5.4 Economic valuation of forest ecosystem services

Forests can provide multiple benefits to society other than wood, with the whole array of benefits depending on the characteristics of the forest and the prevailing management strategies (Duncker et al. 2012). This understanding is a prominent feature of the current literature and is usually associated with the concept of multifunctional forests (e.g., Carvalho-Ribeiro et al. 2010, Gustafsson et al. 2012). One possible approach to capture the contribution of forest ecosystems to humans is through an improved understanding of the linkage between the functioning of the ecological system, which is perceived as a composite of processes and structures, and the functioning of the socioeconomic system. The crucial role that natural systems play in underpinning economic activity and human well-being is of growing concern (Bateman et al. 2010). Thus, economic valuation of ecosystems and their services has been receiving increasing attention in the literature.

Economic valuation is not the only approach to assigning a value to nature, nor is it necessarily the best approach; for examples of other forms of valuation, see Oksanen (1997), Martín López et al. (2012), and TEEB (2010). As Kareiva et al. (2011) pointed out, it is important to emphasize that an economic valuation does not replace or ignore the intrinsic value of nature, nor does it reduce the moral imperative to conserve nature. Following the logic of Martín-López et al. (2009) and Mace and Bateman (2011), we note the importance of combining economic and other valuation approaches to provide a more holistic picture of the value of forests. Nonetheless, in this chapter we will focus on the economic valuation approach. The primary role of economic analysis is to assist decision-making (Daily et al. 2000, Pearce et al. 1989, Tietenberg 1996). In the context of forest management, the high rate of deforestation we are facing globally—13×10^6 ha per year (FAO 2007)—and the rise of international concern about the consequences of deforestation together mean that economic valuation of forest ecosystem services has an important role to play.

Before jumping into the principles and methodological details of economic valuation, we will briefly illustrate how economic valuation of a forest ecosystem can restrain deforestation. As we noted earlier, forests provide many non-market goods, such as watershed protection. Landowners seek profit maximization, and in the absence of other mechanisms, they rely on existing markets to pursue this goal. Existing markets define their costs and revenues. Hence, even though we know that clearing the forest would increase problems such as downstream flooding and sedimentation, these costs do not accrue to the landowner who will decide whether to harvest the forest; thus, these costs are not factored into the landowner's decision. This is clearly a market failure from a larger perspective. Economic valuation can mitigate this problem if the analysis allows for an extended accounting of benefits and costs and, based on this more complete picture, fosters mechanisms such as subsidies, taxes, direct payments, and payments for ecosystem services that can prevent the market failure and reduce the likelihood of deforestation. For a concise review of market-based mechanisms, see Pagiola et al. (2002). These mechanisms aim to fully internalize the benefits and costs that do not accrue directly to landowners but rather that affect other groups in society. In Sect. 4.1, we further explain the occurrence of externalities and market failure from a conceptual point of view.

At this point, and before we begin discussing the principles of economic valuation, we want to emphasize that the value of forest ecosystem services reflects the different ways in which they satisfy human needs. This can be considered from the perspective of the total economic value (TEV) taxonomy (Pearce 1993).

This taxonomy defines the different sources of values that people may attach to the different services provided by a given ecosystem. Note that this taxonomy relies on whether ecosystem services satisfy human needs directly or indirectly. Economic value, then, is a measure of the degree of satisfaction provided by these services. The TEV approach and terminology are not uniform across the literature, but TEV generally includes the following value components: direct use, indirect use, option, and non-use. The first three categories are generally referred to together as use values, and the non-use values often aggregate values such as bequest and existence values.

Among the use values, direct use values include services that are used directly, and include provisioning services (e.g., forest goods) and cultural services (e.g., recreation opportunities). Indirect use values include services that are indirectly used, such as the benefits derived from regulating services (e.g., climate regulation). Non-use values are divided into bequest and existence values, and are almost entirely associated with cultural services. Bequest values represent the value that an individual assigns to an ecosystem or species due to its relevance to the well-being of future generations. Existence value, on the other hand, represents the value that an individual assigns to an ecosystem or species due to its personal relevance at the present time. In other words, it is the satisfaction this individual derives from knowing that a certain species or ecosystem exists.

