Linking standard Economic Account for Forestry and ecosystem accounting:
Total forest incomes and environmental assets in publicly-owned conifer farms in Andalusia-Spain

Pablo Campos a, Alejandro Álvarez a, Bruno Mesa a, José L. Oviedo b, *, Alejandro Caparrós a

a Spanish National Research Council (CSIC), Institute for Public Goods and Policies (IPP), Spain
b Spanish National Research Council (CSIC), Institute of Marine Sciences of Andalusia (ICMAN), Spain

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ABSTRACT

A major problem faced by government as trustee of society charged with conserving the nation’s forest environmental asset is that the standard Economic Account for Forestry (EAF) fails to measure the contribution of nature to total forest incomes and environmental assets. In the context of this government mission, the debate arises with regard to how to uncover the contribution of nature to the total forest incomes enjoyed by people through a refined accounting framework which extends the EAF. The latter is applied by the statistics office to estimate the values added of timber, firewood, cork, resin, industrial nut and other non-woody final products of the forest at national/sub-national scale. Bearing in mind this narrow scope of the EAF, this research proposes the application of the experimental Agroforestry Accounting System (AAS), which extends the forest incomes and environmental asset estimates by applying simulated exchange values stated/revealed by consumers for non-market public goods and services. We apply the EAF and AAS frameworks to 12 large publicly-owned protected conifer forest farms which are not available for sale on the competitive land market and which cover an area of 47,262 ha in Andalusia-Spain. In this conifer farm case study, the EAF considers the economic activities of timber, firewood, aromatic plants and residential service. The AAS adds to the EAF activities those of grazing, conservation forestry, hunting, livestock, agricultural crops, livestock-keeper private amenity, fire services, free access recreation, mushrooms, carbon, landscape conservation, threatened wild biodiversity and water supply runoff stored lower down the watershed in public reservoirs. The objectives of this conifer farm case study are, first, to compare the final products and incomes estimated by applying the EAF and AAS frameworks and, second, to measure the sensitivity of conifer farm environmental assets to changes in land ownership rights and discounting rates in accordance with the AAS results. The conifer farm results show total income measured by the AAS is 38 times higher than the EAF net value added (NVA) for the 2010 period. The AAS economic activities of forestry conservation, fire services and landscape conservation activities generate 71% of the conifer farm labour compensation. The AAS opening environmental asset measured at the assumed competitive real baseline discounting rate of 3% is 6371.6 €/ha, which is 3.7 times lower than it would be if the conifer farm was available for sale on the competitive land market. The change in the baseline discounting rate chosen, from 3% to 1.5%, would lead to an increase of 116% in the value of the opening environmental asset. The above results reveal the inconsistent EAF measurement of total conifer farm incomes. The sensitivity analysis underlines the important effects on the environmental asset arising from changes in land ownership rights and discounting rates.

1. Introduction

More than 70 years after its implementation, we note that the standard Economic Account for Forestry (EAF) still hides or omits the contribution of nature to the net value added (NVA) of products with and without market prices, respectively, from forest-based natural economic activities managed by farmer and government. Although the United Nations Statistics Division (UNSD) acknowledges scientific
advances in the statistical principles for valuation of ecosystem services and environmental assets, a standard manual on economic accounts of forest environmental flows and stocks has not yet been agreed (UNSD, 2021).

This research addresses the challenge of standardising forest economic-environmental accounts by extending the standard EAF. This extension is based on the valuation of final products consumed according to their transaction prices observed in formal markets or simulated markets for products without market prices. In addition, new economic activities are incorporated, intermediate products are recorded and total income is measured by adding capital gains to net value added (Eisner, 1989; European Communities, 2000; Hicks, 1946; Krutilla, 1967; NRC, 1999; McElroy, 1976). Our Agroforestry Accounting System (AAS) can be seen as an experimentally extended EAF representing the forest accounts of society (Campos et al., 2019a, 2019b, 2020; Caparrós et al., 2003, 2017; Oviedo et al., 2017). A brief qualitative comparison description of AAS and EAF is presented in Supplementary text S1.

We apply the AAS to a case study of 12 large publicly-owned protected conifer forest farms (henceforth conifer farms). The predominant species in the average conifer farm are Pinus halepensis Mill., Pinus nigra Arn., Pinus pinaster Ait. and Pinus sylvestris L., covering an area of 47,262 ha in Andalusia-Spain. We apply the EAF to four and the AAS to 17 individual economic activities valued in the conifer farms (see details in Supplementary texts S2–S3). There is relatively little extraction of pasture grazed by livestock, which continue to be reared by family livestock-keepers (see supplementary text S2: Tables ST1–ST2). This is explained by the canopy cover fraction of 51.5% in the pine-tree covered area and the location of the farms in upland areas at the head of the watersheds, with poor soils and steep slopes (see Supplementary text S2: Figs. ST1–ST2).

Government involvement in the management of these conifer farms includes both direct management of public activities and indirect intervention through policy regulations and economic compensations to farmers. The land and livestock farmers manage ten private economic activities: timber, firewood, grazing, conservation forestry, hunting, aromatic plants, residential services, livestock, agricultural crops and amenity service auto-consumption. The government is the collective owner of seven public economic activities: fire services, recreation services, mushrooms, carbon, landscape conservation, threatened wild biodiversity preservation and runoff water supply.

Farmer and government management regimes on these conifer farms are aimed at conserving the multiple traditional and emergent economic uses. This is done by planning the complete rotations or cycles of harvesting and natural growth of multi-period animal and plant products (e.g., timber, firewood and big game species), while also assuring sustainability in the consumption of products with a single production period (e.g., acorns, grass, browse and other wild fruit grazing).

A first objective of this conifer farm research is to estimate and compare the incomes estimated by applying the EAF and AAS frameworks. A second objective is to estimate the sensitivity of the environmental assets arising from simulated changes in the land ownership rights and assumed baseline discount rates under the AAS.

The main innovation of this AAS application to conifer farms is the comparison of environmental asset values under the assumption of changes in land ownership buying/selling rights. The change in ownership rights, making the conifer farm unavailable for sale, implies that the landowners lose the amenity auto-consumption and amenity environmental asset values.

The remainder of this article is organized as follows: Section 2 presents a brief review of selected literature on European forest trends and final products of Mediterranean forests under the EAF according to statistics offices. Section 3 discusses key features of our conceptual extension of the EAF by the experimental AAS. Section 4 describes the economic results of the conifer farms for the 2010 period according the objectives of this research. Section 5 discusses the significance of the differences between the results of the accounting frameworks applied, and policy implications of implementing the UNSD recommended valuation principles of economic ecosystem accounting. Section 6 highlights the main economic accounting innovations of the AAS and pending policy challenges with regard to agreeing future standard total income accounts for forest.

