



An Operative Framework for Total Hicksian Income Measurement

Application to a Multiple-Use Forest

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Accepted 4 November 2002

Abstract. A methodology for estimating total hicksian income in multiple-use forests is presented. The approach consistently incorporates commercial as well as non-commercial economic values and enables the measurement of national accounting aggregates taking into account variation in man-made and natural capital. Innovative solutions are developed (i) for the estimation of non-market values, such as recreation, where an attempt to determine exchange values has been made simulating markets, (ii) for timber, where standing timber valuation methods have been extended to cover uneven stands, and (iii) for carbon fixation valuation, where only permanently fixed carbon after 1990 has been taken into account. The methodology is applied to a multiple-use pinewood in the Guadarrama mountains, near Madrid (Spain). Timber, cattle grazing, hunting, recreation, carbon fixation and conservation values are measured and integrated in the accounting system, using primary microeconomic data from the case study. Results indicate the importance of non-commercial income, which accounts for 51% of the total income, and the social relevance of the analysed forest, implying that only 31% of the total income generated is appropriated by the forest owner.

Key words: contingent valuation, exchange values, green national accounting, hicksian income

Abbreviations: in Appendix 1

JEL classification: Q23, E100

1. Introduction

The current system of national accounts (Eurostat 1996, 1997) measures the commercial income generated by a given forest based on the value of commercial extraction, net of intermediate and man-made fixed capital consumption. Therefore, it does not take into account differences experienced during the period by non-redeemable man-made capital and by natural capital. Nevertheless, an increasing interest in the depletion of natural resources has encouraged several international organizations to promote methodologies that account for differences

in capital (man-made or natural) during the accounting period (United Nations 1993; ISWGNA 1993; LGEA 2002).

The correct measurement of total income, taking into account capital variation, presupposes the use of the definition of income proposed¹ by Hicks (1946, pp. 172–173), and implies a considerable improvement over presently applied national accounting systems (Nordhaus and Kokkelenberg 1999, pp. 183–195). Precedents to this concept that are particularly relevant for the methodology presented here can be found in Fisher as early as 1906, since he pointed out that “The income from any instrument is thus the flow of services rendered by that instrument. The income of a community is the total flow of services from all of its instruments” (Aronsson, Johansson and Löfgren 1997, p. 95).

The methodology currently applied is the *Economic Accounts for Forestry* (EAF) system (Eurostat 1997), which does not consider variations in forest capital during the accounting period. However, the working group responsible for integrating environmental and economic accounts has proposed the *Integrated Environmental and Economic Accounting for Forests* (IEEAF) methodology (Eurostat 1999, 2000), which does integrate the forest capital balance, in accordance with ESA-95 (Eurostat 1996). In the same spirit, Campos (1999a) has developed a *System of Agroforest Accounting* (SAA) that enables the measurement of hicksian income with origin in an agroforest territory, provided that the different values to be included in the accounting system are known and homogeneous. Table I compares the three accounting systems described. It shows that the SAA system is more comprehensive in its inclusion of commercial and environmental benefits compared to the other two methods.

Theoretical literature has recommended the use of the Net National Product (NNP) (or Net Domestic Product (NDP)), a concept closely related to hicksian income. Weitzman (1976) established the theoretical foundation for its utilization and subsequent developments have extended the concept to cover natural resources (see, Dasgupta and Mäler (1999)). In this context, Vincent (1999) has proposed a theoretical framework for forest accounting, studying the concepts that should be included as well as those which should be excluded, and indicating the necessary inter-sectoral adjustments in order to avoid double-counting. Working on these precedents, this paper presents the formalization of the values to be included in the SAA system to ensure theoretical consistency, concentrating on the estimation of standing timber values, capital variations figures and non-commercial income. The proposed methodology is then applied to a mountainous forest area in central Spain using exclusively primary data.

A significant body of literature has focused on the measurement of different incomes associated with forests in recent years (Bergen 1998; Peyron 1998; Campos 1999b; Kristrom 1999; Merlo and Jöbstl 1999; Gutow and Schröder 2000; Haener and Adamowicz 2000). The accounting framework presented here improves the previous literature in two ways. First, it improves on the level of consistency among commercial and non-commercial outputs. Secondly, it enables

Table 1. Comparison of EAF, IEEAF and SAA systems*

Economic values**	SAA			
	IEEAF		Environmental goods (3)	Total (4) = (1)+(2)+(3)
	EAF Commercial goods (1)	Additional commercial goods (2)		
1. Total production (TP)	CTP	CGNG	ETP	TP
2. Intermediate consumption (IC)	CIC	CPPu	EIC	IC
3. Gross value added (GVA) (1-2)	CGVA	CGNG-CPPu	EGVA	GVA
4. Fixed capital consumption (FCC)	CFCC		EFCC	FCC
5. Net value added (NVA) (3-4)	CNVA	CGNG-CPPu	ENVA	NVA
6. Products in progress revaluation (PPr)		CPPr	EPPr	PPr
7. Fixed capital revaluation (FCr)		CFCr	EFCr	FCr
8. Capital destruction (Cd)		CPPd + CFCd	EPPd + EFCd	Cd
9. Social capital gain (SCG) (4+6+7-8)		CSCG	ESCG	SCG
10. Total social income (TSI) (5+9)	CNVA	CGNG - CPPu + CSCG	ENVA + ESCG	TSI

*EAF: Economic Accounts for Forestry (Eurostat 1997); IEEAF: Integrated Environmental and Economic Accounting for Forests (Eurostat 2000); SAA: System of Agroforest Accounting (Campos 1999a).

**In the two first columns a C has been added at the beginning of the acronyms to indicate 'commercial' and in the third column an E has been added standing for 'environmental'. Acronyms not defined above are: CGNG: commercial gross natural growth, CPPu: commercial products in progress used, PPD: products in progress destruction, FCD: fixed capital destruction.

Source: own elaboration.

integration of micro-economic data with national accounting figures. Nevertheless, the main objective of this research is to present an operative accounting methodology for measuring forest multiple-use total income.

This article is organized as follows. Section two presents the methodological approach used and is divided into four subsections: (i) the first discusses the implications of the results obtained by theoretical literature for applied forest accounting, and in particular for the methodology presented in this paper, (ii) the second presents a simplified version of the SAA system; (iii) the third analyses the values to be included in the system, (iv) and the fourth subsection describes the application. In section three applied results are shown, and finally in section four the main conclusions are highlighted.

2. Methodology

2.1. LINKING CONVENTIONAL NATIONAL ACCOUNTING AND THEORETICAL LITERATURE

National accounts contain two sets of accounts, current accounts (production sheet) and asset accounts (capital balances). Current accounts present information on monetary transactions related to the supply and use of goods and services, as well as the allocation of income from productive activities. Gross Domestic Product (GDP) is the main aggregate measure of economic activity within these accounts. Asset accounts (capital balances) present monetary information on stocks of productive assets, and on the changes in the values of these assets. Current accounts and asset accounts contain two common concepts: gross capital formation (gross investment) and consumption of fixed capital (depreciation). Subtracting the latter from GDP yields conventional Net Domestic Product (NDP).

The methodology presented below aims at incorporating non-market goods and services in this structure. In this heading, the relations of this methodology with existing theoretical literature on the extension of conventional NDP to incorporate environmental goods and services will be analysed (Hartwick 1990; Mäler 1991). The bottom line is that NDP should include *the value of the change* in resource stocks (valued by marginal net prices), but not the changes in stock values due to *variations in asset prices* (Hultkrantz 1992).

