VALUING FORESTS

A REVIEW OF METHODS AND APPLICATIONS IN DEVELOPING COUNTRIES

Environmental Economics Programme

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Preface

Economic development is often associated with rising demand for environmental amenities. Forests are a particular focus of environmental concern; in many countries the value of non-timber forest benefits - many of them non-marketed – appears to be increasing faster than the prices of wood products. One result is that certain forest areas are increasingly valued more for the environmental benefits they provide than for their timber. Hence, for example, the "set-side" of timber-rich areas for wildlife conservation and watershed protection, afforestation for carbon sequestration, and the increasing attention of public agencies to managing forests for recreational or aesthetic values.

Problems arise when policy-makers try to balance the twin objectives of wood production and environmental protection. When values conflict, what is the appropriate trade-off? What opportunities exist for "win-win" solutions, where wood and non-wood benefits are complementary? This report focuses on recent advances in the economic evaluation of forestry activities and, in particular, on how techniques for valuing non-timber forest benefits in monetary terms can assist the development of forest policy and management systems. The report considers the nature of non-market values and the need for valuation, as well as the different techniques used to estimate non-market forest benefits. It considers the use of valuation results in cost-benefit analysis and in forest policy and management. The report includes a review of recent empirical studies of the economics of forest land use options in the developing world.

This report draws on and updates material presented previously in a publication entitled: *Economic Analysis of Tropical Forest Land Use Options: A Review of Methodology and Applications* (IIED 1994), which was prepared on behalf of the UK Department for International Development (DFID). The present report has been entirely re-organised and re-written, with many new examples from around the world, as part of the background work for the World Bank Forest Policy Implementation Review and Strategy (FPIRS). The views expressed in this report do not necessarily reflect those of DFID or the World Bank.

Summary

All forest land uses can be characterised in economic terms, but until relatively recently there was no satisfactory way to compare the market and non-market benefits of alternative forest land use options. Recent developments in environmental and resource economics have produced new methods to estimate non-market forest benefits, making more comprehensive assessment of land use options possible.

Forests provide many different economic benefits, both tangible and intangible. These benefits can be grouped into direct and indirect uses, option and non-use values. Not all forest values are reflected in market prices, however, due to widespread market imperfections and policy failures. Historically, both private land users and public policy makers have focused on tangible, marketed forest benefits, especially timber and land for agricultural expansion. Until very recently, people have tended to neglect the non-market environmental benefits of forests. This has resulted in the excessive conversion of forest land to other, mainly agricultural uses, as well as excessive damage to non-market forest services in the process of extracting marketed timber and other goods.

Various methods have been developed to estimate the total economic value of forests, including both marketed and non-marketed benefits. These include valuation using market prices, surrogate market approaches, the production function method, stated preference and cost-based techniques. Each method has its strengths and weaknesses, and certain methods are better suited to particular forest goods and services.

Valuation methods are particularly useful for extending the reach of cost-benefit analysis (CBA), in order to include non-market environmental impacts in the assessment of development projects or alternative forest land uses. CBA is not perfect, nor is it the only way to assess forest land uses, but it is useful for illuminating tradeoffs. Rigorous use of CBA, however, requires careful attention to questions of discounting, risk and uncertainty, price distortions, distributional concerns, and the sustainability of resource use.

Recent empirical work, particularly in temperate forest situations, has generated a large number of studies on the value of non-market forest benefits. This trend has been followed in the developing world. The literature review reveals however that the focus of interest in developing countries is somewhat different from that in wealthier regions. Most published economic studies of forest land use options in developing countries appear to concentrate on direct use values. While the methods used to value these benefits are relatively straightforward, usually involving market prices, data on quantities and inputs are often difficult to obtain. Relatively few of the studies reviewed attempted to calculate the net economic value of forest products.

Early case studies in developing countries concentrated on the value of non-timber forest products (NTFPs) harvested from natural forests, including edible fruits, medicinal plants, honey, dye stuff, resins, etc. This may reflect an assumption (or a hope) that the economic importance of NTFPs was sufficient to justify the conservation of natural forest. Distributional concerns also guided this initial focus. Rural communities living in and around forest areas often rely heavily on NTFP products for both subsistence and cash income. These groups tend to be among the poorest and most deprived members of society. Where forests are perceived mainly as sources of growth for the timber industry, or as potential land for future agricultural expansion, attempts to estimate the value of other harvested forest products are one way to adjust the balance of

perspective. A key question for future research is how the value of different NTFPs changes with urbanisation and income growth.

The early concentration of developing country studies on NTFPs also reflects differences in forest values between developing and industrialised countries. Empirical research on non-market forest benefits in the latter case has focused on recreational and existence values held by urban consumers. This spurred the development of non-market estimation techniques appropriate to such values, such as travel cost models (TCM) and contingent valuation (CVM). In developing countries, on the other hand, forest values related to production and subsistence remain relatively important, although this is changing in regions characterised by rapid urbanisation and income growth. In South East Asia, for example, examples of TCM and CVM used to value forest recreational benefits have become increasingly common, particularly near urban areas. CVM may be more problematic in poor rural societies with different cultural perceptions. Nevertheless it appears to be the only means of eliciting quantitative information about existence values.

The concern of many citizens of industrialised countries about the loss of forests in rural and in developing regions is demonstrated in studies that estimate recreational and non-use values of such forests, which are mainly enjoyed by foreigners or by urban residents. These studies shed light on a key issue: how much do richer citizens of the world value forests, and how much are they willing to pay for forest conservation in rural areas or in developing countries? Difficulties with this type of research include ensuring that benefits are not overestimated by concentrating on only a single site, or extrapolating the results of an unrepresentative group of concerned individuals (e.g. eco-tourists) to a much larger and possibly more disinterested population (e.g. the entire United States). Another problem is the apparent conflict between rich and poor; the former seem to favour more forest conservation, and have the political clout and financial means to pay for it, while the latter prefer to use their forests to make a living, which until recently often meant extractive or destructive uses. The challenge is to find new ways to persuade those who demand forest conservation to pay for it, and thereby reward the provision of environmental benefits, just as markets currently reward logging and the conversion of forest land to agriculture.

Interest in forest conservation in developing regions concerns not only their perceived recreational or non-use values, but also indirect use values. For example, the value of forests in developing countries for mitigating global warming by storing carbon has been included in several case studies. Most of these rely on recently improved estimates of the costs of global warming, and better scientific understanding of carbon flux in forests and deforested areas. Resulting estimates of carbon storage benefits provided by forests tend to dwarf all other benefits, including timber, and are comparable to the returns to agriculture in many cases. As in the case of non-use benefits, the real question is when forest landowners in developing countries (or elsewhere) will be able to collect the money due on the carbon storage benefits they provide.

Watershed protection is another indirect use benefit that has received attention in recent studies. In all cases a production function (or change in productivity) approach is used with varying levels of sophistication and precision. One obstacle to wider application of this technique is the difficulty of quantifying underlying ecological relationships. This may be one reason why the conclusions of case studies are so very mixed. Some suggest that logging or forest conversion has devastating effects downstream, while others maintain that negative effects tend to be short-lived and are offset by positive impacts, mainly increased water yield. Given the difficulties involved and heavy data requirements, existing studies have generally been limited to situations where the linkages are relatively clear. Future work on the value of watershed protection benefits will depend to a large extent on research by natural scientists on the underlying biophysical relationships.

The value of forest biological diversity has been the focus of relatively few case studies. Initial estimates of the value of tropical forests as a source of new drugs and other biochemical products were very optimistic. Subsequent more rigorous studies indicate that genetic and other biological information contained in wild forest species does have economic value, but not enough by itself to justify forest conservation on a massive scale. On the other hand, the relative youth of the biochemistry industry suggests that demand for forest biodiversity may not have peaked. For forest biodiversity, as well as for other non-timber and non-market forest values, there is a need for better information on spatial and temporal variation in willingness to pay, and the underlying factors which determine the magnitude of non-timber values in different forest areas.

Overall, the empirical literature suggests that non-timber and non-market values of forests in developing countries are often significant, when compared to the market value of forest land for timber extraction and agricultural production. Information on the economic significance of non-timber forest benefits can and should be incorporated in private property rights, forestry regulations and pricing policy. This potential has not yet been realised, however, largely due to political and institutional barriers but also because of the lack of regular, reliable information on the use of (and changes in) non-timber benefits.

An important priority is thus to develop routine systems for monitoring and evaluating non-timber forest benefits on a national and local scale. The bigger challenge, however, is finding ways to "internalise" non-market forest values in local, national and international decision-making. Economists need to focus more attention on the institutional requirements and transaction costs of bringing non-market forest values into the market-place, including efforts to estimate the marginal costs to forest land-users of shifting from their current behaviour to more environmentally-friendly land use practices.

In conclusion, the challenge faced by forest managers and policy-makers is:

- to assess the current and expected future economic importance of non-timber benefits at the level of the forest site, region and nation, and under different land use and management regimes;

- to make informed trade-offs between the marketed and non-marketed benefits of forestry activities, both at the level of national or regional land use planning and in the management of particular forest sites; and

- to devise regulations and incentives which lead forest managers and land users to account more fully for non-market benefits in their decision-making. Where non-timber values are held mainly by foreigners, this may imply the need for innovative mechanisms for international financial transfers for environmental benefits.

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1 Introduction

Forests have been important to most human societies for as long as we have inhabited the earth. How people use and value forests at a particular place and time, however, depends in large part on their scarcity or abundance relative to changing human needs. Historical patterns of forest land use reflected the cumulative effect of centuries of individual or small group decisions about where to hunt, where to settle, what land to clear for agriculture, and what land to preserve for religious or other purposes.

In recent years, human population growth, migration and industrialisation, and other socio-economic changes have had a dramatic impact on the world's forest resources.[1] Traditional forest land uses in the tropics have been joined and in some cases displaced by large-scale commercial activities, such as industrial logging, plantation forestry, mining or cattle ranches. Even where forests are not cleared outright, they are often modified by the use of fire or other practices which favour particular plant and animal species.

Deforestation in tropical regions is now widely acknowledged as an issue of global concern, as is the decline in mature or "old-growth" forests in all countries (Barbier *et al.* 1994; Brown and Pearce 1994; Dudley *et al.* 1995; Sharma 1992). The recent increase in secondary forests in temperate regions, while less well-known, will also have a profound effect on the global supply of forest goods and services (Arnold 1991; FAO 1995; Sedjo and Lyon 1990). Meanwhile, human demands on forests are changing rapidly, as we become more aware of the environmental benefits they provide.

All of these trends can be characterised in economic terms, as forest land users have always been concerned with the relative costs and benefits of alternative ways and places to make a living. In the past, however, trial and error or rough rules of thumb were adequate means of determining which land to use and how. Until very recently there was little *formal* economic analysis of what type of land use is best in a particular area, or how to manage that use for maximum benefit.

In the past few decades, the increasing scarcity of "natural" forest on a global scale, together with concern that opportunities for economic development should not be wasted, have led government agencies and private firms to rationalise their decision-making with respect to the use of forest lands. New tools have been developed to evaluate alternatives, both at the level of specific sites and projects, and on a regional scale. Methods of appraisal include physical approaches, such as land suitability classification, as well as financial and economic methods such as cost-benefit analysis and forest sector models. Many of these methods have been developed in the industrial nations, and subsequently adapted for use in developing regions.

Even more recently, there has been growing awareness and concern about the potential adverse social and environmental consequences of land use change. These impacts may be significant, yet because they are generally non-marketed or imperfectly reflected in markets, environmental values in particular tended to be ignored in past decisions about forest land use. In response, many public agencies and private firms now try to ensure that project and policy reviews - from *ex ante* appraisal to *ex post* evaluation - account for social and environmental impacts as well as

[1] Forests currently cover about one quarter of the earth's land surface and are concentrated in the developing countries, although the balance is shifting due to deforestation in the developing world combined with growing forests in the developed regions (FAO 1995).

economic effects. In the forestry sector as elsewhere, new multi-disciplinary procedures have been developed for impact assessment, land use evaluation, project appraisal and policy analysis.

As part of this effort, environmental and resource economists have elaborated new concepts of value, which include the environmental costs and benefits of economic activity. They have also developed new ways to measure these non-market impacts. These include a range of methods to estimate the economic significance of *non-timber forest benefits*, both in aggregate terms and in terms of their value to particular stakeholder groups. The results of these efforts are seen in a growing record of attempts to evaluate the social, economic and environmental trade-offs of alternative forest land uses in monetary terms. This report provides an overview of the new methods and recent applications, focusing on forest land use in the developing world.

1.1 Aims of the report

This report aims to review and illustrate the new concepts and methods used to evaluate the environmental benefits and distributional consequences of alternative forest land use options, with a focus on *non-timber benefits in developing countries*. The report presents a general framework for identifying, estimating and comparing forest values, within the context of cost-benefit analysis. We review the different valuation techniques used in such assessments and illustrate their application with examples drawn from the empirical literature. The report also includes a brief discussion of how the results of valuation studies can contribute to improved forest policy and multiple-use management, and identifies a set of critical issues and research priorities in the valuation of forest land, as a contribution to on-going research efforts. The appendix to the report includes detailed summaries of over 50 economic case studies of forest land use values.[2]

In compiling this report, we were conscious of the many existing publications which go beyond case studies of specific countries or forest areas, and likewise attempt to address the economics of multiple-use forestry in broader terms. These include a wealth of literature reviews, theoretical think pieces, original policy analysis, training manuals and guidelines for practitioners, as well as "state-of-the-art" compilations of new research.[3] The discussion of theory and method presented briefly here can be found elsewhere, and in much more detail. What distinguishes this report, we hope, is the extensive review of recent case studies carried out in the developing world, which to our knowledge have not been compiled previously in any other publication.[4]

The report concentrates on the application of *cost-benefit analysis* (CBA), which is widely used in the economic appraisal of development projects, to forest land use decisions in the developing world. Other appraisal methods are also briefly reviewed, including methods designed to assist decision-making where the information available does not permit a full CBA, as well as methods designed to compensate for perceived weaknesses of CBA. While the focus throughout is on the use of forests in developing countries, many of the issues and methods discussed here are equally relevant in other contexts.

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[2] Most case studies discussed here are from developing countries and focus on tropical forests. No case studies were identified from the Transition Economies, although this gap in the literature will surely be filled soon.
[3] Among many, many others see: Adamowicz *et al.* (1996); Bann (1998); Barbier and Burgess (1997); De Beer and McDermott (1996); Godoy *et al.* (1993); Gregerson *et al.* (1995); Gunton (1991); Lampietti and Dixon (1995); Lee *et al.* (1998); Parks *et al.* (1998); Prins *et al.* (1990); Roper and Clark (1999); Southgate (1998); Wibe (1995).
[4] Almost all of the material reviewed for this report was published in English. No attempt was made to review material published in other languages, although we are aware of some relevant research on the topic.

A major part of the report is devoted to the use of different valuation techniques for estimating willingness to pay (WTP) for non-timber benefits provided by forests.[5] We do not attempt to provide a "cook book" for valuing non-market benefits, as such methods are described more fully in a number of existing publications. The economics of timber production receives no special attention, although logging is included as one of many possible uses of forest land. The report is intended as a supplement to existing manuals on the economic analysis of development projects,[6] the economics of forest management for timber,[7] and the valuation of environmental impacts.[8] Readers seeking more detailed treatment of CBA and valuation techniques (some of which form the subject of entire volumes) will find plenty of references to get them started.[9]

The report is offered as a resource for land use planners and forest policy makers. We hope it will inspire some readers to attempt (and others to insist upon) more comprehensive evaluations of the environmental impacts and distributional implications of tropical forest land use options. The review of applications may also be helpful to students and researchers.

1.2 Structure of the Report

The report provides a general framework for identifying, estimating and comparing forest values. Chapter 2 introduces the range of goods and services provided by forests, drawing on the concept of Total Economic Value. The chapter goes on to draw a distinction between those forest benefits which are traded in markets, and those which are non-marketed or only imperfectly reflected in markets. There follows a brief discussion of why certain forest benefits are more likely to be ignored or under-valued by the market, and the adverse consequences that result for both the environment and the economy as a whole.

Chapter 3 reviews the different valuation methods which can be used to express non-market forest goods and services in monetary terms. These include relatively sophisticated techniques such as travel cost models, hedonic pricing and the contingent valuation method, which were developed in the context of industrialised economies where environmental amenities have assumed greater significance in recent years. Chapter 3 also considers alternative methods such as cost-based valuation and the production function approach. These have emerged from the experience of appraising investment activities in developing countries, where non-marketed goods and services often have greater importance in production processes.

Chapter 4 presents an extended cost-benefit analysis framework, showing how the forest values discussed in preceding chapters can be included in an economic assessment of forest projects and

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[5] Willingness to pay (WTP) is a monetary measure of the demand of consumers for a particular good or service. Normally used in reference to goods and services that are not traded in markets, and for which no price can be observed directly, mean WTP is analogous to price in the sense that it expresses a monetary value which may be compared to other priced or un-priced goods and services. A related concept is willingness to accept (WTA), which refers to the amount of money that consumers demand in compensation to give up a particular good or service. See Freeman (1993) for a fuller explanation.

[6] See for example: Gittinger (1984), Little and Mirrlees (1974), Squire and van der Tak (1975), Winpenny (1988).

[7] See for example: Bowes and Krutilla (1989); Hyde and Newman (1991); Repetto and Gillis (1988).

[8] See for example: Abelson (1996), Cummings *et al.* (1986); Dixon *et al*. (1994), Freeman (1993); Hearne (1996); Hufschmidt *et al.* (1983); Kopp and Smith (1993); Mitchell and Carson (1989); Munasinghe and Lutz (1993); Vincent *et al.* (1991); Winpenny (1991).

[9] Particularly Hanley and Splash (1994) which is specifically concerned with CBA and the environment, and also the Environmental Valuation Reference Inventory, published at http://www.evri.ec.gc.ca (an initiative of Environment Canada).

programmes. The chapter considers various criticisms of valuation, and offers justification for continuing efforts to place monetary values on non-market forest benefits. We also provide some practical guidelines for preparing an assessment and discuss key methodological issues in cost-benefit analysis. Particular emphasis is put on the distinction between a financial perspective and an economic analysis which incorporates both distributional and sustainability concerns. Chapter 4 includes references to relevant case studies in developing countries, as well as additional references on the theory and application of valuation techniques and cost-benefit analysis.

Chapter 5 contains a brief overview of the potential uses of forest valuation results. This includes a discussion of the implications of valuation for land use planning, forest property rights, forestry regulation and forest pricing or tax policy.

Chapter 6 of the report reviews the recent experience of valuing forests in developing countries. It provides an introduction and overview of the literature, focusing on which forest benefits are most often valued, using which methods. An attempt is made to identify general lessons about the potential and limitations of forest valuation in developing countries. Some suggestions for further research in this area are also put forward.

The appendix to this report comprises summaries and commentary on more than 50 case studies containing economic appraisals of forest land use options. The purpose of the summaries is to provide further information on a representative selection of case studies of different forest land use options, market and non-market values, countries and approaches. References included here are those which we think illustrate most clearly the environmental costs of forest land use, the trade-offs among alternative uses and socio-economic groups, and the methods available to value non-marketed forest costs and benefits. References relating to temperate forest land use are included only if they are particularly relevant from a methodological viewpoint.

A complete bibliography is provided at the end of the report. This includes references consulted for both the report and the appendix. All references printed in **bold type** are summarised in the appendix to the report. Additional key references cited (e.g. sources of secondary data for case studies) are also included in this list, although not all have been reviewed by IIED.

2 Forest Goods and Services

Economic development is often associated with rising demand for environmental amenities.[10] Forests are a particular focus of environmental concern; in many countries the demand for non-timber forest benefits may be increasing faster than demand for most wood products. One result is that certain forest areas are increasingly valued, by the public as well as their political representatives, more for the environmental benefits these forests provide than for their timber. Hence the set-side of large areas of timber-rich forest for wildlife conservation. Hence also the increasing attention of public agencies to managing forests for recreational or aesthetic values.

Problems arise, however, when policy-makers try to balance the twin objectives of production and environmental protection. When different values conflict, what is the appropriate trade-off? What opportunities exist for "win-win" solutions, where wood and non-wood benefits are complementary? The first step in answering such questions is to identify clearly the different forest values that are at stake. Hence this chapter begins by reviewing the components of forest value. We briefly consider the distinction between market and non-market costs and benefits, and consider why the market tends to ignore certain forest values.

2.1 Identifying Forest Benefits

It is increasingly recognised that forests provide a range of goods and services, some of which have significant economic value.[11] These include fertile soil and wood, of course, but also non-timber products, recreation, landscape value and a wide range of environmental benefits such as climate regulation, watershed protection and the conservation of biodiversity. Forest benefits may be grouped into general categories, as in Table 2.1. This follows a typology introduced by Pearce *et al.* (1989), which recognises three types of environmental value:

- *direct use* value, e.g. the benefit of using forest resources as input to production or as a consumption good;

- *indirect use* value, comprising the support and protection provided to economic activity and property by natural forest functions, or forest "environmental" services; and

- *non-use* value, including all other benefits which cannot be characterised in terms of a current or future physical interaction between the forest and consumers.

Direct uses of forests include both commercial and non-commercial activities. Commercial uses such as timber or pulpwood production may be significant in both domestic and international markets. Non-commercial direct uses, on the other hand, are often mainly local but can be very important for the subsistence needs of rural populations and poorer groups, e.g. fuelwood, game, edible and medicinal plants (FAO 1990). Direct uses also include important services such as forest recreation, education and research, which are often conducted on a non-commercial basis.

[10] This does not necessarily imply that demand for environmental quality increases faster than income (see Kristrom and Riera 1996; McConnell 1997).
[11] See FAO (1999) for alternative definitions of forest land.

Table 2.1 Types of Forest Value			
Use Values			**Non-Use Values**
1. Direct Use Wood products (timber, fibre, fuel) Non-wood products (food, medicine, genetic material) Educational, recreational & cultural uses Human habitat Amenities (landscape)	2. Indirect Use Watershed protection Nutrient cycling Air pollution reduction Micro-climatic regulation Carbon storage	3. Option Future direct and indirect uses	4. Existence Biodiversity (wildlife) Culture, heritage Intrinsic worth Bequest value

Source: adapted from Barbier (1991).

Indirect use values comprise the many ecological functions of forests. Their value derives from supporting or protecting economic activities that have directly measurable market benefits. For example, some forest may have indirect use value through controlling sedimentation and flood damage that affects downstream agriculture, fishing, water supplies and other economic activities (**Aylward *et al.* 1999**). Likewise the micro-climatic function of certain forests may have indirect use value by maintaining or enhancing the productivity of crop cultivation in adjacent areas (Lopez 1997). Another important indirect use value associated with forests is the storage or "sequestration" of carbon in trees, offsetting the atmospheric accumulation of so-called "greenhouse" gases that are implicated in global warming.

Some people distinguish a further sub-category of *option value*, referring to potential direct and indirect use values which might be realised in the future. According to this view, there may be a premium on preserving forest ecosystems for future uses, particularly if we are uncertain about potential future values but believe they may be high, or if the effects of exploitation or conversion are thought to be irreversible. For example, certain forest resources may be under-utilised today but may have high future value in terms of scientific, educational, commercial and other economic uses. Similarly, the environmental regulatory functions of a forest ecosystem may become more important over time as economic activities develop and spread in neighbouring areas. However, including option value as a separate element of total economic value is controversial since it can be difficult to say what sign this will take.

Finally, there are *non-use* values. These refer to the intangible benefits derived from the mere existence of forests, above and beyond any direct or indirect use value that people may enjoy. Non-use values include both *existence value* and *bequest value*. An example of the former is the value which people attach to the continued existence of certain species of wildlife found in particular forest areas (e.g. bears or tigers). Such values may be most apparent among those who do not live near or use the products of forests directly themselves, and perhaps benefit only very slightly from indirect uses, but who nevertheless wish to see such forests preserved in their own right. *Bequest values* arise when people place a value on the conservation of particular resources for posterity (future generations). Bequest values may be high among local populations using or inhabiting a forest area, to the extent that they wish to see a way of life and culture that has “co-evolved” with the forest passed on to their heirs. By the same token, those who live far from forests may wish to ensure that their descendants have an opportunity to visit and enjoy them.

The *Total Economic Value* (TEV) of a forest system refers to the sum of (compatible) values: i.e. direct and indirect use (and their associated option values), plus non-use values. Different forest land use options will be characterised by a different combination of direct, indirect and non-use values, and thus a different total economic value. Only part of this value is reflected in market prices, however, creating a risk that forest planners and land users will ignore or under-state certain important forest benefits. We now turn to why this happens.

2.2 Market and Non-Market Values of Forests

Only some of the forest benefits listed above are traded in markets and have a directly observable price. In general, direct use values are most likely to be reflected in market prices. Indirect use values may be reflected in the prices of certain goods and services which depend heavily on the underlying environmental benefit, while non-use values are rarely reflected in market prices or decision-making. Clearly, however, the absence of a market price does not mean that a thing has no economic value.[12]

Most forest landowners are aware of the many environmental benefits they provide, in addition to supplying timber or other commodities to the market. Public agencies in many countries, some of them responsible for managing millions of hectares of forest land, often make special efforts to provide non-timber benefits. This includes restricting logging in areas of exceptional natural beauty for the sake of recreational uses, or on steep slopes so as to protect water quality and reduce the risk of flooding downstream. Similarly, some companies provide access to their land to hikers, hunters and fishermen on a voluntary basis.

While such efforts are welcome they are usually limited in scope and often inadequate relative to public demand. The reason is that forest landowners and managers in most countries get little or no material advantage from providing environmental benefits. Both in the private and the public sectors, landowners and managers tend to focus on the direct costs and tangible benefits of their activities. Thus foresters produce timber because they can sell it, while farmers convert forest land because they can cultivate it for profit or subsistence.

Many non-timber forest benefits, on the other hand, cannot easily be bought and sold (e.g. biodiversity, watershed protection, carbon storage[13]). Others generate little or no revenue for the landowner, although they may have significant value to the general public (e.g. aesthetic values). Where non-timber forest benefits are also non-marketed, private landowners will have little motivation to produce them unless compelled to do so. Similarly, public forest agencies may under-estimate the importance of such benefits, which are often less visible than the revenue, taxes and jobs generated by the timber and agriculture industries.

[12] Economists distinguish financial from economic values. The former refer to market prices, while economic values (“efficiency prices”) are estimates of the prices which would prevail in a competitive market, free of any market imperfections (e.g. monopolies) or policy distortions (e.g. taxes or barriers to trade). Efficiency prices are considered a more accurate reflection of the contribution of a good or service to social welfare.

[13] Although it is possible that carbon storage benefits could be sold if a global market for carbon credits emerges as a result of Kyoto.

Even where forest benefits are partly or informally traded, they often escape notice. In many developing countries, for example, rural populations exploit non-timber forest products such as vines and edible fruit for both subsistence and sale, but this activity is rarely recorded and is thus easily ignored by forest authorities. Similarly, in the developed world, entry fees to forest recreational areas often grossly under-value the true willingness to pay of visitors and thus the full value of recreational benefits.

Demand for traditional forest products - timber and pulp - is expected to increase with economic growth (Brooks *et al.* 1996; FAO 1997). Timber prices are also expected to rise in many developing countries, due to the increasing scarcity of easily accessible, mature stands of timber, although price increases will be moderated by new forest plantations and supplies from other parts of the world (Perez-Garcia and Lippke 1993; Sohngen *et al.* 1999). At the same time, demand for forest recreation and landscape amenity values can also be expected to grow rapidly in many developing countries, due to urbanisation and rising incomes, whereas the demand for certain non-timber forest products may fall. For example, higher rural incomes can lead to decline in both the range and volume of forest products used for subsistence, but this may be offset for certain products by increased commercial exploitation and sales in urban markets. Recent work on the consumption of an edible forest fruit in Malaysia has found that urban consumption has increased at almost the same rate as incomes (Woon and Poh 1998).

The fact that many non-timber forest benefits are not traded or do not have a directly observable market price is not a problem in itself. However, the use of forests to produce tradable commodities such as timber or agricultural crops often reduces the availability of non-timber goods and services, with the result that non-market, environmental values are lost or diminished. If the latter are significant, forest resources will be used inefficiently, both in terms of the area devoted to timber or converted to agriculture, and in terms of the technology of production, i.e. management. We now turn to why the market often fails to account for non-timber benefits, even when they are important in economic (as opposed to financial) terms.

2.3 Non-Timber Benefits and Market Failure

In principle, markets will allocate resources efficiently if prices reflect both the full marginal costs of production and the full marginal benefits of consumption, including all components of total economic value.[14] Where prices do not reflect all costs and benefits, however, the so-called "invisible hand" of the market does not work and resources may be used inefficiently, resulting in a loss of human welfare (Baumol and Oates 1988). Economists have identified various reasons why market prices fail to reflect environmental costs and benefits. Two of the most important reasons for market failure in forestry are the prevalence of "public goods" and "externalities".

Public goods are characterised by the fact that: (i) no one can be effectively excluded from consuming them and (ii) increased consumption of the good by one individual does not

[14] The marginal benefit (or cost) of a good refers to the incremental change in consumer welfare (or producer cost) resulting from an incremental change in the quantity of the good consumed (or supplied). In a competitive market the level of output is determined by prices, which will tend to equilibrate at the point where marginal benefit equals marginal cost and social welfare is maximised. This is the "efficient" level of output, for a given distribution of income (Henderson and Quandt, 1958).

reduce its availability to others. For example, no one traveling on a public thoroughfare can be charged for enjoying a pretty view, even if the land in question is privately owned. Nor does one person's enjoyment of the view detract from that of another (provided there is no crowding!). Such aesthetic value is among many public goods provided by forests, along with carbon storage and biodiversity conservation. Economic theory explains why the free market will systematically under-provide such goods, and why collective action, typically by the government, is usually required to ensure their adequate provision.

Externalities are uncompensated costs or benefits arising from economic activity. A classic example in forestry is the decline in availability of game or other non-timber forest products due to logging. Unless the logging company (or landowner) pays compensation to hunters and gatherers for their loss of livelihood, the full economic cost of extracting timber will not have been paid.[15] If similar conditions prevail elsewhere, market prices of timber products will tend to understate true economic costs and consumers will use timber relatively inefficiently.

In addition to public goods and externalities, markets may fail to reflect non-timber forest benefits due to lack of information about their contribution to economic welfare, distortions in prices arising from public policy and regulations, lack of clear or secure property rights over forest lands, and other factors. In such cases, the question arises as to how decision-makers can compensate for market failure, and ensure that non-timber forest benefits are given sufficient weight in land use planning and management.

There are many ways to internalise non-market values in the behaviour of producers and consumers, ranging from the introduction of strict environmental standards to ecological tax reform, and from facilitating environmental damage claims in the courts to the promotion of trade in environmental services or "pollution permits". An extensive literature describes the economics of different approaches to environmental protection (Baumol and Oates 1988; Cropper and Oates 1992; OECD 1989; Portney 1990).

A full review of environmental policy is beyond the scope of this paper. Nevertheless, it is clear that information on the significance of non-market environmental impacts, and the trade-offs between market and non-market values, is an essential input to rational environmental policy-making. Without such information, it is difficult to see how one can determine the urgency, stringency and scope of intervention required. One promising approach is to express non-market environmental costs and benefits in monetary terms, so they can be compared directly with the value of marketed commodities. The following chapter describes the various methods available for this purpose.

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[15] Who should pay whom depends on the allocation of property or use rights. Where rights are informal, customary or disputed, it can be very difficult to agree on appropriate compensation.

3 Methods for Valuing Forest Benefits

To help private firms, government policy-makers and non-governmental organisations make more informed decisions about activities with significant environmental impacts, economists have devoted considerable effort in recent years to developing and applying methods for valuing non-market benefits in monetary terms (Freeman 1993). All of the methods attempt to express consumer demand in monetary terms, i.e. the willingness to pay (WTP) of consumers for a particular non-marketed benefit in monetary terms, or their willingness to accept (WTA) monetary compensation for the loss of the same. In short, these valuation methods attempt to express the utility derived from non-market goods and services in the metric of the market, which is considered to provide an accurate reflection of the relative preferences of producers and consumers for different goods and services. (Just how "accurate" is discussed below.) The resulting values may be used in cost-benefit analysis or as input to more elaborate economic models.

Techniques for estimating non-market or non-timber forest values vary in their theoretical validity and degree of acceptance among economists, their data requirements and ease of use, and the extent to which they have been applied in (and perhaps their relevance to) different countries (Munasinghe and Lutz 1993). For convenience, we have divided the different techniques into five broad groups:[16]

i. *market price* valuation, including methods to estimate the benefits of subsistence production and consumption;

ii. *surrogate market* approaches, including travel cost models, hedonic pricing and the substitute goods approach;

iii. *production function* approaches, which focus on biophysical relationships between forest functions and market activities;

iv. *stated preference* approaches, mainly the contingent valuation method and variants; and

v. *cost-based* approaches, including replacement cost and defensive expenditure.

The remainder of this section reviews the different methods, illustrated with examples from case studies of forest land use evaluation in developing countries. A summary table (3.1) is provided at the end of the chapter, showing the main valuation methods, the forest benefits for which they are most suited, and their respective strengths and weaknesses.

3.1 Valuation Using Market Prices

The simplest valuation methods are those, which rely on market prices. Many goods and services from tropical forest land uses are traded, either in local markets or internationally, including wood products (timber, pulp and fuel), non-wood forest products (food, medicine and

[16] These categories overlap to some degree, and alternative groupings of valuation methods may be used. Certain authors emphasise the distinction between methods which elicit direct statements of willingness to pay (e.g. contingent valuation) and those which rely on indirect indicators or "revealed preference" (including market prices and most other valuation methods). See Freeman (1993) and Maler (1992) for further discussion.

utensils), crops and livestock products, wildlife (meat and fish) and recreation. For those products that are commercially traded, market prices can be used to construct financial accounts to compare the costs and benefits of alternative forest land use options. In some cases, it may be necessary to adjust market prices to account for market or policy failures. The latter step, also sometimes called "shadow pricing", is discussed further in Chapter 4 where we address various methodological issues in cost-benefit analysis.

Prices reflect the interaction of consumers and producers over the demand and supply of goods and services. In an "efficient" market, goods and services will be priced at their marginal value product and reflect the full opportunity costs of resource use.[17] Where available, efficient market prices are usually the first choice for comparing the costs and benefits of alternative activities. For many NTFPs, researchers are able to record prices in local or more distant markets. Despite questions regarding their efficiency, there is often little choice but to rely on actual market prices.

When using market prices for the purpose of financial valuation it is important to determine the *appropriate* market price for the various goods and services of alternative forest land uses. There may be a variety of ways to obtain the relevant market prices, including existing economic and social studies, published or privately held statistics, socio-economic surveys and consultation with agricultural extension officers, forestry service personnel, government market specialists and statisticians. In many cases it will be necessary to carry out new market surveys to collect the prices of so-called minor non-timber forest products, which may be traded on a small-scale or occasionally, and which are typically neglected by official economic statistics. It may also be necessary to take account of seasonal variations in demand or supply that lead to fluctuations in market prices.

Using information derived from such sources it should be possible to derive prices that reflect the prevailing market value of the goods and services of specific forest land uses. The farmgate price, or stumpage price, is what the farmer/forester receives when he or she sells raw products from the boundary of his or her farm/timber stand - that is the price without any transport, processing or marketing costs included. Domestic market prices will reflect any transport and marketing costs involved in getting the product to the local market and may also reflect the costs of processing the product before it reaches the market. Similarly, the border prices of traded goods will reflect transport, marketing and processing costs, and is given by the f.o.b. (free on board) price for exports and the c.i.f. (cost, insurance, freight) price for imports. The choice of which price to use in the analysis depends on whether the good is traded or non-traded, the level and type of analysis and the project boundary.[18] Gittinger (1984) provides a manual for cost-benefit analysis of projects, concentrating on situations where all benefits and costs are evaluated using price data obtained from markets and adjusted as necessary for policy distortions. Dixon *et al.* (1994) provide an overview of the use of market prices for valuing environmentally-related impacts.

In a well-known early example of forest valuation, **Peters *et al.* (1989)** analyse alternative forest uses in Mishana, Rio Nanay, Peru. They compare the financial benefits of maximum sustainable extraction of wild fruits and latex to the potential returns from forest conversion for timber

[17] An efficient market also normally requires that many buyers and sellers compete and none of them are able to exercise significant market power (influence over prices) by virtue of their size or access to information.

[18] Following the conventional definition, a non-tradable good has a domestic supply price, at the given level of local demand, that exceeds the f.o.b. price of exports but falls below the c.i.f. price of imports. This may include perishable goods or goods that are difficult to transport. Traded goods include those goods for which, if exports, the domestic marginal cost of production is less than the f.o.b. price, and if imports, the domestic marginal cost of production exceeds the c.i.f. price.

harvesting. Their estimates of sustainable fruit and latex yields for a one hectare (ha) plot of forest are based on field analysis, interviews with collectors and existing literature. Using average retail prices for forest fruits, based on monthly surveys of the Iquitos produce market, and rubber prices (which were controlled by the Peruvian government) from the agrarian bank office, the value of the harvest was derived by multiplying the sustainable yield by the market price. By deducting estimated harvesting and marketing costs (using data on labour inputs, prevailing wage rates and transport costs), the net revenue from a single year's harvest of fruit and latex production was estimated at US$422/ha. Assuming that this amount can be obtained in perpetuity, constant real prices and a discount rate of 5%, the authors then calculate the net present value (NPV) of the forest for sustainable fruit and latex production at US$6,330/ha.

Much effort can be devoted to assessing the efficiency of market prices and correcting for policy interventions. However, the majority of studies reviewed that use price and expenditure information to value NTFPs appear to have experienced more difficulty in collecting data on quantities and inputs. Markets for NTFPs are often very thin, seasonal and localised. In many situations, a large proportion of NTFPs are consumed by the harvesters or their family. Thus, official statistics on harvesting and trade are usually not available, with the notable exception of some commercially important species, such as rattan or bamboo in some areas. The harvest of animal products may be officially prohibited, making people reluctant to provide information.

The main cost of harvesting NTFPs is typically household labour (processing and transport to market may require other inputs). Pricing labour inputs in rural areas of developing countries can be problematic, due to thin labour markets and seasonal changes in work opportunities. Estimating the amount of time involved in harvesting can also be difficult, due to the complementarity between harvesting NTFPs and other activities (e.g. agriculture). Several of the case studies reviewed use information on labour inputs and wages to estimate the production costs of NTFP extraction, including: **Alcorn (1989); Anderson and Jardim (1989); Godoy and Feaw (1989); Howard (1995); Kramer *et al.* (1992, 1995); Pearce (1991); Peters *et al.* (1989); Pinedo-Vasquez *et al.* (1992); Ruitenbeek (1989a, 1989b);** and **Schwartzman (1989)**.

3.2 Surrogate Market Approaches

A second group of methods rely on the fact that certain non-market values may be reflected indirectly in consumer expenditure, in the prices of marketed goods and services, or in the level of productivity of certain market activities. These techniques statistically sophisticated methods, such as travel cost models and hedonic pricing, as well as simpler techniques such as the substitute goods method. The theoretical basis for all of these approaches is the household production function, which describes how households attempt to maximise their well-being by allocating time and resources to different activities.

3.2.1 Travel Cost Method[19]

The travel cost method (TCM) is based on the assumption that consumers value the experience of a particular forest site at no less than the cost of getting there, including all direct transport costs as well as the opportunity cost of time spent traveling to the site (i.e. foregone earnings). This survey-based method has been used extensively, especially in richer countries, to estimate environmental benefits at recreational sites (including wildlife reserves, special trekking areas and beaches). TCM has recently been applied in several developing countries, particularly where

[19] Travel cost models have now been updated into random utility and count data models.

higher incomes and rapidly developing markets have been associated with growing demand for amenities such as scenic views and recreational areas.[20]

Three basic steps are involved in travel cost models. First, it is necessary to undertake a survey of a sample of individuals visiting the site to determine their costs incurred in visiting the site. These costs include travel time, any financial expenditure involved in getting to and from the site, along with entrance (or parking) fees. In addition, information on the place of origin for the journey, and basic socio-economic factors such as income and education of the individual is required.

The resulting data is manipulated to derive a demand equation for the site. This relates the number of visits to the site to the costs per visit. The third step is to derive the value of a *change* in environmental conditions. For this, it is necessary to determine how willingness to pay for what the site has to offer alters with changes in the features of the site. By comparing the willingness to pay for sites with different facilities it is possible to determine how the total benefits derived from the site change as the facilities of the site change.

Since the earliest applications of the travel cost method in the USA in the late 1950s, the technique has been steadily improved and a number of theoretical and empirical issues have been tackled (see Bockstael *et al.* 1991 for a thorough review). In spite of these improvements, the usefulness of this technique to value forest recreational uses in developing regions is constrained by the large amount of data required. Increasingly, surveys for the travel cost method are being combined with contingent valuation surveys leading to more robust results, as well as potential estimates of option and non-use values.

In an application of the travel cost method in Costa Rica, **Tobias and Mendelsohn (1991)** estimate the eco-tourism value to domestic users of the Monteverde Cloud Forest Biological Reserve. They derive a national recreational value of the site of approximately $100,000 per year. Other examples of TCM used to value forests in the developing world include: **Adger *et al.* (1995), Kramer *et al.* (1995)** and Willis *et al.* (1998).