2. Brief review of the literature on forest economic accounting

The technical report “European forest ecosystems - State and trends” gives a broad description of the physical information available on forest areas and species, though differing in quality depending on the country (European Environment Agency, 2016). This publication presents a qualitative analysis of recent changes with regard to improvement/degradation of European forest in terms of biological sustainability.

In contrast to the European Environment Agency report (2016), Masiero et al. (2016) present a critical review of the standard EAF based on available economic accounting information for forests in Mediterranean countries. Given the shortcomings of the standard EAF measurement of forest income, Masiero et al. (2016) limit their analysis to final products of timber, firewood, cork, pine cones and resin harvests. In addition, these authors address certain free-access harvested products and estimate the value of net carbon fixation. They state that “the economic value of Mediterranean forest goods and services, however, is only partly reflected in the market and recorded by official statistics [EAF]. This is true both for ‘traditional’ products - such as wood and some NWFPs [non-wood forest products] - and new ones” (Masiero et al., 2016: p.13).

Published case studies of environmental-economic ecosystem accounting applied to forests at national/sub-national scale are restricted to a few single final product ecosystem service valuations. An exception is the Andalusian forest case-study by Campos et al. (2019b) in which the Agroforestry Accounting System (AAS) is applied for the 2010 period. The AAS has also been applied to determine total forest incomes and environmental assets in holm and cork oak woodland farms in Andalusia (Campos et al., 2019a, 2020).

Ovando et al. (2016) applied the AAS to 15 large publicly-owned forest farms in Andalusia in which conifer species predominate, under the assumption that the public forest farms are available for sale on the competitive land market.

Apart from the comparison with the EAF, which was absent in Ovando et al. (2016), this article differs from Ovando et al. (2016) in that: (1) it incorporates non-market services as intermediate products and their counterparts of intermediate consumptions, which we assume arise from government compensations (operating subsidies net of taxes on production) and market net operating margin opportunity costs incurred in manufactured capital investments of individual activities; (2) it removes the environmental asset gain from the private amenity activity on the basis that public forest farms are not available for sale on the competitive land market; (3) it estimates the values added, ecosystem services and environmental assets; and (4) it simulates the sensitivity of the environmental assets of individual activities to changes in land property rights and the assumed competitive real baseline discount rate. These new variables and environmental asset sensitivity analyses modify the scope and valuations of the environmental incomes for individual activities of both farmer and government institutional sectors measured by Ovando et al. (2016).

3. Accounting frameworks and transaction prices

The main reasons why the standard EAF net value added does not measure the total conifer farm income are: (1) it omits the economic activities carried out in the conifer farm which are included in the standard farmer Economic Account for Agriculture and the general standard economic account for government; (2) it assumes zero values for the gross operating surplus of the government activity final products
without market prices consumed; (3) it considers the intermediate consumptions of work in progress used (WPeu) inventoried at the opening of the period as a component of the gross operating surplus; (4) it does not estimate the adjusted capital gains (CG) of market and non-market conifer farm total capital; and (5) it omits the government activities which do not incur manufactured costs.

Given the abovementioned shortcomings in the EAF measurement of the values added of the conifer farms, this study proposes the application of the Agroforestry Accounting System (AAS), which estimates the total products and incomes of the conifer farms from the economic activities of both the farmer and government institutional sectors.

As both methodologies have been published elsewhere (European Communities, 2000; Campos et al., 2019b), to conserve space we have decided to move to supplementary material the comparison of the income and capital concepts of the standard Economic Account for Forestry (EAF) and the experimental Agroforestry Accounting System (AAS). A brief summary of the key differences between the two systems can be found in the Supplementary text SI.

However, in this section we will discuss the transaction prices applied in the conifer farms, as they are relevant to underscore the key features of our approach. The market and non-market transaction prices of the final products consumed are the consistent economic values recorded under the EAF and AAS frameworks applied to the conifer farms (Campos et al., 2019a, 2020; European Communities, 2000; UNSD, 2021). The AAS replaces the unit cost prices for products without market prices under the System of National Accounts (SNA) with the market prices of work in progress used (WPeu) inventoried at the market prices under the System of National Accounts (SNA) with the marginal simulated exchange prices stated or revealed by the users.

The total products at social prices (TPsp) are estimated as the aggregate value of market producer prices (pp), simulated exchange prices (sep), cost prices (cp), government compensation prices (gcp), opportunity cost prices (ocp), basic prices and environmental prices (ep):

\[
TP_{sp} = IP_{sp} + FP_{sp}
\]  
\[
IP_{sp} = IP_{pp} + IP_{cp} + IP_{gcp} + IP_{ocp}
\]  
\[
FP_{sp} = FP_{pp} + FP_{gcp} + FP_{ocp} + FP_{ep}
\]  
\[
TP_{sp} = TP_{pp} + TP_{cp} + TP_{gcp}
\]  

The intermediate products (IP) and final products (FP) of the conifer farm are registered at the different stages of their production processes and are valued according to different price types up until their consumption as final products when they are valued at producer prices and simulated exchange prices in the AAS. The producer prices correspond to the buying/selling market prices of the goods and services without including subsidies or taxes on production (hereafter compensations). The basic prices (bp) are obtained by adding the government compensation prices (gcp) to the values of the products at producer prices (pp) and cost prices (cp). The intermediate products at social prices (IPsp) are measured by adding to the intermediate products at producer prices (IPpp) and cost prices (IPcp) the non-commercial intermediate products at government compensation prices (IPgcp) and opportunity cost prices (IPocp). The consumed final products with market prices are valued at producer prices (FPpp) and those without market prices at simulated exchange prices (FPsep). In the AAS, the own account final products of gross capital formation (GCF) are valued at cost prices (FPcp), imputed producer prices (FPpp) and environmental prices (FPep).

The AAS considers that an activity with manufactured investments, which the owners know in advance will not reach an ordinary manufactured net operating margin at basic prices (NOMmoc) equal to or above that which is assumed competitive (NOMmoc), reveals the existence of a voluntary manufactured opportunity cost. The latter is considered an implicit transaction of a new intermediate product of service associated with that to which the investment is aimed (e.g., livestock rearing market loss increases family livestock-keeper amenity auto-consumption). The unit voluntary opportunity cost incurred in the investment of the activity is considered to be the opportunity cost prices of the intermediate product of amenity service (SSNacs) and donation service (SSNcsd). We have assumed that the owners of the land and livestock obtain a competitive ordinary manufactured net operating margin at basic prices (NOMmoc) from the individual activity investment. The latter was estimated by applying an assumed competitive real baseline discounting rate of 3% to the ordinary manufactured immobilized capital invested (IMcco) in the individual activity (for details see Supplementary text S4). Finally, the environmental prices correspond to the unit price of the resource rent.

