). Regulating services that provide the capacity to respond to environmental stresses and shocks are encompassed by the concepts of infrastructure or primary value associated with the role that functional diversity can play in certain contexts, providing increased ecological stability and resilience. The conservation and protection of regulating and support services capacity is in some ways a decision about reducing risk and the costs of such a risk averse strategy.

2.3 Prices versus values

In addition to the services–benefits problem regarding ecosystem services valuation is the confusion over terms that most people use interchangeably: 'value' and 'price'. That they are not in fact equivalent is actually very easy to demonstrate. Consider that most basic of all necessities, water. This is the stuff of life, without which existence is impossible. Yet the price we pay for water in our household bills is actually very modest. It is clear to see that 'value' and 'price' are not necessarily the same thing. In fact, price is simply that portion of underlying value that is realized within the market place. Now, in many cases price may be a perfectly acceptable approximation of value, particularly for goods produced in competitive markets and where there is not large-scale intervention by governments or other authorities. Indeed, even when these latter distortions (i.e. market power and subsidy effects) do arise, economists can often adjust for their influence to yield what is known as the 'shadow value' of the goods concerned. However, as the water example shows, market price can in some cases be a poor approximation of value. Indeed, this divergence can often be substantial and is a characteristic of many of the goods produced by the natural environment.

So, supply and demand can interact in ways that are highly beneficial to consumers, providing goods at prices that are below the value consumers have for those goods. This excess between price and value is known as the 'consumer surplus'.[1] Of course decision-makers should be interested in the value different goods provide rather than their price. Indeed, this constitutes the fundamental difference between accountants and economists. While the former are interested in price, the latter are (or at least should be) interested in value.

Here the fundamental problem facing any economic analysis is one of measurement – i.e. how do we measure the value or utility provided by any given good? The economist's solution is to use a surrogate measure that is highly compatible with the decision-making process and is transparent and amenable to subsequent adjustment if we wish to allow for different circumstances across individuals. That measure is to assess the amount that individuals are prepared to pay for changes in the provision of goods. Note immediately that we are relating value to willingness to pay (WTP) rather than what actually has to be paid. A simple example serves to illustrate the importance of this difference. Consider the value of walking in a woodland. This generates benefits including exercise, appreciation of nature, perhaps entertainment of one's children and inner calm. Yet if the woodland is publicly owned, the amount paid to enter such a wood is likely to be zero. Clearly, here, price paid is a highly misleading indicator of value.

Arguably, there is no perfect way in which to estimate the value of any good. However, several decades of research have resulted in the development of a variety of valuation methods, including the following:

- Adjusted market prices. For goods that are traded in markets and have prices we can estimate WTP by examining the reaction of demand to observed variations in prices. Adjustments need to be made for distortions arising from factors such as imperfect (non-competitive) markets and policy interventions (e.g. taxes and subsidies). This allows the analyst to estimate consumer surplus and hence values. For example, one can estimate part of the value of improved water quality by examining the increased value of commercial fishing catches.
- Productivity methods. Ecosystem services often provide the factors of production required to produce marketed goods. Production functions relating inputs to the output of goods can be estimated and the contribution of individual services assessed. Continuing the water quality improvement example, one could also estimate the value generated by greater agricultural productivity, or the decreased costs of providing clean drinking water.
- Revealed preference methods. Many goods that capture environmental services can only be enjoyed through money purchases. For example, individuals may pay extra for homes in quiet neighbourhoods or incur substantial costs to visit areas of natural beauty. By relating behaviour to the characteristics of those goods, one can observe the money–environment trade-off and so reveal the values held by individuals for the environmental good.
- Stated-preference methods. The most direct of all approaches is to ask individuals to state their willingness to pay for some change in the provision of an environmental good.

In practice, the costs of conducting novel valuation research across the multitude of potential decision situations often means that analysts are forced to rely on value transfer methods, which transfer existing benefit estimates from studies already completed for another location or issue.

In addition to the various valuation methods described above, many studies adopt simpler ‘pricing methods’, such as avoided damage or expected damage approaches, which examine the costs of avoiding damages due to lost or at-risk services (e.g. the loss of coastal wetlands and subsequent changes in the impact of storm events).

The damage-cost-avoided approach is also used by the IPCC to underpin the economic analysis of their climate change assessments (Pearce *et al*., 1996). Here the process, in situations as complex as climate regulation, is typically an agglomeration of valuation techniques such as revealed preference approaches for market goods and WTP in hypothetical markets for non-market goods.

