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Value and valuation of forest ecosystem services

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In this paper, we first present a total forest economic value framework from an anthropocentric instrumental value perspective and differentiate gross value, economic value, market value, and valuation of forest ecosystem services. We then argue that some of the demand-side-based non-market valuation approaches only provide an estimate of gross value, not economic value. Thus, strictly speaking, they are not market valuation per se as the supply side is ignored, and as many non-marketable and non-extractive forest ecosystem services are concerned, it is often the supply side – the opportunity costs of resources used to produce them that determine the economic values of these services. Finally, we identify the role of economic valuation of forest ecosystem services in the political market that often allocates resources directly to produce these services.

Keywords: total economic value framework; forest ecosystems; valuation; market value; use value; political market

1. A forest's values

Forests as an ecosystem, large or small, produce various beneficial forest outputs, such as timber, forage, water, recreation, habitats for species, and carbon sequestration. Some of these outputs are marketed, and others are not. In order to maximise all these social benefits generated from these outputs, it is often necessary to appropriately value them and to allocate resources efficiently to produce them, considering various forms of joint and separated production of these outputs in various temporal and spatial scales.

This paper focuses on the economic values of forest ecosystem services and their valuations. From an anthropocentric instrumental value perspective (National Research Council 2005; Turner et al. 2003), the total economic value (Randall and Stoll 1983 and a concept of the London School of Economics in the 1990s) applied to forest can be grouped into two main, and, in most cases, mutually exclusive categories as shown in Figure 1. Extractive values involve physically harvesting and removing resources for uses, often outside of the forest, and may be further divided into timber and non-timber forest products (such as mushroom, nuts, rattan, and fruits). The other is non-extractive values realised without extracting resources from the forest and is further divided into two subcategories. These subcategories are environmental service values such as soil and water conservation, biodiversity, and climate mitigation; and preservation values, which include existence value, option value, and bequest value (Zhang and Pearse 2011).

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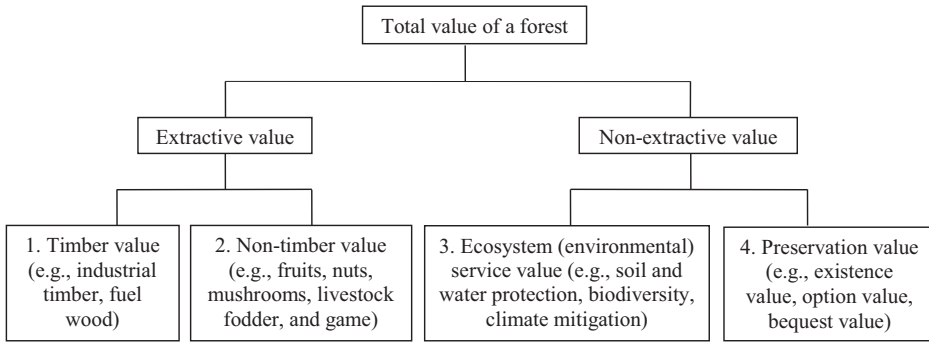


Figure 1. A forest's economic value.

Recreational or cultural uses of forests can have extractive value (such as hunting), non-extractive value (bird-watching, hiking, and spiritual renewal), or both.

This total economic value framework is rooted in the multi-functionality of forests and can be used as a guide to assess the flows of benefits that forests produce (e.g., Gamborg and Rune 2004; National Research Council 2005). Pearce (2001) proposes a similar approach, and Merlo and Croitoru (2005) use it to assess the comprehensive values of the Mediterranean forests. Similarly, Adger et al. (1994) estimate the total economic value for the Mexican forest estate, noting the problems of non-additivity and quantification among various components.

In recent years, scholars have used terms like 'ecosystem services' and 'preservation values' in various ways (Boyd and Banzhaf 2007; Fisher, Turner, and Morling 2008). The most encompassing definition of ecosystem services is that of United Nations MA (2005) embracing all benefits that human being receives from ecosystems. For forests or forest ecosystems, this means all values listed in Figure 1. Such an encompassing definition draws attentions to the importance of ecosystem services, but may overshadow challenges they present for measurement and for marking trade-offs among them in forest management decision-making.

To assess the value of forest ecosystem services, it is necessary to look into each component of these services as well as to their links (physical, ecological, and economic) that can interfere, either positively or negatively, in a joint production process (Robert 2013; Robert and Stenger 2013). The context is bundling private goods that are often extractive and marketable and that have rivalry and excludability, and public goods that are not extractive and difficult to market.