Vincent (1999) proposes a theoretical model to study the adjustments to make to conventional GDP and NDP. His model develops, for the forestry sector, the one proposed by Mäler (1991). The discussion will be done focusing on Vincent's model, since it is the best adapted to the forestry sector, but it could be done in similar terms with any of the more general models. According to Vincent (1999), adjustments to the NDP can be classified into two groups: (i) adjustments to the level of GDP and NDP, and (ii) inter-sectoral adjustments.

Vincent (1999) shows that the adjustments to the national aggregate figures to be done are:

$$\begin{aligned} \text{Adjusted NDP} = & \hspace{15em} (1) \\ & \text{Conventional GDP} + \textit{Non-market values to be added to GDP} - \\ & \text{Depreciation of man-made capital} + \textit{Net accumulation of natural capital} \end{aligned}$$

The adjustments (in italics) in the second line of equation (1) have to be done within the current accounts (production sheet) of the national accounts. The adjustments shown in the third line (in italics) have to be done in the asset accounts (capital balances) of the national accounts (note that: Conventional NDP = Conventional GDP – Depreciation of man-made capital).

Vincent (1999) shows further that the non-market values to be added to GDP can be classified in: (i) non-timber products (e.g., firewood) and (ii) forest amenities (defined narrowly, including only amenities totally independent from markets, such as existence values associated with biodiversity). The original setting of the optimal

control model used by Vincent is in terms of welfare units ('utils'). Nevertheless, market prices for non-timber goods are proposed as first option if at least some of the non-timber goods are purchased in a market. However, for forest amenities the whole discussion is made in terms of 'utils'.

As stated above, the adjustment proposed in the second line of equation (1) has to be done in the asset accounts (as it is the case in conventional national accounting for the "Depreciation of man-made capital"). In Vincent's model, the "Net accumulation of natural capital" is calculated by multiplying the variation in natural capital stocks (in physical terms) by the corresponding adjoint (costate) variables² (which can be interpreted as the shadow prices of the different natural capital stocks considered). The adjoint variables are then expressed in terms of future returns to the corresponding capital stock.

In order to incorporate this method in the context of conventional national accounting, this paper proposes to calculate the stock values in the capital balances (at the beginning and at the end of the accounting period) discounting future returns to the corresponding capital stock. In this way, the "Net accumulation of natural (and man-made) capital" obtained using the capital balances (see below), is equal to the figure that would be obtained adding up, for the different assets considered, the physical variations multiplied by the shadow price (discounted future returns).

Vincent (1999) derives alternative and more simplified methods to estimate the adjoint variables. For example, the marginal stumpage value (the marginal 'net price') is proposed as a proxy for the timber stock. Nevertheless, and as Vincent recognizes, this method provides only a good approximation if the age-class of the forest does not greatly affect the price of the asset. Since this is not usually the case (and is definitively not true in the case study here presented, since Scotch Pine price is highly dependent on the diameter-age), it is more accurate to project timber harvest and stumpage values for different age-classes into the future. Hence, in the methodology described below, stock values are always estimated discounting future returns (taking into account the age-structure of the forest).

In addition to the adjustments to the level of GDP and NDP discussed above, sectoral adjustments have to be done to incorporate the services provided between sectors. Going by Vincent's (1999) approach, this paper assumes that the forestry sector does not benefit from other sectors but that it provides services to other sectors (e.g., air pollutant deposits). Therefore, part of the value added generated in other sectors should be ascribed to the forestry sector.

The following paragraphs are devoted to describe the theoretical background of the treatment given to the different sources of income analysed in the empirical section.

Timber is included in conventional value added, but net accumulation of natural capital (unfelled timber) is not considered. The methodology presented in this paper estimates the value of the change in the resource stock (timber). This is consistent with the results obtained from theoretical models (see the discussion above). Nevertheless, growth has two effects in a forest where timber prices are

a function of diameter (ultimately age). The increase in volume during the year implies more tons of timber (what is incorporated in the production sheet) but also the revaluation of the stock existing at the beginning of the accounting period. The initial stock has increased its value since the 'quality' of the timber has changed due to the pass from one diameter class to the next (as a consequence of growth). This change in the value of the resource stock is not due to a change in the prices of the asset but on the 'quality' of the asset (and it is incorporated in the asset account). An alternative method would be to suppose that all the timber in the forest at the beginning of the accounting period is incorporated in the production process (as products in progress used) and that all the timber available at the end of the period is production of the period. This would avoid calling 'capital gain' a concept ultimately related to production, but would imply huge figures for total production and total costs, leaving them almost without economic sense (income would, nevertheless, not change). In theoretical literature, since timber prices are generally assumed independent of diameter, this issue is not analysed. On the contrary, since this paper assumes constant prices and a given set of expectations (see, Scott (1990)), the issue of capital gains due to asset price changes does not arise.

Hunting value added is treated as a non-timber product (service). Income associated with the production of pasture resources is considered as a service provided by the forest to other sectors (it should therefore be subtracted from the agricultural sector). The same can be said for carbon fixation, even though the sector from which this value should be subtracted is harder to determine. 'Conservation' income is treated as an amenity, using Vincent's terminology, due to its total independence of markets. However, value added associated with recreation receives a different treatment to that proposed by Vincent (1999). The service offered by the forest to other sectors (i.e., restaurants or hotels) is not measured (that is the value analysed by Vincent). On the contrary, it is assumed that a market value for these recreational services is obtained. Therefore, this form of income will be treated like all other non-timber products and services. The aim is not to analyse the influence of incorporating leisure (recreation) in the utility function of consumers (Mäler 1991), since this goes beyond the scope of this paper. The approach is just to treat the final product 'recreational service' as any other good or service generated by the forest. As Eisner (1988) suggests, this paper focuses on final products in order to estimate income.

Other features of the proposed methodology, in contrast to the more general and simplified model of Vincent (1999), are: (i) the carbon-fixation treatment, concentrated exclusively on the additional permanent fixation, and (ii) the treatment of labour, since Vincent (1999) assumes that only commercial products need labour for production, while this paper includes all types of labour (employees and self employed).

2.2. THE SAA ACCOUNTING SYSTEM

2.2.1. Overview

The SAA accounting system (Campos 1999a) organizes information in three different sheets (see Table II), enabling the estimation of hicksian income using the identities stated in the following paragraphs. As stated above, the SAA recovers the structure of national accounts to apply it at a micro scale (its generalized application would therefore facilitate aggregation; see, however, the discussion below). The *production sheet (PS)* incorporates all the economic flows related to the production process that occur during the accounting period. Capital variations are incorporated in two different balances: the *production in progress balance (PP)* and the *fixed capital balance (FC)*. The first balance incorporates variations in products that remain for more than one period in progress, and the second includes variations borne by fixed capital. The reason for distinguishing between the two capital balance sheets is the particular need in forests to account for goods that remain for longer than one period in the production process (timber).

The SAA methodology distinguishes between social and private insofar as the first does not take into account transfers: taxes and subsidies. This article concentrates on social income for three reasons: (i) valuation is done on a public basis, (ii) income from transfers is not generated in the forest, and (iii) analysis is *ex ante* agri-environmental regulation, in order to enable the development of this policy. Another relevant characteristic of the *social* income concept is that it sums up a variety of different incomes generated, irrespective of final beneficiaries: forestry owners, forest workers, stockbreeders, recreational visitors, hunters or the society as a whole.

