Problems and methods of forest-biodiversity economic valuation

For optimum and effective forest management, determining the economic value of the elements making up biodiversity is necessary but difficult. Methods to facilitate the task do exist.

Biodiversity is a source of value in forests in that it participates directly in production (wood, hunting, various forest amenities, etc.), in regulating production (resilience in the face of hazards and uncertainties) and in adapting to changes that are often complex and abrupt. The many services rendered by ecosystems (see box 1) often depend on biodiversity and thus enhance its value. A second aspect of its value lies in its non-market features, including culture, landscapes, philosophical and moral issues, that are not necessarily tied to "services". Finally, and this list is hardly complete, the existence value of the ecosystems and species making up biodiversity may be critical.

Economic valuation of biodiversity is useful and perhaps indispensable for efficient forest management in that it makes possible, for example, comparisons of the costs and benefits between prior and modified situations (e.g. costs resulting from damage to biodiversity during forestry work). A monetary value placed on biodiversity is the means to provide decision-makers with quantitative data to determine the costs and benefits of programmes intended to conserve or modify biodiversity. This type of valuation raises a number of methodological problems and, to date, no efforts have been made to summarise the work on the topic and thus facilitate concrete case studies. That is why we wrote a book for public and private forest managers (Brahic et Terreaux, 2009) to assist them in selecting the method(s) best suited to the aspect of biodiversity requiring valuation. The book is based essentially on an analysis of international publications and through the various examples presented, it enables managers to put the inevitable difficulties into perspective and possibly find solutions for them. It is this work that we will present briefly here.

Problems in biodiversity valuation

Biological diversity is defined as "*the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*" (article 2 of the 1992 Convention on biological diversity). Consequently, economic valuation of biodiversity consists of analysing, in a simultaneous and integrated manner, not only the genetic variability, the species richness and the ecological diversity, but also and above all their interaction.

That difficult task is made more difficult by the lack of knowledge on the role played by biodiversity of genes and species in the evolution of ecosystems and on their impact on the stability and sustainability (two terms that must be defined more precisely) of ecosystems. The complexity of ecosystems (and the corresponding impossibility of obtaining enough observations to understand the interactions) means that general laws on the above role shall not be available. However, it is via those laws that a significant part of biodiversity value is expressed.

1 Ecosystem services

The *Millennium Ecosystem Assessment* (MEA) evaluates the consequences of the changes affecting ecosystems and identifies four main categories of ecosystem services:

- provisioning services (resources such as food and fresh water),
- regulating services (hydric and climatic factors, pollution and disease control, etc.),
- cultural services (recreation, education, aesthetic and spiritual inspiration, etc.),
- supporting services (soil formation, nutrient cycling, etc.).

For a sustainable and multifunctional forest management, the economic dimension of the biodiversity must be considered. Eagle fern in the Orleans' forest.

What is more, that value is highly relative, i.e. biodiversity does not hold the same value (in particular social value) for different people, different societies or at different points in time.

The difficulties in economic valuation of biodiversity are made worse by the frequent confusion between the terms "biological resource" and "biological diversity". A biological resource is a gene, a species or an ecosystem whereas biological diversity is the variability of biological resources with respect to each other, ranging from genes to entire ecosystems. Most studies deal with evaluating biological resources and not with their diversity. However, a valuation of one component of biodiversity, taken alone, and a valuation of the same component among the other elements of biodiversity generally lead to different results.

Valuation methods

There are two main categories of methods used to assess the non-market values of biodiversity[1], i.e. direct and indirect methods. The indirect methods, called revealed-preference methods, use the information provided by markets and the behaviour observed on those markets. Depending on the situation and available data, researchers use the travel-cost method, the hedonic-pricing technique, the productivity-change method or cost-based approaches (restoration or replacement costs, etc.). Direct methods, called stated-preference methods are used when there is no market for the good or service linked to the environmental asset requiring valuation and, consequently, no prices setting limits to the value for the asset. The goal is to define a hypothetical market where people are asked to say how much they would be willing to pay. This category includes the contingent-valuation and the choice-experiment methods.

Another valuation method, less used but growing rapidly thanks to the accumulation of results obtained via the previous methods, concerns benefit transfer. This method uses the results of previous studies to run a new valuation on a similar object, but in a different place or time, in as much as the situation is similar or comparable. This is a useful alternative for decision-makers because it can be carried out quickly and at low cost. However, it requires great care to limit the transfer errors.

Which valuation methods?