Option values include all values (both use and non-use) that are expected to be enjoyed in the future (e.g., provision of genetic resources, maintenance of a gene pool for bioprospecting, cultural heritage). Note that the option and bequest values both reflect the importance that people give to maintaining or restoring ecosystems in order to ensure the delivery of ecosystem services in the future.

5.4.1 Principles of economic value estimation

The economic value of an ecosystem service refers to the contribution of a certain ecosystem functional dynamic to human well-being. Many ecosystem services are only obtained because of other capital inputs; for instance, agricultural production of food implies the use of machinery and labor together with the use of natural resources and ecosystem processes. Hence, as pointed out by Bateman et al. (2010), estimating the economic value of ecosystem services requires isolation of the ecosystem function's contribution before the value can be converted into a monetary metric. This suggests that it is also necessary to clarify how economic analysis differs from financial analysis: the former examines society as a whole, whereas the latter focuses on particular groups within society. Hence, when estimating the economic value of an ecosystem service, we must account for the costs (private and external) of producing the service and for the benefits (private and external) generated by it. Here, "external" refers to externalities, whether benefits or costs, that are generated as unintended by-products of an economic activity that do not accrue to the parties involved in the activity, and for which no compensation is provided.

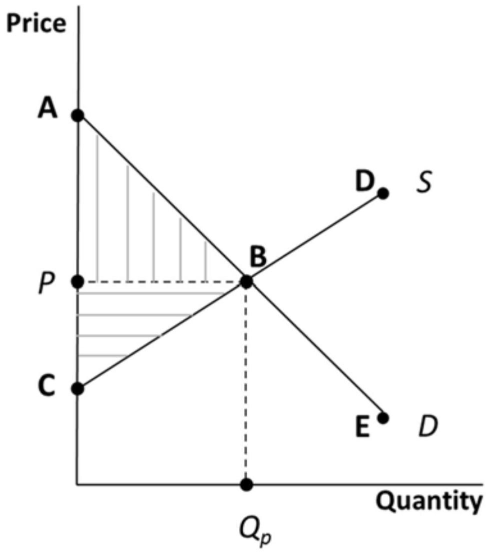

Figure 5.4 Social surplus [*ABC*] for a forest good such as timber under perfect market conditions. *D* demand curve, *S* supply curve, *P* price where *D*=*S* at point *B*, Q_p the quantity at price *P*

Depending on its impact on a third party, an externality may be positive (e.g., the creation of a forest landscape) or negative (e.g., the creation of fragmentation).

We first approach the economic foundation of ecosystem service valuation by considering a well-defined market in which ecosystem services can be traded and in which there are no external costs or benefits. There are two building blocks in the process of estimating economic value: consumer and producer surpluses, with the social surplus equaling the sum of these two surpluses. See Mankiw (2008) for a discussion of this topic. These measures are illustrated in Figure 5.1 for the case of an ecosystem service for which there is a market, such as timber (a forest provisioning service), based on the assumption of a perfectly competitive market. The timber market is in equilibrium when demand (*D*) equals supply (*S*) at price *P*. The demand curve shows consumer marginal willingness to pay (WTP), which represents the consumer's WTP for each additional unit of a product. The supply curve shows the marginal costs of harvesting timber, which represents the producer's marginal willingness to accept (WTA) a given price for their product.

Figure 5.4 tells us that buyers who value the good more than the price (represented by the line segment *AB*) choose to buy the good and receive a surplus of benefit: the area of the triangle *ABP* defines the magnitude of the consumer surplus. This represents the amount a buyer is willing to pay for a good, minus the amount the buyer actually pays for it, or, in different words, the benefit that buyers receive from participating in the market. Buyers who value the good less than the price (represented by the line segment *BE*) choose not to buy the good or receive its benefits. Symmetrically, on the production side, those sellers whose costs are less than the price (represented by the line segment *CB*) choose to produce (in this case, to harvest) and then sell the good (wood). Sellers receive a surplus given by the area of the triangle *PCB*; this represents the amount a seller is paid, minus the cost of production. The producer's surplus measures the benefit sellers receive from participating in the market. Sellers whose costs are greater than the price (represented by the line segment *BD*) do not sell the good or receive benefits from the sale. The social benefit (i.e., the overall surplus) in this case equals the private benefit, which equals the sum of the consumer and producer surpluses (i.e., the area of triangle *ABC*). The social surplus is of interest in economic analysis because it concerns the net benefits that society as a whole derives from the good. Mathematically, the total or social surplus can be expressed as follows:

$$\text{Social surplus} = \begin{bmatrix} (\text{value to buyers} - \text{amount paid by buyers}) \\ +(\text{amount received by sellers} - \text{costs beared by sellers}) \end{bmatrix}$$