With this approach again, the focus is on the benefits, or technically the avoided costs – the damages that are the results of climate change impacts on individual and societal welfare. Ecological and atmospheric modelling are at the cornerstone of this approach, as these underpin any valuation estimates. Table 2.1 shows some of the key damages that could be valued as a result of a doubling of CO_2 concentration in the atmosphere. Here we see that there are both market and non-market effects of CO_2 increases. Major market consequences will be felt in the agricultural sector. The impacts of climate change will be manifested in agricultural production through process effects such as heat stress, soil moisture loss, pest/disease increases, shorter growing season (where temperatures rise too high) and precipitation decrease. Conversely, these same effects might produce benefits, such as increased precipitation in some regions, longer growing seasons in higher latitudes and carbon fertilization effects. This shows exactly why damage and value estimates are spatially heterogeneous and need to be evaluated at scales appropriate to capture these distinctions.

We can see both market and non-market damages from a sector like forestry. Where climate change may negatively affect forest cover and therefore timber values in a region, but also elicit losses in recreational and cultural significance. Several of the impacts in Table 2.1 are easy to estimate and several are rather difficult. Examples of the latter include the values of species loss, and damages due to increases in hot and colds spells, which will be both spatially and temporally heterogeneous.

Table 2.1 Potential damages from CO_2 doubling in market and non-market sectors

	Market impacts	*Non-market impacts*
Primary economic sector	Other sectors Property loss Extreme event damage Ecosystem damage	Human impacts Extreme events
Agriculture	Water supply Dryland lost Hurrican damage Wetland loss	Human life Hurricane damage
Forestry	Energy demand Coastal protection Damage from drought Forest loss	Air pollution Damage from drought
Fisheries	Leisure activities Urban infrastructure Non-tropical storms Species loss	Water pollution Non-tropical storms
Insurance	River floods Other ecosystem loss	Migration River floods
Construction	Hot/cold spells	Morbidity Hot/cold spells
Transport		Physical comfort
Energy supply		Political stability Human hardship

Source: adapted from Pearce *et al.* 1996.

We can see that estimating these damages is heavily reliant on the ecological and atmospheric models that predict how changes in greenhouse gas emissions will affect land cover, seascapes and ecosystem functions and responses. Even with sophisticated, spatially explicit models there are still a number caveats and assumptions that need to be highlighted. On the biophysical side, damages will be a function of the rate of change, as well as the degree to which different ecosystems are linked. For example, how exactly does the evapotranspiration from the Amazon affect agricultural productivity in North America – i.e. how tightly linked are regions and ecosystems?

Another approach has been to use replacement costs as a proxy for the loss of existing ecosystem services. This is not a true valuation method as it is not based on WTP, but can be an effective approach demonstrating the importance of ecosystem services to policy-makers. In this context, the 'cost versus value' distinction raises similar concerns to the 'price versus value' distinction. It is easy to make the error of assuming that the replacement cost is the true value (benefit) of the service under assessment. It is also the case that the method can result in unrealistically high estimates.

2.4 'Here and now' versus 'there and then'

As intimated above, the value of an ecosystem service is dependant on where the service is delivered and the time at which the value is being assessed. The fact that valuation is temporally and spatially contextual is what we mean by 'here and now' versus 'there and then'.

Let us first deal with the spatial aspects. First, there are several spatial relationships between where an ecosystem service is produced and where the benefit is felt. Some ecosystem services are produced in the same area where the benefit is realized. For example, soil formation occurs in a given spot and may be utilized as an ecosystem service when a farmer plants a crop in that locale. Some ecosystem services are produced in one place, but the benefit is felt elsewhere. Water regulation is a good example of this, where an up-slope vegetated landscape may attenuate rain runoff and conduct surface water into the ground, which then returns to the surface as part of a river that flows down-slope. Here a downstream user benefits from the upstream landscape. Another such relationship is where a service is produced in a particular spot, but the entire world may receive benefits from it. Carbon storage is one example, where it does not matter where the carbon is being stored – all of humanity benefits from it (if we desire our current, relatively stable climate regime). In essence, ecosystem services 'flow' from a point of production to a point of use.

This 'flow' of service changes through space in at least three ways:

1 The biophysical process itself varies across the landscape or seascape. This is obvious in the above example, pointing to how carbon storage or net primary productivity is going to vary based on things like slope, aspect, elevation, species and structural diversity.

2 The benefits and beneficiaries change across a landscape. Water regulation might be an important service for providing the irrigation potential to farmers abutting a forest or woodland – the same service might provide the benefit of hydroelectric power to beneficiaries far downstream. These user groups will hold different values and preferences for this water regulation, report different WTP, and hold different information about how the system works. All of these will affect an aggregate valuation assessment.
3 The costs of provision of the ecosystem service will likely vary across space. Consider forest protection for the sake of regulating water flows. To local people habituated to utilize forest resources for non-timber forest products (NTFP) collection, their opportunity cost is the lost availability to collect such resources. To local livestock keepers the cost might be the increased predation or disease transmission to livestock. To urban water users the cost might only be a small additional fee on water bills.