3.2.2 Hedonic Pricing

Another valuation technique is the hedonic pricing method, which attempts to isolate the specific influence of an environmental amenity or risk on the market price of a good or service. The most common applications of this technique are the *property value* approach and the *wage differential* approach, which are used to value environmental amenities and dis-amenities. Hedonic pricing is based on the assumption that the market value of land or labour is related to the stream of net benefits derived from it. This stream of net benefits includes a range of factors, including environmental amenities. Therefore, the value of the environmental amenity can be imputed from the observed land or labour market.

Application of the hedonic pricing approach to property values involves observing systematic differences in the value of properties between locations and isolating the effect of environmental quality on these values. The market value of a residential property, for example, is affected by many variables including its size, location, construction materials, and also the quality of the surrounding environment. With sufficient data on property values and characteristics it may be possible to control for size, location, construction materials and other factors, such that any

[20] TCM has also been used to value the benefits of alternative water supply and sanitation systems in the developing world (see for example: Wittington *et al.* 1990, 1991).

residual price differential may be imputed to differences in environmental quality. The hedonic pricing method requires large data sets, in order to account for and eliminate the influence of all other variables, which affect market prices. The approach also assumes that markets for land are competitive, and that both buyers and sellers are fully informed of the environmental amenity or hazard.

Hedonic pricing has been used in developed countries to estimate the negative impact of air and noise pollution, or the presence of waste disposal facilities, on the market prices of residential property and, conversely, the positive impact of proximity to water or public green space (Garrod and Willis 1992).[21] We found no examples of hedonic pricing used to assess the environmental amenity value (or any other value) of forests in developing countries. One constraint on use of the technique in developing countries is that private property markets are often thin, uncompetitive and poorly documented. This is a particular problem at the frontier of forested areas, where formal title to land may be missing and where land is often essentially an open access resource.

This situation will probably change as incomes grow and land markets in developing countries become more efficient and discriminating (and as land transactions are better documented). It may already be possible to apply the hedonic pricing method to residential property markets in and around high-growth cities in developing countries, especially where new residential housing developments provide home buyers with the opportunity to reside in greener, forested areas, away from the smog and congestion of the city centre.

3.2.3 Substitute Goods Approach

For those forest resources which are non-marketed or which are used directly by the harvester (e.g. fuelwood), value may be approximated by the market price of *similar goods* (e.g. fuelwood sold in other areas) or the value of the next best *alternative or substitute good* (e.g. charcoal). The extent to which the value of the alternative marketed good reflects the value of the non-market good in question depends, to a large extent, on the degree of similarity or substitution between them. That is, if the two goods are perfect substitutes then their economic values should be very close. As the level of substitution decreases so does the extent to which the value of the marketed good can be taken as an indication of the value of the non-marketed forest good.

Examples of the substitute goods approach used to value forest benefits in a developing country context focus on NTFPs. **Adger *et al.* (1995)** and **Gunatilake *et al.* (1993)** use the technique to supplement market price data for NTFPs in Mexico and Sri Lanka, respectively. **Chopra (1993)** uses the approach as an alternative to labour cost analysis for valuing fuelwood, in a study of deciduous forests in India. No examples were found of the substitute goods approach being used to estimate other forest values.

In some circumstances, a substitute good may be non-marketed as well, but it may still be possible to infer a price for the good in question. In a cost-benefit analysis of a management programme for two forested watersheds in Nepal (Fleming 1983, cited in Dixon *et al.* 1994), fuelwood was valued in terms of the alternative uses of its closest substitute, that is cattle dung which can be dried and burned when wood is unavailable. The opportunity cost of using cattle dung as fuel rather than as fertiliser is estimated in terms of losses in food grain resulting from

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[21] The wage differential approach has been used to evaluate the impact of occupational hazards or other environmental factors on wages, based on the assumption that the supply of labour varies with local living and working conditions (see Freeman 1993 for a thorough discussion).

lower dung inputs into agricultural production. Thus this approach involves two stages: first, estimating a conversion factor for equating the two substitutes (in this case, the energy value of dung and wood); and second, estimating the marginal effect on output, and thus profits, of a change in the use of the substitute (in this case cow dung).

The main problem with the *substitute goods* approach is that it is difficult to find substitutes which are perfect and which do not provide additional side-benefits. Thus, such value estimates should be viewed with caution.

3.3 Production Function Approaches

A third type of valuation method is variously called the *change-in-production* technique, the *input-output* or *dose-response* method, or the *production function* approach (the latter term is used here). Whatever the name used, all involve an attempt to relate human well-being (or more narrowly, the incremental output of a marketed good or service) to a measurable change in the quality or quantity of a natural resource (Maler 1992).[22] The production function approach may be used to estimate the indirect use value of ecological functions of forests, through their contribution to market activities. The approach is referred to as the production function method because many studies estimate impacts on economic production. However, the same approach can be used to estimate consumption losses directly, e.g. siltation of bathing areas.[23]

Use of this approach involves a two-step procedure. First, the physical effects of changes in the environment on economic activity are determined. This may be done through laboratory or field research, observation or controlled experiments, or statistical techniques. The second step consists of valuing the resulting changes in production or consumption, usually using market prices. In this way the monetary value of the ecological function is derived indirectly.

The production function approach has been used extensively in both developed and developing regions to estimate the impacts of changes in environmental quality (e.g. deforestation, soil erosion, air and water pollution) on productivity in agriculture, forestry and fisheries, on human health, and on the useful life span or costs of maintaining economic infrastructure.[24] An essential requirement of the approach is good information on the physical relationship between the state of the environmental resource and the economic activity or asset it supports. In addition, market conditions and policy distortions affecting production decisions need to be taken into account.

An example of the production function approach is provided in a study by **Hodgson and Dixon (1988)**, who conducted an evaluation of alternative development plans for a coastal zone in the Philippines. The study used a production function approach to estimate the impact of the ecological effects of coastal logging on terrestrial and marine ecosystems, and thus on tourism and marine fisheries. A reduction in the fish catch resulting from increased sedimentation due to logging was estimated through regression analysis, using information on coral cover, species diversity and fish biomass. Similar analyses of the relation between mangrove conversion and

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[22] Maler (1992) subsumes all valuation methods except stated preference techniques into the production function approach. For this discussion we focus on Maler's first sub-category, i.e. where output is measurable.

[23] In this case, it may be necessary to use other valuation methods to estimate the change in consumption benefits.

[24] Sometimes the benefits of an environmental resource are expressed in terms of *damage costs avoided*, e.g. when the carbon content of a forest is valued in terms of the potential economic losses which would occur if that amount of carbon were released into the atmosphere and exacerbated global warming (Fankhauser 1995). The value of the environmental service consists in reducing the amount of other (marketed) inputs needed to sustain economic activity and assets. Variants include some cost-based methods (see section 3.5).

the productivity of tropical marine fisheries can be found in cases studies of El Salvador (Gammage 1997), Mexico (Barbier and Strand 1998), Indonesia (**Ruitenbeek 1992**), and the Philippines (Janssen and Padilla 1997; Nickerson 1999).

Another common application of the production function approach is to evaluate the impact of forest disturbance on hydro-electric power generation and fresh water supply. **Aylward *et al.* (1999)**, for example, use the production function approach (along with other methods) to value the hydrological impacts of forest conversion in upland areas, in a case study of the Arenal watershed, in Costa Rica. Other case studies of the downstream hydrological impacts of logging or forest conversion in the developing world include research in Bolivia (Richards 1997), Peninsular Malaysia (Mohd. Shahwahid *et al.* 1998) and Thailand (Johnson and Kolvalli 1984).

The production function approach is relatively straightforward in the case of *single use systems*, i.e. forest areas in which the main non-market value is a single ecological function as described above. In the case of *multiple use systems*, i.e. where a single forest regulatory function supports several economic activities, or where there is more than one non-market ecological function of economic value, applications of the production function approach are more problematic.[25] In particular, assumptions concerning the relationship between the various uses must be carefully constructed. One difficulty is the risk of "double counting" when estimating the total economic value of a forest area from various sub-component values (Aylward and Barbier 1992).

3.4 Stated Preference Approaches

Price-based, surrogate market and production function approaches all rely on the use of market prices (revealed preference) to estimate the value of forest goods and services. An alternative is to ask consumers to state their preferences directly, in terms of hypothetical markets or payments. In this approach, information on the value of an environmental benefit is obtained by posing direct questions to consumers about their willingness to pay for it or, alternatively, their willingness to accept cash compensation for losing the benefit. The most widely used and well-developed stated preference technique is the contingent valuation method (CV or CVM). Alternative but less widely used stated preference methods include choice experiments (CE) and the use of participatory or "focus group" approaches to elicit preferences.

3.4.1 Contingent Valuation

CV elicits individual expressions of value from respondents for specified increases or decreases in the quantity or quality of a non-market good. Most CV studies use data from interviews or postal surveys (Mitchell and Carson 1989). Valuations produced by CVM are "contingent" because value estimates are derived from a hypothetical situation that is presented by the researcher to the respondent. The two main variants of CV are open-ended and dichotomous choice (DC) formats. The former involves letting respondents determine their "bids" freely, while the latter format presents respondents with two alternatives among which they are asked to choose. Open-ended CVM formats typically generate lower estimates of WTP than DC designs (Bateman *et al.* 1995).

[25] **Ruitenbeek (1992)** explicitly incorporates the possible ecological linkages between direct and indirect use values in his analysis of mangrove wetlands of Bintuni Bay, Irian Jaya, Indonesia.

Proponents of CVM (e.g. Carson 1991) argue that its theoretical foundations are firmer than those of other valuation techniques, because it directly measures Hicksian welfare measures, or true WTP (or WTA).[26] Moreover, CV is the only generally accepted method for estimating non-use values, which are not traded in markets and for which there are no traded substitutes, complements or surrogate goods, which can be used to impute values.

On the other hand, because no payment is made in most cases, some observers question the validity of stated preference techniques. Critics argue that CVM fails to measure preferences accurately and does not provide useful information for policy (Diamond and Hausmann 1994). Even practitioners accept that poorly designed or badly implemented CV surveys can influence and distort responses, leading to results that bear little resemblance to the relevant population's true WTP. Much recent attention has focused on overcoming potential sources of bias in CVM studies.[27] Resolving these difficulties involves careful design and pre-testing of questionnaires, rigorous survey administration, and sophisticated econometric analysis to detect and eliminate biased data. While CVM is accepted by the US legal system as a basis for assessing environmental damages, the procedural requirements for using CV estimates in court cases are very strict (Arrow *et al.* 1993). Whittington (1996) reviews issues arising from the use of CVM in developing countries.

It should be noted that in applications of CVM in developing countries WTP can be measured in non-monetary units if respondents are very poor. The use of CVM for valuing environmental resources originated and was largely developed in North America. In forestry, CVM has been used to value wildlife and recreational benefits of protected areas. Several recent studies have demonstrated the feasibility of applying CVM to forest land use in the developing world. For example, in a case study of forest recreation in Costa Rica, Echeverría, Hanrahan and Solórzano (1995) used a "take-it-or-leave-it" personal interview survey of eco-tourists to estimate WTP for the Monteverde Cloud Forest Preserve. In another example, Willis *et al.* (1998) used CVM together with an Individual Travel Cost Model to estimate consumer demand for forest recreational sites in Peninsular Malaysia. They found that the two methods generated comparable estimates, and that the aggregate benefits of forest recreational areas exceed the (direct) costs of their provision. Additional examples of CVM used to estimate WTP for forest recreation and non-use benefits in developing countries include: **Adger *et al.* (1995)**, **Dixon and Sherman (1990)**, **Hadker *et al.* (1997)**, **Kumari (1995a)**, and **Prasanthi Gunawardena *et al.* (1999)**.

In a slightly different vein, **Smith *et al.* (1997)** use a CV survey to assess Peruvian farmers' willingness to accept (WTA) compensation for adopting alternative land use practices which store more carbon (as a mitigation strategy for global warming), and farmers' WTP for forest use benefits. The resulting estimates cover a wide range of direct, indirect use and non-use values. Similarly, **Kramer *et al.* (1992, 1995)** use CV to evaluate the direct use benefits to rural communities' from harvesting NTFPs and using forest areas for agriculture and residential space, near the Mantadia National Park, in Madagascar. Their estimates may also capture non-use existence or cultural values placed on the forest by local residents. As in the Peru study, the results of the CV are subsequently used to estimate farmers' WTA compensation for loss of

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[26] Other techniques such as travel cost models measure Marshallian consumer surplus. The degree to which they approximate true WTP (or WTA) relies on the strength of assumptions regarding the form of the utility function. See Braden and Kolstead (1991) for a technical discussion, and Carson *et al.* (1996) for a comparison of estimates.

[27] Bias is any aspect of a study that consistently skews responses in one direction, thereby leading to results that diverge from the true WTP of the population. Bias may arise in any of the four steps in survey design and implementation: construction of the market scenario; development and application of the method and vehicle for eliciting responses; sample design and implementation; and drawing inferences from the results.

access to forests in the park. The survey data revealed an annual mean value per household of US$108 and an aggregate net present value for the affected population (about 3,400 people) of US$673,000. Price-based assessment of foregone forest income yielded comparable estimates of US$91 per household and US$566,000 in aggregate present value terms.[28]

The Madagascar case study demonstrates how CVM can be used to value the direct use benefits of forests, such as non-timber forest products, in terms of local people's WTA compensation for loss of access to these benefits. Similarly, the study in Peru illustrates how CVM can be used to determine the cost of maintaining forest environmental services, such as carbon storage, in terms of local people's WTA compensation for adopting "ecologically sound" land use practices. On the other hand, CVM may be less appropriate for estimating the benefits (as opposed to the costs) of forest environmental services. This is because the relation between alternative forest land uses and the degree of protection or support afforded to off-site market activities (e.g. fisheries) is not well understood by consumers, or indeed by scientists!

3.4.2 Contingent Ranking

A variant of contingent valuation, this method involves asking respondents to rank a series of alternative non-market goods (Foster and Mourato 1997). One advantage of contingent ranking is that monetary bids may or may not be used. Some have suggested that the use of hypothetical cash payments in CVM may be inappropriate in remote rural communities in the developing world, where people may have relatively little exposure to the market economy (**Lynam *et al.* 1994; Emerton 1996**). In such cases monetary values can be assigned indirectly, by including in the contingent ranking one or more "anchor" goods with known market values.

An illustration of contingent ranking is provided by **Lynam *et al.* (1994)**, who use the method to value multi-purpose tree resources in Zimbabwe. The authors asked smallholder farmers to rank and score ten categories of benefits obtained from trees. These non-monetary preferences were "anchored" by simultaneously asking respondents to score a hand-pump borehole and a well-known type of pit latrine. Respondents were then asked for their WTP for the borehole and latrine in order to provide a monetary benchmark from which to impute the value of the non-market forest products and services. The results indicated that forest products consumed directly by households scored the highest, with production inputs and forest-related services following lower down the scale. In a similar vein, **Emerton (1996)** uses contingent ranking to value a range of direct use benefits of forests (timber, fuelwood, grazing, etc.) to rural households in Kenya, including the use of several monetary "anchors" (a radio, bicycle or milk cow).

The contingent ranking method is conceptually simple, easy to administer and able to generate rough estimates of value for a number of forest goods and services at once, without conducting separate WTP surveys for each use and non-use value. On the other hand, contingent ranking may not provide accurate estimates of WTP. A fundamental question is whether the scores generated by contingent ranking reflect an ordinal ranking of relative preference (i.e. first, second, third, etc.) as opposed to cardinal measurements of value (i.e. one, two, three...). In the former case, it may not be valid to use the cost/price of marketed "anchors" to impute monetary values to non-market goods and services, because they are on different (incommensurate) scales.

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[28] **Hadker *et al.* (1997)** and **Prasanthi Gunawardena *et al.* (1999)** also use CVM to estimate direct use (and other) values, although in these cases it is not possible to validate the resulting estimates with reference to other methods.

3.4.3 Choice Experiments

Another stated preference method for valuing environmental goods is the use of choice experiments (CE). This approach involves asking individual respondents to chose among alternative bundles of non-market goods, which are described in terms of their attributes, including an hypothetical price (Hanley *et al.* 1998; Adamowicz *et al.* 1998a). In the case of forests, for example, a CE survey may present respondents with alternative landscapes (in the form of images), which vary by species mix, age diversity, percentage of open area, the presence of roads and the hypothetical price (given a particular payment vehicle) to the individual. CE shares many features with Dichotomous Choice CV models and the results should be directly comparable with estimates based on DC/CV models. A particular strength of CE is the ability to estimate characteristic values for environmental goods.

CE has been used in North America to estimate recreational values (Adamowicz *et al.* 1994; Boxall *et al.* 1996) and, more recently, to estimate non-use benefits (Adamowicz *et al.* 1998b). Hanley *et al.* (1998) use CE to estimate both use (recreation) and non-use values of alternative forest landscapes in the UK. They find comparable results to using open-ended CVM. The CE approach is currently being used to value wetlands in Malaysia (Hanley, personal communication).

3.4.4 Participatory Methods and Stated Preference Approaches

CVM and CE rely on interviews or questionnaire surveys to collect data on individual WTP for environmental benefits. Contingent ranking may also involve individual interviews. Survey design and administration has been a major focus of concern in all of these methods, with the aim of minimising biased or strategic responses (Hanemann 1996). Some researchers argue that the use of participatory or "focus group" techniques in both data collection and analysis can reduce bias and generate more accurate information.[29] These and related concerns have led researchers to develop variants of CVM which use participatory survey techniques. While such methods have not been widely used, a few examples were identified in the literature review.

One illustration is provided by **McDaniels and Roessler (1998)**, who propose a method of multi-attribute value assessment and use it to estimate the value of wilderness conservation in British Columbia, Canada. In their approach, values are elicited from groups rather than from individuals, with plenty of opportunity for discussion and revision of "bids". The technique is less demanding than CV, in terms of the statistical manipulation of data required, but it is not clear whether bias is minimised or increased when a group of respondents is asked to rank and score a range of environmental amenities together. In a comparison of participatory techniques and household surveys for valuing forest benefits in Zimbabwe, **Davies *et al.* (1999)** found that participatory methods were better at generating qualitative information, but not as good at generating quantitative data (and were also more time consuming for local respondents).

3.5 Cost-based Valuation

In addition to the methods described above for estimating WTP or WTA for non-market forest benefits, some other cost-based approaches may be used to shed light on the costs of

[29] Participatory methods come in various guises, including Participatory Rural Appraisal (PRA), Rapid Rural Appraisal (RRA), Participatory Learning and Action (PLA), etc. See Chambers (1994) and IIED (1997).

maintaining non-market forest benefits, or trade-offs with market values. Three alternative methods focus on the costs of providing, maintaining or restoring environmental goods and services.[30] A thorough discussion of cost-based valuation can be found in Dixon *et al.* (1994). The most common methods are:

- *replacement cost* methods, which measures environmental values by examining the costs of reproducing the original level of benefits;

- *preventive expenditure* methods, which estimate the cost of preventing or defending against degradation of the environment; and

- *opportunity cost* approaches, which use estimated production costs as a rough proxy for the value of non-market benefits.

Cost-based techniques are commonly used where there is limited time and resources for more rigorous estimation of environmental benefits. However, such techniques must be used with care, with particular attention to ensure that non-market *benefits* and *costs* are not confused. Because cost-based techniques do not directly measure WTP for environmental goods and services, the resulting estimates may over- or under-estimate forest benefits by a large margin. Problems arise when potential rather than actual expenditures are used, as it is not always clear that the environmental benefit in question justifies the costs of replacement, relocation, etc. On the other hand, while cost-based methods are inexact, they may be the only practical alternative in some cases, given resource and time constraints. Where such methods are used, key assumptions about the relationship between estimated costs and associated benefits should be stated clearly.

3.5.1 Replacement Cost

The replacement cost technique generates a value for the benefits of an environmental good or service by estimating the cost of replacing the benefits with an alternative good or service.[31] For example, where logging or road construction in upland forest areas leads to increased runoff and sedimentation, some studies use information on the costs of dredging or flood control as a rough estimate of the non-market benefit of watershed protection. The technique rests on the availability of such an alternative, which should - as nearly as possible - produce the same type and level of benefits as supplied by the resource or environmental function being valued. When developing a replacement cost scenario, it is normal practice to select the least cost option among all possible technologies, so as not to over-estimate the value of the environmental benefit.

Relatively few examples of the replacement cost method were found in the literature review. One application to valuing forest benefits is to estimate the value of soil nutrients lost due to increased erosion associated with logging or deforestation in terms of the cost of manufactured fertiliser needed to replace the eroded nutrients (**Chopra 1993; Niskanen 1998**). Another example is provided by **Aylward *et al.* (1999)**, who value changes in runoff water yield for hydro-electric

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[30] As noted above, some cost-based methods overlap with other non-market valuation techniques. An attempt is made to signal such overlaps in the discussion that follows.

[31] The replacement cost method is very similar to the *substitute goods* technique, which was described above under Surrogate Market approaches. The relevant question in both cases is to what extent the original non-marketed environmental benefit can be replaced or substituted by some alternative, marketed good or service. Another variant is the *restoration cost* technique, which is based on estimates of the cost of recreating the original environmental good or service. In the case of natural forests, complete restoration of all benefits following logging, burning or conversion can take centuries, which limits the relevance of the technique.

power generation, under different land uses, in terms of the marginal opportunity cost of alternative (thermal) sources of electric power.

3.5.2 Preventive Expenditure

The preventive expenditure approach (also sometimes called "mitigation" or "defensive" expenditure) places a value on environmental goods and services by estimating the costs of preventing a reduction in the level of those benefits derived from a particular area. This approach may be most applicable for assessing the indirect use values of forests.

No case studies using preventive expenditure were found in the literature review. However, a hypothetical example can illustrate how the technique could be used to estimate non-market forest values. For instance, projected expenditures on soil conservation measures aimed at halting or reversing soil degradation could be used as a rough proxy for the benefits generated by the natural nutrient cycling and watershed protection functions of forests. In the case of logging, the watershed protection benefits that might be diminished by building roads for the extraction of timber could be valued by examining the incremental cost of adopting less damaging extraction methods, such as non-mechanised extraction, helicopter logging, or alternative road layouts. As always, it is important to ensure that the benefits of the preventive expenditure match those originally provided by the environmental function, in order to obtain a realistic cost estimate.

The preventive expenditure method is sometimes confused with a variant of the production function approach known as "damage costs avoided". The difference is that the latter approach uses information on the costs of making good or repairing damages incurred as a result of some environmental change, whereas the preventive expenditure approach focuses on the costs of avoiding or mitigating damages before they occur. Where alternative valuation techniques yield different estimates of a particular forest benefit, it is generally preferable to use the lowest estimate so as not to over-estimate the non-market benefit in question.

3.5.3 Opportunity Cost of Labour

Another valuation approach focuses on the employment opportunities foregone in order to secure or protect a particular non-market benefit. As with other cost-based approaches, the focus is on the costs of providing a non-market benefit, rather than the magnitude of the benefit *per se*. The basic idea is that a non-market benefit is worth at least as much as the return that could be obtained by private producers if they were to devote the same effort (i.e. the labour used to secure the non-market benefit) in some alternative use.[32]

The opportunity cost approach is most often used to value the subsistence benefits of NTFP collection, where labour is the main input and prices are not available because all or most output is consumed directly by producers. In such cases, the implicit assumption is that a producer's decision to spend time collecting non-timber forest products is weighed against alternative uses of household labour. The opportunity cost of time spent harvesting NTFPs is thus taken as a proxy for the value of the product(s) in question.[33] The only data required are the amount of time spent on the harvest, the resulting yield and the prevailing (rural) wage rate.

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[32] Use of the opportunity cost of labour to value non-market forest benefits may be distinguished from the more general concept of the "opportunity cost" of a particular forest land use. The latter typically refers to market values foregone as a result of forest conservation or the adoption of sustainable management (see Chapter 4).

[33] If we assume rational behaviour, the benefits of collecting the good will be at least equal to the costs. Collection costs are thus a minimum estimate of the benefits derived from the good. The intuition is less appealing in the case of public expenditure, where the ratio of benefits to costs may not be a relevant criterion for decision-makers.

Nevertheless, care must be exercised when using rural wage rates. First, it is important to ensure that the effort involved in harvesting a non-timber forest product is commensurate with the effort associated with the prevailing wage rate. For example, one day of a child's time spent collecting wild foods should not be valued at the same level as the wage received by an adult for physically demanding agricultural work. In such cases, it may be appropriate to adjust the wage rate used. Similarly, seasonal variations in rural wages should be considered, as the harvesting of NTFPs may be concentrated in periods of slack labour demand, when wages are lower. Third, gathering forest products is often combined with agricultural activities, for example when walking to or from the fields. This must also be taken into account when deciding how much labour time to include in NTFP harvesting costs.

Of the case studies reviewed, most of those which estimated NTFP benefits used labour cost data to estimate production costs. These were deducted from the market value of products (for which prices were available) to calculate the net benefits of NTFP extraction (see section 3.1). In a few cases, however, market prices were apparently missing and rural wages were used directly to value NTFPs themselves (**Browder *et al.* 1996; Chopra 1993)**. No examples were found of using other inputs to estimate non-market forest benefits.

Table 3.1 Methods for valuing forests

Valuation method	Relevant forest benefits	Strengths and weaknesses
Market prices: Use data from surveys of producers and consumers, adjusted if necessary to account for seasonal variation, value-added processing and/or public policy distortions.	Price-based valuation is commonly applied to non-timber forest products which are partly or informally traded, in order to estimate subsistence and/or unrecorded consumption.	Market prices clearly reflect consumer preferences, but often need adjustment to account for public policy distortions or market failures. Aggregation or extrapolation of values based on potential production is not valid unless account is taken of likely price effects (elasticity of demand).
Surrogate markets: Travel cost - use survey data on direct costs (e.g. fares, accommodation) and, in some cases, opportunity costs of time spent travelling to and from a site, evaluated at some fraction of the average wage rate. Hedonic pricing - use statistical methods to correlate variation in the price of a marketed good to changes in the level of a related, non-marketed environmental amenity. Substitute goods - use market prices of substitutes for non-marketed benefits.	Travel cost is often used to estimate demand for forest recreation at specific locations. Related methods used mainly in developing countries estimate the value of non-marketed, non-timber forest products in terms of the opportunity cost of time spent collecting and/or processing them. Hedonic pricing is used to estimate the impact of proximity to forested land and/or logging on the prices of residential and commercial property. Substitute goods approaches may be used wherever close market substitutes for non-timber benefits exist.	Provided the relation between the benefit being valued and the surrogate market is correctly specified, and prices in the surrogate market are not very distorted (e.g. by policy intervention), such methods are generally reliable. Travel cost estimates may need to account for various objectives (benefits) in a single trip. Hedonic pricing requires large data sets, in order to isolate the influence of a non-market benefit on market price, relative to other factors.
Production function: Change in production method - uses data on the physical relation between level (or quality) of a non-market benefit and level (or quality) of output of a marketed good/service.	Change in production (or "input-output" or "dose-response") methods are used to estimate both on- and off-site impacts of land use change, e.g. the effect of logging on hunting, downstream water users, fisheries, climate.	Change in production methods require good data on biophysical relationships (dose-response).
Stated preference Contingent valuation method - use consumer surveys to elicit hypothetical individual willingness to pay for a benefit, or willingness to accept compensation for the loss of that benefit. Contingent ranking / focus groups - use participatory techniques in group setting to elicit preferences for non-market benefits, either in relative terms (ranking) or in monetary terms.	Recreational values are often estimated using contingent valuation. Stated preference methods such as CVM are the only generally accepted way to estimate non-use values, e.g. landscape or biodiversity values, for which price data do not exist and/or links to marketed goods cannot easily be established. Contingent ranking may be used where target groups are unfamiliar with cash valuation.	Contingent valuation estimates are generally considered reliable if strict procedural rules are followed. Participatory techniques are more experimental and not widely used to estimate non-market forest benefits. They are good at eliciting qualitative or "contextual" information, but there are doubts about their reliability for estimating willingness to pay.
Cost-based approaches: Uses data on the costs of measures taken to secure, maintain and/or replace forest goods and services.	Cost-based approaches include replacement/relocation cost, defensive expenditure and opportunity cost analysis; may be used (with caution) to value any type of forest benefit.	Cost-based approaches are usually considered less reliable than other methods. One test of validity is evidence that people are prepared to incur costs to secure relevant benefits.

4 Cost-Benefit Analysis of Forest Land Use Options

Chapter 2 described the range of values and uses of forests, including non-market benefits, while Chapter 3 reviewed the methods used to estimate different forest values. A rigorous economic assessment of forest land use ought, ideally, to include an evaluation of all the benefits and costs associated with each relevant land use option. This chapter presents a general framework for assessing the net economic benefits of alternative forest land use options. In particular, we show how these values can be incorporated into cost-benefit analysis (CBA), which provides a useful means of highlighting trade-offs between different development options.

The following section 4.1 describes an extended cost-benefit analysis framework and how it may be used to evaluate alternative forest land use options. Section 4.2 goes on to discuss the concept of economic opportunity cost and its relation to CBA. Of course, CBA is not without its weaknesses and thus section 4.3 briefly reviews some major criticism of valuation, CBA and economic methods generally. Section 4.4 describes some alternative assessment methods which may be used when CBA is considered unfeasible or inappropriate. Section 4.5 then discusses a number methodological issues which arise when applying CBA to issues of forest management. Section 4.6 concludes the chapter with a summary and brief checklist of the key steps involved in undertaking an economic assessment of forest land use options.

4.1 Cost Benefit Analysis

Cost-benefit analysis (CBA) is a standard tool for evaluating the economic merit of investment or development projects, and is widely used to assess forest land use options. When applied correctly, CBA results in a systematic listing of the advantages (benefits) and disadvantages (costs) of any project or land use option. This section does not explain CBA in detail, as there are many excellent texts on the subject.[34] Rather the focus here is on extensions of CBA to incorporate the range of benefits and costs associated with forest land use decisions.

A strength of CBA is the use of explicit and directly comparable decision criteria. The underlying logic of CBA is that, for any set of alternative activities (e.g. land use options), the net benefits of each should be compared, where the net benefits (NB) of a given option are simply the sum of benefits (B) less the total costs (C):[35]

$$NB = B - C \qquad (4.1)$$

These benefits and costs are identified for each time period - usually one year - over some time horizon chosen by the analyst. Using the technique of discounting, net benefits over time can be combined into a single aggregate figure, or net present value (see section 4.3.2).[36] Thus, for any

[34] See Gittinger (1984) for a practical manual on the use of CBA. Dixon *et al.* (1994) provide an overview of CBA for environmental analysis as do Hanley and Splash (1994). For more technical treatments on CBA and its use in evaluating public investment, see Dasgupta *et al.* (1972), Little and Mirrlees (1974), Squire and van der Tak (1975).

[35] Net benefits may be distinguished from Total Economic Value (TEV), which makes no deduction for costs. For a detailed discussion of the theory underlying this methodology see Barbier and Burgess (1997).

[36] Benefits and costs may also be adjusted to account for their relative probability, for policy interventions which distort market prices, or for the distribution of costs and benefits among different stakeholder groups (see section 4.3).

two alternative forest land uses, A and B, the net benefits of A (NB^A) must *exceed* the net benefits of B (NB^B), if A is to be the preferred land use option on purely economic grounds, hence:

$$NB^A - NB^B > 0 \qquad (4.2)$$

The net benefits of a given land use option will comprise both *direct* and *indirect* net benefits, (respectively, NB_D and NB_I). Direct net benefits include the benefits and costs involved in producing marketed output, such as the revenues from timber extraction and associated forest management costs. Indirect net benefits cover the range of environmental goods and services discussed in the previous chapter, less any associated costs. Thus, we may re-write (4.2) as:

$$(NB_D^A + NB_I^A) - (NB_D^B + NB_I^B) > 0 \qquad (4.3)$$

For example, if land use option A involves clearing the forest for agriculture, not only should the direct costs of conversion (e.g. clearing and burning the forest, establishing crops) be included as part of the analysis of this option but so also must the *foregone* values of the forest that has been converted, which could have been conserved closer to its natural state through some alternative use, such as limited and sustainable use of forest resources (option B).[37] These may include both the loss of important *environmental functions* (e.g. watershed protection, carbon storage) and *resources* (e.g., commercial hardwood, non-timber products, recreational amenities).

While CBA is often used to compare alternative land uses, it can also be used to evaluate the net benefits of a single land use option. In the latter case, the question posed in CBA is whether the benefits of a particular land use exceed the costs, and if so, by how much. In other words, is an investment (in that land use option) justified, in economic terms? Of course, even where the net benefits of a given land use are positive, i.e. benefits exceed costs, there may be other land use options which would generate even greater returns. Hence the attraction of comparing several alternative land use options.[38]

Many of the case studies reviewed for this report present estimates of the benefits of a single land use or a single forest value. Moreover, some studies fail to account even for the direct costs of the forest benefit in question, let alone the opportunity cost of foregoing alternative land use options (see below). Of those studies which compare the net benefits of two or more land uses, many confine themselves to analysing closely related options in fairly narrow terms. For example, some studies use CBA to assess the net returns to alternative models of forestry for timber production (e.g. **Sedjo 1988; Veríssimo *et al.* 1992; Uhl *et al.* 1992**). Relatively few studies compare broad categories of land use (e.g. agriculture versus forestry), and only a handful make any serious attempt to consider the full range of forest values (i.e. direct and indirect uses, option and non-use values).

Probably the most well known CBA of alternative forest land use options in the developing world is a case study by **Peters *et al.* (1989)**. Their study estimates the financial costs and benefits of sustainable extraction of wild fruit, latex and timber in the Peruvian Amazon, and compares them to the potential net financial returns from one-off "clear-cut" extraction of timber, plantation forestry and cattle ranching. Non-market forest values are not considered, but the authors nevertheless conclude that the net present value (NPV) of the "sustainable" land use

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[37] Option B may be considered a base case scenario against which alternatives, such as A, should be compared.
[38] There may be other reasons to prefer certain land uses, even if they have relatively low net benefits, such as lower initial investment required, greater local employment impact, less prone to risk, etc. (see section 4.3).

option exceeds that of all three alternatives. While this case study has been criticised for several of its assumptions (see for example **Pinedo-Vasquez *et al.* 1992**), it represents one of the earliest and most influential attempts to compare alternative forest land use options using cost benefit analysis.

Since the publication of **Peters *et al.* (1989)**, many other studies have appeared which find that traditional, "sustainable" or otherwise environmentally-benign uses of forest land generate greater returns than conventional land use practices (e.g. clear-cut logging, plantation forestry or ranching). In some cases, this conclusion depends upon an assumption that new market opportunities such as eco-tourism or pharmaceutical prospecting will quickly generate large financial flows, and that these flows can be "captured" by forest landowners. In other cases, the argument depends on an appeal to entirely non-market forest benefits. Non-market benefits are often crucial to the CBA but do not represent financial benefits to landowners. In a comparison of alternative forest management systems in Malaysia, **Kumari (1995a)** concludes that adopting more sustainable methods of timber extraction from peat swamp forest is preferable in economic terms. Although shifting to a sustainable harvesting system reduces the net benefits of timber harvesting, the case study suggests that this is more than offset by increased non-market benefits, primarily hydrological and carbon storage values. The problem, of course, is that in most cases such non-market benefits do not generate any financial returns, and may never do so.

4.2 Opportunity Cost and CBA

CBA may be used to assess the costs and benefits of a single forest land use, or to compare the net benefits of alternative land use options. In the latter case, reference is often made to the *opportunity cost* of choosing a particular land use, in terms of potential market opportunities foregone.[39] In other words, by choosing a particular land use and set of forest values in a given area, it may be necessary to forgo some other, incompatible forest land uses or values.

Several case studies reviewed for this report present estimates of the opportunity costs of forest conservation, or the opportunity costs of adopting more "sustainable" land use practices. Often this forms part of a Total Economic Valuation of a particular land use, or a CBA of alternative land uses. For example, **Dixon and Sherman (1990)** estimate the opportunity cost of the Khao Yai National Park in northern Thailand, in terms of the loss of alternative land uses including hunting, logging and gathering of forest products. **Emerton (1996)** uses contingent ranking to estimate the opportunity cost of restricting access to protected forests in Kenya, in terms of timber and non-timber values foregone by local residents. **Hodgson and Dixon (1988**) estimate one of the non-market opportunity costs of logging in upland areas, i.e. the potential loss of fisheries and other watershed benefits downstream. **Howard (1995)** estimates the aggregate opportunity cost of protected areas to Uganda, in terms of foregone forestry and agricultural land uses, as part of a broader CBA of protected areas. **Jonish (1992)** evaluates the opportunity cost of adopting sustainable forest management in Malaysia, in terms of potential job losses in the timber industry. **Kramer *et al.* (1992, 1995)** use both market prices and contingent valuation methods to assess the foregone benefits of subsistence (shifting) cultivation, extraction of fuel wood and other non-timber products by local populations due to the creation of the Mantadia National Park, in eastern Madagascar. **Loomis *et al.* (1989)** assess the opportunity costs of converting land to housing in California (building a subdivision), in terms of the loss of deer hunting and viewing opportunities. **Ruitenbeek (1989a, 1989b)** estimates the opportunity

[39] Similarly, the opportunity cost of inputs may be used to estimate specific non-market benefits, although this is rare (see Chapter 3).

cost of foregone timber and agricultural production in and around two protected areas in Cameroon and Nigeria, as part of an analysis of two national park support projects. And **Saastamoinen (1992)** estimates the foregone logging benefits of forest preservation in the Philippines.

4.3 Criticism of CBA and Valuation

Cost-benefit analysis, valuation of non-market impacts and the concept of opportunity cost are all fundamental components of any economic comparison of alternative forest land use options. And yet many people reject the notion of comparing market costs and benefits with non-market social and environmental values. Others take issue with the assumptions of cost-benefit analysis, or the methods of estimating non-market values. This section reviews some of common criticism of CBA, monetary valuation and economic approaches to forest land use decisions generally. We defend the role of economics in forest land use planning, while acknowledging some of the weaknesses of economic approaches. The following section then discusses other land use assessment frameworks, which may be used in place of CBA or in conjunction with it.

Critics of economic evaluation of forest land use options raise various objections, ranging from minor methodological quibbles to sweeping rejection of economic modes of thought. Starting with the most fundamental criticism, some argue that it is not only impossible but ultimately illegitimate to attempt to reduce the range of fundamentally different values to a single measure such as net economic benefit. Many people believe that certain forest values are effectively "priceless", notably the preservation of endangered species of wildlife. Extreme versions of this view consider any economic approach to environmental decision-making to be tainted by association with market forces, which are identified as the root cause of all environmental problems. From this perspective, any attempt to express non-market benefits in monetary terms implies a "slide down the slippery slope" of reducing all concepts of value to an economic bottom-line.

The view put forward in this report is that it is both possible and often desirable to estimate non-market values in monetary terms, as a contribution to rational debate about the relative advantages and disadvantages of alternative courses of action. Trade-offs among widely divergent concerns are inevitable. A variety of methods must be found to reconcile these differences. Economics cannot claim to be the final arbiter of value, but it can contribute to political and other decision-making processes by providing a consistent and transparent accounting framework. Economic valuation makes trade-offs comparable and intelligible, by expressing different costs and benefits in terms of a single *numeraire*, i.e. monetary value. In this way we can directly compare, for example, the value of marketed timber or crop production that must be foregone in order to preserve certain environmental benefits.

Another common complaint is that valuation of non-market benefits is too costly. It is true that rigorous estimation of non-market values is often expensive, mainly because the data required are not readily available. Critics forget the enormous effort continually invested by public institutions, private firms and individuals to keep detailed accounts of financial and market transactions. This cost is simply accepted, and yet when more modest efforts are made to gather information on non-market phenomena, some people complain about the expense. Attempts to address this concern include recent research on "benefits transfer" - the idea that estimates of non-market value from one context may be applied to other situations

(**Bateman *et al.* 1996**). Provided that the underlying determinants of variation in non-market value are understood, this can be a fruitful approach.

Even among those who accept economic approaches to decision-making, there may be concern about the methods used to estimate non-market values. As noted in Chapter 3, a major focus of debate is whether stated preference techniques provide accurate estimates of willingness to pay. Particular attention has been paid to the potential bias in how people respond to surveys, including the frequency of "protest bids" in contingent valuation studies and indications that many people prefer to rely on moral judgement or a rights-based approach, when asked to consider certain environmental benefits (Hanley and Milne 1996). While it is true that non-market valuation methods are imperfect (and improving all the time), the same could be said of most other decision-making processes. The appropriate response is to acknowledge the weak components or gaps in an evaluation, not to give up altogether.

Another frequently noted problem is that monetary estimates fail to account for distributional considerations, i.e. the relative importance of non-market values to different groups of people (this problem is not, of course, confined to non-market valuation studies but affects much economic analysis). In some cases this leads to arguments for social weights to favour the poor, or altogether different criteria for land use decisions, e.g. historical precedence.

Others refer to the poor record of valuation studies in influencing public policy (again a problem which afflicts several branches of applied economics). And some make the further point that valuation by itself may be meaningless, if there is no mechanism to capture and convey consumers' willingness to pay for non-market values to the people who, by their actions, can either fulfil or frustrate that demand.