Thus far, we have analyzed a situation in which the social benefit equals the private benefits. However, when there are external costs and benefits, the private surpluses do not equal the social surpluses. Let's again consider a timber market, but in the presence of external benefits, based on the example provided by Hanley and Barbier (2009). Consider a sustainable timber harvester, with sustainability here defined as a state of non-declining well-being, as defined by Tietenberg (1996; pp. 33–34). This harvester manages their land in a wildlife-friendly manner, thereby improving the ecological quality of their woods and overall forest health by (among other things) creating many habitats for birds and butterflies. They also harvest timber for sale. The market rewards them for their timber production, since they can sell the timber to interested buyers. But the market is unlikely to reward them for their "production" of wildlife habitats, even though these habitats might be valued by society. Although this is not the forum for further discussion of this topic, these types of services fall into the category of public goods (non-excludable and non-rival in consumption). See Boardman et al. (2001) for further explanation. In Figure 5.5, D_m is the market demand curve for timber, *S* is the supply curve for

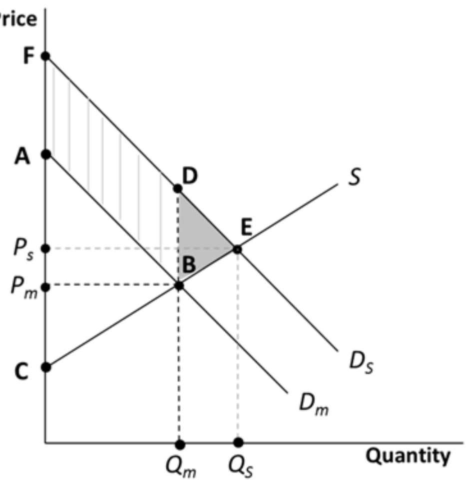

Figure 5.5 Social surplus (*ABDF*) for a good (e.g., timber) in the presence of a positive external effect (e.g., provision of wildlife habitat). *S* supply curve, D_m market demand for timber, D_s society's demand for timber plus its external benefits, Q_m the quantity at price P_m, Q_s the quantity at price P_s. *Grey area* (*BDE*) represents welfare lost under perfect market conditions (e.g., without government intervention)

timber, and D_s is society's demand for timber plus its external benefits (in this example, "production" of wildlife habitats). The market reaches equilibrium at point *B*. At this point, both timber consumers and the rest of society receive a benefit (an external benefit whose magnitude equals the vertical distance between D_m and D_s) which is represented by the line segment *BD*. The social surplus obtained when quantity Q_m is produced therefore equals the area of the polygon *ABDF*. Notwithstanding, the social optimum would be reached at point *E*, where the marginal social cost (which, as no negative externality is being considered, is the same as the marginal private cost) is equal to the marginal social benefit. Under perfect market conditions (e.g., without government intervention), quantity Q_s will not be supplied because harvesters are not rewarded for producing such quantity. The area of triangle *BDE* (grey shade) represents the welfare loss under these market conditions. Many ecosystem services are externalities, in the sense that the benefit or cost they represent to society is generated as a consequence of standard ecosystem management but it is not intentionally produced, and it does not accrue benefits or costs to the producer. This means that, for instance, the value of timber does not reflect the array of benefits that may be jointly provided by forests to society as a whole. Often, in the literature, these externalities are referred to as non-market ecosystem services. As we discuss in the next section, several methods have been developed to estimate the value of such ecosystem services.

5.4.2 Economic valuation methods

Our purpose is not to fully review all the available valuation methods, but rather to provide a concise overview of such methods while illustrating the objective and context of their application. In the previous section, we focused on consumer and producer surpluses as the measures of interest and explained how these measures relate to WTP and WTA. Bearing in mind that these are the measures of interest, we should also note that the focus of economic valuation is to estimate such measures for a well-defined change. This implies estimating the changes in the consumer and producer surpluses and the change in their sum (Freeman 2003) by considering changes in the welfare of both consumers and producers.