4. Economic results for the average conifer farm under the EAF and AAS frameworks

In this section, under a scenario of favourable biological conservation of the environmental assets (see Supplementary text S2), we focus firstly on our application of the Agroforestry Accounting System (AAS); secondly, on the comparison of the AAS and the standard Economic Account for Forestry (EAF), specifically the total product versus final product and total income versus net value added, respectively, of the conifer farm; and, thirdly, in accordance with the AAS results, we analyse the sensitivity of the environmental asset to changes in land ownership rights and the chosen assumed competitive discounting rates.

The data primarily come from the Spanish and Andalusian governments along with our own field data gathered from the conifer farm, as well as our own contingent and choice experiment surveys of free-access forest visitors and Spanish households (Campos et al., 2019b; Ovando et al., 2016). The data for runoff water environmental asset hedonic price (Berbel and Mesa, 2007) and carbon dioxide price (SENDICO2, 2015) are taken from published literature.

4.1. Total capital of the conifer farm under the AAS

The total capital is estimated for the 17 individual activities, those corresponding to the farmer, the government and the conifer farms as a whole (Tables 1, S1–S3). The opening total environmental assets of the conifer farm make up 95% of the total capital (Table 1). The recreation service activity is the main environmental asset of a single activity, accounting for 28.2% of the total environmental asset and exceeding the total farmer environmental asset of precipitation falling on the conifer farm and ending up in public reservoirs for economic use; 85% by the agricultural sector and 15% by industry, services and household sectors. Final consumption of environmental water from the conifer farm is the second most important single environmental asset and accounts for 16.2% of the total environmental asset. The environmental asset of landscape activity is the third most important single environmental asset. The landscape activity accounts for 14.2% of the total environmental asset. Among the environmental assets of the conifer-farm activities, the fourth highest value of single environmental asset is that of greenhouse effect mitigation by carbon in trees and shrubs. Timber accounts for 46.5% of the value of the environmental asset of the farmer and represents 10.1% of the total environmental asset of the conifer farm. The environmental asset value for livestock grazing is similar to that of the timber. The environmental asset of hunting accounts for 7.8% of that corresponding to the farmer and 1.7% of the total environmental asset (Table 1).

What can be clearly derived from the results for a conifer farm which is not available for sale on the competitive land market is that, even if the traditional commercial activities are maintained along with other emerging activities such as game hunting and aromatic plants, the environmental assets of the commercial activities of the farmer make...
Table 1
Total capital account under the Agroforestry Accounting System per economic activity and for the farmer, government and conifer farm as a whole (2010: €/ha).

| Class                  | 1. Opening capitals | 2. Capital entries | 3. Capital withdrawals | 4. Revaluations | 5. Closing capitals |
|------------------------|---------------------|--------------------|------------------------|-----------------|---------------------|
|                        | (Co)                | (Ceb)              | (Ceso)                 | (Ceto)          | (Ceu)               | (Cwo) | (Cws) | (Cwd) | (Cwrc) | (Cwot) | (Cw)  | (Cr)  | (Cc)  |
|                        |                     |                    |                        |                 |                     |       |       |       |        |        |       |       |       |
| 1. Environmental asset (EA) | 6371.6              | 8.4                | 53.3                   | 61.7            | 2.7                 | 57.2  | 22.0  | 81.8  | 82.8   | 6434.3  |       |       |       |
| 1.1 Farmer             | 1387.8              | 8.4                | 0.2                    | 8.6             | 2.7                 | 5.6   | 1.3   | 9.6   | 40.3   | 1427.1  |       |       |       |
| 1.1.1 Timber           | 644.7               | 5.7                | 5.7                    | 1.1             | 5.5                 | 6.7   | 38.8  | 38.8  | 682.5  | 41.3    |       |       |       |
| 1.1.2 Firewood         | 39.3                | 0.0                | 0.0                    | 0.0             | 0.0                 | 0.0   | 2.0   | 0.0   | 578.4  | 108.3   | 16.7  |       |       |
| 1.1.3 Grazing          | 578.8               |                    |                        |                 |                     |       |       |       |        |         |       |       |       |
| 1.1.4 Hunting          | 108.3               | 2.7                | 0.2                    | 2.8             | 1.5                 | 1.3   | 2.9   | 0.0   | 108.3  | 16.7    |       |       |       |
| 1.1.5 Aromatics        | 16.7                |                    |                        |                 |                     |       |       |       |        |         |       |       |       |
| 1.1.6 Amenity          | na                  |                    |                        |                 |                     |       |       |       |        |         |       |       |       |
| 1.2 Government         | 4983.8              | 53.1               | 53.1                   | 51.6            | 20.7                | 72.3  | 42.5  | 5007.2 | 1996.9 | 191.4   | 784.3 | 903.8 | 299.8 |
| 1.2.1 Recreation       | 1796.9              |                    |                        |                 |                     |       |       |       |        |         |       |       |       |
| 1.2.2 Mushrooms        | 191.4               |                    |                        |                 |                     |       |       |       |        |         |       |       |       |
| 1.1.3 Carbon           | 761.0               | 53.1               | 53.1                   | 51.6            | 20.7                | 72.3  | 42.5  | 784.3  | 191.4  |         |       |       |       |
| 1.1.4 Landscape        | 903.8               |                    |                        |                 |                     |       |       |       |        |         |       |       |       |
| 1.1.5 Biodiversity     | 299.8               |                    |                        |                 |                     |       |       |       |        |         |       |       |       |
| 1.1.6 Water            | 1031.0              |                    |                        |                 |                     |       |       |       |        |         |       |       |       |
| 2. Manufactured (FCm)  | 346.6               | 0.2                | 9.3                    | 4.1             | 13.6                | 4.7   | 6.7   | –9.5  | 344.1  | 138.4   | 7.1   |       |       |
| 2.1 Farmer             | 142.3               | 0.2                | 1.9                    | 4.1             | 6.2                 | 4.7   | 6.7   | –3.4  | 138.4  | –0.1    | 7.1   |       |       |
| 2.1.1 Plantations      | 7.1                 |                    |                        |                 |                     |       |       |       |        |         |       |       |       |
| 2.1.2 Constructions    | 81.5                | 0.2                | 0.2                    | 0.2             |                     |       |       |       |        |         |       |       |       |
| 2.1.3 Equipment        | 2.0                 | 0.2                | 0.2                    | 0.2             |                     |       |       |       |        |         |       |       |       |
| 2.1.4 Livestock        | 9.5                 | 1.9                | 4.1                    | 6.0             | 1.1                 | 0.5   | 0.4   | 4.7   | 8.8    | 42.2    | 8.8   |       |       |
| 2.1.5 Agriculture      | 42.2                |                    |                        |                 |                     |       |       |       |        |         |       |       |       |
| 2.2 Government         | 204.3               | 7.4                | 7.4                    | 7.4             | 0.0                 | 0.0   | 0.0   | –6.0  | 205.7  |         |       |       |       |
| 2.1.1 Plantations      | 159.7               | 7.4                | 7.4                    | 7.4             |                     |       |       |       |        | –6.4    | 160.7 |       |       |
| 2.1.2 Constructions    | 40.9                | 7.4                | 7.4                    | 7.4             |                     |       |       |       |        |          | 40.9  |       |       |
| 2.1.3 Equipment        | 3.7                 |                    |                        |                 |                     |       |       |       |        |          | 4.1   |       |       |
| Capital (C)            | 6718.3              | 0.2                | 17.7                   | 57.4            | 75.3                | 3.8   | 0.5   | 0.4   | 57.2   | 26.7    | 88.5  | 73.3  | 6778.4|
up 21.8% of the total opening environmental asset of €371.6/ha in 2010, with the remaining 78.2% of the value of the total environmental asset corresponding to the public activities managed by the government (Tables 1 and S2).