While many of these criticisms of valuation are valid, the problem remains that environmental protection is often incompatible with other social and economic objectives. In forestry as in other spheres, people must often choose between incompatible alternatives, e.g. preservation, timber production or conversion to agriculture. Moreover, the view taken here is that many if not most land use decisions will inevitably have a strong economic basis, and that factors, which are, not quantified risk being ignored. We must acknowledge, however, that economic valuation of forest benefits can provide only part of the total picture, and that economic efficiency must be considered alongside other criteria such as social and cultural value, historical claims, distributional impacts and other factors. Alternative assessment methods, which may help in this regard, are discussed in the next section.

4.4 Alternative Methods of Land Use Assessment

The CBA framework is appropriate for making relatively small-scale decisions. The technique is generally based on the assumption that the project or initiative being considered is not so large as to alter prices or the structure of the wider economy. Yet many decisions concerning forest land use are made on a much larger scale. An obvious example is the classification of entire forest estates into zones, which are assigned particular uses, such as recreation or timber production. Another is reform of timber concession fees throughout an entire economy. This report has not dealt with other evaluation frameworks, such as land use planning or sector modeling techniques, which are better suited to assessing the impact of such large-scale decisions. But these decision-making tools can also be extended to incorporate estimates of a range of forest benefits, in either physical or monetary terms.

Other evaluation methods can help resolve particular weaknesses or difficulties of CBA. These include variants of CBA as well as very different decision-making approaches. This section briefly describes some alternative methods for assessing forest land use options.

In many cases it is not practical to estimate non-market benefits in monetary terms, or to conduct a full-blown CBA. One alternative to estimating non-marketed benefits explicitly is to ask how much it would cost to ensure their preservation by various means. The aim of *cost-effectiveness analysis* (CEA) is to determine the most economical or cost-effective means to achieve a specified objective, where the latter has previously been justified using some other criteria (Dixon *et al.* 1994).

This approach is illustrated by **Sedjo and Bowes (1991)**, who compared alternative management regimes on forest sites of different maturities in the Pacific Northwest (USA). The authors calculate the NPV of logging (per acre) under conventional clear-cut harvesting as well as three "ecological" options. The aim of the exercise was to identify the least-cost ecological regime and to estimate the additional cost of moving from conventional forest management practices to such a regime. The authors estimated that it would cost no more than US$0.28 per acre to switch from the traditional clear-cut to a 15% set-aside regime when starting from bare ground. However, the cost of switching to such an ecological regime rises sharply for older stands, reflecting the opportunity cost of leaving valuable old-growth timber standing.

When the objectives of alternative projects or land use options are more varied, or involve different units of measurement, CEA may be difficult. In such circumstances, *multi-criteria analysis* (MCA) provides a systematic way for evaluating trade-offs in reaching multiple objectives. An example of this approach is provided by a case study of the social, economic and environmental trade-offs among mangrove conservation, commercial forestry and fishpond development in the Philippines (Janssen and Padilla 1997). The authors used both CBA and MCA to explore the preferences of various stakeholder groups, including fishpond owners, local and national government, social and environmental agencies, and the global community. Using a financial CBA, they found that the opportunity costs of mangrove conservation (in terms of the foregone benefits of aquaculture) were very high, over US$6,500 per hectare. They then develop an MCA, in which a range of environmental and social effects are given equal weight with financial outcomes. They find very high trade-offs between equity and economic efficiency, moderate trade-offs between economic and environmental objectives, and relatively little conflict between equity and environmental objectives. On this basis, the authors conclude that commercial forestry offers the best prospect of meeting multiple objectives (social, economic and environmental), while semi-intensive aquaculture dominates in strictly economic terms.

Other assessment approaches focus on issues of risk. Many projects and land use options involve risky events which may affect human welfare. *Risk-benefit analysis* (RBA) evaluates the benefits associated with a land use option in comparison with major risks, such as flooding, landslides, etc. On the other hand, in *decision analysis*, which is an extension of rather than an alternative to CBA, for each action or land use a range of possible outcomes is specified, depending on what conditions or "state of nature" prevail. If possible, these outcomes are assigned probabilities or the impact of varying probabilities is assessed using sensitivity analysis. Where relevant, non-market benefits can be incorporated into such techniques, just as in CBA.

All of the methods described above (CBA, CEA, MCA, RBA, decision analysis) are quantitative tools which rely (at least in part) on economic information. Non-economic criteria also have an important role to play in forest land use planning. CEA and MCA, for example, use other types of information to assess trade-offs between economic and other (social or environmental) objectives. Non-economic information can also be used on its own, for example to define the ecological suitability or physical carrying capacity of forest lands for particular uses. Physical indicators are essential when certain forest goods and services evade monetary valuation.

One of the most widely-used non-economic frameworks for assessing development projects is *environmental impact assessment* (EIA). EIA involves the prediction of environmental impacts, either adverse or beneficial, of any proposed action. Like cost-benefit analysis, EIA has become a standard tool for project design and appraisal. Although EIA usually has no economic content, it may be well-suited to forest planning, not only because the environmental implications of many land use options are numerous, long-term (or even irreversible) and far-reaching, but also because many of the benefits (or values) provided by forests fall outside of the market. EIA can be seen as a complement, even as a necessary foundation for proper CBA, by specifying the impacts which CBA should attempt to evaluate. In general, it is not practical to value all of the impacts identified through an EIA. On the other hand, awareness of the range of forest goods and services, as well as how they can be valued, may be incorporated into EIA.

4.5 Methodological Issues in Conducting CBA

Some of the assessment methods described in the preceding section were developed to address specific weaknesses of CBA, or as alternatives when comprehensive economic analysis is not possible. For those who are prepared to undertake the rigors of CBA, a number of methodological challenges must be resolved. This section discusses key issues involved in conducting a CBA, including the treatment of time and discounting, risk and uncertainty, financial versus economic analysis, distributional concerns, and the sustainability of resource exploitation.

4.5.1 Time and Discounting

CBA entails identifying all the costs and benefits of a proposed activity, as well as when they are expected to occur. With many forest land use options, some benefits and costs may occur over relatively long time periods, reflecting the pace of natural processes. Setting an appropriate time horizon for land use appraisal is therefore a significant issue.

In the case of agricultural uses, for example, this may be a relatively short period of a few years, corresponding to one complete crop rotation (including fallow where relevant). In the case of forestry, normal practice is to consider the entire cycle of tree growth and maturation. For certain environmental or aesthetic benefits, however, even a 50-year timber rotation may not be enough time to reflect all of the consequences of a change in land use. Changes in soil fertility, hydrology or climate, for example, may not be revealed for decades. The aesthetic value of certain old-growth forest ecosystems may reflect centuries of growth, decay and natural adaptation.

On the other hand, any attempt to account for costs and benefits beyond a few years hence can seem naive in the face of rapidly changing tastes and technology. Thus there is no hard and fast rule for fixing a time horizon for forest land use appraisal. The appropriate time horizon may be determined by the nature of the problem being evaluated. What is important is to ensure that all relevant costs and benefits are included in the analysis, whenever (and wherever) they occur, and that alternative land uses are compared over the same time frame.

The question then is how to compare costs and benefits which occur at different points in time. The conventional answer is *discounting*, which involves weighting costs and benefits differently, depending on the period in which they occur. There are two fundamental justifications for discounting: first, the fact that most people prefer to receive benefits as soon as possible and to postpone costs (*pure time preference*); and second, the fact that alternative investment opportunities - including forest land uses - must compete for scarce savings (*opportunity cost of capital*). The cost of capital is normally measured by the market *rate of interest* or the cost of funds to the decision-making agency. Pure time preference is not so easily measured, but it is implicit in people's behaviour. The economic rationale for discounting and its implications for environmental management in developing countries are extensively discussed in the literature.[40]

Conventional discounting procedures are alleged to discriminate against environmental quality and resource conservation as a consequence of:

- reducing the negative impacts to society of long lived effects, such as global warming or species extinction;

- discriminating against investments with long gestation periods, such as reforestation or afforestation with slower growing indigenous species; and

- accelerating the depletion of natural resources generally - the higher the discount rate the more likely is extinction of biological resources and the greater the rate of extraction of non-renewable resources.[41]

The relation between the market rate of interest and the use of forest land is not always clear. Certain environmentally benign projects, such as sustainable harvesting of high value timber species, may satisfy the requirement of a high rate of return and use of a market rate of interest may not discriminate against them. Moreover, because high rates of interest discourage private investment and economic activity generally, they may retard the pace of development of forestry and agriculture and can therefore indirectly slow the pace of deforestation. On the other hand, a high interest rate may encourage more rapid extraction of timber and other resources, by making it financially unattractive to hold natural resource assets for long periods of time.

A related problem arises from the widespread assumption that individual firms and households have a higher rate of time preference, and thus employ higher discount rates, than society as a whole. The argument is that society can more effectively minimise risk by diversifying its investments; and of course society "lives" forever while private firms and households do not. High rates of private time preference may be associated with extreme poverty, when immediate subsistence is uncertain. Tenure problems and inappropriate concession terms can also engender high rates of private time preference, wherever insecure or short-term use rights or shared access to scarce resources discourage private investment and prudent management (Magrath 1989; Southgate 1988). The divergence between public and private rates of time preference leads the

[40] See, for example, Markandya and Pearce (1991) and Pearce, Barbier and Markandya (1990).

[41] High discount rates imply a greater opportunity cost to leaving resources "in the forest". If the market rate of interest is greater than the rate of growth of a biological resource (plus the expected rate of increase in prices), it may make financial sense for the owner to liquidate the resource and put the proceeds in the bank. In the case of non-renewable resources, e.g. mineral deposits, the relevant criterion is simply expected growth in prices. If natural resources are taxed differently than financial assets, this also needs to be taken into account.

private sector to discount future costs and benefits excessively and thus to consume assets that society as a whole would choose to conserve (Markandya and Pearce 1991). According to this argument, a socially optimal rate of logging and forest clearance will fall below the level chosen by private concession-holders and farmers.

Thus the discount rate remains a matter of concern. Some environmentally desirable land use options may not satisfy a high discount rate criterion. As a result, the allocation of forest land according to such a criterion may not be optimal. There are essentially two ways around this problem. One is to adopt a lower, *social* rate of discount where environmental concerns are paramount. This, however, raises the problem of how to choose which projects or land use options will benefit from the lower rate, given that all forest land use options have environmental effects. Another alternative is to impose a *sustainability criterion* on projects with environmental impacts. This would require that the total environmental benefits provided by forest lands do not diminish over the long run. Such a condition would imply the need for *compensatory projects* to ensure that total environmental benefits were maintained, although such projects may not have to show a specific rate of return (Pearce, Barbier and Markandya 1990).[42]

For the analyst attempting to provide useful information to decision-makers, a practical approach is to investigate the impact of alternative discount rates, by means of sensitivity analysis. For example, in the study by **Kumari (1995a)** of a Malaysian peat swamp forest, two discount rates are used: 8 per cent (taken as a "conventional" or market rate) and a lower rate of 2 per cent. Even with a discount rate of 8%, the analysis favours a shift from timber extraction using traxcavators and canals to a less environmentally-damaging method, using traxcavators and winches. With a 2% rate an even less damaging system, using winch and tramlines, is the preferred option. Sensitivity analysis is also useful where certain benefits or costs are highly uncertain, as discussed below.

4.5.2 Risk and Uncertainty

All forestry projects and policies entail some element of risk and uncertainty. For instance, in a production-oriented development project, future prices and expected yields will be subject to uncertainty. For watershed conservation projects, the rates of soil erosion and/or their off-site effects both with and without the project may be unknown. Natural events such as drought, windstorm and plant/animal diseases may also seriously affect project outcomes.

The most common way of dealing with risk and uncertainty is to use *expected values* for those variables whose precise values cannot be known in advance. In this way uncertainty (where the probabilities of different outcomes are not known) is transformed into risk (where probabilities can be assigned to the likelihood of occurrence of various outcomes). Each potential outcome is weighted by the probability of its occurrence and the weighted outcomes are then summed to arrive at a mean, or expected value.

Sensitivity analysis is another means of dealing with risk and uncertainty. This entails examining the effect of different assumptions about key input variables on key outputs. Using optimistic and pessimistic values for different variables can indicate which ones have the most pronounced effect on benefits and costs. While sensitivity analysis need not reflect the probability of occurrence of the upper or lower values, it is useful for determining which variables are most

[42] A basic assumption of this approach is that the compensatory project effectively replaces the benefits destroyed by the original activity. An application of this idea currently in vogue is to compensate for industrial contributions to global warming by initiating "carbon storage" projects - principally forest plantations in developing countries.

important to the success or failure of a project. On the other hand, some argue that sensitivity analysis is not a substitute for proper risk assessment, especially where environmental impacts are concerned.

Another alternative, when risk cannot be quantified, is to make a subjective assessment of the confidence which can be placed on certain values in a CBA. This may be appropriate where there are many non-market benefits, all of them estimated using the valuation techniques described above. **Kumari (1995a)** assigns one of three confidence levels (low, medium and high) to each of the forest benefits estimated in that case. Rather than the precise numeric confidence intervals of statistical analysis, this approach requires the analyst to assess his/her confidence in the results, based on the source of data, valuation methods used and the plausibility of any assumptions made. **Ruitenbeek (1992)** proposes a similar approach, in this case using confidence categories to define data needs, based on the practice of engineering cost analysis. Interpretation of an economic analysis involving estimates of non-marketed benefits or costs is much easier when the analyst provides some assessment of how confident he/she is that the stated results fall within a given range. Unfortunately, few other studies reviewed here included this type of information.

4.5.3 Financial versus Economic Analysis

Financial analysis is usually the first step in assessing the economic costs and benefits of projects or land use options. The aim is to measure private profits accruing to households or firms, based on market (financial) costs and benefits. Financial analysis can be invaluable in illustrating the motivations of the private sector. Only by looking at costs and benefits as perceived by different social and economic groups can we begin to understand how they will respond to government policies and programmes.

Economic analysis, on the other hand, measures the effect of a project or land use on the welfare of society as a whole. This usually requires various adjustments to financial prices, in order to correct for market imperfections, policy distortions and (in some cases) distributional inequities. In the context of a single project, these adjustments involve the estimation of *shadow prices*.[43]
In comparing financial with economic analysis, the question as to who are the winners and who are the losers in CBA is sometimes a difficult one.

As discussed in Chapter 2, market prices will not reflect true economic values when there are significant market failures or policy interventions.[44] *Market failures* include the absence of secure tenure (e.g. forests subject to "open access" exploitation), the presence of public goods (i.e. non-rivalrous and non-exclusive forest environmental services such as carbon storage), externalities (e.g. downstream siltation and flooding due to logging), incomplete information (e.g. ignorance of the potential future benefits of biodiversity) and imperfect competition (e.g. monopolies). *Policy failure* occurs when government interventions necessary to correct market failures are absent or inadequate (e.g. ineffective regulation of access to public forests). They also occur when government decisions or policies are themselves responsible for distorting market prices, such as exchange rate controls, price ceilings or supports, subsidies or taxes that create incentives for unsustainable forest use.

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[43] For a larger scale activity, such as land use appraisal at a national level, a more complicated procedure involving the estimation of marginal social cost and benefit curves is required (i.e. when potential changes in output are large relative to market demand, prices can no longer be assumed to remain constant).

[44] See Baumol and Oates (1988) for a general introduction to the theory of market and policy failures. Wibe and Jones (1992) provide case studies of market and policy failure in European forestry.

Empirical methods to account for market and policy distortions in CBA are available. The literature on CBA has concentrated on policy distortions.[45] Recent efforts by environmental economists have concentrated on market failures, leading to the development of non-market valuation techniques as well as new policy instruments to correct for environmental market failures.[46]

Economic analysis extends financial analysis by substituting economic values, or shadow prices, in place of financial prices. In addition, non-market costs and benefits are estimated and included where possible. Caution should be exercised in the use of shadow prices, due to the sometimes arbitrary and imperfect manner in which they are calculated. A recent review of experience at the World Bank, for example, found that shadow prices for conventional (as opposed to environmentally-related) policy failures were rarely used in project appraisals (Little and Mirrlees 1990). In many cases the market price is taken as a rough proxy of the real economic value of a good or service, on the grounds that the effects of policy on prices are trivial, or simply due to lack of data or expertise to estimate accurate shadow prices! In practice, analysts often limit themselves to adjusting for the most visible policy distortions, such as those created by government intervention in foreign exchange markets, taxes and direct financial subsidies.

Few of the case studies reviewed for this report attempt to make adjustments to financial prices, perhaps because the focus is on estimating the value of non-market forest benefits. Yet the use of economic prices can easily change the conclusions of a CBA. **Godoy and Feaw (1989)** provide a relevant illustration of the use of shadow prices in a CBA involving non-timber forest products. Their analysis of the profitability of smallholder rattan (*irit*) cultivation in Central Kalimantan, Indonesia, estimates the farmgate shadow price of rattan by accounting for an over-valued exchange rate as well as marketing and transport costs (including related fees and taxes). The results indicate that the economic return to rattan production is about 12 per cent lower than the financial return. Similarly, studies by **Browder (1985, 1988)** show how deforestation in Brazil was stimulated by subsidies to cattle ranching.

4.5.4 Distributional Concerns

The main objective of economic appraisal is to evaluate the costs and benefits of alternative activities in terms of aggregate economic efficiency, i.e. irrespective of the distribution of costs and benefits among different groups of people. Most policy-makers, of course, are concerned about distributional impacts, and we may expect alternative forest land use options to impose costs and confer benefits to varying degrees on different social and economic groups.

For example, the designation of forests as protected areas can be seen as a means by which certain interest groups (typically not the poor) secure recreational, amenity or non-use values. This may result in significant loss to another group, e.g. subsistence farmers who rely on forest land for extraction of non-timber forest products, or for shifting agriculture. Where the values of domestic and foreign consumers differ widely the resulting conflict may be international in scale, as shown by recent heated debates about tropical forestry and timber trade policy in global fora.

[45] Gittinger (1984) provides a good introduction while Mishan (1971) and Squire and van der Tak (1975) offer more theoretical treatments.

[46] Attention has focused on methods to estimate non-market public goods and externalities.

Similarly, efficiency and equity objectives in forest land use often conflict. Cost benefit analysis may lend weight to certain values and associated land use options that are unavailable to poorer groups, due to their limited access to capital and information. These groups must therefore confine themselves to "inferior" uses. For example, a study of a new national park in Madagascar estimated the value of additional benefits to international tourists at two to three times the loss, in terms of lost agricultural land, incurred by local villagers, despite measures allowing them access to buffer zones (**Kramer *et al.* 1995**). While such a change in land use may be economically efficient, since the potential for compensation exists, it will aggravate poverty where compensation is absent or inadequate.

Distributional concerns may be incorporated in an economic appraisal of forest land use options in at least three ways:

- the *distributional consequences* of land use options can be made explicit by assigning costs and benefits to specific groups;

- *distributional weights* can be used in the economic analysis to adjust the benefits and costs according to which groups enjoys or bears them; and

- the *entitlements* (use and access rights) of particular groups with respect to certain forest resources or benefits may be protected by defining minimum standards or guarantees.

To some extent the first approach is a prerequisite of the second and third. Unless the costs and benefits of a project or land use option can be linked to specific groups there is no way to know where distributional weights should be attached or what rights need to be protected. Therefore, the first step in any distributional analysis is to identify the different *stakeholders* in alternative forest land use options. Depending on the region and the particular land uses in question, this may include:

- indigenous hunter/gatherer populations
- subsistence farmers
- commercial farmers
- small-scale traders
- industrial firms (owners and employees)
- local, state and national government agencies
- domestic and foreign consumers

The next step is to determine which groups are affected by the various impacts of alternative land use options. Some costs and benefits may be spread widely among a number of groups, while in other cases the impact on certain stakeholders will be more concentrated. For example, the benefits of timber harvesting will be spread among the owners of logging companies and their employees, as well as firms involved in providing equipment, wood processing, transport, distribution and sales. It may not be possible to single out every industry (let alone every firm) which benefits from a particular forest land use option. However, it is usually possible to distinguish impacts on broad sectors of the economy and on different categories of labour (e.g. skilled versus unskilled).

Finally, the link between costs and benefits and different groups needs to be quantified, if possible, to show the magnitude of the distributional impact. Ideally this will be in monetary terms, although if certain costs and benefits have not been measured or monetised it may be necessary to describe their impact on different stakeholders in physical or qualitative terms. Costs and benefits may be expressed in financial terms, using market prices, or in economic terms, with adjustments made to account for market imperfections and/or policy distortions, although it is preferable to use the former when looking at distributional impacts.

It may be more difficult to trace the distribution of *non-marketed* costs and benefits, although the techniques used to value these items can often be extended to distinguish different groups. For example, in the case of watershed protection benefits provided by an upland forest, it may be possible to identify those who stand to lose if these services are disrupted, e.g. land-owners and residents of the downstream flood plain, the regional water or irrigation management authority controlling a downstream reservoir subject to sedimentation, etc.

Only a few studies of land use options attempt to quantify the distribution of costs and benefits among different groups. But even where particular groups are not singled out, the distribution of costs and benefits is often implicit. The case study of the creation of a national park in Madagascar, by **Kramer *et al.* (1992, 1995)**, examines the benefits and costs to various groups, including those residing within or around the protected area, other agricultural communities in the same watershed, domestic and foreign tourists, and foreign populations. In this case communities around the park bear much of the cost of its establishment, in terms of loss of access to forest products and land, while all other groups gain. Likewise **Kumari (1995a)** concludes her case study of alternative management systems for peat swamp forests in Malaysia by noting that the largest benefit to be gained from more sustainable exploitation will accrue to the global community, in the form of carbon storage and reduced global warming. These examples highlight the range of groups who are increasingly claiming a stake in the future of tropical forests. Trading off the gains and losses of various groups with wide-ranging levels of income and wealth can raise difficult ethical questions.

Concerns about the equity of distributional impacts can be integrated into CBA formally, by using distribution weights. The underlying justification for doing so is that prevailing market prices reflect the *existing* distribution of income and wealth and are therefore "distorted" with respect to social equity objectives. The usual practice is to define a multiplier, which is applied to some or all costs and benefits accruing to the target group(s).[47] This results in a number of *socially-adjusted prices*. Despite strong theoretical arguments, distribution weights, like full shadow pricing, are rarely used in economic analysis. To some observers the approach seems too subjective. No examples of the use of distribution weights were found in our review of case studies of forest land use options.

Another way to ensure that land use decisions do not adversely affect certain groups is to define certain rights or minimum standards as absolute targets or limits. This approach is similar to cost-effectiveness analysis (CEA) in that the analysis proceeds from certain "givens", for instance the requirement that indigenous populations retain their traditional rights of access to particular forest areas. Such entitlements thus define the feasible set of land use options. Like distribution weights, such rights or limits cannot be determined objectively but are the product of a political or ethical judgement.[48] Thus, the basis for assigning them should be made clear. However, this

[47] For a detailed explanation of how to derive distributional weights and calculate socially-oriented shadow prices see, for example, Ray (1984) and Squire and van der Tak (1975).
[48] Normally rights or entitlements are defined with respect to human beings, although some conservationists insist that plant and animal species also have a "right" to exist. Laws on wildlife protection have been used in this way,

approach is more prescriptive than analytical and is essentially non-economic, to the extent that trade-offs are not made explicit.

4.5.5 Sustainability and the Depletion of Resources

Many forest areas in developing countries are currently exploited under an *open access* regime, or are public property and sold at prices below their true opportunity cost (e.g. wildlife, fuelwood, timber). As a result, the prevailing rates of extraction may be inefficient, in economic terms, or unsustainable in ecological terms. In such cases, simply multiplying the current periodic harvest by the price (even when an efficient price is used) will grossly overstate the net benefit of the resource or land use. Hence the need, noted above, to adopt a time horizon sufficiently long to allow for the potential degradation or depletion of the resource over the long run.

When comparing alternative land use options, however, it may be more appropriate to define an optimal or sustainable rate of exploitation. A conventional method for renewable resources is to define the harvest in purely biological terms and to estimate the *maximum sustainable yield* (MSY), as demonstrated by **Peters *et al.* (1989)**. When comparing alternative land use options, it may be possible to compare two or more *sustainable* management regimes, e.g. maximum sustainable wildlife harvest or maximum sustainable yield agriculture. The physical output in each case is given by the zoologist or the agronomist, based on models that relate animal population growth or crop productivity to fundamental ecological constraints. The value of the sustainable harvest is then calculated directly, by multiplying the estimated harvest by the appropriate efficiency price.[49]

Alternatively, the analyst may attempt to estimate the efficient or "optimal" rate of exploitation in *economic* terms, i.e. the rate of harvest that maximises profit rather than physical output (see Tietenberg 1996 for a detailed discussion).[50] The procedure used to estimate net benefit, however, would remain the same, i.e. gross revenue less total cost, where the latter is the sum of direct costs and any indirect or environmental costs.

In many cases, however, the sustainable or economically efficient harvest rate is not known and cannot be estimated directly. The analyst may then simply rely on *sensitivity analysis* to illustrate differences in net benefits under different assumptions about physical output or impact (see for example **Ruitenbeek 1992**). The compensatory project approach may also be helpful in this situation, as a way of accounting for the loss of benefits due to excessive levels of resource exploitation (see the earlier section on time and discounting).

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for example in the United States. If this principle were generally applied in the developing world it would of course imply an immediate halt to further encroachment on natural forest lands, where conversion poses the greatest threat of species extinction.

[49] Note that even when market prices for forest benefits exist and are not distorted by public policy, they may understate the full economic value of the resource if the bulk of market supply comes from land over which there are no clear property rights or other restrictions on harvest levels. The reason is that in such cases, market prices will fail to reflect *user costs* (e.g. the stumpage value of standing timber). Any off-site impacts would also need to be considered. See section 4.5.3 for more details.

[50] The optimal economic rate of harvest for a renewable resource is normally less than MSY but is heavily dependent on the choice of the discount rate (see Pearce, Barbier and Markandya 1990; Clark 1976).

5 Conclusion: The Uses of Forest Valuation

Chapters 2 to 4 have described the range of benefits provided by forests, the methods available to estimate market and non-market forest values, and alternative decision frameworks for assessing the trade-offs among competing forest values and land uses. Chapter 6 and the appendix to the report provide a review of empirical research in this area, along with detailed summaries of selected case studies. The question remains, however, what is it all for? Why undertake the effort and expense of evaluating alternative forest land use options? Who can use the results, and how?

This chapter focuses on potential applications of forest valuation results. In contrast to the considerable advances made in valuing non-timber forest benefits, there appears to be relatively little progress in applying the results of valuation studies to forest policy and management. This is probably due to political and institutional barriers rather than a reflection of the quality or relevance of valuation studies. Despite the discouraging record to date, a number of potential applications can be identified.

The integration of forest values in policy is a crucial step. Forest land users and managers are often reluctant to modify their management practices, even where they acknowledge the importance of environmental benefits, due to the constant pressure to increase revenue and reduce costs. Careful design of forestry regulations, concessions and tax policy can encourage forest managers and land users to account for non-market benefits in their own interests (Richards 1999). This in turn can reduce the need for and costs of supervision by regulatory agencies, while achieving a more efficient mix of market and non-market benefits.

Information on the economic value of non-timber forest benefits can be applied at different geographic scales: in determining the appropriate extent and type of forest cover (i.e. for land use planning); and in deciding how individual forest stands should be managed. In both cases the scope for improving policies runs the gamut from zoning and property rights to regulation and pricing schemes.

5.1 How much forest is needed, of what type and where?

Virtually all forests have some positive non-market value. This implies that the value of keeping land under forest is almost always greater than the amount that can be realised by private firms producing for the market. This, in turn, means that private landowners will systematically under-provide forested land.

Similarly, valuation studies suggest that the general public prefers forested landscapes composed of mixed species and varying ages. For recreational purposes (e.g. trekking, camping) the public generally prefers mature forests with little undergrowth, high canopies and relatively few stems, to younger, denser stands. Both of these preferences run counter to the usual aims of industrial forestry, which in turn implies that private firms will tend to under-supply older and more diverse forest landscapes.

The traditional solution to this problem is for the state to provide recreational and amenity forests on publicly owned land, in which industrial uses are strictly limited or forbidden. An alternative to public provision is to introduce land use zoning or other restrictions on the use of private land, to ensure greater forest cover and/or more diverse forests in areas of relatively high demand.

One interesting implication of travel cost and other valuation studies is that many forests may be misplaced. In effect, there should be more (and more diverse) forests near population centres. On the other hand, existing land use restrictions in some areas may already provide an appropriate level of forest cover with respect to recreational, landscape and other non-market values. This applies particularly to blanket restrictions on farming or logging of slopes above a certain steepness, irrespective of opportunity costs or actual downstream water uses and flood risk.

5.2 Non-timber values and private property rights

Economists often argue that a fundamental cause of the under-supply of non-market benefits (and the over-supply of non-market costs or "externalities") is the lack of exclusive property rights. The notion is that private property, where it is enforceable, creates an opportunity for profitable exchange and thus an incentive for more careful management. As a rule, therefore, economists tend to favour the creation of property rights over regulation or price policy. One advantage of such an approach is that government need not concern itself with the difficult task of setting prices but can devote its efforts to enforcing property rights and contracts.

Promising areas for property rights-based solutions to the under-supply of non-timber forestry benefits include concessions for non-timber forest products and for recreational uses.[51] These may overlap with timber concessions, requiring logging companies (or landowners) to make proper compensation for loss of non-timber benefits. Constraints on the viability of private concessions include the difficulty of excluding poachers and/or free-loaders, and competition from publicly-owned lands, where access to comparable benefits may be free or below cost.

5.3 Non-timber values and forestry regulations

Where private property rights are not feasible[52], it may be possible to account directly for the value of non-timber benefits in forestry regulations. In fact, many public agencies already account for environmental values either explicitly or implicitly. Timber cutting limits and rotation length, careful road layout, mandatory low-impact logging methods, stream-side buffer strips and wildlife corridors, etc. are all increasingly standard practice and can help to mitigate damage or loss of non-timber benefits due to logging.

The weakness of such regulatory approaches is their insensitivity to differences in the costs and benefits of compliance at different forest sites. Many forestry regulations are applied uniformly to all areas in the same way, regardless of the type of forest involved or its location. And yet evidence from valuation studies suggests that demand for many non-timber benefits varies widely from place to place, mainly as a function of the proximity and density of human populations but also as a function of forest characteristics (e.g. age and species composition, topography and accessibility, presence or absence of streams and water falls).

[51] The results of valuation studies may provide a bench mark or reserve price for auctioning concessions.

[52] For example, an exclusive right to the carbon storage benefits of a particular forest is a ridiculous notion: first, because one person's enjoyment of the climate benefits secured thereby does not detract from another's, and, second, because it is impossible for the "owner" of the right to prevent others from enjoying the benefit.

This in turn implies a need for greater flexibility and sensitivity of forestry regulations to the effective demand for non-timber benefits at particular sites. Valuation studies can help by demonstrating the relation between key characteristics and WTP for non-timber benefits.

5.4 Non-timber benefits and forest pricing policy

Landowners are clearly sensitive to taxes in their choice of land use. Similarly, timber concession holders and logging firms are sensitive to royalties, taxes and other fees. The results of valuation studies may be incorporated in such policies and can be expected to induce changes in land use and logging practices.[53]

For example, the sale price of timber concessions on public forest land can be adjusted to account for the relative importance of non-timber benefits in different areas and the impact of timber harvesting on them (positive or negative). This can apply whether the price of timber concessions is fixed administratively or by auction. At the margin, higher (or lower) prices will lead firms to lose (increase) interest in harvesting timber from certain areas altogether (i.e. forests which are less accessible or less densely stocked with mature commercial timber species). Similarly, on private land, rates of tax may be adjusted up or down according to the level of provision and the importance of non-timber forest benefits in that area. Of course, both measures require detailed knowledge of local conditions and thus may be best administered by local government.

Finally, the results of recreational demand studies (using travel cost and/or contingent valuation) can be and often are used to set entry and licence fees for forest recreational areas, including day trippers, campers and hunters.

[53] Industry often argues that such measures erode their competitive position. However, there is some evidence that suggests the reverse, namely that the adoption of environmentally sensitive production methods, if combined with appropriate marketing efforts, can confer a "green" market advantage and improve profitability.

6 Applications of Forest Valuation in Developing Countries

The empirical literature on valuing non-timber forest benefits and land use options is large and growing fast. Good examples can now be found for virtually all types of forest benefits and most valuation methods, even if one restricts attention to studies conducted in the developing world. It is hardly feasible, nor particularly helpful, to attempt an exhaustive inventory of published studies. Any review must therefore be selective, and this is no exception.

The aim of this chapter is to review some of the more complete and/or influential case studies of non-timber forest benefits and forest land use options published during the past ten years. Several examples were provided earlier in the report, as part of the review of valuation methods and discussion of practical issues in conducting CBA. Additional illustrations are presented below, organised here in terms of the main categories of forest value as defined in Chapter 2 - i.e. *direct* and *indirect use* value, *option* value, and *non-use* value. Examples of *total economic valuation* are considered separately. Suggestions for future research are offered where appropriate. More detailed summaries and commentary on over 50 case studies which were selected from among a larger number of studies reviewed can be found in the appendix to this report.

6.1 Direct Forest Land Uses

The type of forest benefits most commonly estimated are direct use values, including timber and non-timber forest *products* (NTFPs or “extractive” benefits), as well as certain forest *services* (notably recreation and “passive” uses such as landscape or amenity values). Some case studies also compare forest benefits with the value of alternative uses of forest land, e.g. agriculture. In general, the value of marketed products and services of forest land is easier to estimate than the value of non-marketed or subsistence uses. This is one reason why many private landowners and public policy makers often fail to consider non-market forest values in their land use and development decisions.[54]

6.1.1 Timber and Non-Timber Forest Products

Valuation of timber and most NTFPs is relatively straightforward. It can usually be undertaken using market prices or the prices of substitute goods, as opposed to more sophisticated non-market valuation techniques. However, while the valuation of timber and NTFPs presents few analytical difficulties, for many of the latter there is little publicly-available information on the quantities harvested, consumed and sold or the costs incurred, including tools as well as non-priced inputs such as household labour. This is due in part to the perceived “minor” significance of NTFPs and their concentration in informal or subsistence economies (FAO 1990).

The economic importance of NTFPs in subsistence agriculture is probably underestimated. These products are widely used in most rural communities throughout the developing world, and in some cases even in urban areas. Edible forest plants and animals are often important as dietary supplements, as seasonal supplements - most often when cultivated food supplies are in short supply at the end of the crop season - and as emergency supplies during wars and famines. Unfortunately, lack of systematic monitoring and information systems means that it is often necessary to collect this data from scratch, using surveys.

[54] There are also powerful institutional reasons for this failure, including widespread lack of secure or exclusive property rights over many non-timber forest benefits, which means that land users cannot control access to or demand payment for their provision (see Chapter 2).

Case studies reviewed here which provide estimates of the value of both timber and non-timber forest products include: **Emerton (1996); Howard (1995); Kumari (1995a); Peters *et al.* (1989); Pinedo-Vasquez *et al.* (1992); Ruitenbeek (1989a, 1989b, 1992); and Saastamoinen (1992)**. Several other case studies estimate the value of NTFPs (and in some cases other forest benefits) but do not consider timber values. These include: **Appasamy (1993); Chopra (1993); Davies *et al.* (1999); Godoy and Feaw (1989); Gunatilake *et al.* (1993); Kramer *et al.* (1992, 1995); Lynam *et al.* (1994); and Schwartzman (1989)**.[55] Finally, a few case studies consider timber values alone: **Jonish (1992); Sedjo (1988); Sedjo and Bowes (1991); Veríssimo *et al.* (1992); and Uhl *et al.* (1992)**. Case studies which estimate timber values alongside other land use options (e.g. agriculture) are discussed below.

Most of the studies reviewed use market prices to estimate the value of forest products. Some studies simply estimate the gross value of extracted products, while others attempt to calculate net returns by deducting the costs of harvesting, processing, transport and marketing margins. Some include the opportunity cost of capital (especially important in industrial timber production), while others do not. The resulting estimates cover a range of different products and are expressed in various ways: as average annual returns per hectare, per household or per firm; in gross terms or net of production costs; using "forest-gate" prices for unprocessed product or using prices of semi-processed products in nearby markets; in annual or net present value terms; etc.

Unfortunately, the use of inconsistent methods and data from different periods to estimate timber and NTFP values makes it difficult to compare the results of different studies. In addition, real returns would be expected to vary dramatically depending on the location of the case study. Thus, for example, the net returns to timber estimated in the studies reviewed here range from just US$12 per hectare in Brazil (NPV of "extensive" timber extraction, using a discount rate of 12%, reported by **Almeida and Uhl 1995**), up to $3,184 per hectare, also in Brazil (NPV of *Gmelina arborea* plantation, using a discount rate of 5%, reported by **Peters *et al.* 1989**). Reported returns to NTFP extraction also vary widely, from as little as $1.22 per hectare per year (net returns to extraction of rubber and Brazil nuts, reported by **Schwartzman 1989**) up to about $350 per ha/yr. (net returns to fruit and latex extraction in Peru, reported by **Peters *et al.* 1989**). Clearly, if researchers would adopt common accounting methods and assumptions, it would be much easier to compare the estimates of different studies (Godoy *et al*. 1993). Moreover, greater methodological consistency would also help focus attention on the underlying factors that determine the relative returns to alternative forest land uses, such as access to markets, population density, land capability for agriculture, etc.

NTFP values seem to have lost prominence as a focus of valuation research in recent years, perhaps due to disillusion with the apparently modest returns to management of forests for their extraction (Southgate 1998). And yet we know that extractivism can be competitive in certain circumstances, e.g. harvest of wild mushrooms in southern Europe and the US Pacific NW, maple syrup extraction in New England and eastern Canada, etc. Questions for future research in this area include:

- Which NTFPs retain or increase in value with urbanisation and rising incomes, and why?

[55] Other examples of NTFP valuation can be found in: Anderson and Ioris (1992); Balick and Mendelsohn (1992); Bann (1997a, 1997b); De Beer and McDermott (1996); Dixon and Sherman (1990); Emerton (1996); Gammage (1997); Kramer *et al.* (1994); Kumari *et al.* (1998); Padoch (1987); and Woon and Poh (1998), among many others.

- Can we predict which types of NTFP will maintain or increase in value with development, and which ones will decline?
- How should forest planners monitor and respond to shifting NTFP values?

6.1.2 Alternative Land Uses

A few of the case studies reviewed estimate the returns to several different uses of forest land, as part of a comparison of alternative land use options. In most cases, the studies compare forest conservation or "sustainable" management with conventional (unsustainable) timber extraction and/or conversion to agriculture. Many studies find that environmentally-friendly land use options are superior, in economic terms, but only when indirect use and non-use forest values are included in the CBA.

Case studies reviewed here which estimate returns to alternative forest and non-forest land uses include: **Almeida and Uhl (1995); Aylward *et al.* (1999); Bennett and Reynolds (1993); Browder (1988); Dixon and Sherman (1990); Gunatilake *et al.* (1993); Hodgson and Dixon (1988); Howard (1995); Kramer *et al.* (1992, 1995); Kumari (1995a); Paris and Ruzicka (1991); Peters *et al.* (1989); Pinedo-Vasquez *et al.* (1992); Ruitenbeek (1992); Smith *et al.* (1997);** and **Southgate (1992).** As in the case of forest products, estimated returns to non-forest land uses are calculated and expressed in different ways and the results vary widely. Thus for example we observe estimates of financial returns to traditional "slash-and-burn" farming ranging from as little as $75 per ha/yr. in the Philippines (**Paris and Ruzicka 1991)** up to about $450 per ha/yr. (**Pinedo-Vasquez *et al.* 1992)**. Likewise estimates of the NPV of cattle ranching vary from as low as *negative* $279/ha in Brazil (**Almeida and Uhl 1995**) up to *positive* $8,700 in Costa Rica (including social and environmental benefits, net of foregone direct use values of forestry, reported by **Aylward *et al.* 1999**).

6.1.3 Forest Recreation

The direct use value of forests for recreation in developing countries has received more attention lately, with a growing number of researchers applying travel cost and contingent valuation methods. Travel cost and CV studies have proved useful for setting and revising fees charged to recreational visitors to forest or park land, for determining the government's "reserve price" when negotiating concessions to private operators seeking to offer recreational services on public land, or simply to justify public designation of, and expenditure on, protected areas.

Significant examples reviewed here include: **Dixon and Sherman (1990); Hadker *et al.* (1997); Kramer *et al.* (1992, 1995); Prasanthi Gunawardena *et al.* (1999); and Tobias and Mendelsohn (1991)**.[56] Estimated values are usually expressed as a marginal WTP in US$ per visit, or as a total value for a particular forest area. In a few cases estimates are expressed as a NPV per hectare. Average reported values for those studies that undertook original surveys are in the order of US$30-40 per visit.

To some extent, the recent interest of researchers in recreational values probably reflects increased familiarity with travel cost models and contingent valuation methods. It may also reflect the growth of international tourism to forest areas in developing countries, along with increased domestic demand for recreational experiences in natural areas in some countries,

[56] Other developing country examples include: Echeverría *et al.* (1995); Mercer *et al.* (1993); Willis *et al.* (1998).

notably those characterised by significant urbanisation and rapid income growth.[57] Note also that a substantial portion of this value is potentially recoverable, e.g. through park entrance or concession fees, leading both public and private landowners to commission valuation studies of recreational benefits as part of their price-setting and budget procedures.