2.2.2. National accounting aggregates at the micro scale

Total social income. The definition of income used in this article is as follow: *the total sustainable income of a forest is the monetary flow (real or simulated) generated in the period (one year) that, totally spent within the period, leaves the agent with the same stock of richness (forest capital) at the end of the period as he had at the beginning in real terms, in absence of new discoveries and net transfers from outside of the forest.*³ This is a definition of hicksian income (Hicks 1946, pp. 172–173), since it focuses on consumption and takes into account the variations in capital. Nevertheless, the relationships to fisherian income (the yield on society's capital) are also relevant (Aronsson, Johansson and Löfgren 1997, p. 95).

Total social income (*TSI*) of a given accounting period generated by a forest is estimated summing up net value added at market prices (*NVAmp*) – not including net operating subsidies or taxes – and capital gain (*SCG*): $TSI = NVAmp + SCG$.

Net value added at market prices. Net value added at market prices (*NVAmp*) is defined in national accounting systems as the aggregation of labour costs (*L*) and net operating margin (*NOM*): $NVAmp = L + NOM$. The production sheet (Table II.a) enables reckoning *NVAmp*, since it incorporates the necessary infor-

mation to estimate: (i) net operating margin, defined as the difference between total production (TP) and total cost (TC): $NOM = TP - TC$, (ii) as well as the labour cost generated (L).

Forest total production is classified in terms of intermediate production (IP) and final production (FP): $TP = IP + FP$ (intermediate production is not taken into account by national accounting in the current measurement of silviculture net value added (Eurostat 1997)). The economic costs of the production process are classified as: (i) intermediate consumption (IC), (ii) labour (L) and (iii) fixed capital consumption (FCC): $TC = IC + L + FCC$.

Social capital gain: Trees growth, herd growth and, in some cases, growth of agrarian crops, all require more than one accounting period to fulfil *in situ* production process, so that it is common in forests – especially with long rotation timber species – to have products in process of production (which can vary in value during the accounting period, even assuming constant prices; see discussion above). Apart from this, economic activity associated with forestry requires the use of fixed capital products, given by nature (land) or produced by man (machinery, infrastructure ...). Machinery and infrastructure are assumed to be perfectly divisible and constantly replaced.

Social capital gain (SCG) is estimated by summing capital revaluation (Cr) and fixed capital consumption⁴ (FCC), and deducting capital destruction (Cd): $SCG = Cr + FCC - Cd$. Capital revaluation and destruction can be referred to production in progress and to fixed capital ($Cr = PPr + FCr$; $Cd = PPd + FCd$). Capital revaluation is obtained from the products in progress balance (Table II.b; $PPr = PPf - PPi + PPs - PPe$) and from the fixed capital balance (Table II.c; $FCr = FCf - FCi + FCS - FCE$). Nevertheless, with the assumptions made,⁵ fixed capital revaluation equals fixed capital consumption (FCC) and implies no capital gain.

Social capital income. Social capital income (SCI) is defined as the sum of net operating margin and social capital gain ($SCI = NOM + SCG$), and indicates the income obtained by the capitalist owner. The difference with total social income is that labour is not included.

2.3. VALUES TO INCLUDE IN THE ACCOUNTING SYSTEM

2.3.1. The production sheet

The production sheet (Table II.a) incorporates costs and production generated during the accounting period. As shown in Table II.a the production sheet is divided into different sections, each one accounting for one of the activities considered.

Values obtained directly from markets. In the case study, timber represents the only genuine market value, since all remaining values are presently external to the market (this situation is common in forests).

The timber section of the production sheet (Table II.a) incorporates revenues and costs associated with timber production that have occurred during the

accounting period. Market prices are used and quantities of timber are directly observable, so that no great theoretical problems arise.

The production sheet is related with the products in progress balance (Table II.b) through the *final products stock (FST)*, which remain in the forest at the end of the accounting period, and through the *used products in progress (PPu)*, which indicate wood extracted from the forest and included in the production process as intermediate consumption from felling.

Values obtained by simulating markets. Pasture resources, game, recreational services, carbon fixation, and conservation all represent non-market goods and services in the case study. Markets have been simulated for all of them. Neither consumer surplus, nor any hicksian variation have been estimated, the aim has been to calculate the income (net operating margin and labour values) that would occur in a hypothetical market.

The aim of maintaining consistency between the estimation of income for commercial and non-commercial products is especially relevant if the interest is to compare the relative importance of the different incomes generated. Furthermore, the aggregate result obtained is an income figure.

In short, exchange values, and not use values have been estimated (Vanoli 1998, p. 363). This procedure is quite common in the central normative national accounts framework (ISWGNA 1993), where the use of prices from similar markets is proposed as the first criterion for cases where no market prices are observable. Hultkrantz (1992) uses this method for the estimation of values for several non-timber products only partially traded in markets in Sweden (see also, LGEA (2002, p. 8.50)).

In the methodology presented here, the procedure is extended to include cases where no similar market prices exist (i.e., recreational services). In principle, nothing distinguishes a service like recreation (presently outside the market since access is free, but which could be incorporated) from a non-timber product like berries in Sweden (presently outside of the market since picking is free, see, Hultkrantz (1992)). Nevertheless, since no market for the recreational services of forests exists it is necessary to simulate the market to determine what the price would be if the services were internalized. The first temptation is to use consumer surplus measurements (or any other welfare measure) provided by contingent valuation studies. However, this implies assuming that all the visitors pay their maximum willingness to pay (WTP) and this is too strong an assumption if the objective is to simulate a real market (see, LGEA (2002, p. 9.18)). Therefore, this paper assumes that the owner can only choose one price and that his revenues will be given according to demand. This paper further assumes that the forest-owner will set the price in order to maximize his revenues (assuming a linear demand function, this maximization will occur for the median, for the price half of the population is ready to pay). This provides an upper limit for the market revenue of the recreational services provided by the forests (costs still need to be deducted). A lower limit will be given by the costs of the services, assuming that

the owner sets the price in order to cover the costs⁶ with no margin (or with a given 'standard' margin). The former option implies a monopolistic solution assuming that no variable costs exist (the monopolist would maximize his benefit and with no variable costs this implies maximization of the revenues) and the latter option is a perfect market solution. The real market price would be in between, and in the particular case study considered, probably close to the monopoly solution, since the area studied is the only mountain resort close to Madrid and it is divided into few large estates.

The issue of the number of units consumed remains. The conventional procedure (Hultkrantz 1992) consists in multiplying the simulated market price by all the units consumed outside the market; thus, assuming that the setting of a price would not reduce consumption. This assumption is acceptable if the influence on the overall results is small (see hunting below). Nevertheless, establishing a price would obviously reduce the number of units consumed. Concretely, if the price for the recreational service were set equal to the median of the WTP, only 50% of current visitors would be ready to pay it.

As stated, the use of simulated market values is present in the central national accounts framework, but it is particularly relevant for the different proposals to develop them integrating environmental values (United Nations 1993) since modeling is unavoidable for this task (Vanoli 1998). Nevertheless, although this criterion permits greater consistency than the use of exchange values for commercial goods and services and welfare measures for non-commercial goods and services, it nevertheless suffers from the problems associated with all the extension of national accounts based on simulations. Transactions that actually do not exist are simulated, but the budget constraint is not actually affected. Even if the contingent valuation question is well understood and the respondents answer taking into account their budget constraint (the wording used recalls the budget constraint, see appendix 2), the accounts of the other sectors should all be modified to incorporate the new distribution of expenses the individuals would make if they needed to pay for recreation. However, the information needed for this task is not easy to obtain, since the contingent valuation study should not only recall the budget constraint and ask the individual what his expenditures in recreation would be, it should also ask which consumption (or savings) the respondents would reduce.