Further, the term ecosystem services used in MA tends to advocate ecosystem protection. However, a closer look at the notion of forest ecosystem services and the total economic value concept based on the traditional conceptualisation of multiple forest benefits reveals that the main difference between them is that the former emphasises ecosystems as an organising structure of benefits and the latter looks at benefits at a stand or forest level (Kline, Mazzotta, and Patterson 2009). Thus, the total economic value framework is perhaps more practical and operational at the individual forest level as it highlights the challenges for measuring these benefits and for making trade-offs among them in forest management decision-making.

This total economic value framework covers only the economic benefits of a forest or its usefulness to humans. It is an anthropocentric instrumental value, based on the utility of the forest and assessed using various economic methods. Some environmentalists,

biologists, and philosophers argue that forests, as other ecosystems, have non-anthropocentric instrumental and intrinsic values that are independent of their instrumental values to human beings (Maris 2006). As such, an economic valuation is too anthropocentric to capture the full value of an ecosystem (e.g., Farber, Costanza, and Wilson 2002). As the intrinsic value cannot be measured by anthropocentric or economic methods, they call for ethical and moral norms with respect to the management of forest and other ecosystems. While the economic value of forests and other ecosystems is undoubtedly influenced by the prevailing ethical and moral norms of our society towards them, many forest management decisions are guided by their economic value, defined broadly to include all their identifiable priced and unpriced values. Furthermore, estimates of the total economic values of various ecosystems remain an approximation and are subject to bias if the possible overlapping of different values is not considered.

In the next section, we first differentiate values and valuation. Values are subjective, can be based on ethical/moral ground, and may cover human perceptions of the intrinsic values. When there is not market distortion, the gross economic value of a good or service is reflected in its demand and its economic value is determined by both demand and supply. Valuation is an objective and market-based process that determines the economic value of a good or service. We then discuss the application of these concepts and methods in measuring the value of non-market forest ecosystem services, as shown in Box 3 in Figure 1, as well as preservation value in Box 4 of Figure 1. Because valuations may be imprecise due to market failures or some values cannot be estimated in dollars, a political process is often used to directly produce non-market forest ecosystem services, to create a market for ecosystem services, or to preserve some resources. We, therefore, note the political economy of producing non-priced forest ecosystem services. Finally, we draw some conclusions on the policy and practical complications in valuing forest ecosystem services.

2. Value and valuation of forest ecosystem services

Under perfect competition, the economic value of a marketed good or service is determined by its supply and demand, as shown in Figure 2. The societal or market demand

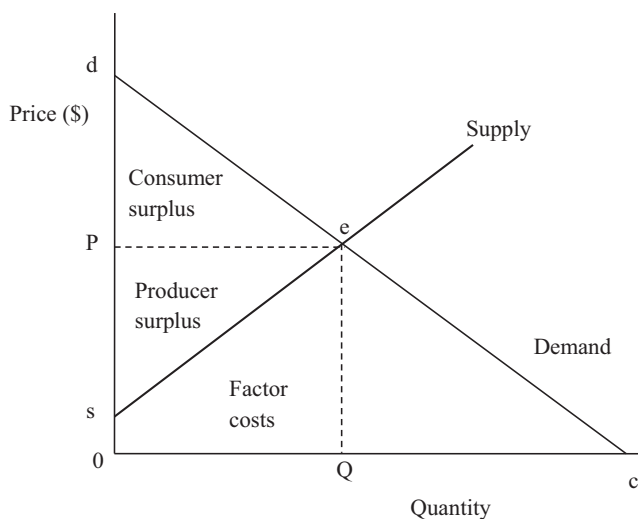


Figure 2. Market supply, demand, and net value of a good or service.

curve of a good or service, which traces the relationship between quantity demanded and price, assumes all else equal and is an aggregation of all individual demands. Typically and often for illustration purposes, one draws a demand curve that has an intercept (point d in Figure 2) with the vertical (or price) axis. However, the true shape of a demand curve, especially beyond certain locus of the equilibrium point, and its exact intercept with the vertical axis are often unknown and thus present difficulty in estimations. Nonetheless, the area below the demand curve (0dc in Figure 2) represents the *gross* economic value that human society puts on that good or service. In other words, area 0dc in Figure 2 is the total *use value* of that good or service to society.