The opening manufactured capital of the conifer farms accounts for 5% of the total capital. The road infrastructures are the main manufactured fixed capital. Equipment is of scarce importance per unit area due to the large average area of the conifer farms. Other fixed capital includes minor intangible durable consumable investments, such as the forest management plan (Table 1).

The livestock work in progress is simultaneously registered as opening period entries and withdrawals used. All entries of livestock work in progress during the period are immediately registered as withdrawals used. For this reason, there is no revaluation of the livestock in the AAS work in progress inventories since they remain as manufactured work in progress for the whole period in the livestock activity production account, and are recorded as input of intermediate consumption (Tables 2 and S1). In contrast, the livestock fixed capital does register capital revaluation, although in this case it does not reach the minimum value of €0.1/ha and the notation 0.0 indicates its true existence (Table S1).

The conifer farm presents low revaluation values for the environmental assets as these revaluations are mainly due to the one-year decrease in the discount of the environmental assets of timber and carbon, which were valued at the opening of the period and which continue to be on the inventory at the closing of the period (Tables 1 and S1).

The depreciation (negative revaluation) of the manufactured fixed capital has little importance in the revaluation of capital given its scarce relative weight per unit area in the conifer farm valued. The only significant revaluation recorded is the negative price change for breeding livestock in the period. Breeding livestock mortality is the only extraordinary destruction of capital recorded.

Finally, the revaluation is estimated as the residual value between closing capital less opening capital and withdrawal less entries gives a value of €73.3/ha (Tables 1 and S1).

### 4.2. Net value added of the conifer farm under the AAS

The AAS results show that the commercial intermediate products of services (ISScs) exceed the non-commercial (ISSncs) ones (Fig. S1, Tables 2 and S4). The activities of conservation forestry and fire services generate the largest contributions of ISSc to the total products consumed. The main activities which generate the ISSnca/d are the livestock and hunting activities. The landscape conservation activity is the main beneficiary of own ordinary intermediate consumption of services (SSsoo) (Fig. S2, Tables 2 and S4).

The total intermediate product (IP) of the conifer farm makes up 25% of the final product consumed (FPc) (Fig. 1, Tables 2 and S4). The final products consumed (FPc) account for 81% of the final product (FP) of the conifer farm. The good which accounts for the largest part of the farmer FPc is timber, although it only makes up 2.5% of the FPc of the conifer farms as a whole, well behind the consumptions of the final products of the landscape, recreation, water and carbon.

The favourable situation of the natural regeneration of the conifer farms explains the marginality of the own account manufactured gross capital formation (GCFm) of the conservation forestry activity (Table S4). Labour compensation makes up 23.3% of the net value added of the conifer farm as a whole (Fig. 2, Tables 2, S4 and S5). The forest firefighting service activity accounts for 43.7% of the conifer farm labour compensation, followed at some distance by the activities of conservation forestry, landscape, hunting, threatened wild biodiversity and timber.

The main net operating margins of the conifer farm come from the recreation, water, carbon and landscape services (Fig. 2, Tables 2, S4 and S5). The farmer activities, mainly hunting and timber, make up 11% of the net operating margin, most of which corresponds to hunting and timber.

The government activities of recreation, water, landscape, carbon and firefighting services are those which contribute most to the total net value added of the conifer farms; followed at a considerable distance by the threatened biodiversity, hunting, timber and landscape conservation services (Fig. 2, Tables 2, S4 and S5). Farmer activities contribute 15.3% and timber contributes a small amount to the total net value added of the conifer farm activities as a whole.
4.3. Ecosystem services of the conifer farm under the AAS

In the conifer farm case-study, 11 of the 17 economic activities have ecosystem services (ES) embedded in the total product. The recreational service, water, carbon and landscape activities make up 90.8% of the ecosystem services of the conifer farm (Figs. 1 and 3, Tables 2, S4 and S5).

The example of harvested timber serves to illustrate the differences between the concepts of consumed product and ecosystem service as a production factor service of the environmental asset. In the conifer farm, the ecosystem service of harvested timber corresponds to the WPeu which, valued by its environmental price at the opening of the period, contributes 1.1 €/ha to the final harvested timber product (FPc) valued at the farm gate producer price of 7.6 €/ha (Fig. 3, Tables 2 and S4). Although it would be possible for the value of an ecosystem service to coincide with the value of its product, the ecosystem service, as an...
Abbreviations: sp. are social prices; ep are environmental prices; rp are replacement prices; bp are basic prices and pp. are producer prices.

4.4. Total income of the conifer farm under the AAS

The factorial allocations of the total income show limited contributions of the incomes from labour and manufactured capital, at 21% and 5%, respectively, compared to the contribution of the environmental income, which accounts for 74% of the total income of the conifer farms (Figs. 4-5, Table S5).

The net values added account for 92% of the total income, revealing the scarce relevance of capital gain, with the exception of the timber inventory revaluation in the case of the environmental asset of accumulated timber. This is due to the discounting effect under a steady state price situation, all other things being equal.

The adjustment of the environmental asset of the conifer farms is due to reclassification of timber growth and to the carbon fixation valued according to opening environmental asset values (Tables S1 and S5). The final result of subtracting the destruction and adjustment of capital in the capital revaluation is the modest capital gain of 21.4 €/ha (Fig. 5, Table S5). The capital gains make up just 8% of the total income.

Timber and grazing account for moderate amounts of the total forest income, while the rest of the traditional conifer farm products corresponding to the farmer contribute even less to the total forest income; the government public products being those which account for the greatest percentage of the total forest income of the conifer farms at 74.4% (Fig. 5, Table S5).