Therefore, the generalised application of the SAA methodology would enable the estimation of the 'true' hicksian income for the forestry sector, but the influence on the budget constraint should be incorporated to estimate the national NDP for all the sectors. However, this problem also applies if goods produced for own consumption are valued with market prices, as the central national accounting framework does or as previous studies (Hultkrantz 1992) have done for non-timber products. The new System of Environmental and Economic Accounts (LGEA 2002, pp. 8–50) also proposes to value non-timber goods produced for own consumption at market prices.

Acknowledging the limitations described, the proposed solution is considered to be an improvement compared to the alternative of excluding any value for recreational services (the only way to avoid the problems mentioned). On the other hand, estimating welfare measures for both commercial and non-commercial goods and services, in a cost-benefit analysis setting, diverges too much from the national accounting framework and is therefore not well suited for its enlargement.

2.3.2. Capital balances

Capital reflects the discounted stream of future net benefits to its owners. As expressed in the system of national accounts:

"The value of a fixed asset to its owner at any point of time is determined by the present value of future rentals (i.e., the sum of the discounted values of the stream of future rentals) that can be expected over its remaining service life. Consumption of fixed capital is therefore measured by the decrease, between the beginning and the end of the current accounting period, in the present value of the remaining sequence of rentals" (ISWGNA 1993, para. 6182).

In a simplified formal way capital (C) can be written as a function of the future capital incomes:

$$C = \int_0^{\infty} e^{-r(t-j)} (TCI_t + GCI_t + HCI_t + RCI_t + CaCI_t + CoCI_t) dt \quad (2)$$

Where, TCI: timber capital income, GCI: grazing capital income, HCI: hunting capital income, RCI: recreational capital income, CaCI: carbon capital income, CoCI: conservation capital income, j : the valuation year, and r : discount rate.

Estimating this value at the beginning and at the end of the period and calculating the difference is the same than multiplying the variation in capital stocks (in physical terms) by the corresponding adjoint (costate) variable (recall that the adjoint variable is expressed in terms of future returns to the corresponding capital stock, see above).

As mentioned above the capital balance is divided in the SAA system into two balances, the production in progress (PP) balance and the fixed capital (FC) balance, due to the relevance in forests of products in progress. Hence, we defined:

$$C = PP + FC \quad (3)$$

Products in progress balance. The only product in progress considered is standing timber (Table II.b). A complex silviculture is studied, which involves selective thinning and cutting where trees of different ages are simultaneously present. Standing timber is valued by the stream of future net returns associated with it. In general terms the value of the standing timber can be expressed as:

$$PP_j = \int_j^T p_{ht} q_{ht} e^{-r(t-j)} dt \quad (4)$$

where p_h is the standing price of harvested timber and q_h the quantity of timber harvested.

Nevertheless, in the forests analysed (and in most European forests) trees are cut selectively so that it is only possible to estimate that a tree (representing a diameter or age class) will be cut with a given probability in each one of the different diameters (ages) it will reach in the future. The proposed procedure is as follows. Historical extraction data is used to determine the probability – for each diameter class d – that existing timber will be cut in each of the i diameter classes that remain to reach ($i > d$). It should be noted that this is the conditional probability (π_{id}) that a given living tree of class d will be felled at class i ($i > d$; N_d is the number of classes d , arranging all classes from small to large).

$$\pi_{id} = Pr(i/d) = \frac{q_{hi}}{\sum_{j=N_d}^n q_{hj}} \quad (5)$$

The price for not felled standing timber (p_s) is, for each diameter class, the mathematical expectation formed with the prices that the timber will have at the future time of felling, consequently discounted (N is the total number of diameter classes, arranged by age; t_i is the average age of class i ; and t_d is the age of the present diameter class).

$$p_{sd} = E(p_h) = \sum_{i=N_d}^N p_{hi} \pi_{id} (1+r)^{-(t_i-t_d)} \quad (6)$$

Using the calculated not felled timber prices, products in progress are valued at the beginning (PP_i) and at the end (PP_f) of the accounting period, with the following expression (j indicates the moment of valuation):

$$PP_j = \sum_{i=1}^n p_{sij} q_{sij} \quad (7)$$

Used products in progress (PP_u), the timber extracted from the forest, is valued at the present market price for the different age classes (in the study case analysed PP_u is the only stock outlet, so that $PP_s = PP_u$):

$$PP_s = \sum_{i=1}^n p_{hi} q_{hi} \quad (8)$$

Natural gross commercial growth ($CGNG$) is valued (assuming extraction occurs at the end of the period) according to expression (9). This term multiplies (for each age class) growth which has occurred over the period by its price, taking into account whether new timber growth is felled in the same year or remains standing ($CGNG$ equals total stock entrance since the only production in progress considered is timber, $CGNG = PPe$):

$$ppe = \sum_{i=1}^n \left[g_{ci} p_s \frac{(g_{ci} - g_{chi})}{g_{ci}} + g_{ci} p_{hi} \frac{g_{chi}}{g_{ci}} \right] \quad (9)$$

Where g_c is annual commercial gross growth and g_{ch} the portion of this growth which is extracted in the same year. In the case of long-rotation species the latter parameter can be ignored, so that the expression simplifies to:

$$PPe = \sum_{i=1}^n g_{ci} p_{si} \quad (9.b)$$

Using the previously calculated values the revaluation of timber during the period is estimated as remainder: $PPr = PPf - PPi + PPs - PPe$ (see Table II.b).

Fixed capital balance. As previously indicated capital is separated into production in progress and fixed capital. Taking (2) and (3) together, fixed capital can be written:

$$FC = \int_j^\infty e^{-r(t-j)} (TCI_t + GCI_t + HCI_t + RCI_t + CaCI_t + CoCI_t) dt - PP \quad (10)$$

Since it is considered relevant to withdraw not only products in progress, but also the value of machinery (M) and infrastructure (IN) (they are supposed to be known and ascribed totally to timber), land value for timber (LT) has been defined as remnant:

$$LT = \int_j^\infty e^{-r(t-j)} TCI dt - PP - IN - M \quad (11)$$

This enables one to highlight the value of the infrastructure and of the machinery while capital assets are still calculated discounting future streams of returns.

Finally, fixed capital (Table II.c) can be written as follows (substituting (11) in (10) and rearranging):

$$FC = LT + \int_j^\infty e^{-r(t-j)} (GCI_t + HCI_t + RCI_t + CaCI_t + CoCI_t) dt + IN + M \quad (12)$$

2.4. DESCRIPTION OF THE APPLICATION

The *Cabeza de Hierro* Scotch Pine Forest is located in the *Guadarrama* mountain area, approximately 100 km north of Madrid, and recreation visits to this multiple-use forest are high. The *Cabeza de Hierro* pinewood has 1966 hectares. Analysed incomes have been:⁷ (i) timber, (ii) cattle grazing resources, (iii) hunting, (iv) recreational services, (v) carbon fixation, and (vi) conservation.