Nevertheless, forest recreational values remain controversial. This is not so much out of concern for the methods used to estimate them (although many still distrust CVM), but rather because of the conflict between recreational and other more "local" forest uses (e.g. grazing, extractivism, agriculture, logging). In the developing world, the problem is exacerbated by the unequal political and economic power of recreational (primarily urban, upper income) and local (rural) forest users.

6.1.4 Amenity/Landscape Values

The amenity value of forested landscapes may be considered a direct use value to the extent that consumers take advantage of it, even if it is by enjoying the view only.[58] Various techniques can be used to estimate this benefit, including TCM, CVM and hedonic pricing models. Studies of forest recreation in developing countries using TCM or CVM probably include landscape value, although it may not always be possible to distinguish this benefit from the rest of the recreational experience.

One way to isolate landscape value is to apply hedonic pricing models, using data from residential property markets. An illustration of the latter approach used to value forests in the UK is provided by Garrod and Willis (1992). No examples of this approach were found in developing countries, perhaps due to relatively poorly developed and/or badly documented housing markets. Such studies may become more feasible in future years, particularly in peri-urban areas of middle-income countries, where more and better data on private property transactions should permit robust econometric analyses of the effects of proximity to different types of forest on residential house prices. Such research might help to justify preservation of "green space" in and around rapidly-growing southern cities, and would also shed light on the distributional impacts of land use planning restrictions (since the rich are more often able to afford the higher cost of property located near greenery).

6.2 Indirect Forest Uses

Case studies of the indirect use benefits of forests are less common in the literature than studies of direct uses such as NTFPs. Important forest environmental functions such as protection of watersheds and coastal marine resources, biodiversity conservation and carbon storage are usually non-marketed, financially unrewarded and only indirectly connected to economic activities.[59] They are also difficult to measure, as the indirect use value of an environmental function may only become apparent when there is a change in the market value of one or more activities or properties that can be attributed to a change in the nature, intensity, duration or

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[57] Note that WTP for forest recreation rises with ability to pay (income), but not necessarily at the same rate (Kristrom and Riera 1996). There is a consistent bias in all monetary valuation methods towards those forest uses which are of relatively greater interest to richer groups in society (see section 4.5.4).

[58] Where landscape values are unrelated to any direct contact with or experience of the forest area in question, they may be characterised as non-use values (see section 6.4 below).

[59] Estimates of biodiversity conservation benefits are discussed along with other option values in section 1.3, on the grounds that most cases studies to date have looked at *potential* rather than actual benefits.

extent of the function itself. For this reason, the production function approach is often used to value indirect uses, although other methods can also be used (Aylward and Barbier 1992).

The two indirect use benefits that have received the most attention in forest valuation studies are watershed/fisheries protection and, more recently, carbon storage. We found just one published case study, which estimates the benefits of micro-climate regulation (Lopez 1997). None of the studies reviewed attempted to estimate the benefits of forests in terms of soil nutrient cycling or air pollution reduction. This may be because, in the latter cases, the underlying ecological relationships are still not well understood and thus not amenable to economic analysis.

6.2.1 Watershed/Fisheries Protection

The benefits that forests provide by protecting watersheds and fisheries, including the regulation of both the quality and quantity of water runoff, are considered especially significant in hilly tropical areas subject to intense and heavy rainfall. Likewise, tropical mangrove forests are considered to play a key role in maintaining the productivity of near- and off-shore fisheries (among other benefits). Unfortunately, in most developing regions little data is available on the relationships between forest disturbance and downstream or off-site economic activities.

The evidence with respect to watershed and fisheries protection values is mixed. Some studies suggest that the off-site hydrological impacts of logging or forest conversion are mainly negative (e.g. **Bennett and Reynolds 1993; Hodgson and Dixon 1988; Kumari 1995a; Paris and Ruzicka 1991; Ruitenbeek 1989a, 1992)**. These and other authors refer to:

- increased risk or magnitude of drought or flood damages;
- increased turbidity and sedimentation of rivers, reservoirs, harbours, irrigation channels, etc. resulting in higher water treatment and dredging costs, or reduced capacity and life span of economic infrastructure (e.g. pumps, turbines, etc.);
- reduced recreational value of lakes, streams, rivers and off-shore coral reefs;
- reduced diversity or productivity of inland- and near-shore fisheries,
- reduced soil nutrient cycling and/or soil formation, etc.

Such arguments should, of course, be based on careful estimation and/or measurement to determine the impact of forest disturbance on one or more downstream activities. The benefit of maintaining forest areas, or of adopting low-impact logging methods, for example, would then be expressed in terms of the net value of downstream activities that would otherwise be lost, using the production function approach (see Chapter 3).

Unfortunately, many studies do not undertake detailed estimation or measurement of the off-site impacts of forest disturbance, but simply assume a damage function. For example, **Bennett and Reynolds (1993)** argue in their case study that the entire near-shore fishing industry in the Kuching Division of Sarawak, East Malaysia, is "at risk" from mangrove conversion. While this may be true, more rigorous documentation of the links between forests and fisheries is needed to support recommendations of forest conservation or other land use restrictions.

Some detailed studies present a more nuanced picture. For example, in their study of the Arenal watershed in Costa Rica, **Aylward *et al.* (1999)** conclude that the impacts of forest conversion on hydroelectric power production are broadly positive. Although increased sedimentation due to forest conversion does slightly reduce the capacity of the Arenal reservoir to hold water for electric power generation (and for irrigated agriculture), the authors find that the benefits of increased water run-off, in terms of additional electric power generating capacity, are far more significant. Similarly, **Niskanen (1998)** concludes that reforestation imposes a significant cost through reduced water availability for irrigated agriculture.

These findings are supported by other studies which show that deforestation leads to increased runoff from upland areas (due to lower evapo-transpiration). In other words, the removal of forest cover may enhance supplies of fresh water, albeit with increased sedimentation and higher risk of flooding in some cases (Bruijnzeel 1990; Hamilton 1983; Calder 1992). Clearly, much depends on local terrain and hydrological conditions, the type of land use in upland areas, the type of land and water uses in downstream areas, and the links between them.

A priority for future research in this area is to enable land use planners to move beyond existing, crude decision rules for upland forest management (e.g. bans on logging or agriculture above X slope or Y metres elevation; minimum riparian buffer strips of N metres width, etc.). Where there is high demand for water, for example, it may make little sense to maintain upland areas under forests which consume large quantities of fresh water, even if water treatment costs rise slightly.[60] Conversely, where upland forests protect existing communities and infrastructure against the risk of flooding, continued forest conservation may be justified. Of course, some watershed protection services may become apparent only when they are lost, but this is probably a reason for proceeding cautiously rather than not at all.

Closely related to the need for more detailed valuations of watershed protection services themselves, research is also needed on the institutional requirements and transaction costs of watershed protection. As with other off-site forest benefits, the development of markets for watershed protection services is likely to be constrained above all by institutional factors, e.g. the costs of conferring property rights, making contracts, and enforcing liability for damages incurred (Hyde *et al.* 1996). A useful area for future research would be to assess the costs of coordinating forest use and/or enforcing property rights over non-timber benefits. Where are these costs prohibitive and why? Are these costs rising or declining, in real terms?

6.2.2 Carbon Storage

The benefits of forest cover for slowing down global warming by storing carbon in trees and other vegetation have been incorporated recently into several studies. While this is clearly an indirect use value, the nature of carbon storage makes it unique in comparison to other forest benefits. First, the mitigation of climate change is a global benefit and thus benefits the entire world population.[61] Second, the benefits of storing a tonne of carbon do not appear to depend on the type of forest or where it is located. As a result, a "global" estimate of the value of carbon storage can be used virtually anywhere.

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[60] Obviously one would want to consider other non-timber forest values before deciding to log or convert upland forests. High demand for water is not sufficient reason on its own!

[61] Certain regions of the world are likely to suffer more than others under continued global warming. However, because of the variety of interests involved and the high degree of uncertainty, slowing global warming is usually considered to be a global benefit.

Recent research has concentrated on assessing the magnitude of carbon storage benefits. The approach has concentrated on estimating the marginal damages caused by releasing additional carbon dioxide into the atmosphere. Thus the benefit of carbon storage is defined in terms of the damage costs avoided. Published estimates range from as little as US$0.3 up to US$221 per tonne of carbon, in net present value terms, with the wide range attributable to a variety of different assumptions. Recent research has narrowed this range considerably (e.g. Cline 1992, Nordhaus 1993). Fankhauser (1995) reviews previous research and adds his own analysis in order to propose a "central" or benchmark figure of US$20 per tonne. Fankhauser's analysis refines previous work by modeling the impacts of climate change on separate regions of the world (rather than simply extrapolating from the US economy).[62]

Using these estimates, several recent case studies calculate the carbon storage value of forests in a developing country setting. With the unit value of the benefit taken as given, the researcher simply needs to determine the amount of carbon stored or released under alternative land use scenarios, for a particular region. For example, in a case study of a Malaysian peat swamp forest, **Kumari (1995a)** estimates the change in carbon stored per hectare under a range of management options. These changes are valued at US$14 per tonne, corresponding to the more conservative estimates available prior to the publication of Fankhauser's paper. Nevertheless, under a base case scenario involving unsustainable timber harvesting, carbon storage accounts for almost 70 per cent of the economic benefits measured, far more than timber or any other non-timber benefit estimated in the study. Other case studies reviewed here which estimate the carbon storage benefits of forests include: **Adger *et al.* (1995), Niskanen (1998)** and **Smith *et al.* (1997)**. Some case studies quantify carbon storage or emissions in physical terms, but do not ascribe monetary values (e.g. **Almeida and Uhl 1995**). In general, because of the high carbon content of forests and the potentially large damages of global warming, estimates of carbon storage values tend to swamp all other forest benefits, often including timber.[63] Estimates reported in the case studies reviewed here range from US$650 to $3,500 per hectare, in net present value terms.

Despite the apparent magnitude of carbon storage benefits, until recently there was no mechanism for recovering this value. The challenge is to persuade the "consumers" of carbon storage (effectively everyone) to pay forest landowners for carbon storage services rendered. Even today, despite the emergence of carbon trading and commercial sequestration services in response to national commitments made at Kyoto in 1997, most forest landowners cannot turn their carbon "assets" into cash as readily as they can timber and other forest products. Moreover, most developing countries have made no formal commitment to reduce carbon emissions, and for many developing country governments carbon storage remains a relatively low priority. When valuing carbon storage benefits, therefore, some judgment must be made about the likelihood of financial compensation from abroad, and the importance of carbon storage from a national perspective.

It remains to be seen whether carbon values will be realised on a large scale in developing countries, and if they are, whether the resulting financial transfers will have a significant impact on the pace or nature of land use change in those regions which have experienced rapid deforestation in the recent past. Additional case studies of the carbon profile of

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[62] Fankhauser's model incorporates uncertainty by using random variables for several parameters, such as the sensitivity of climate to a doubling of atmospheric concentrations of carbon dioxide and the magnitude of estimated damages.

[63] See Fankhauser (1995) for more detail on the economics of carbon storage and the greenhouse effect. Methods for estimating carbon storage and emissions from forest land are described in Brown (1992) and Brown *et al.* (1997).

alternative forest land uses would add little, at this stage. Far more pressing is a better understanding of the marginal cost of switching to more "climate-friendly" land uses, i.e. what does it take to persuade land users to modify their practices? (e.g. **Smith *et al.* 1997**) Other research needs include determining which types of forest and forest user will benefit most from markets for carbon storage, and how to ensure that small-scale land users (who are often implicated in tropical deforestation) benefit from the sale of carbon storage services.

6.3 Option Values (Biodiversity)

Assessment of option values related to future use of forests is particularly challenging, as it requires fairly strong assumptions about future incomes and preferences, as well as technological change. One area where progress has been made is in estimating the potential future value of genetic information and organic compounds derived from wild plant and animal species found in tropical forests. These may be used as "raw material" for the development of new crop cultivars, pharmaceutical products and pesticides, among other uses.

Adger *et al.* (1995) and **Kumari (1995b)**, for example, use a technique developed by Pearce and Puroshothaman (1992) and Pearce and Moran (1994), which in turn build on earlier work by **Ruitenbeek (1989a)**. The approach estimates the production value of plant-based drugs as a function of many variables including the number of plant species in forests, the probability of a species providing a commercial drug (i.e. the "hit rate"), the royalty rate paid to prospecting companies, the proportion of this paid to the country where the plant is found and the average value of drugs. Unfortunately, little information on these parameters is available for developing countries; hence the resulting estimates of biodiversity values vary wildly. Depending on the assumptions made, reported annual values range from just US$0.20/ha (minimum estimate reported in **Howard 1995)** up to $695/ha (maximum estimate reported in **Kumari 1995b)**.

Another case study reported by Barbier and Aylward (1996) assesses the value of genetic information from wildlife on public forest land in Costa Rica for the development of new drugs. In this case, detailed information on hit rates and research and development costs were used to estimate the net value of the wild product, rather than simply applying the market value of the final product, as in some previous studies. The authors conclude that the economic value of biodiversity for such "pharmaceutical prospecting" can be locally significant, but is probably not sufficient by itself to justify forest conservation in the face of alternative land use options.

Finally, a case study by **Evenson (1990)** takes a slightly different approach to estimate the benefits of using genetic material from wild rice stocks to improve the yield of cultivated rice. The study used data on varietal improvements in rice and changes in productivity from the period 1959-84. (The resulting estimate of US$74 million in present value terms is perhaps more accurately described as an indirect use value, as the benefits were real rather than potential). Note that while this study does not focus on forests *per se*, wild rice may be found in forest areas and the methodology could be used to value the benefits of using wild genetic material from other species to improve the yield, disease resistance or other characteristics of commercial crops.

Initial optimism about the commercial value of biological diversity, as a motive for conserving tropical forests, seems to have diminished in recent years. The latest estimates of the benefits of using genetic information from wild species for pharmaceutical, agro-chemical and other commercial purposes have declined dramatically from early projections

(Simpson *et al.* 1996). More modest estimates of biodiversity value reflect in turn a better understanding of the difficulty of finding commercially useful genetic information or chemical compounds from wild organisms (i.e. the low "hit rate" of screening efforts), as well as the realisation that only a small part of the market value of a new drug or product can be attributed to the natural environment (most value is added further down the product pipeline, in the process of testing, refining, seeking regulatory approval, production and marketing). Finally, technical innovation quickly reduces the value of material in the wild, once the genetic or chemical information it contains has been isolated (often at very low cost). Modern chemical, industrial and agricultural processes allow firms and farmers to produce additional material (on farm, in the laboratory or factory) without recourse to the wild (Aylward 1993). This is good news, in the sense that there is less risk of over-exploiting wild resources, but it also limits the value that can be attributed to biodiversity in its natural state.

On the other hand, the bioengineering industry continues to grow in importance, while genetically modified organisms become more and more common in the market place (notwithstanding a recent consumer backlash in Europe). These trends suggest that the storehouse of genetic information contained in forests, particularly in the more diverse humid tropics, will continue to yield new riches. Previously published estimates of the "hit rate" for biochemical prospecting may be low, particularly if they have been taken from single-purpose studies (e.g. the search for a cure for a particular form of cancer).

Recent experience with carbon storage may be relevant. Only a few years ago there seemed to be little prospect of selling carbon storage services through forestry. Today, in the aftermath of Kyoto, several firms are competing for carbon storage contracts around the world. While the prospects of an international financial support framework for biodiversity conservation (i.e. a Kyoto Protocol or Clean Development Mechanism for biodiversity) are more problematic than for carbon, not least due to problems of measurement, it may be premature to dismiss biodiversity values altogether. A useful focus for future economic research will be to identify the most cost-effective strategies for shifting to "biodiversity-friendly" land uses (**Smith *et al.* 1997** is a useful model; see also Lippke and Bishop 1999).

6.4 Non-Use Values

Existence and bequest values are among the most difficult forest benefits to estimate in monetary terms. Stated preference techniques are usually considered the only way to estimate them.[64] In the case of bequest values, respondents must make assumptions about the preferences of their descendants, while in the case of existence values respondents must make subjective valuations unrelated to either their own or others' use, whether current or future.

Despite these difficulties, the non-use values of forests have been a focus of research effort in the developed world, mainly using CVM. Likewise, several researchers have attempted to estimate the non-use values of forests in developing countries. Examples in the literature reviewed for this report include: **Davies *et al.* (1999); Hadker *et al.* (1997); Kramer *et al.* (1995); McDaniels and Roessler (1998); Prasanthi *et al.* Gunawardena (1999); and Smith *et al.* (1997)**.

[64] Some authors suggest that donations to "rainforest conservation" organisations are a rough indicator of consumers' revealed preference for non-use forest values. However, estimates based on such donations may under-estimate true WTP, as they ignore "free-riders" who enjoy non-use benefits provided by others but do not pay for them.

In many cases it is not possible to isolate non-use benefits from other forest values in reported estimates of WTP. One case study which did attempt to isolate bequest value from other forest use values found them to be roughly comparable in magnitude, although the absolute values were small in both cases (less than 1% of average household income among urban and rural communities in Sri Lanka, see **Prasanthi Gunawardena *et al.* 1999)**. This may be compared with estimates from the USA suggesting WTP for the non-use value of "rainforest conservation" or "protection of forest quality" ranging from US$24 to $47 per capita per annum (**Kramer *et al.* 1995; Walsh *et al.* 1990)**. The latter figures are also well under 1% of average per capita income in the US.

6.5 Total Economic Valuation

Finally, some of the most ambitious case studies reviewed attempt to synthesis information on a wide range of forest values, in order to calculate the Total Economic Value (TEV) of a particular forest area or national forest estate. Often this forms part of an analysis of several alternative forest land use options.

Among the case studies reviewed, some of the most comprehensive evaluations of market and non-market forest benefits include: **Howard (1995); Kumari (1995a);** and **Ruitenbeek (1989a, 1989b, 1992)**. **Adger *et al.* (1995)** estimate several non-timber forest benefits, but do not include timber values in their analysis. **Kramer *et al.* (1995)** estimate a wide range of forest benefits, but stop short of conducting a full-blown CBA. While it is difficult to generalise from the results of these very different studies, some issues and findings recur:

- the largest non-market values seem, ironically, to be those which forest owners are least able to "capture" (**Adger *et al.* 1995**). The benefits of carbon sequestration, biodiversity conservation (for pharmaceutical prospecting) and existence values often exceed direct and indirect use values by a wide margin. Carbon storage in particular dominates other non-timber values, and often exceeds timber values (**Kumari 1995a**).

- non-timber forest values are often assumed to be compatible (complementary) with each other, whereas timber (and of course agriculture) are assumed to be incompatible with non-timber values in most cases (**Kumari 1995a**). Few case studies explore the potential complementarities between timber and non-timber benefits (e.g. Woon and Poh 1998).

- many of the case study results suggest that forest conservation or the adoption of more "sustainable" forest management regimes is economically justifiable, because non-timber benefits exceed the foregone value of timber or land conversion (**Kramer *et al.* 1995; Kumari 1995a; Ruitenbeek 1989a, 1989b, 1992**). Often this reflects low returns to timber or agriculture, and may be very site specific.

- several case studies emphasise the significant opportunity cost of forest conversion or sustainable management to local land users in developing countries, underscoring the need for better compensation mechanisms to win support for forest conservation (**Howard 1995; Kramer *et al.* 1995; Ruitenbeek 1989b**).

Note that the most comprehensive case studies, in terms of the number of different forest benefits estimated, often rely heavily on fairly crude assumptions or secondary sources of data. This is not surprising, given the considerable effort and information required to estimate even a single forest benefit. In some cases, however, it also means that detailed information on estimation procedures and primary data sources are not provided, making it difficult to judge the validity of the results.

7 References

*This list includes references consulted for both the report and the appendix. All references in **bold type** are summarised in the appendix to the report.*

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Appendix

Summaries of Selected Case Studies of Forest Benefits

This annex contains summaries and commentary on over 50 case studies of the economics of forest benefits. The main criteria used to select studies for this section were as follows:

- published or widely available;
- present original data and analysis;
- focus on developing countries;
- good use of valuation methods; and/or
- detailed analysis of cost-benefit trade-offs.

For articles singled out on this basis, a standard outline was used to prepare a brief summary and assessment. The outline is presented below, followed by summaries of the selected articles.

1. Type of assessment and main findings
- cost-benefit analysis of alternative land uses
- total economic valuation of a specific land use
- valuation of specific non-timber forest benefits

2. Empirical data
- source(s)
- type (time-series, cross-sectional)
- coverage

3. Details of CBA (where relevant)
- financial versus economic (shadow-price) analysis
- perspective (government, individual, household, company, community)
- time horizon and discount rate(s) used
- treatment of risk and uncertainty
- analysis of sustainability/depletion of resources

4. Economic values considered (where relevant)
- direct use
- indirect use
- option
- non-use

5. Valuation techniques used
- market (and shadow) prices
- surrogate market (travel cost, hedonic prices, substitute goods)
- production function
- stated preference (contingent valuation and variants)
- cost-based (replacement, defensive, opportunity cost)

6. Socio-economic groups affected

- government, political elites
- subsistence forest dwellers
- commercial forest-based industry
- other forest land-users
- domestic, global communities

7. Comments (where relevant)

8. Key references (e.g. for secondary data)

Adger, W.N., Brown, K., Cervigni, R. and D. Moran. 1995. "Total Economic Value of Forests in Mexico" in *Ambio*, 24(5): 286-296.

Type of assessment & main findings: The study presents a total economic valuation of the Mexican natural forest estate, when used for tourism and recreation, NTFPs, carbon storage, watershed protection, potential pharmaceutical products, and existence values. The study concludes that non-timber forest benefits are significant, with the value for carbon storage alone being greater than typical forest land values in many parts of the world.

Empirical data: The analysis uses benefit estimates from a variety of secondary studies, and transfers, or extrapolates, these to the entire Mexican forest estate.

Economic values considered: Direct use, indirect use, option and existence values

Valuation techniques used: The forest estate was divided into four forest types: tropical evergreen, tropical deciduous, temperate coniferous and temperate deciduous. The valuation techniques used for the range of forest benefits are described below. Some of the benefits were estimated according to the type of forest.

Tourism and recreation: Draws on secondary sources and no specific information is provided on the techniques used. Reference is made to consumer surplus and WTP estimates, implying that TCM and CVM were used in the valuation. Data was gathered on six different forest reserves and extrapolated to the national level. The analysis differentiates between eco-tourist visits (estimated revenues of US$14 million per year) and multi-purpose visits (estimated consumer surplus of US$16.6 - 19.6 million per year). The combination of these priced and unpriced benefits produces a total benefit range of US$30.6 - 33.6 million per year.

NTFPs: Shadow pricing of market and substitute goods was used in the secondary study to value the direct use benefits of a range of products (including building materials, medicines, fuelwood and fruits). This resulted in a value of US$330 per hectare per year for tropical evergreen and temperate deciduous forests. But as this estimate is based on one area, the study does not extrapolate it across the forest estate. The authors note however that this result accords with estimates from other Latin American countries.

Carbon storage: The study used previous studies to estimate the amount of carbon retained by not converting the forest estate to pasture or agricultural land. This ranges from about 30 to 160 tonnes of carbon per hectare depending on the forest type. Fankhauser's (1995) estimate of the value of a tonne of carbon (US$20) is used. This reflects the damage cost avoided by maintaining the land under forest. The present value of the forest carbon storage service comes to US$650 - 3,400 per hectare. This produces a total benefit of almost US$3.8 million per year.

Watershed protection: Of the various benefits resulting from forest watershed protection services, this study limits itself to estimating the water purification benefits which result from lower sedimentation rates. Other benefits of watershed protection, e.g. reduced flooding, were omitted owing to data limitations and estimation difficulties. A "damage cost avoided" approach is used to estimate the value of water purification benefits. The likely cost of water purification is estimated using existing studies of sediment production in Mexico and average US treatment costs. An earlier study estimated that approximately 113 million tonnes of deposition induces some form of purification on an annual basis. Valued at the US average of US$20 per 1000 tonnes of discharge, the authors obtain an estimate of US$2.3 million savings per year. The study notes that this result supports other research that likely savings in water treatment costs from reduced erosion are a relatively minor benefit.

Option value of pharmaceuticals: The option value of novel pharmaceuticals derived from genetic material in Mexican forests is estimated using a model developed by Pearce and Puroshothaman (1992). The model multiplies the number of species present in the forest by the probability of a species yielding a useful product. This number is then multiplied by the royalty rate on sales of such a product, a coefficient of rent capture and the average value of internationally traded pharmaceutical products. This overall value can then be divided by the total forest area to yield an option value expressed in per hectare terms. Many of the variables in this model suffer from a high degree of uncertainty leading to estimates of between US$1 and US$90 per hectare per year. The study uses a central estimate of US$6.4 per hectare per year, or US$330 million per year for the entire forest estate.

Existence value: To estimate existence values, the study gathered information on a variety of transactions related to natural area conservation in Mexico, including contributions to conservation organisations and programmes, a tourism survey and debt for nature swaps. Such transactions are interpreted as indications of WTP for the maintenance of existence values. The study notes that this only includes captured values; a large proportion of existence value, which is difficult and costly to estimate, remains uncaptured due to their public good nature. This approach reveals a range of US$0.03-US$10 per hectare. The study uses the upper bound to derive an estimate of US$60 million for the entire forest estate, acknowledging that only a proportion of this value is attributable to forest areas.

Socio-economic groups affected: The groups vary according to the benefits: subsistence forest dwellers (NTFPs); Mexican consumers (tourism, watershed protection, option values, existence values); developed country consumers (tourism, existence values); global community (carbon storage).

Comments: The authors chose not to include timber values. The study points out that large gains can be obtained from measures to capture a greater proportion of these values.

Key references:

Pearce, D. and S. Puroshothaman. 1992. *Protecting Biological Diversity: The Economic Value of Pharmaceutical Plants*. Global Environmental Change Working Paper 92-27. CSERGE, UEA and UCL, London.

Alcorn, J.B. 1989. "An Economic Analysis of Huastec Mayan Forest Management" in Browder, J.O. (ed.) *Fragile Lands of Latin America: Strategies for Sustainable Development*, pp. 182-206. Westview Press: Boulder.

Type of assessment & main findings: The study calculates the net benefits associated with a social forestry system employed by indigenous (*Huastec*) farmers in northeastern Mexico in 1987. The system is a mix of commercial (sugarcane, coffee) and subsistence (*milpa*) plantations and managed forest groves (*te'lom*) containing elements of primary and secondary forests. The study concludes that when coffee is produced alongside *te'lom*, the total return on investment comes to about US$598 per hectare, of which 65% is accounted for by *te'lom*. This result is contrasted with production excluding coffee, in which case *te'lom* accounts for only 29% of total returns. The conclusion suggests that the main economic returns from *te'lom* are derived from exotic products (like coffee) rather than from native species.

Empirical data: Estimates are provided of the inputs and outputs of the main cultures (*milpa*, sugarcane, *te'lom* and livestock) in terms of:

- labour input on *Huastec* farms, in person-days/hectare/year and person-days/community/year
- animal labour input, in horse-days
- production inputs on *Huastec* farms, both cash (market prices) and non-cash (shadow prices), in Pesos/community/year
- value of *Huastec* production consumed (subsistence) and sold, in Pesos/community/year
- economic return on cash and non-cash 'investment' (more precisely, current costs) from *Huastec* production (total inputs and benefits), in Pesos/community/year

Economic values considered: Direct uses. There are qualitative references to other values, but no monetary estimation is presented:

> *"For the Huastec, over 90% of te'lom species have 'use values'. And Huastec farmers do perceive that the te'lom has an 'option value', because they believe that its constituent species may have some future use not known today. It also seems that Huastec give the te'lom some 'existence value' in their land use decisions in so far as (1) they give traditional respect to the Earth and its vestment of plants, and (2) the comfortable prosperous Huastec farmer is seen as one who has a te'lom on his farmstead" (p.197).*

Valuation techniques used: Market prices and shadow prices (for non-cash inputs).

Comments: The discussion focuses on a land use system in which the managed forest grove has a complementary role with other cultures.

Almeida, O.T. de and C. Uhl. 1995. "Developing a Quantitative Framework for Sustainable Resource-Use Planning in the Brazilian Amazon" in *World Development*, 23(10):1745-1764.

Type of assessment & main findings: The study presents a comparative CBA of logging, ranching and rainfed crop production in the county of Paragominas, northeastern Brazil. The costs and benefits of these activities are considered under alternative management systems: extensive (90 year cutting cycle) versus intensive (30 year cycle) forest management; extensive (unimproved) versus intensive ("reformed") pasture; and extensive (slash-and-burn) versus intensive (permanent perennial) rainfed cropping. These alternative land uses are compared in terms of their gross returns, profits, tax payments, start-up capital requirement and employment generation per hectare. Estimates are presented of the current importance and sustainability of each activity in the economy of Paragominas country. The authors also provide guidelines for economic development planning at a county-level in the Brazilian Amazon. They conclude that more intensive land use systems generate higher financial returns, although forest management for timber and extensive cattle ranching are not viable when capital costs are included (see Table 1). The authors calculate that intensive land uses generate more tax revenue for government and more employment, on a per hectare basis. They also estimate carbon losses associated with each land use option, compared to mature forest, in physical terms (tons of carbon per hectare).

Table 1. Comparison of land use options in Pará, Brazil (1992 US$/hectare/year)

Land Use	Gross Return [a]	Profit [b]	Start-up Investment	Taxes Paid	NPV (r=6%) [c]	NPV (r=12%) [c]
Timber (extensive, 90 yrs.) [d]	31	11	2,391	4	35	12
Timber (intensive, 30 yrs.) [d]	92	28	2,504	11	(36)	(123)
Ranching (extensive)	31	2-6	307	5	(285)	(279)
Ranching (reformed)	104	55	539	18	516	(8)
Slash-and-burn Agriculture	90	33	291	15	648	384
Intensive/Perennial Agriculture	2,366	802	2,695	367	13,502	6,049

Notes: a/ Average annual cash flow over sustainable management cycle.
b/ Includes depreciation and taxes but not the opportunity cost of capital.
c/ Based on 90 year time horizon; percentages are discount rates used.
d/ NPV is for extraction only (not processing) and includes the cost of buying logging rights ($70/ha) under the extensive model and the cost of buying land ($150/ha) for the intensive model.

Empirical data: The paper is a synthesis of previous studies of land use activities in the county of Paragominas. Data for the financial CBA is drawn mainly from previous studies carried out by IMAZON, an independent research group based in Belem, Para (see Barreto *et al.* 1993; Mattos and Uhl 1994; Veríssimo *et al.* 1992).

Details of CBA: The analysis focuses on financial returns to land and capital under alternative land use systems. Allowance is made for the opportunity cost of capital, but no adjustment is made for economic policy distortions. Based on secondary data the authors calculate:

- gross return, profit, capital investment and tax receipts for each land use system;
- net present value (at r=6% and 12%) and the internal rate of return for each land use system;
- employment generation by each system (in hectares required to employ one person);
- carbon losses associated with different land uses, compared to mature forest;
- area required to supply the calorie and protein requirement of the population of Paragominas following the prevailing extensive land use model and under more intensive approaches; and
- total area available and sum of gross returns, profits, capital investment required, tax and job generation for the six land use options in the county of Paragominas.

Economic values considered: Mainly direct uses (ranching, crop and timber production). Indirect use values (carbon storage) are considered in physical terms only.

Valuation techniques used: Market prices for financial analysis of land use options.

Socio-economic groups affected: Farmers, ranchers, loggers and timber millers; casual labour (employment), government (tax receipts), global community (CO_2 emissions).

Key references:

Barreto, P., Uhl, C. and J. Yared. 1993. “O potenciel de produção sustentavel de madeira em Paragominas-Pa, na Amazonia Oriental: consideracoes ecologicas e economicas” in *Anais do 7E Congresso Florestal Brasileiro*, Vol. 1 (Sao Paulo: Sociedade Brasileira de Silvicultura / Sociedade Brasileira de Engenheiros Florestais), pp. 387-392.

Mattos, M. and C. Uhl. 1994. “Economic and ecological perspectives on ranching in the Eastern Amazon” in *World Development*, **22**(2): 145-158.

Toniolo, A. and C. Uhl. 1995. “Economic and ecological perspectives on agriculture in the Eastern Amazon” in *World Development* (forthcoming).

Veríssimo, A., Barreto, P., Mattos, M., Tarifa, R. and C. Uhl. 1992. “Logging impacts and prospects for sustainable forest management in an old Amazonian frontier: The case of Paragominas” in *Forest Ecology and Management*, **55**: 169-199.

Anderson, A.B. and M.A.G. Jardim. 1989. "Costs and Benefits of Floodplain Forest Management by Rural Inhabitants in the Amazon Estuary: A Case Study of Açaí Palm Production" in Browder, J.O. (ed.) *Fragile Lands of Latin America: Strategies for Sustainable Development*, pp. 114-129. Westview Press: Boulder.

Type of assessment & main findings: The authors undertake a CBA to compare the returns to managed and unmanaged plots of *açaí* palm in the floodplains of the Amazon estuary (State of Pará, Brazil). The management techniques studied in 16 permanent plots are thinning and pruning, and are traditionally practised by the local river dwellers (*Ribeirinhos*) in sustainable harvesting of *açaí* fruits and palm-hearts.

The results show that selective thinning of forest competitors produces a statistically significant ($P < 0.05$) increase in fruit productivity. In conjunction with pruning, this treatment serves to concentrate production in a smaller number of stems, facilitating the task of fruit collection. The average net return to treatment is US$109.50 per hectare, equal to a 47% return on the effort invested. The benefit of palm heart extraction was estimated at an additional income of US$47 per hectare. The authors conclude that the land use option of managed *açaí* harvesting "is in fact a rational one from ecological, cultural, and economic perspectives" (p.115).

Empirical data:
(i) An inventory of species with diameter at breast-height (DBH) > 5 cm in 0.25 hectare of unmanaged floodplain forest on *Ilha das Onças* (an island close to the city of Belém), where the study was conducted.
(ii) Average sample results of *açaí* fruit output (kg/year) per plot, vegetative clump and stem, under four different treatments: pruning and thinning, thinning only, pruning only and control (no treatment).
(iii) Market prices of *açaí* fruits and palm hearts, obtained in the *açaí* market of Belém.
(iv) Labour input and cost (estimated using the mean minimum wage).
(v) Relative proportion of monetary income derived from natural products [*açaí* fruit (63%), timber (13%), palm heart (12%), shrimp (6%), rubber (5%) and other (1%)] obtained by a single family on *Ilha das Onças* during 1986.

Valuation techniques used: Market prices for direct uses only. The authors make qualitative reference to a non-monetary benefit of managed areas, which is the greater facility of obtaining other forest resources.

Socio-economic groups affected: Local inhabitants (*Ribeirinhos*).

Comments: The analysis does not refer to the total costs and benefits of harvesting *açaí* products, but rather to the costs and relative productivity of alternative management techniques. No data is presented for other forms of land use.

Appasamy, P.P. 1993. "Role of Non-Timber Forest Products in a Subsistence Economy: The Case of a Joint Forestry Project in India" in *Economic Botany*, 47(3): 258-267.

Type of assessment & main findings: Describes the role of NTFPs in the subsistence economy of Tamil Nadu State, India, including a case study of NTFP extraction from the Kadavakurichi Forest Reserve. For all products, the total estimated value extracted was Rs 1.9 million per year, or about Rs 2,090 (US$70) per hectare per year.

Empirical data: Reports data from a forestry survey of 324 villages conducted in Tamil Nadu (Neelakantan 1991), including the number of "head-loaders" (men, women and children) entering the forest daily and the quantity (in tonnes) of product removed annually (fuelwood, small timber and fodder). Also reports data from a case study carried out under a social forestry project managed by the Palni Hills Conservation Council (PHCC). The latter included surveys of forest product extraction by local villagers, i.e. fuelwood, fodder, honey and other products (medicinal plants, small game, green manure, etc.). Data derive from "footpath" surveys in which 43 entry paths into the FR were monitored over a seven week period to determine the number of trips made, the quantity of each product extracted and other variables (age and sex of collector, intended end use, etc.). Data from an inventory of vegetation occuring in the reserve, and their uses, are also reported.

Valuation techniques used: Market prices were used to estimate direct use values only. NTFP extraction is expressed in term of the average (per headloader) and total (for the entire Forest Reserve) value per annum.

Key references:

Neelakantan, K.S. 1991. "Survey of Fuelwood Use in Tamil Nadu." Paper presented at 21st Interdisciplinary Research Methodology Workshop, Madras Institute of Development Studies: Hyderabad.

Palni Hills Conservation Council. 1991. *Kadavakurichi Interface Forestry: Surveys and Analysis.* Kodaikanal, Tamil Nadu: India.

Aylward, B., Echeverría, J., Allen, K., Mejías, R. and I.T. Porras. 1999. *Market and Policy Incentives for Livestock Production and Watershed Protection in Arenal, Costa Rica*. CREED Working Paper no. 25. IIED: London.

Type of assessment & main findings: This paper undertakes financial and economic CBAs of ranching in the Rio Chiquito watershed of the Arenal region of Costa Rica. The study concludes that ranching for beef and dairy production are more economically valuable land uses than timber production or forest protection. Apart from on-site productive benefits associated with ranching, significant and unexpected off-site hydrological benefits mean that the social benefits from ranching outweigh private benefits.

Empirical data: Data was collected from numerous primary and secondary sources. The main data presented include:

- official statistics on production and sales of beef, milk and cheese since 1995;
- costs of forest protection based on experience in other Costa Rican protected areas;
- questionnaire responses regarding landholders' inputs in ranching, soil erosion problems and the age of their pasture(s);
- software programmes, e.g. CALSITE, and related literature on sediment loads and water yields from watersheds under different land uses;
- information on hydro-electric power generation costs and revenues, reservoir capacity and operating constraints; and
- price and cost information for thermal power generation.

Details of CBA: The costs and benefits of ranching (for beef, dairy or a mix of the two) are compared with forestry production/protection from both the private landholder's perspective and from a wider social perspective. NPV is calculated for seven different types of holdings (ranging from small pastures used for ranching to large, mechanised dairy operations) and for four life zones which relate to the forest type and level of run-off. Values are considered over a 70 year time horizon. The key factor distinguishing the private CBA from the social CBA is the consideration of hydrological impacts. While the private CBA considers on-site costs and benefits, the social CBA also incorporates the off-site impacts of alternative land uses on the hydrological system and downstream water users.

Private CBA

Using an incremental approach, the authors start by considering private cash flows and then add the opportunity costs of non-monetary inputs and outputs. In a third step they undertake a private economic CBA. The evaluation of cash flows, or the financial CBA, shows all three land uses to yield positive returns (although the larger units yield considerably more than smaller plots). These are on average far higher than the returns obtained in forestry (timber production). A broader opportunity cost-based CBA includes non-monetary factors such as household labour and subsistence consumption of milk and beef, as well as cash flow. On this basis returns to ranching fall, and small ranches in particular (less than 80 hectares) appear to lose money.

The economic CBA converts all costs and prices to their shadow values by removing tax and price distortions. Discount rates of between 10% and 13% used for the private CBA are replaced by a lower value of 9% in the economic CBA. These changes improve returns, but small-scale ranchers continue to make losses. An attempt is made to assess the user cost of soil erosion associated with conversion of forests to pasture, but no evidence is found to support a link between the age of pasture (a proxy for soil erosion) and production levels.

Social CBA
The social CBA focuses on the impacts of forest conversion on three hydroelectric power plants which draw water from Lake Arenal. These plants account for 44% of Costa Rica's hydroelectric power, which itself accounts for over 70% of the nation's total electric power generating capacity. Other off-site impacts (e.g. irrigation and drinking water) are passed over as relatively insignificant. Other environmental impacts (e.g. biodiversity) are also excluded from the quantitative analysis, but are considered in qualitative terms and some estimates are made for the benefits of carbon storage. No attempt is made to incorporate existence or option values.

The evaluation of off-site hydrological impacts is based on an algorithm developed by Aylward (1998) which links land use change to welfare change. The algorithm incorporates changes in sedimentation and run-off associated with forest conversion, and provides a framework for estimating impacts on dead and live storage in reservoirs, in a context of changing demand and supply of electricity through time.

Contrary to expectations, the analysis shows that the impact of forest conversion on hydroelectric power production is broadly positive. Increased sedimentation due to forest conversion does slightly reduce the capacity of the reservoir to hold water for electric power generation. However, the benefits of increased water run-off in terms of additional electric power generating capacity are far more significant. The analysis suggests that conversion of forests to ranching results in net economic benefits ranging from US$610 per hectare in the least profitable case of small-scale ranching to over US$8,700 per hectare in the case of dairy farming by Dos Pinos Producers. Only small holders undertaking ranching in the lower west region achieve negative returns of US$(185) per hectare. These figures include the avoided costs of forest protection (the alternative land use).

For each CBA, the authors undertake sensitivity analyses. The main factors tested for their importance to the results include:

- the social and private discount rates;
- input and output prices related to ranching production; and
- assumptions relating to hydrological impacts such as seasonal water flows and the order and length of the wet and dry seasons.

Valuation techniques used: Market prices are used in the calculation of landowners' cash flows which form the basis of the financial CBA. Shadow prices are used to calculate both the non-marketed costs and benefits and to adjust market prices for policy distortions in the private opportunity-cost CBA and the economic CBA.