The contribution of the environmental income for farmer activities significantly exceeds the minor contribution of the ecosystem service, this being almost entirely due to the incorporation of natural growth in the environmental income (Fig. 5, Table S5). The rotations for final commercial felling exceed 80 years for all species of Pinus in the case-study conifer farms (see Campos et al., 2019b; Supplementary texts S2, S3 and S12). In the modelling of timber natural growth, it is assumed that when the inventoried real standing timber existing in 2010 is felled at the end of the rotation period, it will be regenerated in successive rotations. In a given period, although the stands are approaching maturity, it may be that the physical quantities of timber extracted are well below the natural growth for the period. This is what is in fact happening in the case studies, so that even with constant future prices, the variation in the timber assets is due both to physical changes and to the revaluation effect of discounting and not to revaluations in the prices. This is the case of the physical extractions of timber from the farms, which in 2010 represented 38% of the natural growth (Supplementary text S2.1, Table ST4, p. 7). The values for timber extraction at environmental prices (WPeuti) only correspond to 19.3% of the natural growth (NGti) (Table S4). The difference in values is even greater in the case of the ecosystem service and environmental income for firewood, since no extractions of firewood took place in 2010 (Table S4). In short, in a context of natural growth of timber and firewood which is several times greater than the physical quantities extracted in the average forestry cycles prior to reaching final maturity, the resource rent (ecosystem service) values may be several times lower than the environmental income in the period (year) in which they are estimated. In contrast, in the context of assumed steady state of the grazing, game captures and other farmer products of the conifer farms, the ecosystem services and the environmental incomes present the same values (Figs. 3 and 5, Table S5).

Among the individual activities, the greatest contributions to the environmental incomes of the conifer farms are those of the recreation services, water, timber, carbon and landscape services (Fig. 5, Table S5). The environmental incomes of the economic activities of the farmer account for 64.8% of the respective total income and this percentage increases to 77.4% for the contribution of the environmental income to the total incomes of the government activities. The sum of the farmer and government environmental incomes gives a mean contribution of 74.2% to the total income generated in the conifer farms in 2010.

4.5. Conifer farm product and income results comparison under AAS and EAF

The EAF registers based on the investment rationale of maximizing the net operating surpluses of the final commercial production of vegetal goods (timber, firewood and aromatic plants) and residential service do not reflect the true motivation for investment by the public owner of the conifer farm. The EAF does not admit any economic activity other than that aimed at producing a good or service destined for potential sale with the goal of obtaining the maximum benefit from the immobilized capital investment. This economic rationale of the public owner of the conifer farm implies the absence of production of other economic goods.
and services associated with the main product for which the investment is made.

In contrast, the AAS recognizes that the investment rationale in the conifer farm vegetation related activities is aimed mainly at maximizing the benefits of the landscape conservation forestry activity. The consequence of this refinement of the investment in the activities of timber, firewood and aromatic plants is the appearance of the conservation forestry activity and the non-commercial intermediate product of services donated of the forest vegetation activities. The AAS transfers the cost of the forestry activities in the EAF to the new activity of conservation forestry.

The AAS refinement of the "industrial" (business as usual) rationale of the EAF consists of substituting it for the "non-industrial" forest investment rationale of the conifer farm public owner and of overcoming the 'timing' bias. The AAS registers the harvesting costs in the vegetation activities along with the non-commercial intermediate products of services donated (ISSncd) of the timber, firewood and aromatic plants. It also adds the conservation forestry activity, which registers the silvicultural costs of the forestry activities and their commercial intermediate products of services (ISSc) valued according to the cost prices incremented by an assumed competitive net operating margin. We assume that, rather than final services consumed, this activity generates commercial intermediate products of services (ISSc) "bought" by the government and used as own ordinary intermediate consumption by the landscape conservation activity.

The EAF refinement concludes with the timing bias associated with the forest vegetation products which is overcome by the AAS. The elimination of this bias is achieved by including the natural growth of the period and the environmental work in progress products harvested according to the environmental prices for the woody vegetation activities.

The production account and income generation results under the standard Economic Account for Forestry (EAF) reveal that the official economic statistics are far from the economic results of the conifer farm.
Table 3 presents the EAF measurements for the individual final products and the aggregate conifer farm values added at market prices. We estimate the EAF individual values added based on our own conifer farm data, although the government standard EAF office does not estimate the costs for individual activities.

The comparison of the estimates for total product and net operating margins for timber, firewood, aromatic plants and residential service activities reveals that the AAS estimates are 1.6 and 2.7 times greater, respectively, than those for the final products and net operating surpluses under the EAF (Tables 2, 3 and S5, Fig. 4).

Table 4 Conifer farm environmental asset sensitivity to changes in assumed discount rates under the Agroforestry Accounting System (2010: €/ha).

| Class | Discount rate 1.5% | Discount rate 3.0% | Discount rate 4.5% |
|-------|-------------------|-------------------|-------------------|
| Farmer | 3410              | 1388              | 800               |
| Timber | 1903              | 645               | 320               |
| Firewood | 96               | 39                | 12                |
| Grazing | 1161             | 579               | 385               |
| Hunting | 217               | 108               | 72                |
| Aromatics | 33               | 17                | 11                |
| Government | 10,339          | 4984              | 3251              |
| Recreation | 3594            | 1797              | 1198              |
| Mushrooms | 383              | 191               | 128               |
| Carbon | 1893              | 761               | 436               |
| Landscape | 1808             | 904               | 603               |
| Biodiversity | 600             | 300               | 200               |
| Water | 2062              | 1031              | 687               |
| Farm environmental asset | 13,749            | 6372              | 4052              |
| Change (%) | 216              | 100               | 64                |

The AAS results for the final product and total income of the conifer farm are 32 and 38 times greater than the respective EAF final product and net value added for timber, firewood, aromatic plants and residential service activities (Tables 2, 3 and S5, Fig. 4). The results for the same variables in the case of the farmer activities are 3 and 10 times greater, respectively, under the AAS than under the EAF.

4.6. Sensitivity of environmental assets to changes in discount rates and ownership rights

In this sub-section we focus on presenting the results for environmental asset sensitivity to simulated changes in assumed competitive baseline discount rate of 3% and land ownership rights in the conifer farm.

Reducing the discount rate from 3% to 1.5% would increase the farmer environmental assets by 2.5-fold, by 2.1 in the case of the government environmental assets, and by 2.2 for those of the conifer farms as a whole (Table 4). Increasing the discount rate from 3% to 4.5% would decrease the environmental assets of the farmer, government and conifer farm as whole by 1.7, 1.5 and 1.6-fold, respectively (Table 4).