The supply curve measures the relationship between quantity supplied and the price of that good or service. The area below the supply curve (0seQ in Figure 2) represents the cost of production, including wages for labour, interests for capital, and rewards for entrepreneurship. The point e where demand and supply curves meet is the equilibrium point, and the *market value* of that good or service is thus reflected in its price, P . The *total market value* of that good or service to society is $P \times Q$ (area 0PeQ). The area between the supply curve and the price curve (area sPe) is called producer surplus, which represents producer welfares. For forest land, the area sPe in Figure 2 is called land rent (or Richardian or differential rent), which is a surplus accruing to land and is captured by landowners. The area above the price curve and below the demand curve (area dPe in Figure 2) is called consumer surplus.

Thus, the *gross value* of a forest ecosystem service is reflected on its demand curve or more precisely, the area below its demand curve. However, assuming there is no market distortion, the *market* or *economic value* of this service is reflected area 0PeQ, which is much smaller than the area below the demand curve. As most ecosystem services are public goods and are not up to sell, various economic methods have been used to assess the market values of these services. This is so-called *valuation*: a process for finding the economic value of these services or the prices they could expect to fetch if these services were offered to sell in a market. These values, assessed by economists and others, are then presented to managers and decision-makers who decide whether to provide these services and to what extent these services will be provided. When the issues are significant and affect many people, decisions are often made through a political process in which economic values are only one among many factors considered.

Unfortunately, the concepts of value, gross value, economic value, market value, and valuation have not been used in a consistent fashion among economists, biologists, and philosophers; let along the general public (Zhang and Li 2005). For economists, the word *value* has two meanings: the utility of a good or service (*use value*, which is reflected in an individual's demand curve for it) and its power of exchange with other goods (*exchange value*). The aggregation of societal use value on a good (its *gross value*) is reflected in its market demand curve, while the exchange value of that good (its *economic value*) is reflected in its market price. These concepts are often confused, especially among non-economists. For example, some valuation studies on forest ecosystem services (e.g., Ninan and Inoue 2013) only estimate the total willingness-to-pay for these services (or the total area under the demand curve), which are societal *use values* rather than *economic values* (which is social exchange value or price multiplied by equilibrium quantity). These valuation studies only cover one side of the market – demand – and as such, the results from these studies alone cannot be directly used in resource allocation.

Note that the appropriate economic values being the exchange values or market values are only true if market prices are the result of perfectly competitive markets. Otherwise, proper shadow prices have to be estimated (Harou 1984). Often, market prices need to be

corrected for market failures as well as political and institutional failures (Markandya et al. 2002, 278). Further, private benefits and social benefits, including the implications of the absence of preferences of future generations, often diverge. Finally, recent research suggests that social values are not merely the sum of individual ones (e.g., Arrow 1970). Although these considerations all complicate the valuation of non-market services, the differentiation of concepts stands. In the following discussion, we assume the market value and economic value of an ecosystem service are identical, and if not, the market value is corrected to reflect the economic values to society.

To make our point clear, let us use the aggregate measure of total value of goods and services produced in an economy in a year – gross domestic products (GDP) – as an example. Granted, GDP is merely an approximation of social welfare, and many have called for a modification of it. Green GDP, for example, would include environmental benefits and damages of production or consumption activities in a country. Nonetheless, GDP is still the most widely used measure of production or consumption activities in a country. If a country only produces one good in a year and the market for this good is competitive, then $P \times Q$ (or area $0PeQ$ in Figure 2) is its annual GDP. Typically, a country produces numerous goods and services, and aggregating all the areas measured in $P \times Q$ for these goods and services produced would generate its GDP. Consumer surplus is *not* measured in the GDP.

This one-good example is illustrative for different reasons. First, it shows that some human values, even if all of these values are reflected in the demand curve, are not captured in GDP. The glaring omission in the calculation of GDP is consumer surplus. Thus, GDP does not measure all human utility, let alone human happiness.¹ It is, at best, an imperfect measure of human welfare. Therefore, some human values on a good or service, especially from those with high incomes (and thus whose demand for that good is likely located above point e on the demand curve in Figure 2), are not captured in market or economic value of the good or service. If some human values, such as sentimental values and ethical considerations, are not fully reflected in the demand curve, this mismeasurement would be more serious.

Further, this one-good example presents a clear picture that the upper limit of the world population's willingness-to-pay for all goods and services is their aggregate incomes. And the aggregate global incomes are the sum of the areas measured by $P \times Q$ for all goods and services. In this sense, Costanza et al. (1997) who estimate the total value of ecosystem services roughly twice as much as the global GDP have violated the very principle of economic valuation: the willingness-to-pay for all global ecosystem services cannot exceed world income (Pearce 1998). Similar overestimation could have been made by scholars who try to estimate the total value of forest ecosystem services (e.g., Xie et al. 2003; Yu, Lu, and Jin 2005).

