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Agroforestry Accounting System for measuring environmental incomes at social prices: application to holm oak open woodlands in Andalusia-Spain

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Highlights

Ecosystem services make up 60% of ordinary total product in Andalusian HOWs.
The GVA of National accounting is 37% that of the Agroforestry Accounting System.
Andalusian holm oak environmental asset is 94% of opening total capital.
Andalusian holm oak environmental income is 88% of total income.
The amenity ecosystem service makes up 46% of total ES in Andalusian HOWs.
The ecosystem service of water supply makes up 20% of total ES in Andalusian HOWs.

Abstract

The brief description of the sequence of accounts for the products in the SNA and SEEA-EEA guidelines compared does not allow for a detailed discussion on what might be the future development of the satellite standard system of accounts. The ultimate environmental-economic aim of the application of the Agroforestry Accounting System (AAS) to holm oak open woodlands (HOW) in Andalusia-Spain is to test the hypothesis that the valuations of ecosystem services and changes in individual environmental assets of products consumed in the period and those expected to be consumed in the future require the prior measurement of the total income of the products valued at social price in order to carry out estimates, since the environmental component of the total income of an individual product is a residual value subjected to the priorities of remuneration for labor services and manufactured capital. We show that it is possible to coherently estimate the total income from products of a silvopastoral landscape by applying the AAS and the refined System of National Accounts (rSNA) as both embrace the privately-owned farmer activities of timber, cork, firewood, nuts, grazing (by game species and livestock), conservation forestry, landowner residential services and private amenity, as well as public activities by government of fire services, water supply, mushrooms, carbon, free- access recreation, landscape conservation and threatened wild biodiversity preservation. The comparisons of the results, at producer prices in the rSNA and at social price in the ASS, reveal that the rSNA values the total ES and GVA of the HOW at 28% and 37% respectively of the AAS valuations.

Keywords: Total income, ecosystem accounting, ecosystem services, environmental asset, national accounts, private amenity

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1. Introduction

Since 2010, national and international government institutions responsible for elaborating economic statistics on environmental governance and economic development have been pointing to the urgent need to incorporate the contribution of nature to the income and capital of nations, although to date, these concerns have not led to consequences as regards environmental refinement in applications of the System of National Accounts (SNA) (European Commission, 2011, 2016; Edens and Hein, 2013; EFTEC, 2015; European Commission et al., 2009; European Communities, 2000; FAO, 2017; Masiero et al., 2019; Obst et al., 2016; Senado, 2010; United Nations, 2012). One of the main challenges complicating the extension of the SNA to explicitly incorporate the environment as a production factor is the consistency of the inclusion of values for products with and without market prices. Another of the challenges regards the limits of environmental valuations in situations of "critical" (threshold) biophysical amounts of non-reproducible renewable environmental assets.

The coordinated response, currently in progress, of the departments for statistics to the demand by governments to extend the SNA indicators, involves the development of the satellite System of Environmental Economic Accounting – Experimental Ecosystem Accounting (SEEA- EEA) (United Nations, 2017; United Nations et al., 2014). Until now, the guidelines in the SEEA-EEA process have focused on the conceptualization of the economic variables of ecosystem services and environmental assets, based on the consumer preferences evidenced in the transactions observed in formal markets and other simulated transactions declared: "The SEEA EEA […] provided the first framing, from a national accounting perspective, for the integration of information on ecosystem services and ecosystem assets. This framing is described further below to provide a general understanding of the logic and motivation for the valuation of ecosystem services. It is recognized, however, that the precise description of the relationships between ecosystem assets, ecosystem services and the associated production, consumption and balance sheet information in the standard national accounts is subject to ongoing discussion. […] a more precise and commonly agreed framing is required to support discussion and exchange on this issue" (Atkinson and Obst, 2017: 11). This incipient development of the structure of SEEA- EEA accounts linked to the SNA is a circumstance that makes it difficult to meet institutional demands for its voluntary experimental implementation by national governments. The brief description of the sequence of SEEA-EEA and SNA accounts compared in Obst et al. (2019) does not permit a detailed discussion on what its future development might be.