The conifer farm environmental assets price index is 100 at a 3% discount rate; it increases to 216 with a discount rate of 1.5%, and decreases to 64 with a discount rate of 4.5% (Table 4).

In Table 4, the estimation of farmer environmental assets assumes...
that the protected case-study conifer farms will be outside the land market for ever. In contrast, if the land ownership rights of the farmer were expected to change from the current legal status to another status under which it would be possible to sell on the competitive land market, then the environmental assets, with complete ownership rights, would exceed 5149 €/ha, instead of the current 1388 €/ha (Table 5), with an applied normal rate of return of 3% under both market scenarios. We assume the hypothesis that the annual resource rent does not change for the other activities due to the market internalization of landowner private amenities. With discount rates of 1.5% and 4.5%, the value obtained by including private amenities is 4562 €/ha and 7171 €/ha, respectively. In these case-study conifer farms, private amenities are not affected by the normal discount rate chosen, since it is obtained through analysing surveys of private-forest-farm owners in Andalusia (Oviedo et al., 2015, 2017). If the results from a single farm are analysed it can be observed that when the value of private amenities is interiorized, the amount represents between 80% and 46% of the total value of the environmental assets, assuming a 3% discount rate (Table 5).

The value of the private amenities, with complete land market ownership rights, accounts for 37% of the total value of the environmental assets of the conifer farms, assuming a discount rate of 3%. If a rate of 4.5% is applied, the value of the private amenities accounts for 48% of the total environmental assets of the conifer farms, while they account for 21% if a rate of 1.5% is assumed.

5. Accounting frameworks and policy discussions

5.1. Values added and ecosystem services with low or zero values are important indicators for appropriate forest management

The conifer farm results reveal the relatively low weight of the ecosystem services in the value of the timber and grazing. However, they are the nature-based products which allow the continuity of other manufactured activities of the conifer farm which generate incomes from labour as well as regulation-maintenance and cultural ecosystem services. Furthermore, the native Mediterranean conifers contribute to the existence of other non-nature based activities that generate the manufactured commercial intermediate services (ISSc) which provide most of the incomes from labour in the conifer farms. This is the case of the conservation forestry activity, which, as a landowner investment compensated by the government, allows the production of timber and firewood without these products incurring manufactured forestry costs. This is also the case of the government firefighting service, which helps mitigate landowner environmental asset destruction as well as favouring the production of recreational, landscape conservation and threatened wild biodiversity service activities.

We emphasize the importance of using value added and manufactured total income, especially when the price of the ecosystem service of a product is zero (free service). In this case, we point to the need to maintain an accounting record of the quantities consumed, multiplied by their environmental price of zero in order to show the dependence of the manufactured gross value added on nature-based material in the context of non-economic ecosystem services. We consider that it is not possible to expose the contribution of nature in subsistence economy situations if free biophysical natural inputs are not explicitly shown in the ecosystem accounts (Cavendish, 2002).

Thus, the sustainability of ecosystem environmental asset management for the individual activities of conifer farms must also take into account, beyond the environmental assets, the individual changes in biophysical stocks and flows of the conifer farms.

5.2. Standard forest account failure to value hidden non-market products

The applications of the standard Economic Account for Forestry (EAF) and the Agroforestry Accounting System (AAS) to measure the incomes of the case-study conifer farms reveal that the government fails to provide complete economic statistics for the total income and environmental asset of the forest. The shortcomings of the EAF are due to the omission, on the one hand, of the private activities of the forest hidden in the standard Economic Account for Agriculture (EAA) as well as of the private amenity activity and the government public activities. On the other hand, the EAF presents the inconsistency of the political decision, far removed from the concept of transaction price, that the final products without market prices consumed do not generate operating profits or losses (termed as surpluses and margins by EAF and AAS, respectively). Thus, as the government applies the cost prices, it is unavoidable that the values for the products without market prices consumed will be either much higher or much lower than the simulated transaction value of the product revealed/stated by the consumers. The cost prices do not provide a guide consistent with the concept of income which can be put forward to explain the forest investments by private owners and government.

5.3. Strengths and weaknesses of the AAS conifer farm application

The main strengths of the AAS are: (1) the consistent integration of the values added and the capital gains of forest products with and without market prices, with the aim of measuring the total sustainable incomes from these products at national level with the farm as the real economic unit for testing; (2) the total income and environmental income do not incur double counting bias, in contrast to the net value added, which incurs an overvaluation bias of the timber natural growth and carbon final product consumption; (3) the subjective valuations at cost prices of the intermediate product of the conservation forestry and

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**Table 5**

Conifer farm environmental asset sensitivity to changes in ownership rights at an assumed 3% competitive discount rate under the Agroforestry Accounting System (2010: €/ha).

| Class | Owner amenity environmental assets | Environmental assets with farm not available for sale on the competitive land market | Environmental assets with farm available for sale on the competitive land market. |
|-------|-----------------------------------|-----------------------------------------|-----------------------------------------------|
| Farm 1 | 4048 | 1970 | 6018 |
| Farm 2 | 900 | 685 | 1585 |
| Farm 3 | 1196 | 1398 | 2594 |
| Farm 4 | 4878 | 2232 | 7110 |
| Farm 5 | 1237 | 871 | 2108 |
| Farm 6 | 3710 | 1620 | 5330 |
| Farm 7 | 5011 | 1101 | 611 |
| Farm 8 | 2448 | 868 | 3317 |
| Farm 9 | 3739 | 916 | 4655 |
| Farm 10 | 1101 | 769 | 1871 |
| Farm 11 | 4836 | 2391 | 722 |
| Farm 12 | 4539 | 1536 | 6074 |
| Mean | 3761 | 1388 | 5149 |
fire service activities are cancelled out by the counterpart of own intermediate consumption of the landscape conservation activity; (4) the inclusion of final product natural growth and the intermediate consumption of the environmental work in progress used resolve the bias associated with the ‘timing’ of the value added in the EAF; and (5) the consumption of fixed environmental asset (environmental degradation) is omitted in the production account and implicitly included in the environmental asset revaluation, the exception being the carbon emission registered as investment consumption of fixed environmental asset (for details see Campos et al., 2019b: Supplementary text S1.7).