Valuation of off-site impacts on hydroelectricity production is more complex. The authors draw on both production function and replacement cost approaches to calculate the impacts of forest conversion. Both techniques are incorporated into an algorithm, which in turn has four key parts: (1) formulas linking land-use types to deposits of sediment in the reservoir; (2) formulas linking these deposits to certain operational features of the reservoir, e.g. inflows, storage and capacity; (3) a production function linking reservoir productivity to hydroelectricity generation; and (4) the marginal opportunity cost of alternative power sources, e.g. thermal power. Application of the algorithm to the Rio Chiquito study site involved considerable background research of existing literature, as well as primary data collection.

Comments: The study presents a detailed analysis of the impacts of forest conversion on hydroelectricity production. The results are of interest to both land-use planners and researchers, illustrating how forest conversion can sometimes have positive external impacts, as well as presenting a methodology for use in similar assessments in other watersheds. As with many valuation exercises, however, wider application in other countries may be limited by available resources (labour, funding and data).

The report is less thorough with regards to other elements of the CBA. For instance, apart from impacts on hydroelectric power generation, no other offsite impacts (e.g. drinking water) are included in the social CBA. Moreover, the alternative land use option associated with forest cover is not explained in detail here and appears to change from forest extraction in the case of private CBAs to protection in the case of the social CBA. No explanation is given for not including multiple-use forestry as an alternative to ranching in the social analysis. Also, as the authors note, there are potential revenues consistent with forest protection (e.g. from eco-tourism and bioprospecting) which are not explored here.

Key references:

Aylward, B. 1998. *Economic Valuation of the Downstream Hydrological Effects of Land Use Change: Large Hydroelectric Reservoirs*. Ph.D dissertation, Fletcher School of Law and Diplomacy: Medford, MA.

Baldares C., Laarman, M.J. and J.G. Laarman. 1990. "User Fees at Protected Areas in Costa Rica" in Vincent, J.R., Crawford, E.W. and J.P. Hoehn (eds.) *Valuing Environmental Benefits in Developing Economies: Proceedings of a seminar series held February-May 1990*, pp. 87-108. Michigan State University: Ann Arbor, MI.

Type of assessment & main findings: The paper presents the results of a study of willingness to pay (WTP) for four protected areas in Costa Rica (three National Parks - Poas, Manuel Antonio, and Cahuita - and one private reserve - Monteverde). Respondents are distinguished according to whether they are local residents or foreign visitors. All visitors are found to be willing to pay higher fees than the existing charges, on average 25 Colones (US$ 30) more, but the increase varies by place of residence and according to whether the respondent is a local resident or foreigner. Both residents and non-residents agree that residents should pay less. The paper concludes that an increase of 100% in the resident user fee (to 50 Colones) and of 200% in the non-resident fee (to 100 Colones) would generate substantial revenues.

Empirical data: Willingness to pay was estimated using survey responses from more than 860 visitors during selected days in August through October 1989. Respondents were asked to select among ten possible fee levels, ranging from zero to 1000 Colones. The following variables were expected to affect WTP: place of residence (Costa Rica or elsewhere), the area visited, number of family members entering together, main purpose of the visit, length of stay, perceived satisfaction with the visit, number of previous visits or other experience factors, income, education, age and sex (the latter four as control variables). Responses of zero charge were not considered.

Economic values considered: Direct use values (recreation).

Socio-economic groups affected: Visitors of protected areas.

Comments: The main purpose of the paper is to show that different user fees for residents and non-residents (in order to account for income disparities) is a valid and feasible instrument to achieve greater fairness and higher revenues to National Parks in Costa Rica.

Bateman, I., Brainard, J. and A. Lovett. 1999. "Developing a Benefits Transfer Model of Woodland Recreation: A GIS Approach" in Roper, C.S. and A. Park (eds.) *The Living Forest: Non-Market Benefits of Forestry*. Proceedings of an International Symposium, Edinburgh 24-28 June 1996, Forestry Commission. H.M. Stationary Office: London, pp. 66-82.

Type of assessment & main findings: The paper explores the potential for using existing valuation estimates for amenity benefits in specific woodland areas to value other sites. While such "benefit transfer" studies have been conducted in the USA, this paper represents the first attempt in the UK. Two applications of benefit transfer are presented.

Empirical data: Information for the analysis was taken from an earlier joint travel cost and contingent valuation study reported in Bateman (1993) and Bateman and Turner (1993). Integrating information on woodland visitor origins with a geographical information system (GIS), the authors produced maps indicating travel time to Thetford Forests in East Anglia.

For the second study, information on socio-economic characteristics (unemployment) and substitute recreation sites is gathered from secondary sources including the 1991 UK Census, the Land Cover Map of Great Britain and Whiteman (1995).

Economic values considered: The authors analyse existing TCM and CVM studies in the UK in an attempt to establish a mathematical relationship between rates of visitation at recreational sites and various exogenous factors (e.g. the distance between recreational sites and different residential areas, the time taken to travel there, the accessibility of substitute sites, socio-economic characteristics of visitors, etc.). Such a model could be used to predict visits to recreational sites and WTP for each site's amenity values and thus reduce the need for land-use planners to commission new studies each time they wish to consider options for new or existing recreational sites.

As a first step in developing such a model, the authors consider a case study. Using data on visitation rates, road networks, time and distance travelled to Thetford Forest in East Anglia, they devise a model linking visitation rates from particular points of origin to travel times. A statistically significant inverse relationship is found. The model's predictive power is tested in a sample of Welsh recreational sites for which information on distances from urban centres, road networks and travel time are collected. The model predicts over 90% of actual visitation rates.

In addition to predicting visitation rates, the authors aim to predict individuals' WTP for access to woodland sites for recreational purposes. Based on a review of existing CVM studies, the authors identify nine previous studies reporting 48 estimates of WTP (per person and per visit). These are considered sufficiently robust and comparable to support a predictive model, despite the fact that the nine studies used slightly different techniques to elicit WTP bids.

In a second part of the paper, the authors describe more recent efforts to develop predictive models for land-use planners. The aim is to elaborate the relatively simple model described above, which uses just one independent variable - travel time. A new model proposed here includes additional determinants of visitation rates, namely a socio-economic factor (male unemployment levels), and the proximity of substitute recreational sites. Information on these variables is grouped into 4 and 3 classes respectively and combined with information on travel time before being mapped and integrated in the GIS. Visitation rates are then calculated as a function of all three factors.

Despite various drawbacks with the model highlighted by the authors, notably problems associated with grouping data into categories, both the socio-economic and substitute factors are found to improve the model's predictive power. The authors conclude that the use of existing studies to predict recreational values in new sites has potential, but there is a need for more data to allow more accurate comparisons.

Comments: The study presents an interesting approach to cutting the costs of valuation studies. Generic models which relate environmental benefits or costs to physical and socio-economic factors in a consistent way would allow land-use planners to avoid commissioning expensive studies each time they consider a new project. This approach may have special appeal in developing countries, where resources to conduct valuation studies are limited.

On the other hand, while the cost-savings to be gained through the development of predictive models may be substantial, the authors' argument is somewhat weakened given their emphasis on the need for plenty of high quality data for such models to be developed in the first place. Given the difficulties they faced in assembling the necessary data in the UK, the prospects for using a similar approach in poorer countries are daunting.

Key references:

Bateman, I.J. 1993. *Valuation of the Environment, Methods and Techniques: Revealed Preference Methods* in Turner, R.K. (ed.) *Sustainable Economics and Management: Principles and Practice*. Belhaven Press, London, pp. 192-265.

Bateman, I.J. and R.K. Turner. 1993. *Valuation of the Environment, Methods and Techniques: The Contingent Valuation Method* in Turner, R.K. (ed.) *Sustainable Economics and Management: Principles and Practice*. Belhaven Press, London, pp. 120-191.

Whiteman, A. 1995. *The Supply and Demand for Timber, Recreation, and Community Forest Outputs from Forests in Great Britain*. Ph.D dissertation, University of Edinburgh.

Bennett, E.L. and C.J. Reynolds. 1993. "The Value of a Mangrove Area in Sarawak" in *Biodiversity and Conservation* 2(4): 359-375.

Type of assessment & main findings: A financial CBA is undertaken to evaluate the case for maintaining Sarawak Mangroves Forest Reserve, Malaysia, versus its conversion for oil palm plantations and prawn ponds. The main finding is that the returns to conversion are outweighed by the forgone benefits of conservation.

Empirical data: The study reports the following data:
- market value of commercial forestry products extracted from the Reserve in 1989 (mangrove poles, charcoal, semi-charcoal and cordwood); and
- revenues from fishing and tourism in the area for 1989.

Economic values considered: Direct and indirect use values for several products:
- on-site mangrove products (mangrove poles and charcoal);
- off-site mangrove products (tourism and fish production);
- oil palm plantation products; and
- prawn pond products.

Valuation techniques used: Market prices and a simplified production function approach (PFA) are used to estimate the benefits of maintaining the mangrove. Market prices are used to calculate the direct use values of on-site mangrove products. The PFA is used to estimate off-site fishing and tourism benefits which are supported indirectly by the existence of the mangrove. Additional indirect benefits such as conservation of wild species, mitigation of flood risk/damage, prevention of coastal erosion and protection of adjacent agricultural land from saline intrusion are mentioned but not estimated in monetary terms.

Fishing: The authors argue that virtually the entire marine fishery catch in the Kuching Division of Sarawak is dependent on the mangrove, in part because the reserve is the last remaining large area of relatively intact mangrove in the region. On these grounds they estimate that converting the mangroves could result in a loss of up to US$19.3 million, which was the total income derived from commercial fisheries in the Kuching Division in 1989. While the study does not undertake a full cost appraisal, the authors estimate that the capital costs of commercial fishing accounted for less than US$1 million of this figure. In addition, subsistence fishing valued at 10-20% of the income from commercial fisheries (i.e. US$1.9 - 3.9 million per year) is also considered to be threatened by mangrove conversion.

Tourism: The authors claim that conversion of the mangroves could lead to the slow death of nearby coral reefs and the silting of local beaches, in an area they call "the most important coastal tourism spot in Sarawak". The authors estimate that at least half the tourism industry would be lost. The industry generated total revenues of about US$3.7 million in 1989.

Conversion benefits: The benefits of converting the reserve consist of potential revenues from oil palm plantations and/or prawn ponds. Gross revenues from palm oil production are estimated from secondary data and total US$14 million per year. Due to high capital costs, estimated net revenues are much lower, at US$1.67 million per year. The latter, in turn, is far less than the income from fisheries associated with preservation of the reserve. Estimated output of fish biomass from prawn ponds (again based on secondary data) is less than that from existing onshore and offshore fisheries. Cost differences between prawn ponds and other fishing activities are not considered.

Socio-economic groups affected: Local residents engaged in fishing, forest product harvesting and tourist industries; urban residents; international tourists.

Comments: The authors acknowledge that their quantitative analysis is very approximate, using data for just one year and including output figures which may represent excessive (unsustainable) harvest levels for various products. Moreover, the costs of different activities are treated inconsistently, with deductions in some cases but not others. Notwithstanding these limitations, the authors argue that conservation is a more attractive than conversion.

Browder, J.O. 1985. *Subsidies, Deforestation, and the Forest Sector in the Brazilian Amazon*. World Resources Institute: Washington, D.C.

Type of assessment & main findings: The author undertakes financial analyses of the net returns to livestock ranching (and thus pasture formation). The aim of the study is to investigate the impacts of government subsidies on deforestation. Three principal incentive schemes considered are capital investment incentive programmes, rural credit programmes and colonisation programmes (some since discontinued).

The main means of financing was through the Superintendency for the Development of the Amazon (SUDAM), which provided tax credits and exemptions for the establishment of large-scale pasture formation and ranching operations. Survey data was used to examine the cost structure and returns for a typical SUDAM-financed beef cattle ranch during a five-year development period. The analysis indicates that, on average, the subsidy amounted to 54% of livestock project development costs in Amazonia. In addition, half of the remaining investment by private ranch operators was financed through subsidised rural credit loans.

Empirical data: Cost data for livestock ranching was collected through a survey of 21 government-financed livestock ranching operations in the Legal Amazon in 1984-85. Regional data on deforestation due to pasture formation are presented, along with estimates of the effects of government subsidies on land use, prices and quantities.

Economic values considered: Direct use values for livestock, crop and timber production.

Valuation techniques used: Market prices and expenditures.

Socio-economic groups effected: Ranchers, farmers, timber producers.

Comments: The analysis of the impacts of government subsidies on financial returns to pasture formation is persuasive and relevant, notwithstanding subsequent policy reforms. Much of the information contained in this report was re-used in Browder (1998), Browder (1990) and Repetto and Gillis (1988). The first of these is reviewed below.

Key references:

Browder, J.O. 1988. The Social Costs of Rainforest Destruction: A Critique and Economic Analysis of the 'Hamburger' Debate" in *Interciencia* 13(3): 115-120.

Browder, J.O. 1990. *Social and Economic Constraints on the Development of Market-Oriented Extractive Systems in Amazon Rain Forests*. Draft paper. Virginia Polytechnic Institute: Blacksburg, Virginia.

Repetto, R. and M. Gillis (eds.) 1988. *Government Policies and the Misuse of Forest Resources.* World Resources Institute, Washington, DC.

Browder, J.O. 1988. "The Social Costs of Rain Forest Destruction: A Critique and Economic Analysis of the 'Hamburger' Debate" in *Interciencia* 13(3): 115-120.

Type of assessment & main findings: The paper presents an economic CBA of ranching in Amazonia, with an emphasis on the social opportunity costs of foregone timber and government expenditure on subsidies to ranchers. Government subsidies are valued at US$224 per hectare, on average, while foregone timber values are estimated at US$511 per hectare, for a total social opportunity cost of US$735 per hectare, on average. This may be compared to the estimated average NPV of ranching (US$162 per hectare).

Empirical data: see Browder (1985), above.

Details of CBA: The evaluation builds on earlier work reported in Browder (1985) and includes the estimated social costs of pasture formation, in terms of the opportunity cost of public funds used to subsidise ranching and the opportunity cost of merchantable timber lost during forest clearance and conversion to pasture.

Economic values considered: Direct use values (timber, livestock).

Valuation techniques used: The opportunity cost approach is used to value the social costs of the government's ranching subsidy schemes. The opportunity cost of government expenditure is calculated using the average annual returns on investments in US long-term corporate bonds, government securities and Treasury Bills. This is multiplied by the total US$ equivalent annual government disbursements for ranching between 1966 and 1983 (for tax credits) and from 1977 to 1983 (for rural credit subsidies). The opportunity cost of lost timber is calculated based on an estimate of the volume of timber felled but not sold. Browder assumed 50% of timber was lost. Social opportunity costs are aggregated over the period 1966 to 1983.

Socio-economic groups affected: Ranchers and timber producers.

Comments: The study focuses on timber wastage to evaluate the opportunity cost of lost timber, but does not consider the loss of potential future streams of income from sustainable timber production as an alternative land use to ranching. The analysis also excludes the costs of pasture formation linked to environmental impacts, lost NTFPs and forgone option and existence values.

Key references:

Hecht, S.B. 1985. "Environment, Development and Politics: Capital Accumulation and the Livestock Sector in Latin America" in *World Development* 13(6): 663-684.

Anderson, A.B. 1989. "Ecological Ingredients for Successful Extraction". Paper presented at the *Symposium on Extractive Economies in Tropical Forests: A Course of Action*. National Wildlife Federation, 30 November - 1 December 1989, Washington, D.C.

Lafluer, J. 1989. "Alternative Economic Models for Elevating Forest Value in Amazonia." Paper presented at the *Symposium on Extractive Economies in Tropical Forests: A Course of Action*. National Wildlife Federation, 30 November - 1 December 1989, Washington D.C.

Browder, J.O., Matricardi, E.A.T. and W.S. Abdala. 1996. "Is Sustainable Tropical Timber Production Financially Viable? A Comparative Analysis of Mahogany Silviculture Among Small Farmers in the Brazilian Amazon" in *Ecological Economics* 16(2): 147-159.

Type of assessment & main findings: The paper presents a financial CBA comparing net returns per hectare of three small-scale mahogany planting regimes in the Brazilian state of Rondonia: degraded fallow enrichment planting; agroforestry (mahogany and coffee); and pure-stand mahogany plantations. The authors conclude that pure-stand plantations are the least risky and most financially lucrative option, although they require greater capital inputs and may be more environmentally damaging.

Empirical data: The study reports the following data:
- details of mahogany plantings on seven farms. Information is provided on planting, spacing, mortality, diameter at breast height (DBH), average annual increment, expected years to harvest, rate of shoot-borer attack, etc.
- local unit costs for key inputs, including fertiliser, insecticide, fungicide, ant killer, seedlings and transport.

Details of CBA: The analysis is conducted from an individual farmer's perspective. Only financial costs and benefits and direct use values (timber) are considered. Sensitivity analysis is used to assess the vulnerability of net revenues to changes in tree survival, maturation period, real interest rates, the opportunity cost of labour, and the farm-gate price of mahogany roundwood.

Environmental impacts are considered in qualitative terms. Pure-stand plantations are the most desirable alternative from a strictly financial perspective, but may have negative environmental impacts. However, the authors note that investment in mahogany plantations outside the Amazon region could have a positive impact on tropical forest conservation, by alleviating pressure on the remaining natural forests. The authors also suggest that intensive mahogany production outside the Amazon region may justify the conservation of large tracts of undisturbed mahogany habitat, as a genetic seed bank.

Valuation techniques used: Market prices used where available. Other values are estimated using the opportunity cost of labour approach.

Socio-economic groups affected: Small-holder farmers.

Comments: No attempt is made to value non-marketed goods and services.

Chopra, K. 1993. "The Value of Non-Timber Forest Products: An Estimation for Tropical Deciduous Forests in India" in *Economic Botany*, 47(3):251-257.

Type of assessment & main findings: The paper presents a financial CBA of non-timber benefits per hectare for tropical moist (37% of total forest area) and tropical dry (28.6%) deciduous forests in India. The sum of direct and indirect use values is estimated to fall between US$220 and $357 per hectare per year.

Empirical data: Secondary data on monetary values for fuelwood, fodder and other forest products, soil conservation, nutrient cycling, tourism and recreation are used, drawn from a range of studies carried out in India and elsewhere.

Details of CBA: The analysis includes direct and indirect use values, option and existence values, and is undertaken from an economic perspective. A 12% discount rate over a 30 year time horizon is used to convert annual returns into net present values (NPV).

Valuation techniques used: Various market and non-market techniques are used in the source studies, including substitute pricing, cost-based and experimental approaches. Details of the underlying data and valuation procedures are not described here. Where available, alternative estimates for a single good/service are reported.

Item	Valuation technique	Source
Fuelwood	1. Substitute good approach - price of soft coke. 2. Labour inputs - cost of time spent in collection.	Chopra (1987 - not listed) Sharma and Bhatia (1986)
Fodder	PFA - market value of fertiliser and milk output from cattle feeding on established pasture and scrubland.	Fleming (1983)
Other forest products (*sal* and *bidi* leaves, *tassan* cocoons, dyes and lacquer)	Labour inputs (as above).	Bajaj (1990)
Soil conservation benefits	1. Replacement cost approach - cost of fertiliser required to restore nutrients lost due to soil erosion. 2. Restoration cost technique - cost of dredging accumulations of silt downstream.	Hufschmidt *et al*. (1983); Chopra, Kadekodi and Murty (1990)
Nutrient cycling function	Experimental data on litter fall in different kinds of forest.	Mishra (1969)
Tourism and recreational values	Based on aggregate expenditure data from the national accounts.	Lal (1992)
Option value	Assumed equivalent to user cost, i.e. the amount of annual income that must be invested in order to ensure an equivalent perpetual income stream upon exhaustion of the resource. With a 6% "rate of pure time preference" and assuming 30 years to exhaustion the resulting user cost or option value equals 16% of current annual revenue.	Based on methods suggested in Brookshire, Eubanks and Randall (1983)
Existence value	Estimated at 91% of the sum of use and option values.	Based on estimates in Pearce and Turner (1990)

Key references:

Bajaj, M. 1990. "Natural Regeneration vs Afforestation: An Examination of the Potential for Investment in Natural Regeneration of Degraded Forests, with Community Participation", Paper presented at a *Seminar on the Economics of the Sustainable Use of Forest Resources*, Centre for Science and Environment, New Delhi.

Brookshire, D., Eubanks, L. and A. Randall. 1983. "Estimating Option Prices and Existence Values for Wildlife Resources" in *Land Economics* 59:1-15.

Chopra, K., Kadekodi, G.K. and M.N. Murty. 1990. *Participatory Development: People and Common Property Resources*. Sage Publications India, Pvt. Ltd: New Delhi.

Fleming, W.M. 1983. "Phewa Tal Catchment Management Programme: Benefits and Costs of Forestry and Soil Conservation in Nepal" in Hamilton, L.S. (ed.) *Forest and Watershed Development and Conservation in Asia and the Pacific*. Westview Press: Boulder, CO.

Hufschmidt, M.M., James, D.E., Meister, A.D., Bower, B.F. and J.A. Dixon. 1983. *Environment, Natural Systems and Development: an Economic Valuation Guide*. Johns Hopkins: London.

Lal, J.B. 1992. "Economic Value of India's Forest Stock." In Agarwal, A.A. (ed.). *The Price of Forests*. Centre for Science and Environment: New Delhi.

Mishra, R. 1969. "Studies on the Primary Productivity of Terrestrial Communities at Varanasi" in *Tropical Ecology* 10:1-15.

Pearce, D.W. and R.K. Turner. 1990. *Economics of Natural Resources and the Environment*. Harvester Wheatsheaf: New York.

Sharma, R. and R. Bhatia. 1986. *India: Meeting Basic Energy Needs of the Poor.* Vol. 2 ILO-Artep: New Delhi.

Davies, J., Richards, M. and W. Cavendish. 1999. *Beyond the Limits of PRA? A Comparison of Participatory and Conventional Economic Research Methods in the Analysis of Ilala Palm Use in South-eastern Zimbabwe*. Overseas Development Institute: London.

Type of assessment & main findings: The study provides insight into the costs and benefits of alternative methods of collecting economic information on NTFPs. Participatory methods (PRA) and conventional surveys are used to evaluate the economic returns from Ilala palm extraction in south-eastern Zimbabwe. The focus of discussion is on the relative merits of different data gathering techniques rather than the value of alternative uses of palms.

Empirical data: Information was collected on the direct use values of Ilala palm using a random single-visit household survey, key informants and PRA. The key informant approach was found to be compatible with both PRA and household survey methods. Data include the relative importance of different palm-based occupations (wine producers, craftswomen and craftsmen), the main sources of cash income, output of Ilala palm-based products (wine, baskets, thatch, sleeping mats, crafts, etc.), and sales, trade and/or domestic use of these products. Information on labour inputs was also recorded.

Economic values considered: Information on direct use values (e.g. wine, food and craft production), indirect use values (the role of palms in stabilising soil) and non-use values (cultural and social) are collected using both household surveys and PRA. Data gathered are used to assess gross and net margins for different types of palm-based outputs.

Comments: The authors conclude that household surveys are not as effective as PRA for gathering qualitative information, but are more accurate where quantitative information is required, eg. cash income and levels of production. Whereas PRA tends to produce broad averages, household surveys highlight individual experiences and diversity within groups. The PRA approach also required much more of the community's time, up to five times as much as the survey. While surveys appears to offer more precise information at lower cost, the authors stress that this does not mean that surveys are always preferable. The choice depends on various factors including the type of information sought (PRA may be better for eliciting qualitative information) and whether the researchers wish to stimulate discussion among local stakeholders (PRA is again better at this). The authors also point out that the two approaches could be used in various combinations tailored to the needs of a particular study.

Key references:

Emerton, L. 1996. *Participatory Environmental Evaluation: Subsistence Forest Use Around the Aberdares, Kenya*. African Wildlife Foundation, Nairobi.

Lynam, T., Vermeulen, S. and Campbell, B. 1991. *Contingent Valuation of Multipurpose Tree Resources in the Smallholder Farming Sector, Zimbabwe.* Paper accepted for presentation at the 11th Annual AFSRE Symposium, October.

Dixon, J. and P. Sherman. 1990. "Analyzing a National Park (Khao Yai)" in Dixon, J. and P. Sherman (eds.) *Economics of Protected Areas: A New Look at Benefits and Costs.* Earthscan: London.

Type of assessment & main findings: The study involves an economic CBA of the continued protection of the Khao Yai National Park in northern Thailand compared to alternative land uses including hunting, logging and gathering of forest products.

Empirical data: Data is from field visits, secondary sources and collaboration with an IUCN-WWF supported Beneficial Use Project (Dobias 1988; Dobias *et al*. 1988).

Details of CBA: Includes use and non-use values; undertaken from a social perspective. Important use values associated with protection are tourism, research and education. Existence and option values are also considered. The indirect use value of biodiversity is thought to be partly captured by existence and option values, which are estimated at over 120 million Baht (US$4.7million) per year. Benefits are weighed against the costs of giving up traditional forest uses such as logging, hunting, gathering and development for agriculture. Although benefits from hydrological impacts are not included in the CBA, they are quantified in physical terms.

Valuation techniques used: Both primary and secondary sources are used to value the various non-marketed costs and benefits using a range of different approaches.

Results of a CV study undertaken under the Beneficial Use Project are used to estimate existence and option values. The survey asked park users their maximum willingness to pay (WTP) to ensure the continued existence of elephants in the wild in Thailand. The average WTP came to 181 Baht (US$7). Park users' value is aggregated for all Thai visitors and added to an estimated WTP for non-park users. The latter is assumed to equal one tenth of the park user's WTP.

Financial and economic values are calculated for tourism benefits. Financial value is derived using statistics collected for the Beneficial Use Project on the mean tourism-related expenditures per person, i.e. accommodation, gate fees, food, transport and guide service, multiplied by the annual number of visitors. The total comes to between 40 and 200 million Baht (US$1.5 to $7.7 million). An estimate of economic benefits is derived from a TC study of consumer surplus for the Lumpinee Park in Bangkok. The authors assume the surplus for Khao Yai is five times greater at 13 million Baht (US$ 490,000) to account for inflation and the larger clientele.

Research and education benefits are based on scientific expenditures within the park. Reports on the Khao Yai Beneficial Use Project (Dobias 1988; Dobias *et al*. 1988) provide some data on scientific expenditure within the park. Research activities within Khao Yai have mainly focused on Gibbons, Hornbills, and Elephants, and involved expenditures of more than 3.6 m Baht. The research-cum-demonstration projects totalled more than 7.1 m Baht in expenditures (not all in Khao Yai). These expenditures do not represent economic value *per se* but they do indicate a minimum reveal preference to take advantage of the Park's resources. Furthermore, foreigners who come to Khao Yai to do research add to the overall tourism statistics for the country and bring in foreign exchange, while some projects employ Thais as assistants and, therefore, provide employment and training opportunities.

While hydrological benefits are not valued, the benefits accorded by Park through its control of sedimentation are described in physical terms. The Park is the main watershed for two major resevoirs which supply water for irrigation and for hydroelectric power. The authors refer to two studies showing that conversion from forest to agricultural land results in increased runoff (Kaeochada 1984; Kasetsart University 1982). They go on to identify data requirements for calculating the value of the Parks' watershed protection function, using either the mitigation cost approach or the production function approach.

The opportunity cost of park protection is assessed using estimates of village income foregone due to prohibitions on traditional hunting of animals, felling of trees and gathering of plants. The continuation of some extraction on an illegal basis is taken into account. A rough estimate of the gross value of resources extracted from Khao Yai is based on data found in a survey reported in the Khao Yai Management Plan (NPD 1986) and assumptions made about current and future use. In the survey 61% of the villages claimed that to support themselves they needed to supplement their income through illegal use of the park. The total income from park resources is estimated at 13.5 million Baht per year, i.e. 2,000 households (60% of those residing in the park) x 0.25 (assumption that the average family receives 1/4 of its income from park resources) x 27,000 Baht (average yearly income of a family of five according to a survey). Assuming that current enforcement reduces illegal use by about two-thirds, in the absence of any enforcement the total use value would be 40.5 m Baht (13.5 x 3). In this case the opportunity cost of protecting Khao Yai would be 27 million Baht per year (40.5 m Baht less 13.5m Baht). The main opportunity cost associated with Thale Noi NP is the benefit forgone from not being able to hunt certain species. Based on the results of a survey conducted by TISTR, it is assumed that 29% of those who cease hunting do so because of changes in hunting regulations and that approximately 1,750 households are affected by the regulations. The data required to estimate this opportunity cost, such as the average number and type of bird killed or captured each year, the value of each bird and the costs associated with hunting, were not available.

Socio-economic groups affected: Local villagers who suffer income losses as a result of restricted access to the park.

Comments: A number of possible valuation methodologies not used in this study are discussed. For instance the mitigation-cost method and the change-in-productivity approach are considered as potential options for estimating the hydrological benefits of forest protection. Improved survey methods to assess changes in visitors' knowledge and opinions before and after their visit to Khao Yai are also discussed.

Key references:

Dobias, R. 1988. *Influencing Decisions Makers About Providing Enhanced Support for Protected Areas in Thailand*. Report to WWF Beneficial Use Project, Contract 3757.

Dobias, R., Wangwacharakul, V. and N. Sangswang. 1988. *Beneficial Use Quantification of Khao Yai National Park: Executive Summary and Main Report*. Thorani Tech. for WWF: Bangkok.

Eutrirak, S. and S. Grandstaff. 1986. "Evaluation of Lumpinee Public Park in Bangkok, Thailand" in Dixon, J. and M. Hufschmidt (eds.). *Economic Valuation Techniques for the Environment*. John Hopkins University Press: Baltimore.

Emerton, L. 1996. *Participatory Environmental Evaluation: Subsistence Forest Use Around the Aberdares, Kenya*. African Wildlife Foundation, Nairobi, Kenya, summarised in Bagri, A., Blockhus, J., Grey, F. and F. Vorhies (eds.). 1998. *Economic Values of Protected Areas: A Guide for Protected Area Managers*. IUCN: Gland.

Type of assessment & main findings: Contingent ranking (modified CVM) is used to assess the importance of forest resources to local communities in the Aberdares of Kenya. A net present value of US$306 per household per annum is estimated, expressing the potential losses to local people of restricting forest use.

Empirical data: Survey data was used to collect information on the value of timber and NTFPs as well as labour inputs to their collection.

Economic values considered: Direct use values for timber and NTFPs.

Valuation techniques used: The author argues that hypothetical cash payments (the usual CV approach) have little meaning in the communities surveyed. Hence questions relating to WTP are abandoned in favour of an alternative "contingent ranking" approach. This involves depicting various forest benefits on cards (e.g. timber, fuelwood, grazing, etc.) and asking people to weigh and rank their relative importance using seeds, stones or other counters. The resulting scores are "anchored" with respect to monetary value by including among the cards a common marketed product (e.g. a radio, bicycle or milk cow), which is weighed and scored at the same time as forest benefits. Based on the score attributed to the marketed item, other benefits are valued indirectly. For instance, if a radio is given a score of 5 seeds and costs $20, then each seed is assumed to be "worth" $4. On this basis, fuelwood scored using 10 seeds would be valued at $40. Forest benefits valued in this way are discounted to 1996 prices and expressed in terms of annual averages per household (US$306).

Socio-economic groups affected: The study focuses on the importance of forests to rural communities and, by implication, the distributional consequences of restricting forest use.

Comments: While the study limits itself to direct use values, the same methods could be extended to estimate other benefits, e.g. watershed protection services or non-use values. However, as with all applications of contingent ranking, the resulting value estimates may not reflect true WTP.

Key references:

Kramer, R.A., N. Sharma, P. Shyamsundar and M. Munasinghe. 1994. *Cost and Compensation Issues in Protecting Tropical Rainforests: Case Study of Madagascar*. Environment Working Paper No. 62, The World Bank: Washington, D.C.

Evenson, R.E. 1990. "Genetic Resources: Assessing Economic Values" in Vincent, J.R., Crawford, E.W. and J.P. Hoehn (eds.). *Valuing Environmental Benefits in Developing Economies: Proceedings of a Seminar Series held February-May 1990*, pp. 169-189. Michigan State University: Ann Arbor.

Type of assessment & main findings: The paper presents estimates of the economic value of rice genetic resources in India, and in the world, using the production function approach. A CBA is then developed, based on these estimates of the potential benefits of the preservation of genetic material and the costs of maintaining gene stock collections.

Empirical data: Data on varietal improvements in rice and changes in productivity for 240 districts of India are presented for the period 1959-84. The costs of maintaining germplasm collections in India and the world are also given.

Details of CBA: The study evaluates the net benefits of maintaining an *ex-situ* supply of genetic material for rice, using a two-stage regression analysis of data from 240 districts of India. The first stage involves an estimation of the relative contribution of overall varietal improvement to productivity growth in rice cultivation over the period 1959-84. If the contribution of modern high-yielding varieties (HYV variable) to rice productivity is significant, then in the second stage variables measuring the genetic content of varieties actually planted by farmers are substituted in the analysis for the HYV variable. The second stage was undertaken only for the most recent five-year period (1979-84), and the analysis focuses on whether rice yields were systematically related to the genetic content of the varieties planted by farmers.

The results indicate that varietal improvement was a significant determinant of rice yields for Indian districts over the 1959-84 period. Moreover, the estimates showed that varietal change contributed more than one-third of the total rice productivity gains realised in the post-Green Revolution period (1972-84). From these results, impact elasticities are measured (percent changes in yield from a unit-change in the genetic content variable). In the case of Indian rice plantations, the author argues that yields were 5.62% higher than they would have been if no new genetic resources beyond the original Green Revolution resources had been available to breeders. Assuming a 20 year average time lag between incurring costs and realising benefits, this represents an average annual yield increase of 0.5% over the period 1973-84.

In present value terms, the annual yield increase is worth only 0.061% assuming a 10% discount rate (0.027% at a 15% discount rate). Multiplying these numbers by the value of India's rice crop (the author states that it is approximately US$10 billion, without specifying the year), the annual discounted benefit derived from the genetic resource is obtained: US$50 million, with a present value of US$6.1 million (10% discount rate) or US$2.7 million (15% discount rate). The costs of maintaining the Indian rice germplasm collections are much lower (US$0.3 million/year).

Since germplasm collections are exchanged internationally, a global calculation was also made using the same impact function estimated for India (0.5% increase in output per unit input 20 years from now). The results again suggest that benefits (US$74 millions at 10% discount rate or US$32 millions at 15%) exceed costs (US$20 millions).

Valuation techniques used: The production function approach was used to link the value of genetic material to increased rice output, reflecting the development of new rice varieties.

Socio-economic groups affected: Producers (farmers), centres of agricultural research and germplasm collections.

Comments: The study considers the costs of maintaining genetic collections but not the costs of adopting new varietals or increasing rice production. Using gross agricultural returns rather than net returns or value-added to determine the value of yield increases may thus over-state the value of genetic management. Nevertheless, the study is a potentially useful model for valuing forest biodiversity values. In the case of forests, however, there may be serious data constraints, as information on the extent of genetic variation in forest plant and animal species and potential commercial applications remains limited.

Godoy, R. and T. Feaw. 1989. "The Profitability of Smallholder Rattan Cultivation in Central Borneo" in *Human Ecology*, 16(4): 397-420.

Type of assessment & main findings: The paper presents a financial and economic CBA of smallholder rattan (*irit*) cultivation in Kalimantan, Indonesia, showing that economic returns to rattan production are about 12% less than financial (market) returns. The article includes some discussion of returns per hectare to rattan compared with rubber, rice and seasonal tropical fruit. Returns to labour in rattan cultivation are shown to compare favourably with other occupations.

Empirical data: Primary data gathered through individual and community level questioning in the village of Dadahup, along the Lower Barito basin in Central Kalimantan (South Borneo). However, a shortage of time precluded a representative, stratified random sample of farmers. Yield information was supplemented with data from Malaysia.

Details of CBA: The authors conduct a financial and economic CBA to estimate the profitability of green and processed rattan cane cultivation by smallholders. The CBA considers only direct use values. The farmgate returns to a representative one hectare plot of secondary forest and abandoned rubber stands over a 25-year period are calculated using a 10% real discount rate.

Valuation techniques used: Both market and shadow prices are used. Shadow prices are used to value rattan output and a shadow foreign exchange rate is used to adjust for over-valuation of the Indonesian currency, the Rupiah. For most smallholder inputs and outputs (i.e. land and labour), however, it was assumed that market prices were not significantly distorted.

Financial (market) prices for green and processed cane at the farmgate were Rupiahs 350,000 per metric tonne (Rp/mt) and 1,776,191 Rp/mt, respectively. To determine the farmgate shadow price for processed rattan it was first necessary to estimate the shadow free on board (fob) price. Given that Indonesia was the major world producer of *irit* in 1988, when the government declared a ban on trade in processed rattan, prices on the international market were considered unreliable. (As the dominant producer Indonesia was able to influence world prices by controlling output.) The 1988 world market price of processed rattan was estimated instead by projecting pre-ban prices (1981-85) for processed rattan. This price was then adjusted to account for over-valuation of the exchange rate, using a conversion factor of 1.1 to derive the shadow fob price of processed rattan. Finally, marketing and transport costs, other fees and taxes were deducted from the shadow fob price to obtain the shadow farmgate price. Fuel costs were also adjusted using the exchange rate conversion factor. The shadow (economic) farmgate price of processed rattan was thus estimated at 1,897,291 Rp/mt.

Estimating the shadow farmgate price for green cane was more problematic because exports of unprocessed cane were banned in the late 1970s. Instead, the percentage price difference between the financial and economic prices of processed cane was assumed to apply as well to green cane. In this way, the financial farmgate price of green cane was adjusted downward by about 5% to obtain a shadow (economic) farmgate price of 331,000 Rp/mt.

Socio-economic groups affected: Smallholder farmers.

Comments: The study is notable for its careful use of shadow prices to estimate the economic costs and benefits of rattan cultivation.

Gunatilake, H.M, Senaratne, D.M.A.H. and P. Abeygunawardena. 1993. "Role of Non-Timber Forest Products in the Economy of Peripheral Communities of Knuckles National Wilderness Area of Sri Lanka: A Farming Systems Approach" in *Economic Botany*, 47(3): 275-281.

Type of assessment & main findings: The authors estimate the economic benefits of forest-based activities of peripheral communities in the Knuckles National Wilderness Area in the Kandy and Matale districts of Sri Lanka. The study focuses on the identification, quantification and valuation of NTFP extraction and use. No attempt is made to estimate collection costs.

NTFPs (excluding grazing) are found to provide US$253 per household per year, equal to 16.2% and 5.3% of total and cash income, respectively. Returns to land from NTFP extraction are about US$92 per hectare per year, compared to $399 and $1,034 per ha/yr from shifting cultivation and cardamom production, respectively.

Empirical data: Data derive from a survey of 60 households (out of a population of 317) in three villages. Data reported include the main sources and income obtained from all household economic activities, the total quantity of NTFP's extracted, the number of collectors and the average value of products collected per household per year. A figure showing the relative importance of NTFPs for different income classes is also provided, indicating the expected decline in importance as household income rises. An appendix provides a list of 47 different forest plants commonly collected, grouped according to category of use.

Economic values considered: Direct use values of NTFPs were calculated, excluding illegal extraction of wildlife, poles and rattan or products collected irregularly.

Valuation techniques used: Market prices of products or prices of close substitutes are used to value the main NTFPs exploited by local communities. A farming systems approach was used to describe all of the economic activities of the community and to estimate net monetary and non-monetary income (without deducting the cost of family labour). Farm and forest gate prices of agricultural and forest products are used to estimate income, adjusted for transport costs where appropriate. Willingness to pay methods (unspecified) were used to value three medicinal plants.

Comments: The study compares returns per hectare per year from NTFP extraction to returns from shifting cultivation and cardamom production. It is not clear, however, whether the figures for shifting cultivation and cardamom are based on the total area required, including both cultivated and fallow land. If not, they may be overestimated.

Hadker, N., Sharma, S., David, S. and T.R. Muraleedharan. 1997. "Willingness-to-pay for Borivli National Park: evidence from a Contingent Valuation" in *Ecological Economics* 21(2): 105-122.

Type of assessment & main findings: CVM is used to assess willingness to pay (WTP) of residents of Bombay (Mumbai) for conservation of the Borivli National Protected Area, which covers a fifth of the metropolitan area and is increasingly threatened by encroachment and deforestation. Average household WTP is estimated at US$0.23 per month, or about US$31.6 million in aggregate present value terms, which far exceeds the current budget of US$520,000 to maintain the area.

Empirical data: Primary data were collected through a four-part survey administered to about 500 people. Information collected included:

- socio-economic data including age, gender, income, education, occupation, membership of environmental groups, etc.;
- environmental interests, i.e. whether respondents consider themselves "pro-environment", "pragmatic" or "pro-development";
- maximum WTP for the introduction of a management plan which will ensure protection of the area, as well as the preferred payment vehicle; and
- respondents' willingness to volunteer time to help protect the area.

Economic values considered: The CVM was administered to both users and non-users of the park for its amenity, or non-consumptive, values. Values of individual components were not evaluated but are likely to include direct and indirect use values and non-use values. The main direct use value of the area is for recreation, with about 2.5 million visitors recorded each year. Indirect use values may be associated with the area's role as a source of Bombay's drinking water and as home to many endangered animals. Existence and bequest values may also be important determinants of WTP.