2.4.1. Model for timber and carbon fixation

A dynamic model has been developed to simulate timber growth. This model has also been used as the basis for estimating carbon dioxide sequestration. It can be written in a simplified form as:

$$X_t = AX_{t-1} + B \quad (13)$$

$X' = \{x_1, x_2, \dots, x_i, \dots, x_{17}\}$ is a state vector representing existing trees in each of the 17 diameter classes, A is the transition matrix shown below (11.b) and $B' = \{z_1 - e_1, -e_2, \dots, -e_i, \dots, -e_{17}\}$. Where z : recruitment, e : felled trees, k : the diameter class duration and m : dead trees not harvested.

$$A = \begin{bmatrix} -m_1 + \frac{k_1-1}{k_1} & 0 & \dots & \dots & 0 \\ \frac{1}{k_i} & -m_2 + \frac{k_2-1}{k_2} & 0 & \dots & 0 \\ 0 & \dots & 0 & \frac{1}{k_{i-1}} & -m_i + \frac{k_i-1}{k_i} & 0 & \dots & 0 \\ 0 & \dots & \dots & \dots & \dots & \frac{1}{k_{16}} & -m_{17} + \frac{k_{17}-1}{k_{17}} \end{bmatrix} \quad (13.b)$$

The initial number of trees of the different diameter classes is known through periodic inventories in the wood (the last inventory was done in 1997, they are full inventories with no statistical estimation). Historical extractions are also known with precision (in number of trees). The number of trees is related to volume through three functions estimated⁸ using historical data from the studied pinewood. Each function represents a stand of different quality (functions are subsequently weighted according to the existing proportion of hectares of each stand quality).

For timber estimation purposes, the model is solely used to ensure that actual future extractions, which are supposed to be constant (due to the protected area status of the forest), do not lead the pinewood to extinction. Since with the estimated parameters $\bar{X} = (I - A)^{-1}B \geq X_0$ holds, extraction can be considered sustainable and generated income hicksian. Assuming constant future timber extractions implies that part of the standing timber has no economic value due to environmental regulation, since only the amount necessary to assure sustainable extractions is valuable. Hence, the forest is in a steady state situation concerning commercial timber.

Costs and revenues associated with timber production have been obtained from the historical accountings of three estates (two public and one private land holdings, covering a considerable proportion of the total area of Scotch Pine in the *Guadarrama* region). Pre-eminence has been given to the data of the private forest (*Cabeza de Hierro* Scotch Pine Forest), since it is assumed that its management is more market oriented, so that data from the public-owned enterprises have been used solely for contrasting purposes. The figures shown correspond to the mean of the data for five years (1994–1998), at 1998 prices.

The model is also used to estimate carbon fixation. Different parameters are used to expand trunks biomass to overall carbon fixed (overall the procedure implies an expansion rate of 0,207 ton C/m³ of timber, see, Campos and Caparrós (1999)). The model is used to estimate, retroactively, the additional permanent fixation occurred since 1990. *Permanent carbon fixation* is the part of fixation that can be considered permanent since it will never be released again, with a given sivilculture (past and future) and a given decay rate for the different products (see, Campos and Caparrós (1999) for further details). This is the only sequestration equivalent to

a *no-emission*, and therefore suitable to be valued using data for emission reduction prices (the carbon price used is 20 €/ton C). The value estimated is a conservative value since 'temporal' sequestration might also have value, but the price should be different.

2.4.2. *Contingent valuation to estimate recreational services and conservation values*

Recreational and conservation values have been valued using contingent valuation surveys. In total, 971 pollster interviews were undertaken for the estimation of recreational and conservation benefits (for a full description of the contingent valuation study see, Caparrós and Campos (2002)).

Recreational benefits. Two different valuation questions were used, one based on an entrance fee (type I) and another (type II) suggesting an increase in petrol prices. Pilot studies of 91 open ended questionnaires of type I and 139 of type II were made to determine the bid values to offer respondents in the main dichotomous choice survey. In all, 221 double-bounded dichotomous choice questionnaires of type I and 520 of type II were completed. A high number of protest responses to type I, as well as opposition to the possibility of an entrance fee was detected (through a control question), so that the results of survey type II were preferred in favour of type I for purposes of aggregation. The concrete wording used can be found in appendix 2.

Having eliminated protest bids, logit and log-logit *censored regressions* (Cameron 1988) were estimated for dichotomous choice data using the information of the first answer solely (single-bounded), as well as *censored regressions* (Cameron and Quiggin 1994) using the information of both answers (double-bounded) and permitting that the first and the second answer correspond to different underlying valuation functions (bivariate normal).

Single-bounded logit and log-logit estimations gave very similar fits, so logit estimations were preferred due to easier direct interpretation. Double-bounded estimations were, for the median, almost equal to single-bounded estimations. Single-bounded results were preferred for simplicity. The mean-median⁹ is 14.12 euros per visit (the distribution is symmetrical) for the single bounded censored logit model finally used, and the confidence interval is (11.72, 16.53).

The value included in the accounting system was the result of multiplying the median by 50% of the visitors (since only 50% of the present visitors would accept to pay the median). Hence, the results of the contingent valuation study are used to estimate the demand function (not hicksian welfare measures), or, more precisely, a particular point of the demand function. As stated above this implies to maximize¹⁰ the revenues of the recreational services (or the final production). Present cleaning and management costs have been considered constant, and internalization with no additional variable costs has been assumed. This assumption is 'generous' in regard to capital income but not in regard to total income, since most of the neglected costs would be attributed to labour. In addition, although the internalization would

suppose additional costs they would be partially compensated by the decrease in cleaning cost associated with a reduction in visitors. Finally, the vigilance costs included are high enough to suppose that the wardens would be able to assure payment if put in charge of this task.

Given the wording used (see appendix 2), the estimated median has been reduced to incorporate the influence of visits to other areas during the trip. The methodology followed has been to apply the method that supposes a bigger reduction from the following: (i) estimate the function only with respondents that did not visit other areas, (ii) reduce value estimates for the overall sample by the percentage resulting from the subjective valuation done by the visitors of the importance of the study area in their decision to undertake the trip (valuation from 1 to 5). The valuation of the journey itself has been taken into account assuming that the visitors that confirmed that they valued the trip, or part of it, valued the time spent on the journey as equivalent to the time spent in the study area. The value finally used for the median is 12.24 euros per visit.

Conservation. The estimated conservation value consists of an aggregate of option and existence values. The wording used in the open-ended question can be found in appendix 2. Altogether 568 questionnaires were undertaken to determine willingness to pay (WTP) for conservation. This number was reduced to 453 since the rest of the questionnaires did not include the reminder of other places potentially valued by the visitor, in order to test the influence of this reminder on WTP. The estimated mean¹¹ was 24.51 euros per year (20.01, 29.01) and the median 12.02 euros per year.

The value used for aggregation is the median multiplied by all the distinct¹² visitors which indicated they were prepared to pay for the conservation of the area. This criterion differs from the method proposed in the last section, but the payment vehicle used (a voluntary fund) permits each individual to pay his maximum WTP. In fact, it even enables the use of the mean for aggregation, but the prudence principle (since mean is usually bigger than median), as well as greater dependence of mean to assumed distribution in parametric estimations, advised using the median. This conservative measure might reduce the effect of potential double accounting if respondents do include their future recreation in the 'conservation' value (the question used tries to minimize this effect, but the difficulty of this separation is acknowledged).¹³

2.4.3. *Other simulated markets: game and cattle-grazing resources*

Two markets, which at present do not exist in the study area, have not yet been presented: game and cattle grazing resources. In both cases values have been estimated using actual use data and prices from similar markets outside of the study area.

Present game activity is concentrated on roe deer and wild boar. Quantities captured could be determined and prices were taken from commercial hunting in relatively similar area (Horcajada 1999).

For cattle-grazing resources, the aim is to value the quantity freely grazed by the livestock. The method used was as follows. First, maximum compatible livestock was estimated (currently an over-exploitation situation exist, but this has not been considered since it is expected to change in the near future and since it was not possible to estimate the associated timber value decrease). Secondly, the quantity grazed was estimated deducting the quantity fattened from total theoretical requirements of the livestock (Martín et al. 1987). Finally, the number of alimentation units was multiplied by market prices of similar areas (0.084 euros/alimentation unit)¹⁴ to estimate the value of consumed grazing resources.