The type of value (use or non-use[2]) to be assessed is a decisive factor. All methods can assess use values, but only stated-preference methods can assess non-use values. For example, authors have estimated the existence value of threatened species (including the Pyrenees brown bear) using the contingent-valuation method, some have analysed forest-protection and development projects using the choice-experiment method and others have used the travel-cost method for the recreational value of French forests.

What is more, these different valuation methods are not necessarily exclusive, they may be used together. For example, the travel-cost method may be employed for

1. This work deals exclusively with the **non-market values** of biodiversity which are the most difficult to evaluate. **Market values** of biodiversity, or more exactly of biological resources, correspond to goods and services available on a market, notably the products derived from ecosystems (plants, animals, etc.).
Their economic valuation consists of simply assuming that their value is equal to the market price. That is, however, a very limited method. For example, the value of mushrooms is not limited to their market price, they also have an existence or recreational value that is not manifested in the price. In addition, market values often result in confusion between resources and diversity, as mentioned above, and in neglecting the various dimensions of sustainability. The recent report by the Centre for strategic analysis (Chevassus-au-Louis *et al*, 2009) also addresses other aspects of biodiversity, ranging beyond forests.

2. **Use values** correspond to effective use of a good (consumption of products derived from hunting, fishing, harvests, etc. or recreational activities, tourism, etc.), whether planned or possible, including the option value which is that placed on preservation of a natural asset in view of a possible future use.

Non-use values concern the satisfaction of knowing that something or a situation exists. They correspond to the benefit that a person will gain over time from the availability of a good, even though it is not intended for use (bequest value, existence value).

the recreational use value of a site and the contingent-valuation method for its existence value. The difficulty lies in precisely determining what each method can address to avoid double counting in a context of cost-benefit analysis.

Whatever the method selected, the reliability and accuracy of results depend on how well it is applied. It is therefore very useful to examine the many valuation examples in publications to detect any potential difficulties. Analysis of current best practices enabled us to draw up summary tables to assist in selecting the method best suited to each context (see tables ❶ and ❷).

Panorama of valued items

Study of biodiversity economic valuation is fairly recent with major research efforts starting in the beginning of the 1980s. Most studies do not attempt to value the benefits of preserving or improving biodiversity, but rather the benefits of improving or maintaining a particular species, habitat or site.

Valuation of biodiversity as a source of genetic information generally takes place via the study of bioprospection work[3]. The goal is to measure the benefit of direct gene use through bioprospection contracts which manifest the willingness of companies to pay for genetic diversity as an input for the production of marketable goods. An estimation of average values was carried out in 2006 and arrived at 0.30 USD/hectare/year for the Mediterranean basin and 0.20 USD/ha/year for forests along the Atlantic coast. These values are far less than those estimated for so-called hot spots, which can reach 9 000 USD/ha/year.

Valuation of a particular species uses the information in the species-protection and restoration programmes (generally for animal species), where the willingness to pay (WTP) for such programmes is an indirect indication of the value assigned by people to that species. The overall goal is to compare the costs and benefits of the valued programme to determine its efficiency. Various species have been valued and study results produced different values. For example, in the U.S., the average value of a spotted owl has been estimated at 100 to 105 EUR/household/year and that of a bald eagle at 28 to 40 EUR/household/year. The values noted for wolves differ considerably from one country to another. A study in Sweden produced a value of 85 to 110 EUR/household/year whereas in the U.S., studies resulted in values of 15 to 45 EUR/household, but not per year (single payment). It is interesting to note that the median WTP for the establishment of a plan to control wolf populations, their health and habitats depends on whether the questioned person is a local or non-local person. It was approximately 4 EUR/household/year for local persons and 18 EUR/household/year for non-local persons.

3. Bioprospection is used primarily in the fields of pharmacology, biotechnology and agriculture. The goal is to detect, in the existing biological context, any genetic and biochemical resources having commercial value, e.g. for the development of new agricultural products, new medicines or other industrial products.

❶ Which valuation methods?