Valuation techniques used: The CV survey used a double-bounded dichotomous choice formulation (where respondents are offered two bid amounts in sequence and the second bid amount depends on the first response), as well as open-ended questions, to elicit WTP for the implementation of a management plan to protect the area. Respondents were allowed to volunteer time rather than money. Where no payment (either monetary or in kind) is made the existing situation of gradual encroachment and degradation is assumed to continue. WTP is expressed as a monthly payment over a period of five years. Efforts to avoid bias included adoption of recommendations of the NOAA Panel (Arrow *et al*. 1993) to prevent part-whole bias, starting point bias, hypothetical bias and embedding effects. Statistical methods used to reduce bias include elimination of 133 "protest" bids.

Socio-economic groups affected: WTP results were analysed with respect to respondents' age, gender, income, environmental interest, etc. Key determinants of "true" WTP include income, years of schooling, occupation, expressed preference for environmental activities, membership of an environmental group and frequency of visits to the site. Most variables affect WTP as expected, eg. higher income is associated with increased WTP. Interestingly, businessmen express higher average WTP than professionals, even though businessmen are generally less educated than professionals and WTP increases with education.

Hodgson, G. and Dixon, J.A. 1988. *Logging Versus Fisheries and Tourism in Palawan*. Occasional Paper No.7, East West Environment and Policy Institute: Honolulu.

Type of assessment & main findings: The paper presents an economic CBA of a proposed logging ban in the Bacuit Bay coastal zone of Palawan, Philippines, in terms of impacts on the forestry, fisheries and tourism industries. The authors estimate total losses in tourism and fishing (US$17.5-22.6 million) due to sedimentation associated with logging, and point out that these far outweigh the potential benefits from timber production (US$9.7 million).

Empirical data: Data on logging, tourism and fishing are from secondary sources. Timber production is from inventory and yield records. Information on dive-based tourism includes average length of stay, average occupancy rates and advertised daily fee rates plus additional lump-sum fees. Information on fisheries includes catch volume, market prices and costs.

Details of CBA: On-site (logging) and off-site (tourism and fishing) benefits are assessed under two scenarios: with and without logging. Other off-site values beyond those captured by estimates of impacts on tourism and fishing are described in qualitative terms, eg. employment generation, job training, infrastructure development, flood protection and wildlife conservation. Costs are incomplete due to data constraints. The CBA assumes a ten-year time horizon (1987 to 1997).

The NPV of timber production, using a 10% discount rate, is estimated at US$9.7 million, falling to zero with a logging ban. Tourism benefits are assumed to be reduced by logging, due to soil erosion and sedimentation. The main tourist attractions for divers are the pristine coral reefs and clear water. The authors predict that in the case of continued logging in Bacuit Bay, tourism will decline by 10% per year due to degradation of seawater quality and marine life on which the diving resorts depend. The NPV from all dive-based tourism is thus estimated to decline from US$25.5 million in 1987-91 to US$6.3 million in 1992-96 (using a 10% discount rate). Fishing in Bacuit Bay is also assumed to be negatively affected by logging. The decline in the fish catch resulting from sedimentation is estimated through regression analysis, using information on coral cover, species diversity and fish biomass. Two scenarios are considered - with and without tuna - due to uncertainty about the impact of sedimentation on tuna fishing. The NPV of the fish catch is thus estimated to fall from US$17 to US$9 million (excluding tuna from the analysis) and from US$28 to US$15 million (including tuna) over the period 1987-96, assuming a 10% discount rate. Similar results using a 15% discount rate are also reported.

Valuation techniques used: Market prices are used to calculate logging revenues and impacts on tourism and fisheries. Log prices are assumed unaffected by changes in output associated with the two land use options. The production function approach was used to value forest watershed protection services, in terms of the estimated impact of sedimentation associated with logging on the revenues derived from dive-based tourism and marine fisheries.

Socio-economic groups affected: Issues such as income distribution, employment and job training under the different scenarios are considered.

Comments: The conclusions would be strengthened if the authors had considered net economic benefits, rather than gross revenues, of the different activities (logging, fishing, tourism). The links between logging, sedimentation and costs/revenues from tourism and fishing also require more detailed investigation.

Howard, P. 1995. "The Economics of Protected Areas in Uganda: Costs, Benefits, and Policy Issues". Unpublished dissertation, U. of Edinburgh, summarised in Bagri, A., Blockhus, J., Grey, F. and F. Vorhies (eds.). 1998. *Economic Values of Protected Areas: A Guide for Protected Area Managers*. IUCN: Gland.

Type of assessment & main findings: A financial and economic CBA is undertaken from the government's perspective with regard to Uganda's protected area system, including National Protected Areas, Game Reserves and Forest Reserves. While financial analysis yields a positive NPV of US$37.20 per hectare, the economic CBA produces a negative NPV of US$332.40 per hectare. The results highlight the misleading financial incentives facing the government and the large opportunity costs associated with protected areas in highly populated areas. Policy recommendations put forward concern how to ensure that welfare gains outweigh the costs of maintaining the protected areas.

Empirical data: Several sources of data are given. Values of marketed items are calculated from information on concession revenues, protected areas and gate receipts, permits and licences, zoo entrance fees, softwood plantations and other revenues from forest department licences for consumptive goods such as timber, charcoal and building poles. Non-marketed items are valued based on information collected from a survey of 84 households in six villages. Data includes the types of forest items consumed, volume extracted, extraction costs (eg. labour time) and prices received. The main goods valued include firewood, poles, timber, charcoal, thatch, meat, granary materials, food and water. Estimates of indirect benefits and option values are based on secondary data on fish production, afforestation costs, damage costs of carbon emissions and potential benefits from commercial uses of genetic material. Additional cost data is obtained from government expenditure figures and international financial contributions to protected areas. Opportunity costs are derived from estimates of net returns to agro-pastoral development.

Details of CBA: Both the financial and economic CBA use a 5% discount rate and assume a 25-year planning horizon. The financial CBA assesses the monetary flows associated with the protected area system, from the perspective of government. Total revenues earned by government (fees, taxes, etc.) from the protected areas are estimated at US$1 million (in 1993/4). International donors contribute about US$11 million per annum. By deducting the costs of maintaining protected areas (about US$3 million per year) from total revenue, the government appears to gain US$9 million a year, or a NPV of US$121 million. This is equivalent to US$37 per hectare.

For the economic CBA, non-marketed costs and benefits and the opportunity costs of protection are taken into account. Non-marketed benefits are divided between direct and indirect use values and option value. Direct use of wood and NTFPs by local communities is estimated (based on survey results) at about US$74 million per year. Direct use benefits from tourism provide an additional US$16 million per year. Indirect benefits from the forests' environmental services are calculated for carbon sequestration (US$17 million per year) and watershed protection (US$14 million per year). An option value of just over US$2 million is added, based on estimated future spending by pharmaceutical and agro-chemical companies for the use of protected genetic material.

On the cost side, in addition to financial costs borne by the government (US$3 million a year), the annual opportunity cost of protection in terms of the forgone benefits from agricultural and pastoral activities (US$111 million) and the direct costs of crop damage and loss of livestock (US$76 million) are added. In addition, in the economic CBA donor spending must be treated as a cost. Taking all economic benefits and costs together, the authors estimate the total value of the protected area system to be *negative* US$1.08 billion, or negative US$332 per hectare.

Valuation techniques used: Market prices and costs were used for the financial CBA, eg. government licence fees, domestically consumed timber and NTFPs. Indirect benefits and non-use benefits are estimated using a range of valuation techniques. The production function approach is used to estimate the value of forest watershed protection services. Since the watershed is a critical part of the hydrological system and regulates downstream water volumes and quality (eg. nutrient content), it provides critical support to the fishing industry. The value of the watershed protection service is assumed to be equal to the value of the share of the industry which depends on it. Forest carbon sequestration services are valued using two techniques: damage costs avoided and the replacement cost approach. Using the first approach, the service is valued at about US$17 million per year. Using the replacement cost approach, the carbon fixing service is valued at US$20 million per year. The former value is used in the economic CBA. Option value is estimated using an fixed annual figure for future pharmaceutical uses (US$0.40/ha of rainforest and US$0.20/ha of savannah and wetland) and for use of wild coffee genetic material (US$1.5 million).

Socio-economic groups affected: The author highlights the issue of international equity and the fact that the Ugandan government is effectively bearing the opportunity cost of supporting global values such as carbon sequestration. Data collected for the study could be used to assess the domestic distribution of costs and benefits. For instance, the author finds that local populations living around the parks lose about US$135 per household per year. This compares with a range of benefits worth US$30 to $136 per household per year. Off-site fishermen, on the other hand, bear none of the costs but benefit from significant watershed protection services.

Comments: The analysis is undertaken from a macro-perspective and it is likely that some protected areas are more easily justified in economic terms than others, eg. the forgone benefits of agriculture will be lower in relatively infertile or remote areas. Moreover, issues of sustainability do not appear to be addressed explicitly, either in the case of timber and NTFP extraction, or in the case of calculating the forgone benefits of agriculture or pastoralism. While excessive extraction of timber and NTFPs may not be an issue, soil degradation could be a concern if protected areas were converted to other uses, eg. agriculture. Other possible elaborations include sensitivity analysis to test the robustness of results given changes in key assumptions, shadow pricing of marketed items and the use of a social discount rate in the economic CBA, and consideration of other direct use (eg. future eco-tourism/recreation revenues) and indirect benefits (e.g. clean drinking water) of protected areas.

Jonish, J. 1992. *Sustainable Development and Employment: Forestry in Malaysia.* Working Paper No. 234, International Labour Office: Geneva.

Type of assessment & main findings: The paper presents a financial analysis of direct and indirect timber and employment effects of alternative natural forest management regimes in Malaysia, with a special focus on the State of Sarawak. The authors show that shifting to a sustained yield logging regime would have serious negative repercussions for employment.

Empirical data: Secondary data on forest resources in Malaysia, divided into Peninsular Malaysia, Sabah and Sarawak, is derived largely from ITTC (1990). From this the author develops a model of optimal rotation conditions and estimates sustainable annual timber yields for Sarawak and Malaysia as a whole. In Sarawak, the sustainable yield comes to around 6.0-8.2 million cubic metres per annum (MCM) given a 35-year cycle with harvesting of trees of 45 cm or more. This is about one-third of current annual harvests. For Malaysia as a whole, sustainable yields are estimated as 14.8 MCM, against recent annual coupes of 39.8 MCM. Information is also presented for selected years on total forest area (including actual depletion and forecasts of exhaustion of native forests), annual harvesting and production of logs and sawn timber, exports and employment in the timber and wood-based products industry (logging, sawmills, plywood/veneer, moulding, furniture).

Economic values considered: The evaluation focused on direct use values of timber and the employment impacts of moving from existing harvest levels to sustained yield. Comparisons of harvests and employment are made between alternative timber harvesting regimes. The Selective Management System uses a pre-harvest inventory to identify trees for cutting and allows re-harvesting in 25 to 35 years. On the other hand, the Malaysia Uniform System involves the removal of all trees in one felling with poison girdling of the remaining non-economic tree species, and requires more time (50 to 80 years) before the area may be re-harvested.

The employment effects of moving to sustained yield management are dramatic. Adoption of sustained yield harvesting (37% of current yield) is estimated to reduce employment in logging from 69,000 to 25,000, while total employment in the domestic timber and wood-based products industry would decline from 150,000 to 57,000. Shifts into downstream processing and the use of supplemental sources of wood (eg. imports and plantation forests) would reduce the employment impact, but 35,000 to 55,000 jobs would be at risk in the near term.

Valuation techniques used: Market prices are used to value timber. Employment impacts are evaluated in terms of full-time equivalent jobs.

Socio-economic groups affected: The paper refers to effects on government (revenues from timber extraction), employment in extraction and processing industries, indigenous people and the commercial timber industry (both logging and processing).

Key references:

International Tropical Timber Council, 1990. *The Promotion of Sustainable Forest Management: A Case Study in Sarawak, Malaysia.* Mission Report to Eighth Session in Denpasar, Bali, Indonesia, May 16-23, 1990.

Kramer, R., Munasinghe, M., Sharma, N., Mercer, E. and P. Shyamsundar. 1992. "Valuing a Protected Tropical Forest: A Case Study in Madagascar" paper presented

at the *IVth World Congress on National Parks and Protected Areas*, 10-21 February, Caracas, Venezuela.

Type of assessment & main findings: The study presents a CBA of alternative land uses in an area proposed for designation as the Mantadia National Park, in eastern Madagascar. The principal land use options considered are subsistence (shifting) cultivation, extraction of fuel wood and other non-timber products by local populations and tourism by foreigners. Further research (briefly described in an annex) examines local and regional watershed protection benefits and the international existence values associated with biodiversity conservation.

Empirical data: Data in the report derive primarily from interviews with local villagers and foreign tourists visiting Madagascar. A survey was conducted among 351 households (1,598 people) in 17 villages located within a 7.5 km radius of the park boundaries. Data include:

- land use practices (total farmland, planned forest clearance, land under rice, total rice yield, value and quantity marketed) with the number of observations for each variable, range and mean value per household; and
- forest product values (fuelwood, crayfish, crab, *tenreck* and frog) with the number of observations, total annual value for all villages and mean annual value per household.

Additional village-level data include wealth indicators, perceptions of forest values and willingness to accept (WTA) compensation for loss of access to the new park. A survey of tourists was administered to 94 respondents in 1991 but aborted as civil strife in Madagascar led to a temporary downturn in tourist traffic. Supplementary data were collected from tour operators in the US and Europe. Data are presented on total travel expenditure, income, age, educational attainment, country of origin, total trip length and time spent (in days) at the adjacent, smaller Perinet Forest Reserve. Total visits by foreign tourists to Perinet FR are given as 3,900 per year. Data are also presented on the willingness to pay (WTP) of foreign tourists for the new park.

Details of CBA: The analysis includes estimates of direct use values associated with potential subsistence and tourism benefits from the forest area. Estimated annual values per household are aggregated over the total local population. Estimated values per tourist trip are aggregated over the total number of trips per year to Perinet FR. Both estimates are discounted in perpetuity at 10% to obtain the net present value. The results are summarised below.

Estimated Costs and Benefits of Mantadia National Park, Madagascar (Net Present Values in 1991 US$, r = 10%)			
	Opportunity cost	Travel cost	Contingent valuation
Subsistence benefits foregone	758,446	-	451,400
Tourism benefits	-	936,000	2,535,000

While the authors pass over indirect and non-use values in this study, they refer to further research on these in Appendix A. In particular they describe an assessment of watershed protection benefits provided by the park (using a damage-cost-avoided approach) and a survey of 1,200 US residents carried out in 1992 to elicit WTP for tropical forest preservation (existence values). However, no results are presented in this report (see Kramer *et al.* 1995, below).

Valuation techniques used: Market prices are used to value agricultural and non-timber forest benefits foregone in the case of protection. The travel cost approach is used to estimate the value of potential tourism benefits and CVM is used to value both foregone subsistence and tourism benefits. Sources for market price data are not described in the report. The travel cost model used here is a standard random utility model which “examines the allocation of trip choices to Madagascar and other international nature tourism destinations as a function of travel costs, socioe-conomic characteristics, and quality variables” (page 7). Predicted benefits to tourists, assuming that the Mantadia NP delivered a 10% increase in the quality of local guides, educational materials and facilities, are estimated at US$24 per tourist per trip.

Contingent valuation involved two discrete-choice surveys, at the village level and as part of the tourist survey. In the former, respondents were asked their WTA compensation for loss of access to land taken for the Mantadia NP. Expressed in terms of an annual in-kind payment of rice, the mean WTA was 200 kg of rice per year per household (worth about US$61). An alternative estimate of the opportunity cost of the park calculates agricultural and other subsistence benefits foregone at US$120 per household per year, based on aerial photographs of land use patterns and household survey data.

In the tourist survey, CV was used to estimate WTP for the benefits provided by the new park. Respondents were asked how much more they would have been willing to pay to visit the new park during their trip to Madagascar, assuming similar attractions to those enjoyed at the Perinet FR. Using this approach, the mean WTP expressed by survey respondents was US$65 per trip.

Socio-economic groups affected: The authors distinguish between impacts primarily affecting the poor and those affecting better off groups. Local subsistence farmers (mean annual income US$190 per capita) would lose access to land taken for the park. Foreign tourists (mean annual income US$59,000) would enjoy the additional attractions of the new park. The authors note that estimates of WTP or WTA inevitably reflect ability to pay and may discriminate against the poor. They stress that WTP is, in this case, a necessary but insufficient criteria for land use allocation and call for supplementary criteria to protect the “basic rights and needs” of local residents.

Comments: The study is a forerunner of Kramer *et al.* (1995), which is described in more detail below.

Kramer, R.A., Sharma, N. and M. Munasinghe. 1995. *Valuing Tropical Forests: Methodology and Case Study of Madagascar*. Environment Paper No. 13, The World Bank: Washington D.C.

Type of assessment & main findings: The paper summarises the results of four studies (see references below) which employ a range of techniques to estimate the direct use, indirect use and non-use values associated with creation of the Mantadia National Park in Madagascar. No overall CBA is presented, but the research illustrates the potentially significant WTP of foreigners for recreational benefits and for rainforest conservation.

Empirical data: The four source studies use information collected from both primary and secondary sources. The main data sources for each study are provided in the table below.

Economic values considered: Estimates are given for the following forest values:

- direct use values associated with forest use for timber and NTFPs and for shifting cultivation by local communities prior to the creation of the Park. These values reflect the forgone benefits, or opportunity cost, of the Park's creation;
- non-use values (e.g. cultural values) enjoyed by local communities;
- indirect use value to downstream rice farmers of reduced flooding. This is an important benefit which results from reduced deforestation associated with the new Park;
- direct use value associated with forest use for recreation by international tourists; and
- existence value placed on tropical forest protection by US residents.

Forgone benefits to local households
Two different approaches were used to estimate the benefits which local communities obtained from the Park before access was restricted: valuation of direct use benefits using market prices, and contingent valuation of local direct use, indirect use and non-use values.

The first approach focuses on fuelwood and agricultural benefits, although financial gains from extraction of other NTFPs are also included. Drawing on information collected through a household survey (community dependence on forest products and shifting cultivation) and data collected from secondary sources (prices etc.), the net returns to households from harvesting forest products and from shifting agriculture were estimated. Three separate cash flows were produced, reflecting different costs and benefits to three distinct groups around the Park (the affected area comprises a population of approximately 3,400 people). Based on these cash flows over a 20-year time horizon, an average annual net present value (NPV) of the forests to the communities was calculated. Note that the value estimated in this way represents only part of the opportunity cost to local communities of losing access to the Park, as it excludes non-use values, indirect use values and non-marketed direct use values foregone.

The second approach used to assess the value of benefits foregone by local residents from creation of the Park involved a CV survey, to elicit households' willingness to accept (WTA) compensation for loss of access to the park area. The survey presented households with a dichotomous choice question ("take it or leave it") offering a certain quantity of rice per year in return for their agreeing not to use the forests in the Park. The responses were used to estimate a mean WTA expressed in terms of bags of rice. On this basis, a quantity of rice worth US$108 per household per year was estimated to be sufficient to leave the average household indifferent between having access to the Park and not having access. This figure may be compared with the mean estimate of US$91 per household per year using the market value of output foregone. The difference ($17) may reflect local WTA compensation for loss of indirect use and non-use values ignored under the first approach, or perhaps just inherent differences of measurement.

Indirect use values for downstream farmers
A separate valuation study used the production function approach to assess the benefits provided by the Park to nearby communities in terms of reduced flooding. The focus of the analysis was the impact of flooding on rice production. Other values associated with flooding such as destruction of infrastructure or water quality impacts were not considered.[65]

Using information on the rate of forest clearance without the Park (over an estimated 45 years), the impact of deforestation on local flooding, the impact of flooding on rice production, and the average net returns to rice cultivation, the authors develop a dose-response model linking deforestation to the value of rice production. By comparing rice production under the "with Park" scenario and a "without Park" scenario the authors estimate that the Park has saved farmers about US$71,000 worth of rice. In other words, the net present value of the benefit attributable to the Park's flood control function is US$71,000. Note that this benefit accrues to farmers in the upper watershed who enjoy reduced flooding but *not* to those communities discussed in the previous section who lose access to forest land (i.e. they are different groups).

Direct use values for international tourists
The study used both travel cost, or recreational demand, models and CVM to estimate the value of the Park to tourists. The creation of the Park is expected to increase tourist visits to the area as a result of improved opportunities for accommodation and viewing wildlife. Data was collected through a survey of foreign visitors to the Perinet Special Reserve, located near the Park. The questionnaire was administered to almost 100 international visitors to the Reserve in 1991 (see Kramer *et al*. 1992, above).

Two types of recreational demand models were estimated: a typical trip model and a random utility model. The trip model estimates an equation relating the *sum of the number of trips* that an individual has made or plans to make within the next five years, to eight different developing country destinations, to a range of explanatory factors. The latter include the cost of reaching those destinations, an index of their relative quality and several socio-economic variables.[66] The random utility model, on the other hand, defines a function relating the *probability of visiting each site* to a similar range of explanatory factors. The authors note that the typical trip model may be more appropriate for situations in which visitors make numerous trips to a variety of sites over a shorter time period, such as residents of Madagascar who may visit the Park and other sites. The random utility model may be more appropriate for international tourists with a limited number of opportunities to undertake major trips.

The CVM used the dichotomous choice method and asked whether the individual would be willing to pay a certain amount more for their trip if this included a visit to the new Park. All three models are used to estimate the WTP of tourists for the improved benefits of the Park. The recreational demand models estimate the mean benefits per tourist, in terms of the increase in

[65] It is often claimed that the off-site effects of upland forest clearing are significant even far downstream. In this particular case, the authors refer to earlier research finding no evidence of a relationship between forest cutting in headwaters and floods in the lower basin.

[66] The tourist surveys were used to select the seven most important destinations serving as alternatives to Madagascar. Cost and quality variables for these sites were constructed using an expert opinion survey administered to 27 US and European nature tour organisers.

consumer surplus due to increased quality of local guides, educational materials and facilities for interpreting natural areas. In addition, the CVM is thought to capture WTP for improved accommodation facilities and possibly some non-use, or existence values. By aggregating these benefits for the total number of tourists visiting the Perinet Reserve in 1990 and assuming this level of visitation is maintained in perpetuity, the authors obtain an estimate of the NPV of the Park for international tourists.

Existence value for US residents
This study involved a CV survey by mail of households living in the United States to assess the value that US residents place on tropical rainforest protection. While the results apply only to US residents and to rainforest protection in general, it is possible to view part of the estimated values as capturing WTP for initiatives such as the creation of the Mantadia National Park.

A total of 542 mail surveys were returned with a stated WTP for the creation of parks and reserves to protect 45 million hectares (equal to about 5 per cent) of all remaining rainforests.[67] The data was used to estimate a model relating individual WTP to several socio-economic and attitudinal variables. The results indicate that WTP rises with income, an expected response for this type of environmental good. In addition, WTP was higher for those individuals that ranked tropical deforestation higher among a list of environmental issues.

Based on the model a mean WTP of US$24 - $31 per household was estimated.[68] Aggregating across the US, and assuming that only households with income over US$35,000 would actually donate the funds, total WTP was estimated at about US$1 billion. As these figures apply to the conservation of approximately 45 million hectares of “generic” rainforest, as opposed to the 10,000 hectare Mantadia National Park, they cannot be compared directly to the results of the earlier sections. Moreover, these estimates are for US residents only and households in Europe, Japan and other high-income countries may also have substantial WTP for rainforest conservation. Nevertheless, the results suggest that global existence values for tropical rainforests such as the Mantadia National Park may be significant.

Socio-economic groups affected: Each valuation exercise considered values enjoyed by different groups of stakeholders. Direct use, indirect use and non-use benefits enjoyed by local communities which depend(ed) on the forests are valued separately from the indirect use value of flood control, which is captured by downstream farmers. Existence values and recreational values are also estimated separately for international stakeholders; the former for US residents who have not visited, and do not plan to visit, the Park and the latter for tourists who may make use of the Park’s facilities. No direct comparison is made between the different values captured by the various groups.

Valuation techniques used: See table

[67] The final survey was based in part on the results of focus groups and a pretest. The payment vehicle was a hypothetical contribution to a “United Nations Save the Rain Forest Fund”; see Kramer *et al.* (1993) for details.
[68] Two payment vehicles were used, accounting for the two different values at either end of the mean 'range'.

Values calculated	Valuation technique(s)	Estimated NPV	Data source	Source
Direct use value to local communities (timber and NTFPs, agriculture)	Market prices to estimate cash flow from extraction of timber and NTFPs, and from shifting agriculture.	US$566,000 or US$91/household/yr. (based on a 20 year time horizon, using a 10% discount rate).	secondary - government agricultural records, price surveys. primary - household survey for production volumes.	Shyamsundar *et al.* (1993); Kramer *et al.* (1994)
Direct use and non-use values to local communities (unspecified)	CVM to estimate willingness to accept compensation for loss of access to forest. Bags of rice used as method of payment.	US$673,000 or US$108/household/yr. (based on a 20 year time horizon, using a 10% discount rate).	primary - household survey.	Shyamsundar *et al.* (1993); Kramer *et al.* (1994)
Indirect use value to downstream rice farmers (flood control)	Production function approach to estimate rice crop losses from flooding associated with deforestation.	US$71,000.	secondary - landsat images, topographical maps, aerial photos, hydrological experiments and data on past floods and lost rice crops.	Kramer *et al.* (1995)
Direct use value to international tourists (recreation)	TCM to estimate tourists' consumer surplus from forest recreation.	US$936,000 using the random utility model; $1.7 million using the typical trip model (in perpetuity, 10% discount rate).	primary - questionnaire administered to 100 visitors in 1991.	Mercer *et al.* (1993)
Direct use value to international tourists (recreation)	CVM to estimate tourists' willingness to pay for access to Mantadia National Park.	US$2.53 million.	primary - questionnaire administered to 100 visitors in 1991.	Mercer *et al.* (1993)
Non-use value to US residents (rainforest conservation)	CVM to estimate willingness to pay for protection of tropical forests around the world (45 million hectares).	US$1 billion.	primary - mail survey of US households; 542 completed.	Kramer *et al.* (1993)

Comments: The authors do not directly compare their estimates of different values or assess the implicit trade-offs among different stakeholder groups, although it is tempting to do so. Any such attempt, however, would require an effort to address difficult methodological and ethical issues involved in comparing changes in income of groups with widely varying levels of wealth. For example, to what extent can \$1 of forest benefits foregone by local residents be compared to \$1 of increased consumer surplus enjoyed by international tourists? An explicit attempt to grapple with this issue would have made the analysis even more penetrating. A more comprehensive CBA would also presumably include sensitivity analysis of various key parameters, such as the discount rates used and the time horizon chosen.

Key references:

Kramer, R.A., Sharma, N., Shyamsundar, P. and M. Munasinghe. 1994. *Cost and Compensation Issues in Protecting Tropical Rainforests: Case Study of Madagascar*. Environment Working Paper No. 62, Environment Department, The World Bank: Washington D.C.

Kramer, R.A., Mercer, E. and N. Sharma. 1993. *Valuing Tropical Rain Forest Protection as a Global Environmental Good*. Center for Resource and Environmental Policy Research, Duke University: Durham, North Carolina.

Mercer, D.E., Kramer, R.A. and N. Sharma. 1993. *Estimating the Nature Tourism Benefits of Establishing the Mantadia National Park in Madagascar*. Center for Resource and Environmental Policy Research, Duke University: Durham, North Carolina.

Shyamsundar, P., Kramer, R.A. and N. Sharma. 1993. *Estimating the Costs to Local Inhabitants of Establishing the Mantadia National Park in Madagascar*. Working Paper 93-1. Center for Resource and Environmental Policy Research, Duke University: Durham, North Carolina.

Kumari, K. 1995a. *An Environmental and Economic Assessment of Forest Management Options: A Case Study in Malaysia*. Environmental Economics Series No. 26, Environment Department, The World Bank: Washington D.C.

Type of assessment & main findings: The study evaluates the total economic value (TEV) of four options (one "unsustainable", three "sustainable") for logging a peat swamp forest in Peninsular Malaysia. All three sustainable options have higher net present values than the unsustainable option, for which a TEV of M$10,238 (about US$4,000) per hectare was calculated. Over 90% of TEV in all cases is made up of timber and carbon storage benefits.

Empirical data: A variety of secondary sources were used to calculate the component values included in the TEV. These are listed in the last column in Table 1, below.

Economic values considered: Estimates of the following forest benefits are presented:
- direct use values associated with extraction of timber and NTFPs (rattan and bamboo);
- indirect and direct use values associated with forest water regulation/purification services;
- direct use value associated with forest recreational benefits;
- indirect use value associated with forest carbon sequestration; and
- existence and option values associated with wildlife conservation.

Valuation techniques used: See Tables 1 and 2.

Table 1. Goods and Services Valued			
Type of Forest Good/Service	**Type of Value**	**Valuation Technique**	**Data Source/Approach**
Timber	Direct use	Market price	From forest harvest levels, mean annual increments, etc. National Forest Inventory.
NTFPs (rattan, bamboo)	Direct use	Market price	National Forest Inventory.
Hydrological - agricultural	Indirect use	PFA	Data on the hydrological disturbance in the swamps used to determine the effect on water shortage on the rice crop.
Hydrological - domestic	Direct use	Cost-based	Water abstracted from the canal to meet domestic requirements of residents living at the agricultural scheme.
Recreation	Direct use	TCM	Potential recreational value derived from information from existing visitor numbers to the nearby Kuala Selangor Nature Park, and from the results of TCM studies of other forest recreational sites in Malaysia.
Carbon sequestration	Indirect use	Damage cost avoided	Information on biomass and carbon stock in peat swamp forests used to determine the total carbon stored. Rates of carbon sequestration are established from biomass growth data and valued using marginal damage cost estimates from other studies.
Wildlife Conservation (Sumatran Rhinoceros)	Option and existence	CVM and opportunity cost	Contingent valuation estimates from other studies used to estimate the mean WTP of Malaysians for the population of rhinos at the site. Foregone timber benefits are calculated for the area set aside for wildlife conservation.

Source: Kumari (1995), Table 2.

For each logging option, benefits are valued over a 100-year time horizon and discounted to present values using discount rates of 2% and 8%. The impact of logging damage to the residual timber stand on future benefits is assessed for each logging option using two different levels of damage (20% and 50% damage intensity).

In the final analysis, the benefits associated with each logging option are aggregated to allow a direct comparison. Results vary depending on the discount rate used and the assumptions made about damage to the residual stand. Table 2 presents some results using an 8% discount rate and plausible assumptions regarding stand damage for each option. The NPV is given for each of the forest benefits under the existing "unsustainable" system, along with the change in these values for the other land use options.

Table 2. Summary Results (1990 prices, 8 per cent discount rate)

			Change from Base Case to:		
Forest Good/Service	**Base Case (unsustainable traxcavator and canal) (M$/ha)**	**Percent of Total Economic Value (TEV)**	**Sustainable Traxcavator and Canal (M$/ha)**	**Sustainable Traxcavator and Winch (M$/ha)**	**Sustainable Winch and Tramline (M$/ha)**
Timber	2,149	21.3	-696	-399	-873
Hydrological - agricultural	319	3.1	0	411	680
Wildlife conservation	454	4.4	35	20	44
Carbon sequestration	7,080	69.2	969	1,597	1,597
Rattan	22	0.2	88	172	192
Bamboo	98	1.0	0	-20	-20
Recreation	57	0.6	0	0	0
Domestic Water	30	0.3	0	0	0
Fish	29	0.3	0	0	0
Total Economic Value	10,238	100.0	396	1,782	1,620

Source: Kumari (1995), Table 12.

Socio-economic groups affected: The author notes that the global community is the largest winner from moves to more sustainable logging practices, benefiting from forest carbon sequestration services and protection of endangered species. Together these values account for almost three-quarters of TEV in the base case scenario and a large share of the increase in TEV for the three alternative options. This result is used to underline the need for innovative financial mechanisms, such as Global Environment Facility (GEF), to capture and convey the value of such global non-market benefits to local land owners. The study also highlights the unequal distribution of benefits between loggers and local communities. Loggers lose from a shift to more sustainable methods, while local communities enjoy the benefits of increased access to NTFPs and hydrological services.

Comments: The author stresses that the results should be seen as indicating orders of magnitude, rather than precise estimates of value. Various shortcomings are acknowledged, including lack of consistency in using net, as opposed to gross, measures of benefit. One innovative feature is the authors' use of confidence levels (low, medium and high) to assess the relative precision of benefit estimates. These are based on a qualitative evaluation of the reliability of the data used, the methods used to value different benefits, and the soundness of the assumptions made.

The author also attempts to identify those benefits whose loss would be harder to restore (a practical interpretation of irreversibility and the precautionary principle). This involves attaching a ranking (low, medium and high) to each benefit, which reflects the degree of risk aversion which must be exercised in order to ensure the health of underlying natural systems, or to maintain stocks of natural capital. These scores represent the author's own assessment of how critical the continued functioning of underlying natural systems are to the stability of wider ecosystems and to human welfare. Quantitative results are thus enriched by a subjective assessment of confidence and precaution. Underlining this point, the author notes that forest policy and management decisions should be based on value estimates for which there is a relatively high degree of confidence, and low risk of irreversible impacts.

Kumari, K. 1995b. "Mainstreaming biodiversity conservation: a Peninsular Malaysian case" in *International Journal of Sustainable Development and World Ecology*. 2(1995): 182-198.

Type of assessment & main findings: The paper is in two parts; the first part develops a framework for evaluating forest biodiversity in Peninsular Malaysia. Emphasis is placed on the contribution of both managed and protected forests to biodiversity protection. The second part of the paper draws on earlier work by Pearce and Puroshothaman (1992) in an attempt to calculate the option value component of total biodiversity value (TBV). The approach used here links option value to the value of potential future forest-based pharmaceutical products. Different scenarios for drug development are considered, yielding a range of option values from an annualised US$0.52 per hectare to US$695.11 per hectare. Critical determinants of option value include the level of government rent capture, the final value of the drugs developed and the 'effective' forest area considered valuable as a store of biodiversity.

Empirical data: The author draws on Pearce and Puroshothaman (1992) to guide the theoretical discussion. Information on endemic species of trees and herbaceous plants and forest area is taken from official and academic sources, e.g. the 1989 tree flora inventory. Foreign sources are consulted for estimates of the probability of drug development, royalty rates, government rent capture (or appropriation) and the average value of future drugs.

Economic values considered: The author divides the TBV of forests into *protected area* biodiversity value and *production forest* biodiversity value. While the biodiversity value of timber-production forests is considered less than that of protected areas, both can make a significant contribution to biodiversity conservation. Moreover, the two types of biodiversity are closely related. Thus biodiversity in protected areas may be enhanced by proximity to production forests and vice versa, although the relationship is not easily evaluated. The author also notes the importance of distinguishing between the value of forest products and the value of biodiversity *per se*, i.e. the additional benefits which accrue from having a diverse range of genes, species and ecosystems.

Valuation techniques used: The author focuses on one benefit of biodiversity associated with the forests of Peninsular Malaysia, i.e. option value. A production function approach is used to link forest value to markets for pharmaceutical products, based on a model developed by Pearce and Puroshothaman (1992). This model identifies the main determinants of the medicinal value of one hectare of forest per year. These parameters and the values used in this study are given below:

- number of species at risk - assumed equal to 2,826, or the total number of endemic species of trees and herbaceous plants in Peninsular Malaysia.
- probability of a plant species being developed as a drug - assumed to be 5 in 10,000 a middle value in the range identified by Principe (1989).
- royalty rate - a rate of 5% is used.
- appropriation rate - three rates are considered: 10%, 50% and 100%
- average value of drugs developed - three values are used: US$390 million, $1 billion and $7 billion to represent low, medium and high possibilities.
- total area of forests - a range of values is considered to reflect different assumptions about the relative value of production and protection forests in terms of their contribution to biodiversity. Production forests are considered less valuable as a store of biodiversity, due to damage caused by logging. The relative importance of the two types of forests depends

on the extraction method used. Estimates of stand damage due to logging in Peninsular Malaysia range from 30% to 70%. For the purposes of the study, maximum damage is assumed. The area of production forests is thus converted into 'effective' protected forest (for purposes of biodiversity conservation) by multiplying the former by 0.3. Adding these 'effective' protected forests to actual protected areas in Peninsular Malaysia yields a total 'effective' protected area of 2.1 million hectares.

A range of results are produced reflecting the range of scenarios considered. These are reproduced in the table below.

Biodiversity value of Peninsular Malaysia using 'medicinal' plant value as a surrogate			
Scenario	**Drug value**		
	Low	**Medium**	**High**
100% appropriation rate ($/ha/yr)			
protected area	38.73	99.30	695.11
protected area + production forests	5.16	13.23	92.61
'effective' protected area	13.12	33.64	235.50
(partial) biodiversity value (US$ millions)	27.55	70.65	494.55
50% appropriation rate ($/ha/yr)			
protected area	19.36	49.65	347.55
protected area + production forests	2.58	6.62	46.31
'effective' protected area	6.56	16.82	117.75
(partial) biodiversity value (US$ millions)	13.78	35.33	247.28
10% appropriation rate ($/ha/yr)			
protected area	3.87	9.93	69.51
protected area + production forests	0.52	1.32	9.26
'effective' protected area	1.31	3.36	23.55
(partial) biodiversity value (US$ millions)	2.76	7.07	49.46

source: Kumari (1995)

In general, the higher the drug value and the appropriation rate the higher the option value of biodiversity conservation for Peninsular Malaysia. The results are also sensitive to the area of forest considered, given a fixed level of endemic species. The larger the area, the lower the value of each additional hectare. The author highlights significant values and the importance of maximising the appropriation rate. In the last row for each appropriation rate considered, the author calculates the present value of the option value using a X% discount rate.

Key references:

Pearce, D, and S. Puroshothaman. 1992. *Protecting Biological Diversity: The Economic Value of Pharmaceutical Plants*. Global Environmental Change Working Paper 92-27. CSERGE/UEA and UCL, London.

Principe, P. 1989. "The economic significance of plants and their constituents as drugs" in Wagner, H., Hikino, H. and N. Farnsworth. (eds.) *Economic and Medicinal Plant Research*. Vol. 3. pp. 1-17.

Lal, J.B. 1990. "Economic Value of India's Forest Stock" in *Van Vigyan (Journal of the Society of Indian Foresters)*. 28(3): 63-72.

Type of assessment & main findings: The paper estimates the total economic value (TEV) of India's forest stock including direct and indirect use values and non-use values. The total value given is 785.5 billion Rupees per year, or 27% of GNP (1987-88), an amount considerably larger than the contribution recorded in the national accounts (1.2% of the GNP). Assuming a discount rate of 5%, the net present worth of Indian forests is estimated at 15,910 billion Rupees.

Empirical data: Information from other sources is used to estimate forest values.

Economic values considered: Direct values (wood and non-wood products, grazing, recreation), indirect values (production of oxygen, soil conservation and maintenance of fertility, recycling of water and regulation of ambient humidity, control of air pollution, sheltering of fauna and flora), option and non-use values (conservation of biodiversity).

Valuation techniques used: Various methods are used but not all described in detail. Starting with direct use values, market prices are used in most cases. The value of timber and fuelwood is derived from the potential productivity of woody biomass, which is given as 36 million m^3 of timber and 54 million m^3 of firewood per year (Lal 1989). Assigning a stumpage value of 3000 Rupees/m^3 to timber and 200 Rupees/m^3 to firewood, the annual value of wood is 118.8 billion Rupees. Non-woody biomass was excluded because it is seasonal, perishable and negligible in comparison to the value of woody biomass. The value of animal fodder is based on 730 kg/year per cattle unit (assuming that grazing is limited to the carrying capacity) and is estimated at 22 billion Rupees. The potential annual revenue from all minor forest produce is estimated at 10.9 billion Rupees. The value of environmental services is obtained from the results of a previous study which estimated a figure for the total benefits of a medium-sized tree (which yields a biomass of 50 tonnes over a period of 50 years) using surrogate market techniques (Das 1980). These results are transformed to estimate the annual value of environmental services at 1,063 Rupees/tonne of biomass. The author multiplies this figure by the total biomass in four different kinds of forest in India (tropical, sub-tropical, temperate and alpine) to calculate a total annual value of 566.8 billion Rupees. The role of forests as harbours of genetic diversity is viewed as an option value, and is valued in terms of a hypothetical 'risk premium' paid to avoid not having something available which may be wanted in the future. The author assumes that the nation as a whole would be willing to spend 10% of gross national savings to avoid this risk, implying a value of 66 billion Rupees per year. Finally, forest recreational services are valued at 5% of the total recreational expenditure in the country, or 1 billion Rupees.

Comments: The author provides no information on how shadow prices were determined, while certain valuation procedures and assumption seem rather arbitrary (for example, the methods used to estimate biodiversity and recreational values).

Key references:

Das, T.M. 1980. "The Value of a Tree"'. *Proceedings of the Indian Science Congress*.

Lal, J.B. 1989. *India's Forests - Myth & Reality*. Natraj Publishers, Dehra Dun.

Loomis, J., Updike, D. and W. Unkel. 1989. "Consumptive and Nonconsumptive Values of a Game Animal: The Case of California Deer" in *Transactions of the 54th National Association of Wildlife and Natural Resources Conference*, pp. 640-50.

Type of assessment & main findings: The article presents estimates of the economic benefits of deer hunting and viewing in California, using the contingent valuation method (CVM). The resulting figures are used to assess the opportunity costs of converting land to housing (building a subdivision), in terms of the loss of deer hunting and viewing opportunities. The value of forage for deer production is also estimated and found to be comparable to the value of forage for livestock production.