3. Results

In this section empirical findings will be shown, focusing on the results for the whole system. Table II presents: a) the production sheet, b) the product in progress balance and c) the final capital balance.

Capital income is formed adding the net operating margin (NOM; see Table II.a) and the capital gain. Nevertheless, the only capital gain considered is product in progress revaluation, so that, except for timber, capital income (CI) is equal to the NOM. For timber, capital gain is given by the revaluation of the products in progress (PPr; see Table II.b) and is due to the change in the 'quality' of timber described in the theoretical section ($TCI = NOM(\text{timber}) + PPr$). The negative revaluation of 8 euros in Table II.c is the fixed capital consumption of Table II.a (it appears only to avoid double accounting and does not imply capital gain).

The values for capital (Table II, (b) and (c)), are calculated discounting future returns at a 2% discount rate. For grazing, hunting, recreation and conservation, the values for FCi (and FCf) can be obtained dividing the NOM by the discount rate (since the future stream of rental is assumed to be constant). For timber, extractions are also assumed to be constant in the future (due to the protected status of the area). Therefore, timber capital income ($TCI = NOM(\text{timber}) + PPr$) divided by the discount rate equals the sum of $PPi + LTi + INi + Mi$ (recall that LT is the value of the land for timber and that the infrastructure (IN) and the machinery (M) are totally ascribed to timber). In addition, and since expectations are assumed constant: $PPi = PPf$, or $PPi + LTi + INi + Mi = PPf + LTf + LNf + Mf$.

However, for carbon sequestration the future stream of rentals is not constant (hence, FCi for carbon sequestration cannot be calculated directly dividing NOM for carbon by the discount rate). The dynamic model developed to simulate the biomass evolution shows that the present extraction, constantly maintained in the future, implies an increase in the biomass in the forest. Since the continuation of the current extractions will lead to a steady state with more biomass, the increase in carbon sequestration is permanent, and can be evaluated using prices for avoided emissions. Therefore, a gross internal investment (GII) appears in the production sheet (Table II.a) in the column for carbon sequestration (7 euros) and the same concept can be found in the fixed capital balance (Table II.c).

Table II. The System of Agroforest Accounts (SAA) for the *Cabeza de Hierro* Scotch Pine Forest (1998 euros per hectare)

Table II.a Production sheet

Class	Timber	Cattle-grazing	Hunting	Recreation	Carbon	Conservation	Total
1. Total production (<i>TP</i>)	382	12	3	178	7	33	615
1.1 Intermediate production (<i>IP</i>)							
1.2 Final production (<i>FP</i>)	282	12	3	178	7	33	615
1.2.1 Gross internal investment (<i>GII</i>)					7		7
1.2.2 Final sales (<i>FS</i>)	235	12	3				250
1.2.3 Final stock (<i>FST</i>)	147						147
1.2.4 Other final productions (<i>OFPP</i>)				178		33	211
2. Total cost (<i>TC</i>)	314	2	0*	32	1	5	354
2.1 Intermediate consumption (<i>IC</i>)	255	1	0	25	1	3	286
2.1.1 Raw materials (<i>RM</i>)	4						4
2.1.2 Services (<i>SS</i>)	58	1	0	25	1	3	89
2.1.3 Products in process used (<i>PPU</i>)	193						193
2.2 Labour (<i>L</i>)	52	0	0	7	0	1	61
2.3 Fixed capital consumption (<i>FCC</i>)	8						8
Net operating margin ($NOM = TP - TC$)	67	11	3	147	6	28	261

Table II. Continued

Table II.b Products in progress balance

Class	Initial stock (<i>PPi</i>)	Stock entrance			Stock exist			Final stock (<i>PPf</i>)	Revaluation (<i>PPr</i>)
		Bought (<i>PPb</i>)	Own (<i>PPo</i>)	Others (<i>PPot</i>)	Total (<i>PPe</i>)	Used (<i>PPu</i>)	Extraordinary destruction (<i>PPd</i>)	Others (<i>PPst</i>)	Total (<i>PPs</i>)
Timber	6434		147		147	193		193	46

Table II.c Fixed capital balance

Class	Land						Man-made capital		
	Timber (<i>LT</i>)	Grazing	Hunting	Recreation	Carbon	Conservation	Infrastructure (<i>IN</i>)	Machinery (<i>M</i>)	Total
1. Initial fixed capital (<i>FCi</i>)	31	613	126	8506	67	1420	10763	241	11072
2. Fixed capital entrance** (<i>FCe</i>)					7		7	0	14
3. Fixed capital exit*** (<i>FCs</i>)									
4. Final fixed capital (<i>FCf</i>)	31	613	126	8506	74	1420	10770	241	11079
Revaluation (<i>FCr</i>)							-0	-7	-8

Source: own elaboration.

*0 stays for quantities smaller than 0.5.

Includes gross investment (*GI*).*Includes fixed capital destruction (*FCd*).

Discount rate: 2%.

Table III. Capital and total income in *Cabeza de Hierro* Scotch Pine Forest

	Capital income			Total income		
	€/ha	%	% acum.	€/ha	%	% acum.
Timber	113	37	37	165	45	45
Cattle grazing	11	3	40	11	3	48
Hunting	3	1	41	3	1	49
Recreation	147	48	89	153	42	90
Carbon	6	2	91	6	2	92
Conservation	28	9	100	30	8	100
Total	307	100		367	100	

Source: own elaboration.

Capital and total income for the different activities considered in the analysed forest can be found in Table III. Results show that timber and recreation are, by far, the most relevant activities in the forest. Nevertheless, recreational capital income (or margin) would be reduced to approximately 6 euros per hectare if the value would be estimated based on the supply side (assuming a 20% margin on total costs). The recreational total income would be 13 euros per hectare.

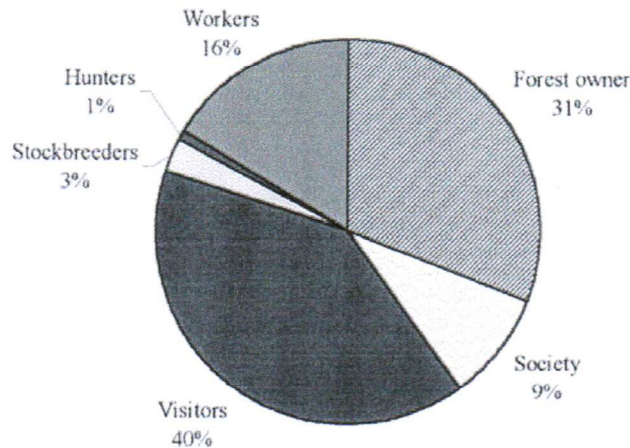
Since the present system of national accounts (SNA) only attributes timber income to forests,¹⁵ 55% of generated total income is not ascribed by the SNA to forest ecosystems. Of this 55%, approximately 6% is measured in other sectors (as indicated before, the 4% of game and cattle grazing resources is incorporated in the agricultural sector, and the 2% of carbon fixation is theoretically also incorporated in other sectors) while the remaining 50% is not measured at all.

Figure 1 shows the present distribution of the generated income among different agents. Income associated with carbon fixation and conservation has been attributed to *society*. This implies a considerable under-valuation of the benefits received by society as a whole, since the conservation value has only been measured for visitors, being therefore only the value appropriated by visitors as part of society (i.e., the conservation value for non-visitors has not been estimated).