Third, it demonstrates the difference between value and valuation, the focus of this paper. Again, the gross economic value of a good to all individuals in a society is reflected in its demand curve and measured as the area under it. Valuation is a process that derives the economic value of this good, measured by $P \times Q$ (area $0PeQ$ in Figure 2), a much smaller area than the area under the whole demand curve (area $0dc$ in Figure 2). Thus, estimating the demand curve of a forest ecosystem service in itself is not a complete valuation of such a service; it is merely a first step of valuation. The next step is to find the supply or cost function of such service and to assess the economic value of such a service at the equilibrium price (exchange value) and quantity.

Being cognitive of this difference is important when conducting valuations and management decisions regarding marketed and unmarketed goods. Market goods are valued

at $P \times Q$. When a good or service is not marketed and priced at zero, it is often 'valued' as the full area under the demand curve (area Odc). We have seen studies reporting the whole area under the demand curve as the economic or market value of a forest ecosystem service. For example, we have seen a study that shows the total value of ecosystem services produced from a working (not unique) private forest in the Czech Republic (excluding timber) is about twice as the market price of forestland. One has to wonder that, if the value of ecosystem service is so high, why nobody (including the government) buys it at the market price and gain two extra times of benefits from ecosystem services. A detailed look reveals that the study provides an estimate of the gross value, not economic value. Consequently, it inflates the economic values of forest ecosystem services and their importance relative to the marketed goods, potentially making management trade-off and decision-making biased against marketed goods.

Fourth, this demonstrates, as the economic values of a good is determined by its supply and demand, the supply or costs of protecting some unmarketed goods or services such as ecosystem services must be considered in economic valuation. For example, if a city is planning to buy some lands and build a park, the cost of the land purchase, construction, and maintenance must be considered. And it is often the supply side – whether the city has enough money to buy the lands and build the park in this case – that decides the economic (market) value of the park. Similarly, if a forest is going to be designated as a wildness area, the cost of doing so in terms of lost revenues in timber harvesting and recreations must be considered.

Finally, all economic *valuations* have a defined context and proposed changes, on the margin (close to equilibrium point, e). It is thus the process of quantifying the economic value of a particular *change* in the level of a good or service. A benefit of using economic valuation is that it provides a process that is grounded in economic theory and information that can be used to evaluate the trade-offs that inevitably arise in management and environmental policy choices (National Research Council 2005; Turner et al. 2003). As such, the economic value of an ecosystem service must be stated in comparative terms – the answer to a question with two or more clearly defined alternatives. Furthermore, the estimated economic value of small changes in ecosystems, holding all else constant, is specific in both the default and changed situations. Such an estimated value is valid only under the particular circumstances and thus is specific to the context of valuation. One cannot multiply these out to estimate the value of the loss of the entire global ecosystems (Bockstael et al. 2000) or even a large forest ecosystem such as the Amazon rain forests. A simple aggregation or generalisation raises many unsolved problems in getting a total economic value like double counting.

3. Methods of valuing non-market forest ecosystem services

By definition, there are not market equilibriums to be observed for non-market goods and services. Therefore, the equilibriums must be inferred from both the demand and supply sides. Various methods have been developed to assess the economic value of non-market goods and services based on the principle of valuing market goods. While some of them provide an estimate of gross value, others provide an estimate of economic values. In decision-making, it is the economic values (not the gross values) of non-market goods and services that should be used when comparing with the economic values of market goods.

Recent forest economics or environmental economics textbooks often present six such techniques: contingent valuation (including conjoint analysis), travel cost, hedonic

pricing, avoided cost, replacement cost, and production function models. The first three are demand-side approaches and are based on household production function that involve modelling consumer behaviour, based on the relationship between an ecosystem service and one or more marketed goods (e.g., household incomes). The other three are supply-side approaches. Here, we point out whether they provide an estimate for gross value or economic value and discuss when to use each of them.

The contingent valuation approach and more generally stated preference techniques are based on asking consumers (or the general public, recreationists, and resource users) for information that is needed to specify the relevant demand curve of a good or service. It is called contingent valuation method because it is based on consumers' expressed willingness-to-pay or willingness to accept, contingent on specific information about the services and their own economic and social circumstances.