Empirical data: Primary data derive from a 1987 mail survey of hunters (15,300 purchasers of licences, 60% responded) and the general public (3,000 randomly selected, 44% responded). Data and the survey questionnaires are not provided in the paper. Secondary sources include USDA statistics on the value of forage.

Details of CBA: Survey data were used to estimate the average cost of deer hunting in 1987 for several areas in California. Total willingness to pay (WTP) for deer hunting was estimated using contingent valuation methods. Hunters were asked how much more they would be willing to pay for the same experience. They were also asked their marginal WTP for additional deer, a longer hunting season, fewer crowds, increased chances of bagging a four point buck, etc. The general public were surveyed at the same time in order to estimate their average WTP for viewing deer on trips made for other reasons and on trips made solely to look at deer. They were also asked their marginal WTP for additional deer.

The impacts of converting land to housing were expressed in terms of a loss of forage for deer, fewer hunting licences or a shorter hunting season. The value of forage was estimated using a simple production function linking forage availability to the size of the deer population. WTP for deer hunting and viewing (based on the CV surveys) were expressed in present value terms and compared to the value of forage to ranchers (the latter based on USDA data). The resulting values were found to be comparable ($10.40 versus $11.00 per Annual Unit Month of forage).

Valuation techniques used: Three techniques are used:
(i) market prices and expenditure (for spending on hunting and/or viewing trips);
(ii) production function approach (for the link between forage and deer productivity); and
(iii) CVM to elicit consumer willingness to pay (WTP) for deer hunting and viewing.

Socio-economic groups affected: In addition to estimating the benefits of wild deer to hunters and viewers, the authors also estimated total personal and business income generated in the State of California from deer hunting and viewing (using Commerce Department multipliers), as well as total employment.

Key references:

Loomis, J. Creel, M. and J. Cooper. 1989. *Economic benefits of deer in California: Hunting and viewing values*. Environmental Studies, UC Davis.

Lynam, T.J.P, Campbell, B.M. and S.J. Vermeulen. 1994. "Contingent Valuation of Multipurpose Tree Resources in the Smallholder Farming Sector, Zimbabwe" in *Studies in Environmental Economics and Development*, 1994:8 (November), Gothenburg University: Gothenburg, Sweden.

Type of assessment & main findings: The study presents an economic assessment of forest benefits to smallholder farmers in three agro-ecological zones in Zimbabwe (all are potentially *Miombo* woodland). A comparison is also made between the estimated value of locally gathered fuelwood, as revealed by CV, and the cost of production of fuelwood on eucalyptus plantations.

Empirical data: Based on a survey of about 360 smallholder farmers. Also uses manufacturers' data on the costs of construction of hand-pump boreholes and improved pit latrines.

Economic values considered: Ten direct and indirect use values of forests are assessed including forage, building and household materials, fuel, food, cash income, inputs to crop production, shade, social aspects, health and ecological functions.

Valuation techniques used: The authors employed non-monetary ranking and scoring methods (participatory rural appraisal) to elicit the relative preferences of Zimbabwean smallholder farmers for ten categories of forest value. These non-monetary preferences were 'anchored' by simultaneously asking respondents to score a hand-pump borehole and a well-known type of pit latrine. In a second stage, respondents were asked their WTP and WTA for the borehole, as well as a series of dichotomous choice (DC) questions relating the borehole to five other commodities of known value. Information was also collected on the socio-economic status of each respondent.

Respondents' relative preferences for tree commodities and for the pit latrine were expressed in terms of 'borehole equivalents' and thus as monetary values. The validity of WTP, WTA and DC estimates for boreholes (and indirectly WTP for latrines) was checked by comparison to actual construction costs (which were generally slightly higher). Results include preference ranking and estimated values of tree commodities. The top three commodities are fuel, farm/household materials and crop production inputs. The authors compared the present value of the annual benefit stream from trees to rural incomes (on and off-farm). They also compare estimated WTP for fuelwood benefits to the average cost of production of plantation-grown fuel. Differences in estimated WTP for key tree commodities in high versus low tree cover zones is assumed to reflect their relative scarcity.

Socio-economic groups affected: Smallholder farmers.

Comments: The study illustrates the use of non-monetary ranking and scoring methods as an adjunct of CVM. Such an approach may be most appropriate for rural populations with limited exposure to markets or monetary valuation. However, the conversion of non-monetary rankings into monetary values requires the strong assumption that the respective scales are comparable.

Mattos, M. and C. Uhl. 1994. "Economic and ecological perspectives on ranching in the Eastern Amazon" in *World Development*, 22(2): 145-158.

Type of assessment & main findings: The authors present a financial analysis of ranching in the Paragominas region of the Eastern Amazon (Brazil). The authors distinguish large, medium and small scale operations. The variables studied are annual income and direct costs, productivity under different management practices (extensive or semi-intensive, beef or dairy) and the capital requirements of shifting from extensive to semi-intensive management. All forms of ranching are found to be financially viable, but only because of an implicit environmental "subsidy".

Empirical data: The study is based on interviews of a sample of 14 large properties (more than 6000 hectares), 13 medium properties (from 500 to 3600 hectares) and 22 small scale properties (all less than 100 hectare properties and located in a single community) all within 100 kilometres of the Paragominas municipal seat. A questionnaire was used with each property owner or ranch manager asking the property history, total herd size (numbers by age and sex), ranch operating costs (labour, maintenance of infrastructure, herd maintenance, taxes and transportation) and sources of capital for ranch maintenance. The paper presents data on:

- characteristics of each model of ranching (extensive, semi-intensive beef and semi-intensive beef and dairy) including stocking density, live weight production, milk production, total value of production, production costs and net profits;
- average area by type of use (pasture, degraded pasture, virgin forest, logged forest), average number of head and stocking density in extensive medium-sized and large-sized holdings;
- analysis of the costs and returns of a typical extensive, medium-sized beef cattle ranch;
- analysis of the costs and returns of a typical semi-intensive, small-scale dairy cattle ranch;
- characteristics of small-scale dairy-calf operations;
- costs per hectare to restore degraded pastures;
- costs and returns involved in pasture restoration over a 15-year period;
- net present value and return on investment (%) for large, medium and small scale ranches using extensive or semi-intensive practices.

Details of CBA: Cattle ranching is seen as financially viable, but only because ranchers benefit from hidden "natural subsidies". Pastures on newly cleared land benefit from soil nutrients built up under natural forest, while the restoration of degraded pasture is often financed by sales of timber stocks on remaining uncleared land. Forest reserves are viewed by both small and large land holders as a source of capital with which to finance ranch improvements. Financial returns vary depending on the scale of the operation and management practices:

Type of Ranching	Net Present Value (US$/ha)	Return on Investment (%)
Large scale, extensive	73.3	10.7
Medium scale, extensive	5.7	6.2
Large scale, semi-intensive	288	13.0
Medium scale, semi-intensive	291	14.2
Small scale, semi-intensive	541	16.2

Note: values are in US$ (March 1991), PV is based on a discount rate of 6%.

Valuation techniques used: Market prices. The authors refer to the costs of soil nutrient losses and liberation of CO_2, citing results published by Buschbacher *et al.* (1988) and Nordhaus (1991), but these are not incorporated into the CBA.

Socio-economic groups affected: Small and large scale ranchers.

Comments: The authors note a trend of increasing investment in improvement of forage quality, production techniques and management approaches, suggesting a movement from extensive to semi-intensive strategies. This may reflect increasing land scarcity in the study area.

McDaniels, T. and C. Roessler. 1998. "Multiattribute elicitation of wilderness preservation benefits: a constructive approach" in *Ecological Economics* 27(3): 299-312.

Type of assessment & main findings: The authors present a novel valuation method - multi-attribute value assessment (MVA) - which they claim is more accurate than CVM for eliciting values of unfamiliar goods such as environmental benefits. MVA is used to assess the views of two sets of stakeholders about potential losses of tax revenue to the provincial government if British Columbia's wilderness areas were doubled in size, from 6% of the total land area to 12%. Willingness to pay values are recorded for overall benefits and for the component benefits associated with expansion of wilderness areas.

Empirical data: Information was collected through two half-day workshops involving 28 people. The first workshop involved 13 graduates of the Faculty of Forestry at the University of British Columbia (BC). The second involved 15 graduates of the School of Planning.

Economic values considered: Workshop participants were asked to break down their valuation of a doubling of BC's wilderness area into three components: human demand values (these included marketed and non-marketed use values as well as existence and aesthetic values), human spiritual values (non-use values) and ecological values (indirect use values). In addition, respondents were asked to consider the relative importance of the three types of values for the present generation and for future generations.

Valuation techniques used: The study applies MVA techniques developed by Keeney *et al.* (1990) and called the 'public value forum'. The approach involved drawing together key stakeholder groups in a workshop-style meeting to discuss, learn about and ultimately articulate preferences and values for BC's wilderness area expansion plans. MVA differs from CVM in several ways. While contingent valuation surveys are administered to large random samples of individuals in a defined population, MVAs are administered to small non-random focus groups. CVM assumes that people know and can express their preferences for non-marketed goods and services, whereas MVA assumes that people do not always have well-defined values. MVA practitioners believe that participants must be provided with detailed background information and given an opportunity to discuss and revise their views. Moreover, MVA does not produce aggregate values for use in CBA, but instead aims to inform decision-makers of different values expressed by important stakeholder groups.

In this case study workshops were organised around six questions. The first question asked participants to state how much tax revenue they felt the provincial government should be prepared to forego in order to allow for the expansion of wilderness areas. (It was assumed that revenue would decline due to reduced economic activity in the forest products sector.) The following three questions then asked participants to disaggregate the potential tax revenue foregone into values they would assign to individual benefits associated with the expansion of wilderness areas, namely human demand values, human spiritual values and ecological values. The questions moved from asking participants to rank the individual wilderness area benefits, to asking them to assign weights indicating the relative importance of the different benefits and then asking them to value the benefits in terms of forgone tax revenue. Question four asked participants to state an acceptable decline in tax revenue to allow for an expansion of wilderness areas on behalf of future generations. Question five asked participants to indicate how their valuations might change for smaller or larger expansions of wilderness areas. Question six asked participants to compare their initial response in question one to the result arrived at by aggregating responses to questions two through four and, if they wished, to revise their initial valuation.

One result of the study is the apparently high value placed on the ecological benefits of wilderness areas by both groups. These were valued at an average C$88 million per year, somewhat more than human demand and spiritual benefits, which were valued at C$72 million and C$56 million per year, respectively. The study also illustrated the importance of learning during the workshop. In general, the sum of disaggregated values exceeded the initial overall value placed on benefits from wilderness areas. The most common response to question six was to revise values upwards, perhaps reflecting participants' belief that the disaggregated approach was more accurate. For instance, many participants noted that they had initially overlooked benefits to future generations.

Comments: The study attempts to address a fundamental weakness of CVM, namely the underlying assumption that individuals have a full set of values for non-marketed goods and services, which researchers can elicit with little or no opportunity for learning and revision of responses. On the other hand, it is not clear if constructive elicitation methods provide more accurate measures of 'true' value or simply introduce new sources of bias.

Key references:

Keeney, R.L., Von Winterfeldt, D. and T. Eppel. 1990. "Eliciting public values for complex policy decisions" in *Management Science* 36(9): 1011-1030.

Niskanen, A. 1998. "Value of external environmental impacts of reforestation in Thailand" in *Ecological Economics* 26(3): 287-297.

Type of assessment & main findings: The study presents a CBA of the environmental impacts of alternative reforestation options, as compared with the existing land use (grazing livestock) in northeast Thailand. The analysis considers reforestation with eucalyptus or teak in the form of industrial plantations, community plantations or agroforestry. For all cases the environmental benefits appear to outweigh the costs, though this result is reversed if carbon sequestration benefits are excluded.

Empirical data: All data are from secondary sources. Growth and yield data for alternative plantation options came from various sources including official government documents. See below for more details.

Details of CBA: The CBA was undertaken to evaluate the net environmental impacts (indirect values) of alternative reforestation options as compared with maintaining the land for grazing. Six reforestation options considered were as follows:

- Industrial plantations of eucalyptus or teak;
- Community-based plantations of eucalyptus or teak;
- Agroforestry-based plantations of eucalyptus or teak inter-cropped with cassava.

Global and local environmental impacts are valued for each reforestation option. The impacts considered are: the costs of increased water loss through transpiration and nutrient loss in harvesting, and the benefits of increased erosion control and carbon sequestration. Additional environmental impacts such as changes in the quality of drinking water, off-site impacts linked to run-off and sedimentation, land rehabilitation and shelter benefits are mentioned but not included in the analysis. A 10% discount rate is used throughout. In all cases except for teak and the cassava agroforestry option, the net environmental impact of reforestation is found to be positive. This result is reversed, however, when carbon sequestration benefits are excluded. The largest environmental costs are associated with water loss due to transpiration.

To illustrate the magnitude of the net environmental benefits of different options, they are compared to economic production (market) benefits. The gains are highest for eucalyptus plantations (industrial and community) with net environmental benefits equivalent to 33% of production benefits. Net environmental benefits associated with industrial and community teak plantations were equivalent to 2 to 3% of the productive value. Of the agroforestry options, only eucalyptus yielded a net benefit, equal to 8% of the land's productive value.

The results of the CBA were tested for sensitivity to changes in key variables. The NPV of the alternative reforestation options are shown to be sensitive to changes in the value of transpiration costs and carbon sequestration benefits, the two most uncertain variables considered. The NPV of the eucalyptus options were more sensitive than the teak options. Increasing the discount rate to 14% caused the NPV of all options to fall, reflecting the fact that a large share of benefits arise in later years. In the case of industrial teak plantations, the higher discount rate pushed the NPV into the red. A lower discount rate of 6% was also tested. While all estimated NPV increased, the change was most notable for teak industrial plantations for which the NPV rose over four-fold.

Valuation techniques used: The reduction in on-site soil erosion experienced as a result of reforestation is valued using the replacement cost technique. Soil nutrients losses without reforestation (based on figures from the Philippines, adjusted for lower rainfall and erosion) are valued in terms of the cost of commercial fertilisers needed to replace them. The loss of nutrients due to tree harvesting is valued in the same manner.

The principal transpiration costs associated with reforestation are linked to lost agricultural production due to lower water availability. The production function approach is used to value this impact, by comparing the value of agricultural output with and without plantations. Changes in water availability are estimated using two formulae: the first was developed by Calder *et al.* (1991) and links the rate of transpiration to the basal area of tree trunks. The second formula uses two different water use efficiency (WUE) ratios developed by Larcher (1980) and Jones (1992) to estimate the volume of water that is consumed by a plant during the growing season, per kilogram of dry matter produced. The basal-area approach of Calder *et al.* generated lower estimates of transpiration than the WUE formulae.

The benefits of carbon sequestration in trees are valued using an opportunity cost approach. If the trees were not planted, an equivalent amount of carbon fixation could be achieved through emission controls. The costs of these alternatives represent the savings achieved through planting, and the figure used is US$25 per tonne of carbon, taken from Andersson and Williams (1994). The volume of carbon fixed through reforestation is estimated based on data for *Albizia* spp. plantations (Nabuurs and Mohren 1993), but adjusted for carbon emissions from the decomposition of detritus vegetation. Additional adjustments are made to account for the destination of output from the plantations, and the relative period of time during which carbon is immoblised in different wood products, including paper and fuelwood, before being released into the atmosphere. Carbon sequestered by grass- or shrub-lands (the alternative land use) is finally deducted from carbon storage by timber plantations in order to derive the net carbon benefit of reforestation.

Socio-economic groups affected: The author notes that a major part of the benefits of reforestation accrue to the global community, in the form of carbon sequestration, and that efforts to promote reforestation will make little headway without financial transfers to local landowners.

Key references:

Andersson, D. and R.H. Williams. 1994. *The cost-effectiveness of GEF projects.* UNDP/UNEP/The World Bank. Working Paper No. 6, 36 pp.

Nabuurs, G.J. and G.M.J. Mohren.1993. *Carbon fixation through forestation activities*. Institute for Forestry and Nature Research, Wageningen, Netherlands, IBN Research Report No. 93/4, 205 pp.

Paris, R. and I. Ruzicka. 1991. *Barking Up the Wrong Tree: The Role of Rent Appropriation in Sustainable Tropical Forest Management*. ADB Environmental Office, Occasional Paper No. 1. (May), Asian Development Bank: Manila.

Type of assessment & main findings: An annex to the paper presents CBAs of alternative timber management practices for old growth forests in the Philippines. The calculations illustrate the divergence between the social and private costs of timber extraction. Financial analysis shows a net profit of US$119/ha, while an economic evaluation yields net losses of US$70 to US$922 per hectare. The costs of forest stock depletion and offsite environmental damage are considered substantial and in the light of these results the authors recommend a halt to logging of old-growth forests in the Philippines.

Empirical data: Data are based on estimates prepared in 1990 as part of the Philippine Master Plan for Forestry Development.

Details of CBA: A financial CBA of logging activities in the Philippines, from a purely private perspective, is compared to the economic value of logging activities where old growth forest is: a) selectively logged and subsequently protected (model 1); or b) selectively logged and subsequently not protected (model 2). The economic analysis takes account of indirect values associated with the depletion of timber stocks as well as negative environmental externalities not considered in the financial analysis. It also uses shadow prices as opposed to market prices in the financial analysis. The results are presented in the table below.

For the financial analysis the authors assume that operations are legal and use existing selective logging systems. The direct benefits of logging activities are measured in terms of the market value of logs harvested. These are weighed against the direct costs of road building, harvesting and transportation costs to obtain the financial profit of $119 per hectare per year.

The economic CBA of model 1 estimates the net economic gain from logging assuming the same level of timber extraction. In this case, however, downstream environmental impacts are included explicitly (estimated as a non-market cost of US$223 ha/yr), as well as the financial costs of stand protection, improvement and enrichment planting to ensure sustainable timber production (estimated at US$3.50 ha/yr). If off-site costs are excluded, this option appears to offer superior returns, with a net present value of US$155 ha/yr. However, when the marginal cost of offsite damages to downstream activities is deducted, the result is a net economic loss of US$70 ha/yr.

In Model 2, where no steps are taken to protect the forest after it has been logged, a significant economic loss of US$944 ha/yr is estimated. In this scenario the benefits of logging include the market price of timber harvested plus the value of subsistence farming which would be possible on the deforested land. These benefits are weighed against the foregone potential revenue from sustainable timber production (an opportunity cost), and the loss of watershed protection values (estimated in terms of offsite damage costs), due to inadequate protection of the residual stand.

Valuation techniques used: Market prices are used for harvesting costs and a shadow price is used for logs in the economic analysis. The production function approach is used to estimate a value for watershed protection services in the economic CBA. The value is based on estimated off-site damages in the case of logging.

Financial and Economic Analysis of Logging in the Philippines (1990 US$ ha/yr)

	Financial Analysis	**Economic Analysis**	
		Model 1	Model 2
Volume Extracted (cum)	2.86	2.86	2.86
Market Price of Logs per cum (medium quality)[a]	71	78	78
Value of Log Harvest	204	225	224
Road Building, Harvesting and Transportation Costs	(85)	(67)	(67)
Net Financial Benefit	**119**		
Cost of Protection, Stand Improvement and Enrichment Planting		(3.5)	
Cost of Depletion[b]			(699)
Cost of Marginal Offsite Damage to Downstream Activities		(223)	(455)
Value of Subsistence Farming Crops			75
Net Economic Benefit		**(70)**	**(922)**

Notes: All values are in 1990 US$ per hectare per year (exchange rate: Filipino $28.00 to US$1 from International Financial Statistics 1992).

a/ For the economic analysis, the market price of logs is increased by 10% to account for low cost illegal supplies.

b/ Calculated as the value of sustainable timber production on one hectare in perpetuity, i.e. US$115.5 per annum discounted at 12%.

Pearce, D.W. 1991. *Forestry Expansion - a study of technical, economic and ecological factors; Assessing the Returns to the Economy and Society for Investments in Forestry.* Occasional Paper No. 47, Forestry Commission: Edinburgh.

Type of assessment & main findings: The paper presents a CBA of afforestation in the United Kingdom. NPVs and internal rates of return (IRR) are calculated for eight different forest types. The author concludes that, while under certain circumstances there is an economic justification for afforestation, in many cases it must be justified with reference to values not included in the CBA, e.g. biodiversity conservation.

Empirical data: Shadow prices and costs for 1989/90, secondary sources for market prices and estimates of carbon, recreational values and economic security values. Shadow prices used and sources for their estimation are listed in Table 1 below.

Table 1: Shadow price calculation

Item	Source
Labour	67% of the market wage. Based on a survey of 100 farms carried out in Scotland (Dewar 1991).
Land	50% to 80% of the market value. Derived by removing trade and government distortions (e.g. subsidies) from the market price (this brings the price to 54% of the market value) and adding a premium for amenity and existence values attached to forested land. This premium varies by forest type.
Timber	Border price adjusted for benefits provided by economic security. These benefits are valued as a cost avoided in the case of interruption of timber imports, e.g. due to a trade embargo. This was estimated at between 0.2% and 1.8% of the shadow price of timber by Pearce *et al.* (1988). This study uses a premium of 1% of the shadow price of timber for all forest types.

Details of CBA: The CBA is undertaken from society's perspective and shadow prices are used to value marketed benefits (timber) and costs (labour and land). Furthermore, the analysis attempts to include a range of non-marketed (direct and indirect) benefits and costs. Non-marketed benefits which are valued include:

- recreation (direct use value);
- carbon sequestration (indirect use value); and
- improved economic security of domestic timber supply (indirect use values).

Where benefits and costs cannot be valued, they are described qualitatively. This was the case for biodiversity, landscape values, community values (i.e. maintenance of a rural way of life) and various water resource functions. For instance, forests may increase local water acidity and aluminium content, but decrease air pollution.

A 6% discount rate is used, which is the rate employed by government for evaluating public sector projects. Issues of risk and uncertainty are addressed through sensitivity analysis. Variations in estimates of land, labour and recreational values are considered, leading to numerous estimates of internal rate of return (IRR) for different options.

With land values set at 80% of the market price, labour at 67% and moderate recreational values, afforestation with Spruce in the uplands is seen to be the most desirable option (IRR of 6.0%). No other option has a positive NPV given these assumptions and a discount rate of 6%. Note that timber benefits are negative in every case, reflecting the fact that revenues are more than offset by the costs of production. Under different assumptions, other forest types achieve positive NPVs. Examples of the most viable options include:

- community forests where a very high recreational value is assumed;
- Spruce in uplands where land is valued at 50% of the market price;
- Fir, Spruce and Broadleaf forests in lowlands, where a high recreational value is used and land values are set at 80% of the market price; and
- Pine in lowlands where land is valued at 50% of the market price.

The author stresses that even where NPVs are negative, afforestation may be justifiable if the benefits of those goods and services left out of the evaluation were included.

Valuation techniques used: See Table 2.

Table 2: Valuation techniques used		
Forest benefit	**Type of value**	**Valuation technique**
Timber	direct use	Shadow price - the border price adjusted for economic security benefits. Assumes constant prices.
Recreational use	direct use	Estimated consumer surplus based on Benson and Willis (1991). A range of values are given: low (£3/ha/yr), moderate (£30/ha/yr or £50/ha/yr), high (£220/ha/yr) and very high (£424/ha/yr). These are expected to increase by 1% per year based on Walsh (1986).
Carbon sequestration	indirect use	Damage costs avoided: carbon fixing functions are used to estimate the quantity of carbon stored in different forests. Damage avoided is set at US$13.3/tonne CO_2, an intermediate value in a range of US$3 to US$25 per tonne suggested by Nordhaus (1990).

Key references:

Benson, J. and K. Willis. 1991. *Forestry Expansion - a study of technical economic and ecological factors*; *The Demand for Forest Recreation*. Occasional Paper No. 39, Forestry Commission: Edinburgh.

Dewar, J. 1991. *Forestry Expansion - Forestry Expansion - a study of technical economic and ecological factors*; *New Planting Methods, Costs and Returns.* Occasional Paper No. 46, Forestry Commission: Edinburgh.

Pearce, D., A. Markandya, and I. Knight. 1988. *Economic Security Arguments for Afforestation*. Report to the Forestry Commission, Edinburgh.

Nordhaus, W. 1990. *To Slow or not to Slow: The Economics of Greenhouse Effect*. Unpublished mimeo, Yale University: New Haven, CT.

Walsh, R. 1986. *Recreation Economic Decisions: Comparing Benefits and Costs*. Unpublished mimeo, Venture State College, PA.

Peters, C., Gentry, A. and R. Mendelsohn. 1989. "Valuation of an Amazonian Rainforest" in *Nature,* 339 (June): 655-656.

Type of assessment & main findings: The authors present an economic CBA of subsistence and commercial exploitation of tropical moist forest for native fruit, latex and timber in Peru. These uses are compared to plantation forestry and cattle ranching. The authors conclude that periodic selective timber harvest combined with sustainable fruit and latex harvest is the most profitable land-use option.

Empirical data: The article contains data based on an original survey and supplemented by published statistics. Physical inventory of one hectare of natural forest land at Mishana, Rio Nanay, Peru, yielded the following data:

- number of tree species and number of stems greater than 10.0 cm diameter breast height;
- proportion of tree species and individuals yielding merchantable products (fruit and latex);
- fruit yield for four tree species.

The authors carried out monthly surveys in local markets to collect data on fruit prices in 1987. Timber prices were obtained from local mill operators. Interviews and observation of local forest users enabled the authors to obtain estimates of fruit yields for seven other tree species and of the labour inputs required to harvest fruit and latex. Primary data was supplemented with selected published information, including:

- the minimum wage in Peru in 1987;
- transport costs for fruit and latex products (estimated at 30% of market value);
- logging and transport costs for timber (30-50% of the market value of delivered timber);
- average latex yields;
- for timber tree species, mean annual diameter increment and the relation between diameter breast height and merchantable volume;
- NPV of timber and pulpwood obtained from a 1.0 ha plantation of *Gmelina arborea* in Brazilian Amazonia;
- gross revenues from fully stocked cattle pastures in Brazil (per annum and NPV).

Using these data, the authors generate estimates of:

- tree population, annual yield per tree, market price and total production value for 11 fruit tree species and one latex producing species occurring in one hectare of forest;
- tree population, merchantable volume, unit price at the mill and stumpage value for 60 species of commercial timber (grouped under 23 commercial names) in the same hectare of forest;
- maximum sustainable timber yield (estimated at 30 cubic metres per hectare every 20 years).

Details of CBA: The authors compare the NPV of three land use options: (i) sustainable fruit and latex extraction only, (ii) clear cutting of merchantable timber and (iii) periodic selective timber harvest combined with sustainable fruit and latex harvest. The preferred land-use is option (iii). Sustainable fruit and latex are found to account for over 90% of the total value of tree resources in natural forest (excluding the value of medicinal plants, lianas and small palms which were not studied).

The best option is finally compared to the NPV of plantation forestry and of cattle ranching, under assumptions which appear to favour the latter scenarios. The authors conclude that sustainable multiple use of natural forest generates higher economic value (see table).

Financial Returns to Non-Timber Products and Other Forest Uses in 1 hectare of Natural Forest at Mishana, Rio Nanay, Peru
(Net Present Value, US$/ha 1989, 5% Discount Rate)

1.	Non-Timber Harvesting		
	Fruit and latex		6,330
2.	Sustainable Timber Harvesting		
	Periodic selective cutting	490	
Total Natural Forest Value (1 + 2)		**6,820**	
3.	Clear-Cut Timber Harvesting	1,001	
4.	Plantation Harvesting		
	Timber and pulpwood 1/	3,184	
5.	Cattle Ranching 2/	2,960	

Notes: 1/ 1.0 ha plantation of *Gmelina aborea* in the Brazilian Amazon.
2/ Gross revenues per hectare of fully stocked cattle pastures in the Brazilian Amazon (costs of weeding and fencing and animal care not deducted).

Valuation techniques used: Market (and official) prices and actual expenditure are used to value most items. The official minimum wage is used to estimate the opportunity cost (shadow price) of labour. These data are used to estimate gross and net revenues derived from fruit, latex and timber production on natural forest land.

Socio-economic groups affected: No formal analysis of distributional issues is conducted, but the authors note that non-timber products are primarily a concern of subsistence farmers, forest collectors, middlemen and shop-owners, hence less visible than timber.

Comments: The study is one of the most widely cited examples of an economic comparison of alternative forest land uses. However, while the analysis suggests that returns to non-timber products - in this case fruit and latex - compare favorably with clear-cutting of timber and forest conversion, the results should be interpreted with caution. Firstly, the estimated returns to fruit and latex extraction are *potential* returns. Actual returns might fall far short if local capacity for marketing, post-harvesting processing and/or export of NTFPs are weak. Secondly, the particular hectare of forest studied is located near a village some 30 km distance from Iquitos, the town in which market price data were gathered. The results of the study cannot be extrapolated over a much wider forest area, as transport costs are likely to be higher and net returns proportionately lower. Moreover, any attempt to conduct a similar analysis at a regional or national level would need to account for limits to demand for NTFPs (i.e. consumers might not want or need all the fruit in the forest, even if it were made available). Finally, fruit and latex harvesting can be destructive if not managed carefully. In general, the record for harvesting non-timber forest products for commercial exploitation is not good, especially where harvesting is potentially destructive, such as in the case of tree barks and gum.

Phillips, W., Adamowicz, W., Asafu-Adjaye, J. and P. Boxall. 1989. *An Economic Assessment of the Value of Wildlife Resources in Alberta*. Project Report No. 89-04, prepared for the Alberta Recreation, Parks and Wildlife Foundation by the Dept. of Rural Economy, Faculty of Agriculture & Forestry, U. Alberta, Edmonton, Canada.

Type of assessment & main findings: The study presents a valuation of non-market benefits of wildlife in Alberta, Canada. The benefits considered are wildlife viewing and hunting.

Empirical data: The study presents data and analysis from two surveys conducted in 1988. Surveys were mailed to 2,590 randomly selected hunters (51% response rate) and 2,400 randomly selected households (30% response rate). The results include:

- socio-economic characteristics of respondents, including place of residence, age, gender, family size, years of schooling and income for both hunters and households;
- respondents' self-professed 'attitude' towards wildlife for both hunters and households;
- hunting experience of respondents;
- reasons given for hunting;
- hunting activities by type of game;
- hunting expenditures per person in 1987/88 (broken down by category of expenditure);
- nonconsumptive wildlife-related activities by type and frequency;
- species of wildlife used for nonconsumptive activities;
- expenditure on nonconsumptive activities;
- estimated economic benefits of hunting per person and in aggregate;
- preservation values per person by socio-economic strata;
- preservation benefits of wildlife to hunters and to the general population;
- total economic benefits of big game in Alberta;
- frequency distribution of bids for licences to hunt grizzly bear under supply uncertainty and the empirical relation between option price (bid values) and supply uncertainty.

Appendices to the report include more detailed information on place of residence, family size, years of schooling and income for both hunters and households. For hunters only, data are provided on the reasons for hunting, the preservation values of wildlife and grizzly bears, and the economic value of big game and grizzly bear hunting. For households only, data are provided on the preservation value of wildlife.

Economic values considered: Direct use, indirect use and option value.

Valuation techniques used: CVM is used to estimate wildlife users' willingness to pay (WTP) for wildlife preservation. The questionnaire asked hunters how much more they would be WTP annually (over and above actual hunting expenses) to continue hunting, with separate values for big game and grizzly bear hunting. It also asked those who engage in hunting grizzly how much they would pay 'to a grizzly bear fund' in order to enjoy a specified probability (10%, 50% or 90%) of obtaining a licence to hunt grizzly in the future (i.e. their option price). To derive a general option value, the questionnaire also asked households how much they would be willing to donate to a wildlife trust fund to preserve wildlife in Alberta. Households were split into two groups to examine whether the method of payment (voluntary donation or increased income tax) influenced their WTP.

Pinedo-Vasquez, M., Zarin, D. and P. Jipp. 1992. "Economic Returns from Forest Conversion in the Peruvian Amazon" in *Ecological Economics*, 6:163-173.

Type of assessment & main findings: The paper presents an economic CBA of timber extraction and swidden agriculture, compared to potential revenues from forest fruit and latex extraction in an 800 hectare reserve (60 year old secondary forest) near Iquitos, Peru. The authors conclude that the lack of secure land and resource tenure for individuals, and the absence of attractive alternative land uses, makes conversion of forested land to swidden agriculture a logical choice in the San Rafael region. The study results contradict those reported in Peters *et al*. (1989) for a nearby Peruvian village, Mishana.

Empirical data: The authors draw on unpublished data from a regional farmers' union, combined with interviews and surveys conducted in San Rafael for information on costs and revenues for both timber and agricultural crops. Revenues from forest fruit and latex are re-estimated from data presented in Peters *et al.* (1989), on the assumption that only half of the 12 species inventoried in Mishana are found in San Rafael. An inventory of timber resources (stems > 25 cm in diameter for 29 species) was conducted in the San Rafael forest reserve.

Details of CBA: The benefits of NTFP extraction are compared to those of unsustainable commercial logging and swidden agriculture. Only direct use values are considered. No estimates are presented for sustainable management of timber, as the authors argue that it is unrealistic to compare the present value of potential returns from sustainable extractivism, when lack of secure tenure means that most farmers cannot afford to look more than about two years ahead. A more 'realistic' comparison is thought to be between timber extraction followed by swinden agriculture, and traditional extraction of forest fruit and latex.

The CBA is conducted for one hectare of forested land over a two-year period, assuming a 5% continuous discount rate. The results shows that the returns from one-time extraction of merchantable timber (US$480.94) and conversion of forested land to swidden agriculture (US$893.29) exceed the returns from extraction of fruits and latexes over the same period (US$680.44 at Mishana; US$42.93 at San Rafael). Returns are calculated for one rotation of swinden agriculture only. On this basis the authors reach a very different conclusion than that of Peters *et al.* (1989), who argued that sustainable management of the forest reserve in Mishana would be more profitable than logging or conversion. Sensitivity analysis to test higher discount rates of 10% and 15% does not alter the main conclusion.

Valuation techniques used: Market prices are used to value most costs and benefits.

Socio-economic groups affected: The focus is on the 'ribereños', the rural inhabitants of Peruvian Amazonia.

Key references:

Padoch, C. 1987. "The Economic Importance and Marketing of Forest and Fallow Products in the Iquitos Region" in *Advances in Economic Botany*, 5(1987):74-89.

Prasanthi Gunawardena, U.A.D., Edwards-Jones, G., McGregor, M.J. and P. Abeygunawardena. 1999. "A Contingent Valuation Approach for a Tropical Rainforest: A Case Study of Sinharaja Rainforest Reserve in Sri Lanka" in Roper, C.S. and A. Park (eds.) *The Living Forest: Non-Market Benefits of Forestry*. Proceedings of an International Symposium, Edinburgh 24-28 June 1996, Forestry Commission. H.M. Stationary Office: London, pp. 275-84.

Type of assessment & main findings: The study presents estimates of use and non-use values associated with the Sinharaja Rainforest Reserve, covering about 9,000 hectares in the south-west lowlands of Sri Lanka. The authors conclude that the total economic value (TEV) of the Reserve depends critically on who participates in the survey.

Empirical data: A CV questionnaire was administered to three groups in 1994: rural and urban households (230 and 240 respectively), and people living near the Reserve (224 households). Open-ended willingness to pay (WTP) questions were posed with regards to both use values (collection of forest products, education, recreation) and non-use values (existence and bequest). Users were asked to express their WTP for both sets of values, while non-users were asked to state WTP for non-use values only. Socio-economic data was collected for econometric analyses linking household characteristics to WTP.

Economic values considered: Both use values and non-use values are calculated in an effort to estimate the TEV of the Reserve. Use values include direct benefits from the extraction of forest goods, non-consumptive uses such as recreation, and indirect benefits from the Reserve's environmental services, and were lumped together in a single WTP question. Existence and bequest values were treated separately. Option values were not considered explicitly, but may be part of individual's WTP for existence values.

Valuation techniques used: An open-ended CVM was used, consistent with guidelines given in Mitchell and Carson (1989) and Cummings *et al.* (1986).

Socio-economic groups affected: The distribution of benefits associated with the Reserve was not considered explicitly, although the authors note that WTP for different forest benefits varies among different groups. Local villagers (forest users) express the highest WTP, as a percentage of income, for the preservation of use values. Their estimated WTP is 0.52% of income, compared to 0.21% and 0.33% for rural communities and urban communities, respectively. Local villagers also express the highest WTP for bequest values, at 0.42% of their income, compared to 0.16% and 0.23% for rural and urban groups, respectively. WTP for existence values is similar for all three groups. Foreigners' WTP for non-use values is not estimated, although the authors consider that it may be important.

Key references:

Cummings, R.G., Brookshire, D.S. and W.D. Schultze. 1986. *Valuing environmental goods: a state of the art assessment of the contingent valuation method*. Rowman & Allenheld: Totowa, NJ.

Mitchell, R. and R. Carson. 1989. *Using surveys to value public goods: the contingent valuation method*. Resources for the Future: Washington, DC.

Ruitenbeek, H.J. 1989a. ***Social Cost-Benefit Analysis of the Korup Project, Cameroon*****. Prepared for the World Wide Fund for Nature and the Republic of Cameroon**.

Type of assessment & main findings: The report presents a CBA of conservation and development efforts in the proposed Korup National Park in Southwest Province, Cameroon. The analysis is complementary to a CBA of related efforts focusing on the adjacent Cross River National Parks Project (Oban Division), in Nigeria (Ruitenbeek 1989b; see below). In both cases, project activities aimed to ensure conservation of an important area of tropical rainforest, relieve pressure from hunting and gathering activities and conversion of primary forest to farm land, while also supporting social and economic development in areas around the two parks. In this study, a 'with project' scenario was compared to a 'without project' scenario. Activities include establishing the park, enforcing park regulations, resettling six communities and implementing a complementary economic development plan for a defined management area around the park. In the 'without project' scenario, it was assumed that the forest would suffer continuing encroachment and eventual conversion to other uses. The author's conclusion is that the Park offers significant net benefits at both national and project level.

Empirical data: The analysis is based on secondary data, incorporating the results of studies and surveys up to mid-1989.

Details of CBA: Base case results are presented in Table 1, showing that the net present value of the project as a whole is about UK£1 million, and for the Cameroon, about UK£7.5 million.

Table 1. Cost Benefit Analysis of Korup National Park: Base Case Result (NPV in 1989 UK£ 000, r=8%)

Direct Costs of Conservation		(11,913)
Opportunity Costs		(3,326)
- Lost stumpage value	(706)	
- Lost forest use	(2,620)	
Direct Benefits		11,995
- Sustained forest use	3,291	
- Replaced subsistence production	977	
- Tourism	1,360	
- Genetic value	481	
- Watershed protection of fisheries	3,776	
- Control of flood risk	1,578	
- Soil fertility maintenance	532	
Induced Benefits		4,328
- Agricultural productivity gain	905	
- Induced forestry	207	
- Induced cash crops	3,216	
NET BENEFIT - PROJECT		**1,084**
Adjustments		6,462
- External trade credit	7,246	
- Uncaptured genetic value	(433)	
- Uncaptured watershed benefits	(351)	

NET BENEFIT - CAMEROON	7,545

The direct operating and capital costs of the Project are considered, as well as the opportunity costs of foregone timber earnings (lost stumpage value) and foregone production from six resettled villages (lost forest use). Against this are set direct project benefits in the form of sustained forest use beyond the year 2010, when the forest would otherwise have disappeared, replacement subsistence production of the resettled villages, tourism benefits, minimum expected genetic value of the forest in terms of pharmaceutical products, chemicals and agricultural crop improvements, etc., and environmental functions including watershed protection of fisheries, control of flooding and soil fertility maintenance. Carbon storage values are excluded.

Valuation techniques used: Market prices were used to value most project activities and impacts, including foregone timber benefits (valued at export prices). Labour inputs were shadow-priced at 50% of the market wage. Foregone forest use by local residents is valued based on survey data on the share of hunting and gathering in total household income, and the population affected. Replaced subsistence production for re-settled households is estimated at 25% of average national per capita income. Tourism benefits were valued on the basis of visitor projections and typical expenditures and itineraries at comparable locations.

Potential genetic benefits were based on the market value of patents for firms engaged in genetic research and various assumptions about the expected future value and number of research discoveries. A negative adjustment (uncaptured genetic value) was made to reflect the author's assumption that Cameroon will capture only 10% of total genetic value through existing licensing structures and institutions.

Watershed protection benefits are valued in terms of fisheries and flood control. In the first case, two different but equally crude approaches are used to estimate the gross value of on-shore and offshore fisheries, which are assumed to be entirely dependent on the forest. One estimate is based on the total capacity of the fishery, multiplied by the average market price, while the other is based on average national per capita income, multiplied by the total population engaged in fishing. A negative adjustment (uncaptured watershed benefits) indicates that some watershed protection benefits flow to Nigeria and not to Cameroon.

Forest flood control benefits were valued using rough estimates of expected losses from flooding, assuming the Korup forest were to disappear over the period 2010 to 2040. Soil fertility maintenance was expressed in terms of enhanced crop yields, valued at world market prices. Additional 'induced' benefits included expected increased agricultural productivity and new forestry production resulting from development initiatives in the buffer zone. An external trade credit shows a positive benefit to Cameroon in the form of external funding of the project.