Results show that visitors receive the biggest share of the total income (40%), even though their 'conservation value' has been attributed to society. Somewhat surprisingly, the forest owner receives a lower income share, approximately 10% less (31%).

4. Conclusion

A methodology capable of measuring different incomes for a natural area in a theoretically consistent manner has been presented. This methodology is useful for the estimation of forest national accounting aggregates and it is therefore



Source: own elaboration.

Figure 1. Present beneficiaries of total income in Cabeza de Hierro Scotch Pine Forest.

appropriate to link it to the existing system of national accounts. Nevertheless, the estimated aggregate magnitudes are based on simulations and transactions which actually do not exist are included in the accounts. Hence, and especially if the simulated expenditures are relevant, the income figures obtained could only be added to the income figures of other sectors if the changes in consumption of the individuals due to the simulated expenditures (and the budget constraint) are taken into account. As discussed above, this would require a large amount of information.

Therefore, the utility of the methodology presented is mainly sectoral. However, its generalized application would provide the 'true' income generated by forest, aggregating commercial and non-commercial goods and services in a national accounting framework with consistent market-oriented values for both types of goods and services. Its application would also provide a useful tool for land management, since the income generated by the different land uses could be identified.

Through an application to a multiple-use forest the viability of this methodology, at least at a micro scale, has been shown. Empirical results indicate the relevance of non-commercial income in the case studied. It is fair to state that the studied forest is an extreme case, since it is almost a peri-urban forest with a substantial number of visitors (100 km from Madrid). Nevertheless, the order of magnitude of the income neglected by current systems of national accounts is high, approximately 50%. This shows the need to reform applied accounting methodologies, at least in countries (like most Europeans) where non-commercial use of forests (notably recreation) is relevant. Moreover, since most of this neglected income corresponds to non-market goods and services it would be important to

include these values in the new version of the national accounts for forests currently under preparation by Eurostat (1999, 2000); and in the System of Environmental and Economic Accounts of the London Group on Environmental Accounting (2002). The methodology proposed in this paper to simulate exchange values could be used to value these goods and services in a consistent manner with the market data accounted in the System of National Accounts.

Another interesting conclusion is the social nature of the analysed forest, implying that only 31% of the estimated total income is appropriated by the forest owner. This distribution is caused by actual property rights, more than by legal property rules. Important questions of distribution remain as to whether the existing situation should be maintained, whether the situation should be reversed in favour of private landowners, or whether forest owners should be compensated. Although these issues are not studied here directly, the study findings may aid in discussions over such questions.

Acknowledgements

This paper received financial support from the CICYT (AMB99-1161), the S.A. *Belga de los Pinares del Paular* and the European Commission (EEP-RTN). Authors are grateful to two anonymous referees and to participants to the EAERE-2001 Conference for useful comments.

Notes

1. Previously, Lindahl (1933) proposed a similar concept.
2. The same method is used for man-made capital.
3. The last refinement introduced brings the concept closer to theoretical Net Domestic Product (NDP) instead of Net National Product (NNP), although the original concept (Hicks 1946) is closer to NNP.
4. This procedure avoids double-counting, since FCC has been discounted once in terms of costs and once, implicitly, through fixed capital revaluation.
5. Given set of expectations, constant prices, constant future timber extractions, and machinery and infrastructure perfectly divisible and constantly replaced.
6. Since costs are assumed to be constant, marginal and average costs are equal.
7. Other potential values like mushroom gathering, erosion control, etc. have not been estimated due to lack of data and not included due to the fact that only primary data have been used.
8. R^2 for the three functions are respectively: 0.993, 0.977 and 0.996.
9. The original result was in pesetas, with a standard error of 204.4584 and a t- ratio of 11.4952.
10. With the preferred estimated demand curve (single-bounded, logit censored regression) maximization occurs with the price accepted by 55% of the population. For simplicity, the median (50%) is used.
11. The original result was in pesetas, with a standard error of 6735.
12. Distinct visitors were determined dividing total visits by mean number of visits per individual and year.
13. However, if the valuation question was well understood, the WTP should be referred only to an additional premium for maintaining in the future the present quality (including recreational

- quality), and, if the natural resources provision does not change in the future, this premium should be maintained indefinitely, apart from the future stream of actual recreational use.
14. Defined in INRA (1978).
 15. In the case study, where a steady state for commercial timber exists, since even though timber volume increases future extraction is supposed to be constant, income estimated considering present extractions equals income estimated through commercial growth.

References

- Aronsson, T., P.-O. Johansson and K.-G. Löfgren (1997), *Welfare Measurement, Sustainability and Green National Accounting: A Growth Theoretical Approach*. Cheltenham: Edward Elgar.
- Bergen, V. (1998), 'Forestry as Part of National Accounts', in Institut National de la Recherche Agonomique (INRA), ed., *Accounting and Managerial Economics for Environmentally-Friendly Forestry. Actes et Communications n° 15*. Versailles: INRA.
- Cameron, T. A. (1988), 'A New Paradigm for Valuing Non-market Goods Using Referendum Data: Maximum Likelihood Estimation by Censored Logistic Regression', *Journal of Environmental Economics and Management* **15**, 355–379.
- Cameron, T. A. and J. Quiggin (1994), 'Estimation Using Contingent Valuation Data from a "Dichotomous Choice with Follow-Up" Questionnaire', *Journal of Environmental Economics and Management* **27**, 218–234.
- Campos, P. (1999a), 'Un sistema de cuentas microeconómicas del uso múltiple de un espacio natural de interés ambiental', in J. M. Casado and D. Azqueta, eds., *Lecturas de economía y medio ambiente*. Madrid: Consejo de Colegios de Economistas de España.
- Campos, P. (1999b), 'Hacia la medición de la renta de bienestar del uso múltiple de un bosque', *Investigación Agraria: Sistemas y Recursos Forestales* **2**, 407–422.
- Campos, P. and A. Caparrós (1999), 'Análisis económico de la fijación de carbono por el pino silvestre', in F. Hernández, ed., *El Calentamiento Global en España: un análisis de sus efectos económicos y ambientales*. Madrid: CSIC.
- Caparrós, A. and P. Campos (2002, forthcoming), 'Valoración de los usos recreativo y paisajístico en los pinares de la sierra de Guadarrama', *Revista Española de Estudios Agrosociales y Pesqueros* **195**, 121–146.
- Dasgupta, P. and K. G. Mäler (1999), *Net National Product and Social Well-Being*, Working Paper 125. Stockholm: Beijer International Institute of Ecological Economics.
- Eisner, R. (1988), 'Extended Accounts for National Income and Product', *Journal of Economic Literature* **26**, 1611–1684.
- Eurostat (1996), *European System of Accounts: ESA-95*. Brussels – Luxembourg: ECSC-EC-EAEC.
- Eurostat (1997), *Manual on Economic Accounts for Agriculture and Forestry (Rev. 1)*. Luxembourg: European Communities.
- Eurostat (1999), *The European Framework for Integrated Environmental and Economic Accounting for Forests: Results of Pilot Applications*. Luxembourg: European Communities.
- Eurostat (2000), *The European Framework for Integrated Environmental and Economic Accounting for Forests (IEEAF)*. Luxembourg: European Communities.
- Gutow, S. and H. Schröder (2000), *Die Forstwirtschaft im Volkswirtschaftlichen Rechnungswesen*. Frankfurt: Sauerländer Verlag.
- Haener, M. K. and W. L. Adamowicz (2000), 'Regional Forest Resource Accounting: A Northern Alberta Case Study', *Canadian Journal of Forest Research* **30**, 264–273.
- Hartwick, J. M. (1990), 'Natural Resources, National Accounting and Economic Depreciation', *Journal of Public Economics* **43**, 291–304.
- Hicks, J. (1946), *Value and capital (second edition)*. Oxford: Oxford University Press.