The most recent draft dealing with the design of the SEEA-EEA economic accounts proposes the ecosystem as an institutional sector composed of public products without added manufactured costs to farmers and households in the SNA (Obst et al., 2019). With respect to the SEEA-EEA, our Agroforestry Accounting System (AAS) incorporates the government institutional sector, refined with the inclusion of public products without manufactured costs and considers the ecosystem as a production factor and not as an institutional sector (Campos et al., 2019a). The variable that is the backbone of the conceptual design of the AAS is the environmental income, integrated in the prior factorial distribution of the total income from the landscapes at social price. The AAS methodology integrates the slightly refined SNA (henceforth rSNA) and therefore avoids the independent design of the satellite economic accounts for ecosystem services [1]. In the AAS and rSNA methodologies the changes in the environmental assets are explicitly incorporated in the environmental income estimates for the activities valued.

The AAS and rSNA methodologies have been applied in Andalusia to the measurement of environmental income at regional scale in forests at producer price (Campos et al., 2019a), cork oak open woodlands at social price (Campos et al., 2019c), and at farm scale in the holm oak *dehesa* case studies at social price (Campos et al., 2019d).

This article presents the compared applications of the AAS and rSNA for the estimation of added values, changes in environmental assets and environmental incomes at producer and social prices in the holm oak open woodlands (HOW) of Andalusia-Spain (see HOW extent and institutional characteristics in supplementary text S1). The individual economic activities valued are those privately-owned by farmers, namely timber, cork, firewood, nuts, grazing (by game species and livestock), conservation forestry, landowner residential services and private amenity, along with those publicly-owned by government, namely fire services, water supply, mushrooms, carbon, free-access recreation, landscape conservation and threatened wild biodiversity preservation (see conceptualization in supplementary text S2).

[1] To illustrate the point, instrumental applications of the slightly refined SEEA-EEA and a simplified AAS are presented in Campos et al. (2019b).

The concept of social price refers to the incorporation (with respect to the valuation at producer prices) of own non-commercial intermediate consumption of services (SSnco) imputed to the amenity and landscape activities. The SSnco come from hunting and livestock activities omitted from the HOW on this occasion.

The term ‘environmental income’ has been employed before without reference to the changes in environmental assets in the context of family scale subsistence economies as a synonym of ‘resource rent’ in Cavendish (2002: p. 53) and also assimilated to the gross added value in the absence of opportunity costs of self-employed work and either null or token employment of manufactured capital in subsistence economies (Sjaastad et al., 2005: p. 41). In this article, the concept of environmental income refers to the total income given by nature, integrated into the estimate of total income from the individual landscape activities valued. The residual valuation of the environmental income is conditional to the priority of remuneration for work, and manufactured investment resolves the coherent integration of the rSNA in the AAS. As with the total income, the environmental income comprises a residual term of the production account, as is the resource rent, and another residual term of the balance account, namely, the environmental asset gain for the period. The environmental incomes from the total products valued by the AAS at social price represent the scheduled sustainable economic contributions of management by farmers and government of the environmental assets of the Andalusian HOW. A valuation of the environmental assets at the closing of the period is assumed that corresponds to the forecast regeneration of the trees in the current area over the complete biological/commercial cycle, along with the absence of any loss of currently threatened wild species. Under these conditions the ecological sustainability of future management of the HOW is integrated into the expected future results for the indefinite current resource rents.

The AAS and rSNA applications are drawn up based on information from land use tiles of the third National Forest Inventory for Andalusia and the Spanish Forest Map (DGCN, 2008) showing a predominance of holm oak open woodlands (HOW). The physical data on estimated flows and stocks are for the year 2010. We have omitted the hunting, livestock and agriculture activities from those valued in the holm oak open woodlands (HOW) as regional scale information was not available. For explanatory purposes we have included the SSnco of the omitted activities, which we assume have been used by the amenity and landscape activities valued.