The methods used to value ecosystem services can be grouped into three main categories: direct market valuation approaches, revealed preferences approaches, and stated preferences approaches. Direct market valuation approaches rely on the use of data that can be readily obtained from existing markets (such as prices, demanded quantities, and production costs), and include three main approaches: approaches based on market prices, costs, and production functions. Market price approaches rely on the use of market prices as a proxy for value. Although this appears to be the most straightforward approach, there are several aspects that should be emphasized about its application. Under the general case of perfect competitive markets, prices are defined by the interaction of supply and demand; as a result, prices are acceptable or starting point approximations of the marginal value.

If this holds true, and the change being analyzed is sufficiently small that prices remain constant, application of the method is straightforward: we just multiply the change in the number of units (for instance, the increase or decrease of the available m^3 of water) by the associated marginal price. When the changes are large enough to change prices, then the changes in consumer and producer surplus must be estimated. Even if prices can be taken as a proxy for the marginal value, price distortions created by subsidies and taxes should be taken into account; the cost of making the good available should be subtracted from the price in some cases, since labor and transportation costs involved in making the benefit available represent opportunity costs that could be transferred to generate alternative goods and values; in addition, prices generated by supply and demand reflect scarcity, not value, as is often illustrated using the relative prices of water and diamonds (a paradox originally posed by Adam Smith), since water is vital to support life (unlike diamonds) but because it is generally abundant, it is cheaper than diamonds.

Cost-based approaches include the avoided cost, replacement cost, and mitigation or restoration cost methods, and are used to estimate the costs that would be incurred to artificially provide the benefit instead of using ecosystem services. In the context of forest ecosystem services valuation, the avoided cost method could be used (for example) to estimate the value of flooding protection provided by a forest based on the costs of building protection infrastructures to generate the same benefit; for other applications of the avoided cost method, see Nowak et al. (2006) and van Kooten (2007). The replacement cost method could be applied (for example) to estimate the value of soil protection based on the costs to restore the storage capacity of downstream dams after siltation of the reservoir. For other applications of this method, see Chopra and Kumar (2004) and Rodríguez et al. (2007). The restoration costs may, for instance, be useful in determining the value of water purification or infiltration based on the investments made to reverse degradation of the service. For other examples of the restoration cost approach, see Birch et al. (2010).

The last of the approaches based on market valuation is the production function method, which Barbier (2007) referred to as "valuing the environment as input". Behind the method's application is the idea that several ecosystem services (e.g., regulation services, biodiversity) enhance the production of market goods. Hence, if changes in these services affect the marketed product, then the effects of these changes will be visible through the price system. For instance, if the purification capacity for water decreases and this generates additional costs for the producers of bottled water, then the price of the water would increase. An example of this method in the context of forest ecosystem service valuation is provided by Nahuelhual et al. (2006).

In the revealed preferences approach, the main methods are the travel cost and hedonic pricing methods. These methods use consumption behavior in markets that are related to the non-market goods and that therefore serve as proxies for those goods. The travel cost method is the most commonly used method, and has been widely applied to infer the value of forests for recreation (e.g., Badola et al. 2010, Bowker et al. 2007). This method uses visitation rates and the distance traveled to infer the demand for such a benefit. The observed variation in visitation rates and travel costs (used as a proxy of price) describes the changes in demand for the site, and the demand function allows researchers to determine the consumer surplus. The hedonic pricing method uses the differences in the price of a benefit that reflect its inherent properties to infer the value of non-market attributes of ecosystems. A recent application of the method was provided by Sander and Haight (2012).