- Horcajada, F. (1999), *Ordenación cinegética en el Valle de El Páular. Memoria 2: diseño de los aprovechamientos en la zona de caza controlada. Las batidas*. Madrid: Parque Natural de Pañalara.
- Hultkrantz, L. (1992), 'National Account of Timber and Forest Environmental Services in Sweden', *Environmental and Resource Economics* 2: 283–305.
- Institut National de La Recherche Agronomique (INRA) (1978), *Alimentation des Ruminants*. Versailles: INRA.
- Inter-Secretariat Working Group on National Accounts (ISWGNA) (1993), *System of National Account 1993*. Brussels/Luxembourg, New York, Paris, Washington: EC, IMF, OECD, UN and WB.
- Kriström, B. (1999), 'On the Incorporation of Non-market Outputs of Forests into National Accounting Systems', in C. S. Roper and A. Park, eds., *The Living Forest: Non-market Benefits of Forestry*. London: The Stationary Office.
- Lindahl, E. (1933), 'The Concept of Income', in C. Bagge, ed., *Economic Essays in Honour of Gustav Cassel*. London: George Allen and Unwin.
- London Group on Environmental Accounting (LGEA) (2002), *System of Environmental and Economic Accounts (SEEA 2000 – Draft for Statistical Commission 2002)*. Available at: www4.statcan.ca/citygrp/london/publicrev/pubrev.htm (May 2002).
- Mäler, K. G. (1991), 'National Accounts and Environmental Resources', *Environmental and Resource Economics* 1, 1–15.
- Martín, M., M. Espejo, J. Plaza and T. López (1987), 'Cálculo de la carga ganadera en la dehesa', in P. Campos and M. Martín, eds., *Conservación y desarrollo de las dehesas portuguesas y española*. Madrid: Ministerio de Agricultura, Pesca y Alimentación.
- Merlo, M. and H. Jöbstl (1999), 'Incorporating Non-market Values into the Accounting Systems of Publicly and Privately-owned Forest Enterprises: An Operative Stepwise Approach', in C. S. Roper and A. Park, eds., *The Living Forest: Non-market Benefits of Forestry*. London: The Stationary Office.
- Nordhaus, W. D. and E. C. Kokkelenberg, eds. (1999), *Nature's Numbers: Expanding the National Economic Accounts to Include the Environment*. Washington, D.C.: National Academic Press.
- Peyron, J. L. (1998), *Élaboration d'un système de comptes économiques articulés de la forêt au niveau national*. Nancy: ENGREF.
- Scott, M. (1990), 'Extended Accounts for National Income and Product: A Comment', *Journal of Economic Literature* 38, 1172–1186.
- United Nations (1993), *Integrated Environmental and Economic Accounting*. New York: United Nations.
- Vanoli, A. (1998), 'Modelling and Accounting Work in National and Environmental Accounts', in K. Uno and P. Bartelmus, eds., *Environmental Accounting in Theory and in Practice*. Dordrecht: Kluwer Academic Publishers.
- Vincent, J. R. (1999), 'A Framework for Forest Accounting', *Forest Science* 45(4), 552–561.
- Weitzman, M. L. (1976), 'On the Welfare Significance of National Product in a Dynamic Economy', *Quarterly Journal of Economics* 90, 156–162.

Appendix 1: Abbreviations used

<i>A</i>	Transition matrix	<i>NOM</i>	Net operating margin
<i>B</i>	Felling-recruitment vector	<i>NVAmp</i>	Net value added (at market prices)
<i>CaCI</i>	Carbon capital income	<i>PP</i>	Products in progress
<i>Cd</i>	Capital destruction	<i>PPd</i>	Products in progress destruction
<i>CGNG</i>	Commercial gross natural growth	<i>PPe</i>	Products in progress entrance
<i>CoCI</i>	Conservation capital income	<i>PPf</i>	Products in progress final stock
<i>Cr</i>	Capital revaluation	<i>PPi</i>	Products in progress initial stock
<i>d</i>	Diameter class	<i>PPr</i>	Products in progress revaluation
<i>e</i>	Felled trees	<i>PPs</i>	Products in progress exit
<i>FCC</i>	Fixed capital consumption	<i>p_h</i>	Standing price of harvested timber
<i>FCd</i>	Fixed capital destruction	<i>p_s</i>	Standing price of not harvested timber
<i>FCE</i>	Fixed capital entrance	<i>q_h</i>	Quantity of timber harvested
<i>FCf</i>	Fixed capital final stock	<i>q_s</i>	Quantity of standing timber
<i>FCi</i>	Fixed capital initial stock	<i>r</i>	Discount rate
<i>FCr</i>	Fixed capital revaluation	<i>RCI</i>	Recreational capital income
<i>FCs</i>	Fixed capital exit	<i>SCG</i>	Social capital gain
<i>g_c</i>	Commercial growth	<i>SCI</i>	Social capital income
<i>g_{ch}</i>	Commercial growth harvested	<i>t</i>	Time
<i>GCI</i>	Grazing capital income	<i>TC</i>	Total cost
<i>GVA</i>	Gross value added	<i>TCI</i>	Timber capital income
<i>HCI</i>	Hunting capital income	<i>t_d</i>	Age of diameter class d
<i>i</i>	Diameter class counter	<i>t_i</i>	Age of timber harvested at class i
<i>I</i>	Identity matrix	<i>TP</i>	Total production
<i>IC</i>	Intermediate consumption	<i>TSI</i>	Total social income
<i>j</i>	Valuation moment	<i>X</i>	Existing trees vector
<i>k</i>	Diameter class duration	<i>z</i>	Recruitment
<i>L</i>	Labour	<i>π</i>	Conditional probability of felling
<i>m</i>	Dead trees not harvested		

Source: own elaboration.

Appendix 2: Contingent valuation questions wording

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- Dichotomous questions for recreation:
 [As you know **trip costs** have changed in the last decades (i.e., gas prices have gone up and down). Now we are going to ask you to imagine that **total expenditures** of your visit increase for this reason, even though you realize exactly the same activity you have done (same transport, same food ...)]
10. If the **PER PERSON total expenditures of your visit** would have been pta more than the quantity you have just calculated, would you still have come today? Please take into account that we are asking you to imagine a real payment and that you could not spend the money in alternative uses.
☐ yes (*ques. 11*) ☐ no (*ques. 12*) ☐ don't know (*ques. 15*)
 11. *if yes:* And if the increase in total personal expenditures would have been pta, would you still have come today? (*ques. 13*)
 12. *if no:* And if the increase in total personal expenditures would have been pta, would you still have come today?
- Questions for conservation:
50. Do you think that conservation of nature is a priority in Spain?
☐ yes ☐ no
 51. Would you agree to contribute economically to improve environmental politics in Spain?
☐ yes ☐ no
- [Apart from the recreational use you have made, the *Peñalara Natural Park* and the *Area of Special Protection for Birds* that surrounds it, covers other environmental functions, as protecting wild animals and plants]
52. Would you agree to contribute economically to a fund dedicated exclusively to the conservation of this natural area?
☐ yes ☐ no (*ask reason and go to 54*)
 53. What would be the highest annual amount you would agree to spend? (*please remember that this is only one of the natural areas you could be interested in protecting*)
 pta /year
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