All future costs and benefits were discounted to 1989. The base case was defined using an 8% discount rate and a shadow wage rate of 50% of the market wage. Sensitivity analysis considered a higher discount rate (12%), increased labour costs and an alternative development scenario in which deforestation is delayed by 20 years. Even with these changes net benefits are positive.

Socio-economic groups affected: No special distributional considerations; thus implicitly assuming that the government placed the same welfare weights on benefits or costs accruing to people within the project area as they did to the rest of the country.

Comments: The valuation procedures are crude in some cases, but the study is an impressive early example of attempts to estimate the total economic value of tropical forest land.

Ruitenbeek, H.J. 1989b. *Economic Analysis of Issues and Projects Relating to the Establishment of the Proposed Cross River National Park (Oban Division) and Support Zone*. Prepared by the World Wide Fund for Nature for Cross River National Parks Project, Nigeria.

Type of assessment & main findings: The report presents a CBA of conservation and development efforts in the Cross River National Parks Project (Oban Division), in Nigeria. The analysis is complementary to a CBA of related efforts focusing on the adjacent Korup National Park in Southwest Province, Cameroon (Ruitenbeek 1989a; see above). In both cases, project activities aim to ensure conservation of an important area of tropical rainforest, relieve pressure from traditional hunting and gathering activities and the conversion of primary forest to farm land, while also supporting social and economic development in areas around the two parks.

Land uses considered in this study include logging (both clear cutting and sustained yield management), tourism, agriculture (food and cash crops), hunting and gathering of forest products, exploitation of genetic resources, and watershed protection (for fisheries). The analysis suggests that it would be in Nigeria's economic interest to undertake the project only if the country could capture some of the genetic value that might be attributable to the resource.

Empirical data: Information is derived from three sources: reports prepared for the study by WWF consultants; econometric analysis of behavioural characteristics of villages previously surveyed for the Korup project in Cameroon (using only information judged relevant to the Nigerian context); discussions with Project and Government officials.

Details of CBA: Both direct and indirect use values are considered. On the cost side, the author considers the direct capital and operating costs of the project, the resettlement costs of displaced villagers, and the opportunity costs of forgone hunting, trapping and gathering activities and timber production. Against these costs are set the benefits of sustained forest use, revenue from agriculture and other development initiatives, tourism and watershed protection benefits (see table). At a 12% discount rate the net benefits of the project are negative with a social cost of ECU 12 M, assuming that Nigeria captures no other benefits.

The author introduces the notion of a "*Rainforest Supply Price*", i.e. the amount that Nigeria must capture, either through genetic product development or direct transfers from the international community, in order to justify saving a particular rainforest. Calculations for Oban indicate a supply price of about ECU 12.1 M which works out to just under ECU 50 per hectare. The direct transfers proposed under this project have a value to Nigeria of ECU 12.5 M, just sufficient to give Nigeria an economic incentive to adopt the programme.

Valuation techniques used: Market prices are used and all costs and revenues are expressed in 1989 ECU. Estimated values are judged to be reliable within plus or minus 25%.

Socio-economic groups affected: Distributional consequences are incorporated in terms of changes in the income of local populations. Hunting and farming are an important source of income and subsistence for 35-40,000 inhabitants surrounding the park. Various initiatives are proposed to mitigate the short-term negative impact which enforcement of park policies will have on local populations.

Cross River/Oban Project Assumptions, Costs and Benefits
(NPV in millions of 1989 ECU)

ASSUMPTIONS	
Discount rate = 12% : 90 years	
Standard Conversion Factor (SCF) = 0.85	
Shadow Wage Rate for Unskilled Labour = 1 * SCF	
COSTS	(38.30)
Hunting, Trapping and Gathering Losses	(10.06)
Timber Losses	(15.29)
Capital and Operating Costs of CRMP[a]	(5.24)
Capital and Operating Costs of SZDP[b]	(3.12)
Capital and Operating Costs of CRBL[c] and Hotel	(1.47)
Capital and Operating Costs Agriculture and Aquaculture	(2.87)
Resettlement Costs	(0.25)
BENEFITS	26.20
Sustained Forest Use (HTG)	2.46
Revenues from Agriculture & Development Initiatives	18.66
Other Revenues	1.57
Tourism	1.58
Appropriable Watershed Benefits	1.93
NET BENEFITS PROJECT	(12.10)
INTERNAL ECONOMIC RATE OF RETURN	6.65%
INTERNAL FINANCIAL RATE OF RETURN (S.C.F.= 1)	7.15%
FOREIGN INJECTIONS	12.53
RCF Capitalisation (5 years)	0.63
VCR Payments (5 years)	2.26
Logging Concession Payout	0.73
Other Injections	8.91
NET BENEFITS NIGERIA	0.43
INTERNAL ECONOMIC RATE OF RETURN	12.42%
INTERNAL FINANCIAL RATE OF RETURN (S.C.F.= 1)	15.42%
SUPPLY PRICE ANALYSIS	
Area (ha)	250,000
LDC Rainforest Supply Price (ECU/ha)	48.41
Price Paid through Transfer Mechanism (ECU/ha)	50.14

Notes: a/ CRMP - conservation zone management programme
b/ SZDP - support zone development programme
c/ CRBL - Cross River Bioresources Limited

Ruitenbeek, H.J. 1992. *Mangrove Management: An Economic Analysis of Management Options with a focus on Bintuni Bay, Irian Jaya.* EMDI Environmental Report No. 8. Jakarta and Halifax.

Type of assessment & main findings: The report presents a social and economic CBA of the protection of 300,000 hectares of mangrove in Bintuni Bay, Irian Jaya, in eastern Indonesia. The mangrove is under threat from cutting by woodchip exporters. The analysis considers six options for mangrove use, ranging from clear cutting to a total ban on felling. The best option depends on the assumptions made regarding the impact of cutting on the offshore shrimp fisheries. Where impacts are linear and immediate, a cutting ban is the preferred option. Where linkages are linear but delayed by 5 years, the optimal strategy involves 25% selective felling. Where no linkages exist, clear cutting yields the highest NPV.

Empirical data: Primary data was collected through a survey of 101 households, representing 3% of the local population. The survey gathered information on socio-economic factors, traditional mangrove uses and earnings. Based on this information the author estimates that 70% of total income to local households, on average, derives from use of the mangrove for fishing, hunting and gathering. Information on market prices, costs of production, commercial mangrove uses, agricultural production, and potential biodiversity values are from secondary sources including government statistics.

Details of CBA: The CBA is undertaken from the government's perspective and uses economic prices, including a social discount rate of 7.5%. The analysis compares six mangrove-use options ranging from a cutting ban, through various selective cutting regimes, to a clear cut scenario. Cutting is undertaken for chipwood to feed the rapidly expanding export industry. It is assumed that a 80% selective cut is equivalent to the maximum sustainable yield under a 30 year rotation. A 90-year horizon is used to allow for three rotations. Most prices and costs are assumed constant in real terms for the period of the analysis. For each mangrove-use option the following values are estimated:

Value	Marketed?	Items
Direct use	marketed	timber (chipwood), sagu, offshore fisheries (shrimp and by-catch fish)
	non-marketed	traditional hunting, gathering, fishing
Indirect use	non-marketed	erosion control, biodiversity

Chipwood extraction over time is specified by the six options described above. Extraction rates for other benefits vary. Actual extraction is set to equal estimated sustainable extraction for sagu. Harvesting by shrimp fisheries (where no linkages exist) is assumed to increase by 15% from current levels to an estimated maximum sustainable yield of 5,500 tonnes per year. By-catch fish are assumed to grow in line with shrimp harvesting. Moreover, fish is assumed to becomes more valuable as commercial uses are developed. Traditional non-market uses are assumed to grow in line with population but this growth is slightly offset by reduced dependence on mangroves, which is expected to occur with rising incomes.

Estimation of indirect use values (erosion control and biodiversity benefits) are discussed below. Note that potential eco-tourism values were also considered, but excluded from the CBA due to the low probability that such a use would generate significant profits in the near term. Option and existence values were not considered.

A key strength of the evaluation is the extensive use of sensitivity analysis. For each land-use option considered, costs and benefits are evaluated under different assumptions about the link between mangrove cutting and the productivity of offshore shrimp fisheries. Three main scenarios are developed, reflecting the alternative assumptions of a linear relationship between cutting and shrimp fisheries, a non-linear relationship, and no linkage at all. For the first two scenarios, delay parameters are used to account for the possible time lag between mangrove cutting and off-site impacts. Five and ten year delays are tested. The results are summarised in terms of the incremental benefit of shifting from one land-use option to another, as in the table below. The optimal strategy for each scenario is given in the last row.

Determinants of optimal mangrove management strategy, Bintuni Bay (NPV in billions of 1991 Rps)						
Option 1	**Option 2**	**NPV (option 1) - NPV (option 2)**				
		Linear linkage between cutting and shrimp fishery		Non-linear linkage between cutting and shrimp fishery		No linkage
		5 yr delay	10 yr delay	5 yr delay	10 yr delay	
25% cut	cutting ban	-50	<5	+80	+120	+170
40% cut	25% cut	-30	0	+50	+70	+100
80% cut	40% cut	-80	0	+110	+170	+270
Clear cut	80% cut	-120	-80	-40	0	+60
Optimal strategy		**Ban**	**25% cut**	**80% cut**	**80% cut**	**clear cut**

Alternative discount rates (5% and 10%) are also considered. In general, a lower discount rate increases the appeal of more conservative cutting strategies. Note that with a 5% discount rate, the clear cut option is never optimal. However, even with a high discount rate a cutting ban is preferred when the impact of cutting on the fishery is assumed to be strong.

Valuation techniques used: Shadow prices are used to adjust the market prices of both traded goods and domestic products, based on standard conversion factors for estimated policy distortions. Erosion control and fishery benefits are valued using a production function approach. Several possible relationships between mangrove cutting and fisheries are tested through alternative linkage scenarios. A simple one-to-one relationship links the value of erosion control to that of local agricultural output. Biodiversity was valued for the cash flow it is expected to generate in the future through bilateral grants, multilateral grants (e.g. the GEF) and NGO transfers linked to the protection of biodiversity. Based on previous research (Ruitenbeek 1990), capturable biodiversity value is estimated at US$15 per hectare.

Socio-economic groups affected: Mangrove loss is found to affect poorer households disproportionately. While richer households benefit more in absolute terms from mangrove use, poorer households depend for a larger share of their income on traditional uses such as gathering, hunting and fishing. Moreover, as the formal sector has grown in importance in Bintinu Bay, poorer households have benefited less than rich ones, while their dependence (in terms of contribution to total income) on the mangroves has increased.

Key references:

Ruitenbeek, H. J. 1990. *Evaluating economic policies for promoting rainforest conservation in developing countries*. Ph.D dissertation, London School of Economics: London.

Saastamoinen, O. 1992. *Economic Evaluation of Biodiversity Values of Dipterocarp Forests in the Philippines*. Second Meeting of the International Society of Ecological Economics (ISEE), 3-6 August 1992. Stockholm University: Stockholm.

Type of assessment & main findings: The paper presents a CBA of preserving Dipterocarp forests in the Philippines. It includes the net present (discounted) revenues from known and unknown minor forest products as benefits and the net present revenues from logging as (opportunity) costs. The results show that only with very low discount rates (1%, or 3% if timber harvest is permitted after 25 years) do the potential future benefits of preservation exceed the present value of harvesting the virgin forest over a period of ten years.

Empirical data: The annual revenues derived from minor forest products are based on the Philippines Master Plan (1990).

Details of CBA: Direct use and option values are estimated to value benefits from forest preservation. Direct use values include existing harvests of NTFPs. An average annual value is assumed, based on the official Master Plan (1990) and equivalent to US$65 per ha/yr, at an exchange rate of 23 Pesos/US$. Option values refer to potential future values of undeveloped NTFPs and biological resources. These are thought to amount to US$173 per ha/yr. There is also some consideration of existence value, but recreational and other amenity values are not included. Opportunity costs are valued in terms of the foregone net benefits of logging, and estimated at US$350 per ha/yr over ten years. The results are tested for their sensitivity to changes in the discount rate, using several different rates (1%, 3%, 5%, 10% and 15%).

Valuation techniques used: Market prices were used to value existing minor forest products, timber and option values. Estimation of option values required assumptions regarding future market prices, as well as the future production of lesser known products and biological resources. Lesser-known forest resources are assumed to reach a sustainable production level equal to two-thirds of the existing harvest of minor forest resources. This yield is assumed to be achieved after ten years, at which point it is evaluated at US$43 per ha/yr. Biological resource utilisation is assumed to be sustainable at twice the level of current harvests. This level is reached after 15 years, at which point it is evaluated at US$130 per ha/yr. No details are presented to explain the difference between these categories.

Schwartzman, S. 1989. "Extractive Reserves: The Rubber Tapper's Strategy for Sustainable Use of the Amazon Rainforest" in Browder, J.O. (ed.). *Fragile Lands of Latin America: Strategies for Sustainable Use of the Amazon Rainforest*, pp. 150-163, Westview Press: Boulder, Colorado.

Type of assessment & main findings: The paper presents a financial CBA of rubber tapping and Brazil nut extraction in the Acre River Valley of western Amazonia (Brazil). The author finds that *'the fragile land use strategies of autonomous rubber tappers furnish ... an income that puts them above half of the economically active population of the region'* (pg. 161).

Empirical data: Primary data is obtained from a survey of 33 rubber collecting households in 'Seringal' (rubber state) Cachoeira, in the municipality of Xapuri (state of Acre, Brazil) in October and November of 1987. Average (per family/holding) data are presented on:

(i) total holding size and area used for agriculture and pasture;
(ii) annual production of rubber and Brazil nuts per holding (in kg and 1987 US dollars);
(iii) labour time spent in rubber and Brazil nut production per year (preparing rubber trails, extracting latex, processing latex and collecting Brazil nuts).

Secondary data are presented on:

(iv) area and population of proposed extractive reserves in Acre and Amazonas;
(v) daily formal sector wage rate (in US$) in the state capital (Rio Branco);
(vi) rubber prices in domestic controlled markets and world market price, Brazilian Amazonian rubber production and natural rubber imports by Brazil (1980-1984).

Details of CBA: The analysis is undertaken from the perspective of rubber tappers and only considers direct use values from tapping, i.e. rubber and Brazil nuts. By extrapolating from estimated average gross revenues in Seringal Cachoeira (US$960) to other reserves, the author estimates that gross returns come to US$4.80 per hectare and per year. Cost estimates are based on labour demand. The number of person-days required to collect and process latex and gather Brazil nuts in a 200 hectare holding varies between 142 and 268, with an average value of 199 days. The daily wage rate was estimated at US$2.60. This implies an average cost of US$2.60 per hectare/year for both activities, bounded from US$1.85 per ha/yr in the best case and US$3.58 per ha/yr in the worst case.

Valuation techniques used: Market prices are used to value both outputs and labour inputs.

Socio-economic groups affected: Rubber collector households.

Comments: The author does not compare returns to rubber tapping and Brazil nut extraction to alternative land uses, e.g. agriculture. Policy distortions (import duties) affecting domestic rubber prices are not considered.

Key references:

Noronha, J.F. de *et al.* 1983. *Custo de Produção da Borracha Natural em Seringais Nativos*. SUDHEVEA: Brasilia.

Sedjo, R.A. 1988. *The Economics of Natural and Plantation Forests in Indonesia.* FAO: Rome.

Type of assessment & main findings: The study uses CBA to rank eleven natural forest and plantation management options for timber production in Indonesia. The analysis neglects values thought to vary little under different regimes, e.g. ecological impacts. Comparison of the results indicates that the traditional selective cutting system is inferior to a range of alternative options, at least with respect to timber production values.

Empirical data: Data was gathered on wood prices, harvesting and management costs, and the opportunity cost of capital in Indonesia. Wood prices are forecast to remain constant in real terms for the purpose of the analysis.

Details of CBA: The study focuses on the direct use value of forests for timber production. In a brief discussion of environmental aspects, the author argues that the impact of different regimes on wildlife and genetic resource values, and on environmental services, will be small because the analysis considers only timber production, not protection forests.

The table below presents estimates of the discounted financial returns to six different timber regimes in Indonesia. (The remaining five management regimes considered represent minor adjustments to these six regimes.) TPI is the ‘ideal’ selective cutting system where minimum disruption to the natural forest ecosystem occurs. This is the officially approved management regime for production forests in Indonesia. CHR is ‘complete harvesting and regeneration’, i.e. harvesting of all marketable trees followed by natural regeneration and possibly enrichment planting. INTD is a newly developed system involving the establishment of intensively managed *Dipterocarp* plantations on cleared land. PULP is the establishment of fast-growing pulpwood plantations. SAW10 and SAW20 refer to saw timber plantations on 10 or 20 year rotations.

Comparative Financial Returns of Alternative Timber Production Regimes, Indonesia
(Net Present Value, 1986 US$/ha)

Discount Rate:		6%	10%
Regime:			
PULP	fast-growing pulpwood plantation	2,926	2,562
CHR	harvest all marketable trees; natural regeneration	2,593	2,553
INTD	intensively-managed *Dipterocarp* plantation	2,746	2,203
SAW20	saw timber plantation; 20 year rotation	2,419	2,278
TPI	officially approved ‘selective’ cutting system	2,409	2,177
SAW10	saw timber plantation; 10 year rotation	2,165	2,130

Note: all but TPI involve an initial harvest of all commercially valuable species. The costs of clearing remaining timber are not included in PULP, INTD, SAW20, and SAW10.

The analysis suggests that the official selective management regime (TPI) is less desirable than most plantation systems and than full commercial exploitation. However, while the PULP regime has the greatest financial returns, the author suggests that it may have limited applicability due to its heavy dependence on convenient access to a pulp mill. The author also notes that the INTD system requires further field trials before it can be applied widely. Uncertainy about sawtimber production reduces the appeal of SAW regimes, hence the author ultimately prefers the CHR regime (complete harvest of merchantable timber, followed by natural regeneration).

Valuation techniques used: Market prices are used to value all inputs and outputs.

Comments: Although CHR (along with most other options) appears to be preferable to TPI, this might not hold if the analysis had been extended to a total valuation of market and non-market costs and benefits. Several use and non-use values such as watershed protection functions, non-timber products, and existence values may be greater for a regime such as TPI, which maintains mixed-species, mixed-age forests composed of indigenous species. Given that the difference in the NPV of TPI and CHR is only around US$200-400 per hectare, consideration of such values could easily tip the scales in favor of TPI or alternative selective cutting regimes.

Sedjo, R. and M. Bowes. 1991. ***Managing the Forest for Timber and Ecological Outputs on the Olympic Peninsula.*** **Resources for the Future: Washington, D.C.**

Type of assessment & main findings: The report presents a financial CBA of four alternative forest management regimes in the Olympic Peninsula (Washington, USA). The four regimes are conventional clear-cut and reforestation, and three ecological options including set-aside, green tree retention, and selection harvest. The study aims to identify the least-cost ecological regime by comparing the NPV of each alternative. In addition, the study examines the opportunity costs of moving an existing secondary mature forest onto one of the 'ecological' management paths. The authors conclude that the 15% set-aside regime is optimal in both respects.

Empirical data: Data on management regimes and financial returns from timber are provided by the Washington State DNR.

Details of CBA: Direct use values are considered in the first part of the study. Ecological benefits and non-use values are investigated secondly, using an implicit price approach.

Valuation techniques used: Market prices are used to evaluate all costs and benefits. The second part of the study attempts to calculate an implicit price for the ecological benefits achieved under the alternative, ecological management regimes. Environmental benefits are expressed in terms of the opportunity cost of moving an existing secondary mature forest onto one of the 'ecological' management pathways (versus the conventional clear-cut system). The authors suggest that decision-makers must value the benefits of ecological management at least as much as the costs of making the change (i.e. the foregone benefits of conventional forestry).

The authors calculate that, on a bare (logged) site, moving to an ecological regime would cost only US$0.28 per acre more than conventional management. In the case of an existing forest, on the other hand, the opportunity cost of adopting an ecological regime is estimated at US$466 per acre, for a 60-year old stand, and US$1,026 per acre for a 110-year old timber stand. These higher values reflect the significant cost of forgoing immediate exploitation of mature stocks of timber. The question for policy-makers is whether the non-monetary benefits of an ecological regime are considered to be 'worth' this additional cost.

Smith, J., Mourato, S. Veneklaas, E. Labarta, R. Reategui, K. and G. Sanchez. 1997. *Willingness to Pay for Environmental Services Among Slash-and-Burn Farmers in the Peruvian Amazon: Implications for Deforestation and Global Environmental Markets*. CSERGE/CIAT/ICRAF Working Paper No. GEC97.

Type of assessment and main findings: The paper presents a contingent valuation (CV) study aimed at uncovering Peruvian farmers' willingness to accept (WTA) compensation for changing their land-use practices away from slash-and-burn agriculture towards forest preservation and 'multistrata agroforestry'. Farmers' willingness to pay (WTP) for the benefits associated with forest preservation was estimated separately. The results feed into an evaluation of cost-benefit ratios which compare the global benefits of forest preservation in terms of carbon sequestration to the costs of paying farmers to set aside forests or practice agroforestry. Potential welfare gains from increased forest preservation are shown to be significant. The results also indicate substantial cost savings can be achieved through carbon sequestration as opposed to emission reductions.

Empirical data: Primary data was collected by survey from over 200 farmers, including information on their socio-economic characteristics, e.g. education, income, housing, etc., and their WTA compensation for altering their land-use from traditional slash-and-burn to forest preservation and agroforestry. Farmers were also asked to state their WTP for the benefits arising from forest preservation. NOAA Panel recommendations regarding CV survey design were followed, except with respect to the elicitation method (see Arrow *et al.* 1993, Kopp and Smith 1993, for an overview of the Panel's recommendations). Farmers were asked open-ended questions about their WTA and WTP, rather than more conventional dichotomous choice questions. The latter are often preferred when conducting CVM in poor communities, but pre-tests favoured the open-ended WTA approach in this case.

Secondary data includes estimates of the global benefits of carbon sequestration (Fankhauser 1995), carbon storage in forests (Ricse *et al.* 1996; Schroeder and Winjun 1995; Schroeder 1994), and the costs of carbon emission reductions (Swisher and Masters 1992; Ridley 1997).

Details of CBA: A full CBA is not presented, but the authors compute benefit-cost ratios (BCRs) for carbon sequestration from a global perspective, and the cost effectiveness of carbon sequestration as opposed to emission reduction. In the former case, direct and indirect use and non-use values captured by local farmers under alternative land uses are included, as well as the global value of carbon sequestration. Benefits and costs are calculated over a 15 year time horizon and discounted to present values per hectare for a range of discount rates. Costs of carbon sequestration are born by local farmers and are discounted at 20% and 30%, reflecting farmers' high rate of time preference. Benefits to the global community are discounted at between 0.5% and 3%.

Cost data is from a survey which asked farmers their WTA compensation for changing land-use from slash-and-burn agriculture to forest preservation and multistrata agroforestry. The WTA reflects the loss in returns associated with slash and burn agriculture, over and above the expected benefits of forest preservation and agroforestry. Respondents were initially asked to ignore forest environmental services when stating their WTA. Mean WTA values ranged from US$138 per hectare per year, in the agroforestry scenario, to US$218 per hectare per year in the forest preservation scenario. The forest preservation option is more costly as farmers are prevented from engaging in tree crop cultivation.

These WTA values represent the losses farmers expect to incur by abandoning slash-and-burn agriculture. Benefits to farmers from forest preservation, including improved environmental services (e.g. air purification) and improved access to forest products, were valued separately. The values that farmers place on forest benefits are revealed by their willingness to forgo part of the compensation they stated earlier. This value is interpreted by the authors as an annual WTP for forest benefits. Mean WTP ranged from US$67/ha under the forest preservation scenario to US$41/ha under the agroforestry scenario. Higher WTP for the forestry option reflects the higher environmental values associated with preserved forests as opposed to semi-cultivated forests in the second scenario.

The cost of carbon sequestration to the global community is assumed to equal farmers' WTA compensation to change land-use, minus their WTP for forest benefits, i.e. between US$151 per hectare per year in the forest preservation scenario and US$97 per hectare per year in the agroforestry scenario. The benefits of carbon sequestration are based on estimated damage costs avoided and the amount of carbon stored under competing land uses. Fankhauser (1995) estimates the benefits of carbon storage at US$20.3 per tonne of Carbon (tC) for 1991-2000, and at US$27.8 per tC for 2001-2030. Various sources are used to estimate the amount of carbon stored in the case study area under alternative land uses. An estimate of 180 tC per hectare from Ricse *et al.* (1996) is used for above ground biomass; Schroeder and Winjun's (1995) estimate of 50 tC per hectare is used for root biomass; and Schroeder's (1994) estimate of 10 tC per hectare is used for the agroforestry option. Using these figures, the authors calculate the present value of the net benefits per hectare of moving from slash-and-burn to forest preservation or to agroforestry.

Information on the benefits and costs of changing land uses are combined in BCRs. In addition to mean BCRs, upper and lower bounds are calculated reflecting uncertainty about cost estimates derived from the CVM. BCRs also vary with different discount rates. Overall, the benefits of carbon sequestration were estimated to be between 15 and 141 times greater than the costs to farmers of preserving forests.

The cost effectiveness analysis compares the costs of carbon sequestration born by local farmers to the costs of reducing carbon emissions. Carbon sequestration costs are based on the figures given above, expressed in US$ per tC. A range of US$0.65 to $0.73 per tC is given for forest preservation, and from US$1.17 to $1.41 for agroforestry. Estimates of the costs of emission reduction are taken from several sources and range from US$50 to $429 per tC, indicating that carbon sequestration is a much cheaper option.

The analysis illustrates the significant potential welfare gains from promoting trade in carbon sequestration services. Not only would companies/countries faced with strict limits on carbon emissions save money by pursuing carbon sequestration in place of reduced emissions, but farmers could potentially gain from payments for protecting their forests. The authors note the relevance of their findings for extending the Clean Development Mechanism set up under the Kyoto Protocol to cover trade in carbon sequestration.

Socio-economic groups affected: The central finding of the analysis is that all groups considered (local farmers and the global community) would benefit from a move towards forest protection if trade in carbon sequestration services were possible.

Comments: The use of CVM, and especially the WTA format, to estimate the opportunity costs of forest protection to local farmers is unusual in developing countries. Other studies typically calculate the costs of forest conservation (i.e. forgone economic output) using market and/or shadow prices. Use of CVM allows the authors to incorporate both these economic impacts and the non-market costs and benefits perceived by local people. The research suggests that Amazonian farmers are well aware of the environmental benefits provided by forests and are willing to pay to protect them. As a result the costs of compensating farmers for income lost by abandoning slash-and-burn agriculture is less than it might otherwise be and, in this case, substantially less than the lowest estimates of the benefits of carbon sequestration. One important omission is the failure to consider the transaction costs of making and enforcing contracts with small-holder farmers to modify their land use practices.

Key references:

Arrow, K., R. Solow, P. Portney, E. Leamer, R. Radner and H. Schuman. 1993. *Report of the NOAA Panel on Contingent Valuation.* US Federal Register 58(10): 4602-4614.

Fankhauser, S. 1995. *Valuing Climate Change: The Economics of the Greenhouse*. Earthscan: London.

Kopp, R. and V.K. Smith (eds.). 1993. *Valuing Natural Assets: The Economics of Natural Resource Damage Assessment.* Resources for the Future: Washington, D.C.

Ricse, A., J. Barbaran, J. Alegre and P. Woomer. 1996. *Carbon Dynamics in Slash-and-Burn and Alternative Land Uses at the ASB Benchmark Site in Peru*. INIA: Puccalpa, Peru.

Ridley, M. 1997. *Joint Implementation in the Framework Convention on Climate Change and the Second Sulphur Protocol: An Empirical and Institutional Analysis*. Ph.D dissertation, University College London: London.

Schroeder, P. 1994. "Carbon Storage Benefits of Agroforestry Systems" in *Agroforestry Systems* 27: 89-97.

Schroeder, P. and J.K. Winjum. 1995. "Brazil's Carbon Budget for 1990" in *Interciencia* 20: 68-75.

Swisher, J. and G. Masters. 1992. "A Mechanism to Reconcile Equity and Efficiency in Global Climate Protection: International Carbon Emission Offsets" in *Ambio* 21(2): 154-159.

Southgate, D. 1992. *The Economics of Agricultural Land Clearing in North-western Ecuador.* Mimeo, Instituto de Estrategias Agropecuarias: Quito, Ecuador.

Type of assessment & main findings: The paper presents an economic CBA of three alternative land-uses (ranching with some shifting agriculture, agroforestry and plantation forestry) in north-western Ecuador. The estimated NPV of the three land use options are expressed as 'annuity equivalents,' i.e. as a constant annual income stream. The conclusion drawn is that forestry is competitive with prevailing land uses.

Empirical data: Results of a survey of 179 farmers in seven communities include summary statistics on household size and composition, educational attainment, geographic origin, property rights, land use and other economic activities. The average size of family holdings is under 30 hectares. 50% of holdings were purchased outright by their present owners. Typical land uses include forest (37%), pasture (50%) and cropland (13% of area).

Details of CBA: Direct use values considered are food, timber, cash income. Sensitivity analysis shows the effect of varying stumpage and coffee prices, wages and the discount rate. The author reports the hypothetical minimum 'price' at which farmers surveyed claim that they would be willing to sell their holding, when asked directly. The values are as follows:

price range (US$/ha)	portion of the sample
< 100	29 percent
100 - 200	21
200 - 300	13
300 - 400	21
> 400	16

The report goes on to report the results of a financial analysis of three alternative land uses: laurel plantation, pachaco plantation (both for timber) and an improved agroforestry option of coffee with laurel. Previously published data are used on input and output costs and timing to estimate the net present value of returns over a whole rotation.

Valuation techniques used: Market prices and wages are used for the financial analysis of forestry and agroforestry options. The CVM is used to derive current land use practices and farmers' asking price for their land. The latter is taken as a proxy for the NPV of financial returns under existing land use practices.

Socio-economic groups affected: Subsistence farmers/ranchers.

Comments: No details are given of returns to the current land use system (the author asserts that 31% of the sample reported a negative cash flow and that only 25% earned more than $2,000 during the preceding year). The reported asking price for land may understate its true value and estimated returns to forestry and improve agroforestry may be optimistic. The author points out the advantage of agroforestry, in terms of reduced need for credit, but also recognises the greater vulnerability of this use to wage rate and coffee price fluctuations. The author also notes the recent purchase of nearby degraded land by a timber company for $300-500 per hectare, for plantation under laurel, pachaco and other timber species.

Tobias, D. and R. Mendelsohn. 1991. "Valuing Ecotourism in a Tropical Rain-Forest Reserve" in *Ambio* 20(2): 91-99.

Type of assessment & main findings: The article presents estimates of eco-tourism values at a tropical rainforest site in Costa Rica, based on a travel cost model to examine the WTP of local tourists to visit the Monteverde Cloud Forest Reserve (MCFR). The authors conclude that the benefits of eco-tourism at the site exceed the price paid by the reserve to acquire new land, thereby providing justification for the expansion of protected areas near the reserve.

Empirical data: A survey of 755 park visitors was conducted in 1988. The sample taken was consistent in respect of point of origin with a smaller data set collected independently the year before, and was therefore assumed to be representative of the true domestic visitor population.

Economic values considered: Recreation value is the only benefit considered explicitly.

Valuation techniques used: A travel cost model is used to estimate forest eco-tourism value, based on a cross-sectional analysis of 81 cantons (provinces) in Costa Rica. Information on the number of visitors originating from different cantons is combined with data on the population of each canton to derive visitation rates per canton. Other data used include the distance between each canton and the MCFR, population density and literacy rates for each canton. A demand function for visits to the Reserve is estimated using two different specifications:

Visitation Rate	=	36.17	-	0.121 distance	+	0.006 density		
(t statistics)		(4.20)		(2.77)		(2.76)		
Visitation Rate	=	44.42	-	0.107 distance	+	0.006 density	+	0.001 illiteracy
(t statistics)		(4.28)		(2.40)		(1.82)		(1.40)

The results are used to predict visitation rates by the total domestic visiting population and to derive estimates of the park visitation demand function and consumer surplus. The values for consumer surplus for each canton are summed to obtain total annual consumer surplus, which was estimated at between US$97,500 and US$116,200. On this basis the NPV of the Reserve (for recreation) is estimated at between US$2.4 and US$2.9 million, assuming that the real value of recreational demand remains constant over time and applying a real discount rate of 4%. Given that there are about 3,000 domestic visitors annually, the site is valued at about $35 per visit. The authors point out that their estimate of the value of eco-tourism at MCFR is likely to under-estimate the true value of the site for three reasons:

- the real value of recreational visits to the site is assumed to remain constant over time, whereas the visitation rate had grown at 15% a year over the previous five years;
- the estimate represents the value of the site to domestic (national) visitors only, even though foreign visitors outnumber domestic visitors by four to one. If foreign visitors value the site *at least* as much as domestic visitors (at US$35 per visit), an additional US$400-500,000 should be added to the annual value of MCFR; and
- the recreational value of the site does not reflect other potential conservation values, such as sustainable harvesting of non-timber forest products, watershed protection values, protection of wildlife habitats and rare species, etc.

The authors also express the recreational value of the Reserve in per hectare terms. Given a net present value of domestic and international recreation of about $12.5 million and a total Reserve area of 10,000 hectares, the authors calculate a mean recreational value of US$1,250 per hectare. This value is compared to the market price of land surrounding the reserve, which ranges from US$30 to $100 per hectare. The authors thus assert that expansion of the reserve for eco-tourism would be economically warranted as a superior land use.

Comments: High estimates of eco-tourism value appear to justify expansion of the Reserve. However, it is not clear from the study whether the number of visitors or their WTP would increase with enlargement of the Reserve, sufficient to justify the purchase of adjacent land. The question is critical in this case, as the site is privately managed and any increased costs or investment would need to be covered by increased gate receipts or external subsidy. Simply increasing entrance fees to finance land acquisition could be counter-productive, if it resulted in a more than proportionate decline in visitor numbers. Moreover, higher entrance fees may alienate some visitors and undermine local support for the Reserve. Finally, it is not clear from the study whether land outside the Reserve exhibits the same biological diversity, natural beauty, or other 'amenity' values that are sought by eco-tourists.

Veríssimo, A., Barreto, P., Mattos, M., Tarifa, R. and C. Uhl. 1992. "Logging impacts and prospects for sustainable forest management in an old Amazonian frontier: The case of Paragominas" in *Forest Ecology and Management*, 55: 169-199.

Uhl, C., Veríssimo, A., Barreto, P. and R. Tarifa. 1992. "A evolução da fronteira amazônica: oportunidades para um desenvolvimento sustentável". (Title in English: The evolution of the Amazonian frontier: opportunities for sustainable development.) in *Pará Desenvolvimento*, IDESP, June (special edition): 13-31.

Type of assessment & main findings: The studies use CBA to analyse the logging industry and to assess the financial viability of managing forests for sustained yield of timber in the Brazilian State of Pará (eastern Amazon). The paper by Veríssimo *et al.* (1992) focuses on the costs and benefits of logging, while Uhl *et al.* (1992) presents a detailed analysis of forest management. The authors conclude that forest management is not financially viable, while conventional unsustainable logging is extremely profitable and likely to expand.

Empirical data: The study is based on interviews with sawmill owners and employees, and personal observations. The paper presents primary data on:

- the main features of the timber industry and of entrepreneurs (average output, costs and profits in extraction and processing, origin and previous activities of owners);
- socio-economic characteristics of employees and terms of employment in the industry (average wages, subsistence expenditures, origin and number of previous migrations);
- average volume, density and value of trees harvested per hectare;
- damage associated with timber extraction (in physical terms), including road building;
- volume of residual timber left in the forest;
- percentage of forest canopy area opened during extraction;
- rates of tree regeneration after logging;
- contribution to total sales of logs extracted from cattle ranches;
- price of virgin forest land and costs of reforming pastures;
- costs of forest management (timber inventory and climber cutting one year before harvest; stand enrichment by eliminating undesirable species 1, 10 and 20 years after harvest);
- benefits of forest management (increased timber harvest in physical and monetary terms).

Details of the CBA: The authors consider only the direct use values associated with timber extraction. Estimated revenues from unsustainable forestry range from US$70 per hectare (the average price of a logging concession) to US$200/ha (when extraction is conducted by the rancher). The authors note that timber revenues are an increasingly important source of investment capital for pasture reform (which costs US$260/ha), compensating for a recent decline in subsidies to ranching from government.

The most profitable activity is sawmilling. Logging, transport and processing costs absorb 18%, 13% and 37% of the gross revenues of a typical sawmill in Paragominas, respectively. The resulting profit margin (in cash terms) is about 32%. High profits are explained in large part by the low price of timber, with implicit stumpage prices ranging between US$1 and US$3 per cubic metre.

Analysis of forest management suggests that the expected returns are not sufficient to make this activity financially feasible. The investment cost of implementing improved management is estimated at US$180/ha, of which US$20/ha for inventory, US$25/ha for cutting vines and US$45/ha for each enrichment after harvest. The estimated benefit is an increase of about 32 m^3/ha of timber, plus a reduction in the period between harvests from 50 to 35 years. The implied cost is US$5 per m^3 of raw logs, which is not feasible in light of plentiful supplies of cheap logs from newly converted ranches. In conclusion, the authors propose three options to encourage improved forest management:

- legally mandated management practices. Sawmill and logging profits would decline, but would remain attractive activities; the additional costs of management represent only 7% of the total revenues of sawmills. Gross profit margins would decline to 24%.
- introduction of an 'ecological' tax of 7% on the price of timber products (sawlogs), with revenues recycled to loggers and sawmills, in order to finance forest management.
- reduction of value added tax (VAT) paid by sawmills from 12% to 5% for timber sales, combined with management mandates.

Valuation techniques: Market prices are used to value most items. In the case of stand damage, physical impacts are recorded.

Socio-economic groups affected: Loggers and millers (owners and workers), ranchers.

Walsh, R.G., Bjonback, R.D., Aiken, R.A. and D.H. Rosenthal. 1990. "Estimating the Public Benefits of Protecting Forest Quality" in *Journal of Environmental Management*, 30:175-189.

Type of assessment & main findings: The paper presents a case study of the preservation benefits (including option, existence and bequest values) of intensively used forests in the state of Colorado, USA, including issues of decreasing quality. Values are calculated using CVM, and the results are tested for several possible influences or bias. The authors conclude that the general public in Colorado is willing to pay an average of US$47 per annum for the protection of forest quality, and that CVM can be used to estimate the effect of changes in forest quality on social welfare.

Empirical data: The basic data are obtained from a household survey designed to represent the resident population of Colorado, but no information is given in the paper.

Economic values considered: Direct use values (recreation), option values, non-use values (existence and bequest values).

Valuation techniques: CVM is used to value various forest benefits. A survey sample of approximately 1% of the population was drawn from the current telephone directory for Fort Collins and surrounding rural areas during the first quarter of 1983. Personal interviews were also conducted in the homes of a subsample of 198 households. The questionnaire included questions about individual preferences for forest quality and its importance relative to the quality of other resources, the recreational demand for environmental resources and socio-economic variables (income, education, age, vacation days per year, etc. per household). With this data, a demand function was estimated (WTP_{ij} per household i for forest quality j) using the following specification:

$$WTP_{ij} = B_0 + B_1 RES_k + B_2 USE_{ij} + B_3 SOCIO_{ij} + B_4 STRUC_{ij}$$

where RES_k represents the demand for each other (than forest quality) environmental resource k, USE_{ij} represents recreational use by household i of resource j, $SOCIO_{ij}$ are socio-economic variables and $STRUC_{ij}$ are categorical variables for alternative structures of the CVM procedure h (testing for possible influences or bias).

The results were tested in order to discover possible influences or bias due to the educational background of the interviewer, the starting point of the valuation, the incremental value of forest quality, the place of residence of the household and the presence of environmental substitutes. Where these influences were found to be significant (eg. educational background of the interviewer), the equation was adjusted and WTP was re-estimated.

The total annual WTP averaged US$47 per household with a 95% confidence interval of US$32 to US$62. Public (non-use) preservation values represented nearly three-quarters of total benefits, and their inclusion increased the benefit estimation more than three and one-half times the estimate for recreational use value alone. The authors also estimated total and marginal benefit equations (with and without public preservation benefits) using a quadratic function.

Finally, the results were compared to psychological preferences, which were estimated using both Thurston's method (paired comparisons) and the fractionisation method (scale of 0-100 points ranking the relative importance of each program). A high similarity was observed in the results (high importance of the public preservation benefits), although some differences between the psychological and economic measures remained (not described in the paper).

Comments: The paper presents several ways of testing and adjusting CVM results for the effects of possible biases or influences. The accuracy of the results is related to operational conditions:

"*Respondents who are asked about willingness to pay should understand the resource to be valued, have prior experience valuing it and choosing how much to consume under conditions of little uncertainty*" (p.177).

The main conclusion is that the general public is willing to pay for the protection of forest quality. However, this result may be influenced by the fact that the sample was restricted to the state of Colorado, which is recognised by the authors as a state characterised by intensive recreational use of its forests.

Key references: The paper is a companion piece to:

Walsh, R.G., Ward F.A. and J.P. Olienyk. 1989. "Recreation Demand Effects of Mountain Pine Beetle Damage to the Quality of Forest Recreation Resources in the Colorado Front Range" in *Journal of Environmental Management*, 28:255-268.