The following weaknesses of the AAS application to the conifer farm should be mentioned: (1) a critical limitation of the AAS arises when its associated with the ‘timing’ of the value added associated with the records for final products of natural growth of timber and carbon fixation, while their counterpart inputs of intermediate consumptions according to their values at the opening of the period are omitted; thus, (3) the net operating margins do not accurately reflect operating profits in the case of timber and carbon as they contain double counting of the natural growth of timber and the final carbon product consumed; (4) the possible willingness to pay of the non-industrial livestock keeper for the ecosystem service of Mediterranean native livestock has not been valued, so the valuation of the final product of the private amenity service in the case-study conifer farms may be undervalued, although the limited intensity of livestock grazing reduces this possible bias to an almost negligible amount in the publicly-owned conifer farms studied; (5) there is no legal right of ownership of the economic activity of carbon in these conifer farms, and we subjectively simulate the assignment of ownership of the carbon economic activity to the government institutional sector; (6) possible changes in fertility of the conifer farms have not been taken into consideration or those in the natural productivity of the extractive coastal sea fishing industry caused by variations in the flow of material transported in rivers and ending up in the Mediterranean Sea in the period. Similarly, the ecosystem service of honey production by beekeepers is not valued explicitly, although its ecosystem service is likely to be negligible; as a non-economic ecosystem service it may provide the necessary conditions for the existence of other biological environmental assets as well as the manufactured net value added of the beekeeping activity.

5.4. Policy implications of government implementation of forest total income accounts

The reluctance of government economic institutions and national statistics offices to standardize and integrate environmental income and capital gain in a refined SNA is generally explained by the perceived uncertainty surrounding the valuations of final public products without market prices consumed. The latter is usually obtained through transaction prices simulation, derived from revealed or stated consumer preferences (OECD, 2006; Ailsen and Greaker, 2006). Hence, although it is true that there are grounds for this uncertainty associated with prices derived from the application of simulated exchange values, that in itself is not a legitimate argument for outright rejection, since uncertainty also exists in the manufactured production cost estimate of the consumption of final public products without market prices under the standard EAF. These accounts of society, according to government policy decision, apply the subjective criterion that the values attributed by consumers to the public products which they consume free of charge generate neither positive nor negative net operating surpluses. It may be that, to a large extent, political issues are hampering advances in the refinement and extension of the EAF. Among the issues may be the preference of governments to register the flows of goods and the taxes derived from these flows. It is possible that governments fear revealing the need to improve the equity in legal and, above all, economic ownership rights of the possible implicit donations of ecosystem services in commercial product exchanges between individuals, companies and countries.

In the European Union, forest policy is the exclusive responsibility of member states. This may be one of the reasons, among others, why the European Commission has not addressed the implementation of standard accounts at forest farm scale. Meanwhile, the European Union has been applying the standard Farm Accounting Data Network (FADN) for selected agricultural economic products of farmers for more than fifty years (European Commission, 2018). However, the standard FADN does not recognize the simulated transaction prices for farmer private amenity and omit government activities. Nevertheless, the European Union FADN is worthy of being taken into account in future policy decisions on implementing forest ecosystem accounting at farm scale in European Union.

The problem which must be addressed both by government and by national income accounts experts is how to explain the legitimacy of the free economic products of forests in terms similar to those used for their commercial products. Given the continuing absence of statistics for national and sub-national total incomes of farmer and government in commercial accounts for forests in accordance with existing regulations, the likelihood of future environmental-economic accounts for total income of forests seems remote. Hence, the first step towards making these accounts a reality is to extend the current information produced by the government national statistics offices.

It is expected that the outcome of government engagement in forest accounts will be the standardization of the environmental-economic accounts, specified in accordance with the key indicators consistent with the concept of total income. The involvement of governments in the regulation of the standard manual for extended environmental-economic ecosystem accounts for any territorial scale or ecosystem type has not so far materialized in the form of budgetary allocation. This can be seen as government failure in terms of the delay in the design and application of the preliminary satellite guide for environmental-economic accounting by national statistics offices, specifying the valuations of ecosystem services, total forest incomes and environmental incomes of forests.

The implications for government as regards the concepts of simulated exchange value, opportunity cost, ecosystem services, total income and environmental income applied by the AAS in the conifer farm case-study are highlighted by the fact that these are among the concepts recommended and referenced in the most recent version of the ecosystem accounting manual agreed by the United Nations Statistics Division (UNSD, 2021). While there is no standard monetary accounts for ecosystems as yet, an agreement has been reached in the biophysical ecosystem standard ecosystem accounts guide of the UNSD (UNSD, 2021: chapters 1–7).

6. Concluding remarks

This study demonstrates that by applying the Agroforestry Accounting System (AAS) criteria it is possible to integrate environmental assets with the manufactured capital and to measure environmental assets of products without market prices in a manner consistent with the
System of National Accounts (SNA) valuation criterion of the exchange value of products with market prices. Our application of the AAS has demonstrated that it is feasible, at farm scale, to make visible all the economic and non-economic (free bio-physical ecosystem services) contributions of an ecosystem accounting area to the total incomes and total capitals of the individual activities of a natural area, whatever the territorial scale.

In the conifer farm case study, the application of the official Economic Account for Forestry gives a net value added of 6.9 €/ha versus the total income measured by the AAS of 267.5 €/ha. There are multiple reasons for these large differences in forest income according to the accounting framework used, although the government policy decision to only recognize observed market transaction quantities and prices is key to the ‘meaningless’ result for value added under the EAF. It is expected that future government standard ecosystem accounting will complement the Economic Account for Forestry, but will still fall far short of consistently integrating the forest and environmental income in the total income, as measured in the AAS application to the conifer farms case study.

In addition to the objective of measuring forest environmental assets, this conifer farm case study has also focused on analysing the sensitivity of environmental assets to changes in land ownership rights and assumed competitive baseline discounting rates. The results show the high sensitivity in the total value of the environmental assets of the farmer when we simulate changes in land ownership rights allowing farms to be freely sold on the competitive land market. The changes in individual activity, farmer and government environmental assets when changes in discount rates are simulated are also highly noteworthy. Meanwhile, the valuation of environmental assets shows uncertain year-to-year volatility, despite a historical long-term real cumulative rate of increase in the market prices of land.

We conclude that the pending challenge as regards improving the application of total forest income in the accounts of society is to identify the state of biological species and habitat conservation or preservation of the ecosystem accounting area valued. In a situation of biological sustainability and expected stability of future real prices of products and production factors in the conifer farms of Andalusia, the AAS estimates a net value added which accounts for 92% of the total income. Hence, given the known biological sustainability outside the market prices system, the net value added in this steady state situation is the key variable for total forest income in the accounts of society. The challenge is that it is only possible to discern economic sustainability of value added after having measured the total income of the forests over a multi-period cycle as non-negative variations in successive complete cycles are required.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

Aifon, K.N., Greker, M., 2006. From natural resources and environmental accounting to construction of indicators for sustainable development. In: Statistics Norway, Research Department, Discussion Papers No. 478 (30 pp.). https://www.ssb.no/a/p uklib/statbank/no/pdf/03/dp478.pdf (accessed 10 December 2019).