In the stated preferences approach, contingent valuation is the most well-known method. This method involves directly asking a representative sample of a population to define their WTP and their WTA for a well-defined change in the provision of a certain ecosystem service (for instance, a change in water quality). Researchers can then use compensating variation or equivalent variation to estimate the economic value. Both are exact welfare measures, and may not be identical to the consumer surplus for market goods. Instead, these measures estimate the change in income that is needed to maintain a certain level of utility (welfare, satisfaction). Note that along an ordinary demand curve, utility is not constant if income is kept constant. For further explanation of these measures, see Freeman (2003) and Zerbe and Bellas (2006). Choice modeling is a questionnaire-based method that gained relevance with practitioners of economic valuation of ecosystem services. The method consists of presenting individuals with two or more alternatives defined by a set of attributes regarding the ecosystem services under valuation, and it is designed to elicit the WTP for having that alternative. The levels of the set of attributes vary among the alternative sets that individuals must choose among or rank. Both methods have been applied to estimate the value of several forest ecosystem services. For examples of contingent valuation applications, see Sattout et al. (2007) and Barrio and Loureiro (2010); for examples of choice modeling, see Rolfe et al. (2000) and Brey et al. (2007). Individual-based questionnaires aggregated to represent a socially relevant unit (e.g., a community) might be appropriate when the services being valued are purely enjoyed on an individual level (e.g., valuing forests for timber), but have limited applicability in the cases of more communal services. For example, the value of forests to a community whose social system is intimately dependent on them is more than the sum of the independent personal values (Farber et al. 2002). Hence, another stated preferences method, group valuation, is gaining relevance. Although a stated preferences method, its focus is not on valuing individual preferences but rather on collecting social preferences. Wilson and Howarth (2002) and Chan et al. (2012) provide a detailed discussion of this method.

5.4.3 Challenges in estimating economic value

Estimating the economic value of ecosystem services faces several challenges, and regardless of the objective of the economic valuation, whether to inform macroeconomic policies or to evaluate programs (Bateman et al. 2010), estimation of flows of ecosystem services is often necessary. A flow estimation is usually an estimate of money per unit area obtained for a certain period, usually on an annual basis. Although flow estimations provide valuable information, they are not, per se, relevant to inform land-use decisions because few interventions would result in an entire loss of the flows of ecosystem services. Instead, management often results in incremental small changes. What is needed is an understanding of how land-use changes would affect societal well-being, so the focus of the economic valuation is on valuing the incremental or marginal changes in the flows of services. This is often done by means of scenario analysis, in which researchers compare the consequences of two or more scenarios. Valuing such changes implies a deep understanding of the ecological dynamics of the system and how the system responds to perturbation.

Though the economic valuation approach is remarkably valuable because of its ability to provide more objective comparisons of alternatives, it has not yet overcome significant challenges to tackling such complexity (Robertson 2011). This problem has been pointed out by several authors under the headings of uncertainty, ecological thresholds, and irreversibility (Morse-Jones et al. 2011), and in the contexts of weak or strong sustainability (Olschewski and Klein, 2011). Because the valuation focuses on estimates of marginal changes, caution is needed with the valuation itself because the marginal value may not be constant. This is clearly illustrated by the example provided by Bateman et al. (2010), who examined the recreational value of an urban green space (a park). They found that increasing the area of this space altered the recreational marginal value, with the first increases in area being highly valued, but subsequent increases becoming less valued.

There are other problems related to the assumption of a constant marginal value that suggest a need for caution. Ecosystems and their services are not spatially homogeneous and thus may not provide the same flow throughout the system's spatial extent (Fisher et al. 2009). Moreover, even when ecosystems provide the same flow of services from different areas, the marginal values of these flows may not be the same. We can illustrate this again using the value of a green space for recreation. An urban forest area of a given size may have a higher recreation value when it is near an urban area than when it lies in a region that is not accessible to urban residents. The issue of spatial variability of ecosystems and ecosystem services suggests the need to perform economic valuation on a spatially explicit basis. In addition, the effect of scale is a challenging topic that has not been fully tackled. This affects the discussion of ecosystem services valuation because the scale at which benefits might be provided ranges from local to global. For example, a forest might provide recreational opportunities (local), downstream flood prevention (regional), and climate regulation (global) when considered from the supply side. This variability also holds for the demand side. For instance, endemic species may have beneficiaries very far from the location of their occurrence (as in the case of residents of developed nations placing value on endangered species in developing nations). The issue of scale has been extensively debated (EEA 2010, Hein et al. 2006), and the advantages of spatial analysis in tackling the issue are making scale-explicit analyses increasingly relevant. Failing to properly address the issue of scale may complicate or bias the design of ecosystem services payments, which is an emerging mechanism to ensure the provision of non-market ecosystem services.