The problems raised regarding contingent valuation method is its accuracy as it may suffer from strategic bias, design bias, information bias, hypothetical bias, and operational bias (e.g., Kahneman, Knetsch, and Thaler 1991; Kahneman and Knetsch 1992; Knetsch 1994; Diamond and Hausman 1994). Thus, the design of questionnaires used in contingent valuation requires careful considerations. Studies (e.g., Kramer, Holmes, and Haeffele 2003; Nunes and Schokkaert 2003) show that the decomposition contingent valuation procedures (starting with household income, then deducting all the necessary expenses, and finally estimating the willingness-to-pay from the residual, disposable household incomes) are better than open-ended elicitation of values.

In spite of its inherent difficulty in administering, contingent valuation and conjoint analysis (or choice modelling method) is an appropriate method for estimating the *gross value* of all the ecosystem services together because it allows the estimation of complex multi-attribute values to people and permit such estimation in cases of high correlation among use values (Farber and Griner 2000). Stated preference techniques are the only ones available for estimating preservation values.

In contrast to these techniques, travel cost and hedonic pricing (as well as the supply-side methods) are based on revealed preferences; that is, consumers' actual choices. These methods are widely used in estimating the demand for recreational sites or cultural services of forest ecosystems, but less in soil and water conservation, biodiversity, or climate mitigation.

Many studies using demand-side approaches are not valuation by themselves, because the results generated from them are derived demand (or willingness-to-pay), which is the *use value* to consumers, for the ecosystem service in question. They are not economic value (*exchange value* or *shadow value*) to society. Even if these methods produce the accurate estimates of demand, for evaluation purpose, one still needs to find out their supply and exchange value (price or shadow value).

The supply of an ecosystem service is represented in the opportunity costs of resources used to provide this service. Because of non-rivalry and non-exclusivity, many public goods are supplied by governments through taxes, regulations, and land set aside. The supply of these public goods is thus reflected in the opportunity costs of all government resources that are used to provide these goods. Should the estimated willingness-to-pay for these goods exceed these opportunity costs, they should be provided, and their economic values are reflected in the opportunity costs of resource used.

The replacement cost approach is often used in the absence of reliable estimations of use value. For example, if a government has made a decision that a particular unpriced forest benefit must be maintained, the value of a forest already providing this benefit can be assumed to be worth at least the cost of replacing it by the lowest alternative means.

Thus, the value of a forest in carbon sequestration is at least equal to the cost of achieving the same result by another method. The cost avoided approach is similar to the replacement cost approach.

When they are good reasons to believe that the costs of damage avoidance or replacement of an ecosystem service differ substantially from the benefits it provide, these methods should be avoided, or at least used with caution when comparing with economic values of other goods and services. These approaches are closely related to the cost-effectiveness concept in benefit–cost analysis. For some purposes, forest managers find it sufficient that instead of attempting to estimate the value of certain unpriced forest ecosystem services, they take the objective of providing these services as given and try to find the least cost way to supply them or to avoid the damage the other ways may cause.

The production function approach is also called productivity approach or ‘valuing the environment as input.’ It is applicable in case where ecosystem services are a factor input in the production of a marketed good. Thus, changes in the availability of the ecosystem services can affect the costs and supply of the marketed good, the returns to other factor inputs, or both. For example, a forested watershed regulates water flow and mitigates drought (an ecosystem service) and thus increase production of coffee and rice. An appropriately specified production function may indicate the contribution of this ecosystem service as an input to the output of coffee and rice, and from this information, one may deduce the benefits of such an ecosystem service (Pattanayak and Kramer 2001).

As the production function approach is based on revealed preference and marginal analysis and incorporates both the supply and demand of the marketed good, it is a true *valuation* approach. For this approach to be applied effectively, it is important that the underlying ecological and economic relationships are well understood both in space and time. At time, these relationships may be extremely complex and only simplified functions can be used. Finally, this approach is mostly useful only in the context of one or two specific output production.

4. Valuation in the political process that supplies non-market forest ecosystem services

As noted earlier, many decisions on what non-market forest ecosystem services to supply and how much to supply are often made through a political process in which economic valuation and analysis plays a role. A clear understanding of forest ecosystem services and appropriately valuing them are critical, but values do not mean dollars only. Other considerations such as non-economic values (intrinsic value, ethic norms, or moral principles), political gains and losses (e.g., consideration for re-election), and interest group politics (e.g., lobbying) may be as important as, or more important than, economic valuation. Thus, decisions regarding forest ecosystem services can be seen as a continuum – it may be based solely on economic efficiency on the one hand, and strictly non-economic principles on the others.