Berbel, J., Mesa, P., 2007. Quasi-hedonic method to assess the value of irrigation water. A case study in Guadalquivir basin (Spain). Econ. Agraria Recursos Natural. 7 (14), 127–144. https://doi.org/10.7201/earam.2007.14.07.

Campos, P., Oviedo, J.L., Álvarez, A., Mesa, B., Caparrós, A., 2019a. The role of non-commercial intermediate services in the valuations of ecosystem services: application to cork oak farms in Andalusia, Spain. Ecosystem Serv. 39 https://doi.org/10.1016/j.ecoser.2019.100996.

Campos, P., Caparrós, A., Oviedo, J.L., Ovando, P., Álvarez-Farizo, B., Díaz-Balteiro, L., Carranza, J., Bequeria, S., Díaz, M., Herruzo, A.C., Martínez-Peña, F., Solínº, M., Álvarez, A., Martínez-Jáuregui, M., Pasalodos-Tato, M., de Frutos, P., Aldena, J., Almazán, E., Concepción, E.D., Mesa, B., Romero, C., Serrano-Notivoli, R., Fernández, C., Torres-Porras, J., Montero, G., 2019b. Bridging the gap between national and ecosystem accounting application in Andalusian forests, Spain. Ecol. Econ. 157, 218–236. https://doi.org/10.1016/j.ecolecon.2018.11.017.

Campos, P., Álvarez, A., Mesa, B., Oviedo, J.L., Ovando, P., Caparrós, A., 2020. Total income and ecosystem service sustainability index: accounting applications to holm oak dehesa case study in Andalusia-Spain. Land Use Policy 97, 1–41. https://doi.org/10.1016/j.landusepol.2020.104692.

Caparrós, A., Campos, P., Montero, G., 2003. An operative framework for total Hickson income measurement: application to a multiple use forest. Environ. Resour. Econ. 26, 173–198. https://doi.org/10.1023/A:1026036832349.

Caparrós, A., Oviedo, J.L., Álvarez, A., Campos, P., 2017. Simulated exchange values and ecosystem accounting: theory and application to recreation. Ecol. Econ. 139, 140–149. https://doi.org/10.1016/j.ecolecon.2017.04.011.

Cavendish, W., 2002. Quantitative methods for estimating the economic value of resource use to rural households. In: Cambell, B.M., Luckert, M.K. (Eds.), Uncovering the Hidden Value: Valuation Methods for Woodland & Forest Resources. Earthscan, London, pp. 17–65.

Eiser, R., 1989. The Total Incomes System of Accounts. The University of Chicago Press, Chicago (i–xvi –416 pp.).

European Commission, 2018. Farm Accounting Data Network [FADN]. An A to Z of Methodology. Version 02.07.2018. European Commission, Brussels, 119 pp. http://ec.europa.eu/agriculture/rica/pdfs/site_en.pdf (accessed 24 June 2020).

European Communities, 2000. Manual on the Economic Accounts for Agriculture and Forestry EAA/EAF 97 (Rev. 1.1). European Commission, EUROSTAT, Luxembourg, 172 pp. http://ec.europa.eu/eurostat/documents/385598/3854388/KS-27-00782-EN.PDF/e79eb663-b744-46c1-b41e-0902be421beb (accessed on 14 September 2017).

European Communities, 2002. The European Framework for Integrated Environmental and Economic Accounting for Forests – IEEAF. Office for Official Publications of the European Communities. European Commission, EUROSTAT, Luxembourg, 102 pp. https://ec.europa.eu/eurostat/documents/3855956/3859829/KS-IE-02-0031-EN.PDF?%40t=58867cc-c770-4183-8085-8842a62a9177=1417480543000 (accessed 14 December 2020).

European Environment Agency, 2016. European forest ecosystems - State and trends, 2016 European Environmental Agency, Publications Office of the European Union, Luxembourg, 128 pp. https://www.eea.europa.eu/publications/european-forest-eco-systems (accessed on 24 June 2020).

Hicks, J., 1946. Value and Capital. Oxford University Press, Oxford, 340 pp.

IEEA, 2020. Contabilidad Regional Anual de Andalucía. Revisión estadística 2019. Consejería de Economía, Inversión, Conocimiento, Empresas y Universidad, Instituto Estadística y Cartografía de Andalucía. https://www.juntadeandalucia.es/institutod estadisticaycartografia/craa/index.htm (accessed 31 July 2020).

Krutilla, J.V., 1967. Conservation reconsidered. Am. Econ. Rev. 57 (4), 777–786.

Masiero, M., Pettenella, D.M., Secco, L., 2016. From failure to value: economic valuation for a selected set of products and services from Mediterranean forests. For. Syst. 24 (1), 1–16. https://doi.org/10.5424/fs/2016251-08160.

McElroy, M.B., 1976. Capital gains and social income. Econ. Inq. 221–240. XIV.
NRC, 1999. Nature’s Numbers: Expanding the National Economic Accounts to Include the Environment. National Research Council, The National Academies Press, Washington DC. https://doi.org/10.17226/6374, 262 pp.

OECD, 2006. The new rural paradigm. In: Policy and Governance. Organisation for Economic Co-operation and Development, Paris. https://doi.org/10.1787/19909284.

Ovando, P., Campos, P., Oviedo, J.L., Caparrós, A., 2016. Ecosystem accounting for measuring total income in private and public agroforestry farms. For. Pol. Econ. 71, 43–51. https://doi.org/10.1016/j.forpol.2016.06.031.

Oviedo, J.L., Campos, P., Caparrós, A., 2015. Valoración de servicios ambientales privados de propietarios de fincas agroforestales de Andalucía. In: Campos, P., Ovando, P. (Eds.), Renta Total y Capital de las Fincas Agroforestales de Andalucía. Memorias científicas de RECAMAN, Vol. 4, memoria 4.1, Editorial CSIC, Madrid, pp. 8–155. http://libros.csic.es/product_info.php?products_id=990 (accessed 27 April 2018).

Oviedo, J.L., Huntsinger, L., Campos, P., 2017. Contribution of amenities to landowner income: case of Spanish and Californian hardwood. Rangel. Ecol. Manag. 70, 518–528. https://doi.org/10.1016/j.rama.2017.02.002.

SENDECO2, 2015. Carbon Dioxide Emission Allowances Electronic Trading System. Historical CO2 Prices for EU. https://www.sendeco2.com (accessed 11 March 2021).

UNSD, 2021. System of Environmental-Economic Accounting—Ecosystem Accounting. Final Draft. Version 5 February, 2021. United Nations Statistical Division, New York, 350 pp. https://unstats.un.org/unsd/statcom/52nd-session/documents/RE-3F-SEE-A-EA_Final_draft-E.pdf (accessed 11 March 2021).