Asset	Recommended valuation method(s)
Species biodiversity	• Contingent valuation
Biodiversity of habitats, landscapes	• Contingent valuation • Hedonic pricing • Choice experiment
Recreational services	• Travel cost • Contingent valuation • Choice experiment
Ecosystem services	• Production function • Cost-based valuation approaches (avoidance costs, replacement costs, preventative expenditures) • Contingent valuation • Choice experiment • Hedonic pricing

❷ Summary of valuation methods

	Méthod	Pocedure	Applicable values	Exclusions
Stated preferences	Contingent valuation	Determine individual preferences by directly questioning people about their willingness to pay	All	Special situations where individuals have no prior knowledge
	Choice experiment	Determine individual preferences by directly asking people to select their preferred option among a set of options each having particular characteristics	All	Special situations where individuals have no prior knowledge
Revealed preferences	Travel cost	Estimate travel costs of people by a survey on the time expenses incurred to visit the studied site	Effective-use values: use of a recreational site	Non-use values
	Hedonic pricing	Determine the influence of an environmental characteristic on market prices (e.g. real-estate)	Quality of air, water, cultural benefits, beauty of landscapes (city parks), etc.	Non-use values, those not related to a marketable good
	Production function	Study the impact of change in ecosystem services on the goods produced	All impacts affecting the goods produced	Non-use values
	Protection expenditure	Determine the real or potential costs to individuals in protecting against negative externalities	Negative externalities (protection against fire, etc.)	Non-use values, anything that is not a negative externality
	Replacement cost	Determine the cost to replace a lost good or service	All lost goods and services	Non-use values

Valuation of a habitat involves determining the value of programmes to conserve, preserve and restore habitats such as forests, nature reserves, etc., or programmes to increase the size of protected zones. The final goal is to set a value for different types of landscapes, to value the quality of a forest, its existence value, or to value various environmental attributes (e.g. vegetation, species diversity, landscape diversity, etc.). Concerning forest attributes, a study in the U.K. valued them at 56 EUR/household/year, which corresponds to the WTP for a forest that would have what they consider "ideal" characteristics. Various factors influence the results, e.g. a restoration programme for two primary forests (pine trees) in Scotland were valued at 52 EUR/household/year for one and 79 EUR/household/year for the other. A forest-preservation programme in Australia was valued at 280 EUR/household/year whereas a protection programme for old forests in Finland was valued at 55 EUR/person/year. Again in Finland, a forest-conservation programme was valued at between 52 and 183 EUR/household/year using the contingent-valuation method and at between 107 and 193 EUR/household/year using the choice-experiment method.

Valuation of recreational services concerns natural zones subjected to high demand for such services and tourism. Studies concentrate on the current use of resources and benefit analysis is limited to determining use values. For example, in the Appalachians (U.S.), the value of hunting has been estimated at between 2 100 and 6 300 EUR/ha/year, that of fishing at between 900 and 2 400 EUR/ha/year and that of fauna/flora observing at approximately 1 500 EUR/ha/year. A number of studies have addressed forest recreational values, notably in the U.K. where WTP values are generally less than 4 EUR per visit.

Studies on valuation of ecosystem services supplied by forests concern notably soil erosion (the value of 45 EUR/ha was found by a study in Turkey), water quality (a U.S. study showed a WTP for an improvement in water quality between 14 and 37 EUR/household/year), carbon sequestration (between 300 and 440 EUR/ha for wooded land in the U.K. and 84 EUR/ha for wooded land in Ireland).

This study of the literature shows that for a given element of biodiversity, the values differ not only depending on the context and the forest itself (two similar forests may have different values), but also depending on the valuation method used. Results may vary quite widely and it is therefore important to select the method carefully.

Conclusion

In spite of the difficulties in the economic valuation of biodiversity, it is possible to estimate values using different methods. Selection of a method depends on the type of problem encountered, the type of value to be produced, the available data, etc. But whatever the method selected, the reliability and accuracy of results depend on how well it is applied, which explains why it is very useful to examine the many valuation examples in the literature.

Finally, it should be noted that the value of biodiversity is not limited to the results of these valuations. First of all, biodiversity has value as a source of greater profitability and greater sustainability for forest management. However, an attempt to build biological and economic models in view of operationally determining the value of a given component in biodiversity would not be successful, except for research purposes.

Terreaux and Brahic (2009) showed that the interactions between species are so complex that we cannot hope to formulate general laws on the role of biodiversity or, *a fortiori*, on a component of biodiversity, on the viability of ecosystems (their future capacity to manage certain constraints weighing on their condition or their products), on their resilience (the capacity to adapt to a new context or the speed of finding a new balance) or on the stability of their products (often central parts of forest-management plans). Secondly, biodiversity has its own intrinsic value ranging far beyond the limited field of economics (religious, cultural, heritage and affective values, etc.). In the final analysis, the economic valuation currently available to us provides only a very partial image that must be put into perspective with a much wider range of values. ■

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