For example, the Endangered Species Act of the United States (ESA) views the value of endangered species as ‘incalculable’ and ‘Congress intended endangered species to be afforded the highest priorities. . . The plain intent of Congress in enacting this statute was to halt and reverse the trend toward species extinction, *whatever the cost*’ (*Tennessee Valley Authority v. Hill* 437 U.S. 153,174,184 [1978]; emphasis added). Thus, the ESA may be seen as based on the principles regarding the duties to preserve species for their intrinsic and instrumental values. In response to this finding, US Congress immediately amended the ESA to allow at least the possibility of consideration of benefits and costs

and to create a committee with authority to grant exceptions to the law under very limited conditions that consider, but do not simply compare, benefits and costs (National Research Council 2005). In contrast, a much stricter cost–benefit approach is required to evaluating environmental regulations such as the Clean Air Act and Clean Water Act.

Thus, information about costs and benefits only inform and do not solely drive management and policy decisions. Even so, appropriate economic valuation improves public decision-making by allowing policy-makers to identify, evaluate, and consider trade-offs in environmental policy design and by promoting efficient uses of resources. The role of economists is to appropriately value these services and to present the valuations in a consistent fashion with marketed goods such as timber.

The political process not only allocates resources directly through command and control, but also creates markets in a cap-and-trade system that provides a politically determined price and facilitates resource allocations and valuations. Examples of successful cap-and-trade programmes include the Acid Rain Programmes implemented in the Great Lakes region of the USA and Canada, the wetland mitigation banking programme in the USA, and the carbon trading programme in Europe. Limited transactions also exist in the trading of wildlife (endangered species) habitats, healthy forests for water supply, and forests for carbon sequestration in the USA and elsewhere. From a valuation perspective, an increasing number of transactions in various ecosystem services may help us find the true economic values of these services.

5. Conclusions and implications

In this paper, we try to clarify that the gross values and economic values of forest ecosystem services are two different things. The gross values of forest ecosystem services are their aggregate use values, which can come from utilitarian perspective or from an altruistic and ethical motive. Use values are subjective and can be quite high. Under perfect competition, the gross values of forest ecosystem services are reflected in their demand curves. Economic values of forest ecosystem services, on the other hand, are based on the market or exchange values of these services. When market values and social values do not diverge, the market values of these services are their economic values. Economic values are mostly instrumental values and can be estimated considering the supply and demand of these services. When market values and social value diverge, appropriate adjustment need to be made in the valuation process.

Thus, even if human values of a forest ecosystem service are fully reflected in the demand curve for such a service, one has to consider the supply of such a service in order to assess its economic value. Conceptually, one cannot use the whole area under the demand curve of a forest ecosystem service (which is a gross economic value) as its economic value when comparing with the economic values of market goods such as timber. Aggregately, the willingness-to-pay or the market value of all global ecosystem services cannot exceed world income.

None of the non-market valuation methods provide more than rough estimates of economic values. Perhaps, the better non-market valuation method is based on models that include ecological/economic feedback that can be quantified and valued. These models are quite complex to integrate in economic valuation ecological modelling but there seems that they are increasing in the literature, especially when looking at payment for ecosystem services (Nguyen, Pham, and Tenhunen 2013). Such models must accurately describe the spatial and temporal dimensions of the ecological production function and

the economic value of the inputs and outputs of the ecological production function. In addition, not all values can be converted into dollars.

The difficulties of estimating non-market forest ecosystem services suggest that analysts should take advantage of market indicators of values or revealed preferences wherever they are available. For example, the amenity values of a forest may be captured or capitalised in its market values. The aforementioned water regulation service of a forest can be best estimated using the factor income or productivity approach. Finally, as the political decision-making process regarding non-market forest ecosystem services consider things other than economic value, a better understanding of the evolution and changes in social (ethical and moral) norms regarding forest ecosystem services (e.g., Chen et al. 2009) and of the politics and political process that determines resource allocations in providing these services is warranted.

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Note

1. Human happiness is a subjective utility or a subjective measure of well-being, an ‘experienced utility’ (Kahneman, Wakker, and Sarin 1997) or a ‘life satisfaction approach’ (Veenhoven 1997). It is now an increasing concept in environmental economics and an alternative to monetary valuation of environmental issues like stated or revealed preferences (Welsch 2009).

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