The reality that ecosystem service provision changes in its ecological processes, magnitude, beneficiaries and costs across space is critical for any valuation process. This demands that spatially explicit ecological models, a detailed understanding of benefit stakeholders and knowledge of all costs (including opportunity costs) be incorporated for robust ecosystem service valuation exercises.

The *now* and *then* of ecosystem service research implies that just as services and benefits change across space, they also change across time. Let us consider three reasons why ecosystem services or the value of their benefits change across time and why this is important for valuation.

First, the ecological conditions or processes themselves change over time. For example, a restored wetland attenuates larger storm surges, assimilates more heavy metals and houses more breeding waders. Conversely, a shrinking woodland may produce less NTFPs, store less carbon and house fewer pollinator species. Any ecosystem service assessment occurs at a point in time. Future changes in ecosystem condition or function can be modelled based on past changes, forecasted based on predicted future drivers of change, or perhaps instigated through scenario building and analysis. The very fact that ecosystem service research has risen to such prominence in science and policy circles is based on an acknowledgement that over the past few decades we have seen precipitous declines in the provision of some services in certain locales.

Second, over time societies' preferences change. For example, wetlands were once more commonly and derisorily termed 'bogs' and 'swamps'. They were often considered to be wasteland to be improved by drainage. Now, in many places, such wetlands are highly valued for their ability to provide superb wildlife habitat, store carbon and assimilate pollutants such as nitrogen and heavy metals. To some degree this change in preferences can be explained by the dwindling supply of such natural resources (it is noticeable that in countries where such resources are still common, they are often less prized). However, increasing real incomes and leisure time, and better transportation and a growing appreciation of the services of such areas, all play a part in the transformation of such values. This causes considerable difficulty for economic analyses as it is difficult to assess changes in future preferences.

The sustainability literature offers a strategy based on the maintenance of a set of 'opportunities' carried across intergenerational timescales. The core idea is that future generations should possess at least the equivalent set of economic, social, cultural and other opportunities as previous generations. Natural capital (ecosystems and their relationships) should be conserved as a store of wealth and wealth creation opportunities. Taking a weak sustainability position, natural capital can be extensively substituted for by human and physical capital. From a strong sustainability perspective, important components of the natural capital stock are 'critical' to life support and other services, and cannot be substituted – their loss is effectively irreversible. So-called social capital also needs to be nurtured in a strong sustainability policy world (Neumayer, 2003; Pearce and Turner, 1990).

Third, and linked to this second point, is the complexity that individuals tend to prefer benefits to be provided sooner rather than later (and the opposite for costs). For example, people typically prefer \$100 today rather than \$105 a year from now. This seemingly innocuous facet of preferences leads to the problem of discounting – that the present-day value of future benefits (and costs) falls the further into the future those values occur. Determining the nature and rate of this decline is important as it can radically alter present-day assessments of the value of different options. For ecosystem service assessments it is clear that the economist should not adopt the discount preferences of the individual, but rather use a social discount function (Pearce *et al.*, 2003). It is also becoming more obvious from a strong sustainability viewpoint that the discount function (particularly for non-market benefits – for example, from ecosystem services) should be declining in nature for large-scale societal decisions (Turner, 2007). This means that in each time period the rate at which a benefit (or cost) is discounted should itself decline. This reflects the longevity of society and the greater weight placed upon delayed benefits and costs relative to the preferences of individuals. That said, the choice of discount function can have massive impacts upon the economic assessment of long-term concerns such as ecosystem services – sensitivity analyses of the impact of different discounting strategies are advisable. In the end, ethics plays as important a part as economics in the discounting debate.

2.5 Conclusion

The importance of providing policy-makers with timely and robust estimates of the value and benefits of well-functioning ecosystems has never been more critical. As Professor Jeffrey Sachs said in his 2007 Reith Lectures, the world is 'bursting at the seams'. While there is still much ignorance with regards to how ecosystems function to provide benefits to human, how humans behave and value such benefits, and how these two interact in the face of diminishing natural capital, we are beginning to make some progress, both conceptually and analytically, so that we can deliver estimates and recommendations to decision-makers. In this chapter, we discussed casually a few of the conclusions that natural scientists and economists are coming to regarding this literature, including the importance of delineating between goods and services, the understanding that market prices may serve as a poor proxy for individual or societal values, and that ecosystem service assessment needs to include spatial and temporal aspects to be truly policy relevant. While these are just three small conceptual steps in the typical long journey of an ecosystem service assessment, they are critical steps, in each journey.

Note

1 Of course, where either demand or supply changes, so does price. Consider, for example, the long-standing drought in Australia and how this affects water prices.

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