2. Economic rationales and accounting methods

The economic theory of the investment supporting the measurement of total income and its factorial distribution follows an order of priority which conditions the remuneration of the three conventional production factors of labor, manufactured capital and natural resources. The order of priority for remunerations of the production factors in the first possible transaction of a harvested (ordinary) product of an activity is assumed to be: labor cost (LC) first, ordinary manufactured net operating margin (NOMmo) second and ordinary environmental net operating margin (NOMeo) third. The residual remuneration of the NOMeo of nature based activities in the last position implies that the values cannot be negative. The government voluntarily renounces the remuneration of the ordinary manufactured net operating margin (NOMmo) of the immobilized manufactured capital in the public activities. From these pre-conditions it can be deduced that the ecosystem services cannot contain negative values, given the positive values for products of environmental work in progress used. Consequently, the NOMmo of the amenity and public activities can only present values equal to or less than zero.

We assume that public consumers with free-access to recreational services and gathering of wild products do not incur manufactured costs.

2.1. Economic rationales applied in holm oak open woodlands in Andalusia

In this application of the AAS and rSNA to the HOW, we do not take into the existence of a contractual right/liability of the owner in the presence of a third party regarding the carrying out of an economic activity aimed at the improvement/maintenance of the threshold of a given natural asset at the closing of the period. Under this circumstance, no loan/debt is generated for the increase/loss of natural assets derived from the economic activities and therefore the net worth of the HOW only comprises the real assets.

2.1.1. Economic rational of farmers

There are both private and public owners of the land, with different economic rationales. In this study of HOW it is assumed that the economic rationale of the private owners includes auto-consumption of private amenities. It is accepted that the production function of the private amenity only uses own intermediate consumption of ordinary services (SSoa). The SSoa stem from the omitted HOW activities of hunting and livestock and are composed of commercial (SSco) and non-commercial (SSnco) services, respectively, of the commercial intermediate residential services (ISSc) and the non-commercial intermediate production of amenity services (ISSnc).

The government is the owner and manager in representation of the collective public activities. In the HOW the public activities are those that the government regulates and manages, providing free consumption of the final products to both active and passive consumers. The economic rationale of the public owners implies registering own non-commercial intermediate consumption of services (SSnco) compensations (SSncoc) and donations (SSncod) in the public activities that use them, mainly the landscape activity. The SSncod originate in the non-commercial intermediate service products of donations (ISSncd) from the activities which generate them, mainly game hunting.

The public and private landowners produce ISSc and ISSncc, but the ISSnca only private landowners and the ISSncd only public landowners. The ISSnca/d are estimated according to the voluntary opportunity cost incurred by the owners of the land and the livestock. In this study the ISSncc of the HOW activities valued were not estimated, but they are included in the SSnco originating in the omitted activities of hunting and livestock.

Based on the concept of valuing the existence of a unique genetic variety which is not industrially reproducible, the government is able to accept voluntary negative values in recurrent periods for the NOMmo of a public activity, the main logic for the conservation of a unique biological variety in danger of extinction. However, the omission of consumer preferences is not complete because democratic governments must consider the tolerable cost of avoiding the irreversibility of current generations.

There is a general consensus on the diverse rationalities of the integrated conservationist management of the HOW among the economic actors and this is clearly reflected in the following quote from the president of the HOW non-governmental institution ‘Foro Encinal’, who proposes the integration of sustainable HOW management in the following terms: “From a production perspective, always effected [sustainable management] in a way that focuses on restoring the balance between environment and business, allowing a profitability which facilitates reinvestment in the environment [..], actively organizing the maintenance of the natural scenario in which we carry out our agricultural activity, with the certainty of achieving the economic return for our labor” (García, n.d.: p. 10). Although in principle all the actors accept this conservationist perspective for HOW economic management, controversy arises among the owners, the government and the consumers when attempting to put into practice their perceptions on the concepts of economic profitability and environmental asset conservation. We are faced with numerous subjective interpretations when attempting to apply sustainable management of renewable natural resources in a way that is coherent with ecological and economic sciences.

2.1.2. Government compensation when farmer unwanted opportunity costs matter

The public consumers can reveal/declare a willingness to pay (WTP) if they are uncertain as to whether the owner may cease or reduce future production of HOW public services used in the period.

The recipients of the public compensations should provide services to society which are, at least, equal to the payments they receive from the government. Hence, the necessity for scientific concepts which appropriately report the policy design according to the scheduled objectives (Brundtland, 1997). The concept of benefit loss refers to an unwanted opportunity cost to the land and livestock owners, which has the counterpart of a compensated non-commercial intermediate service (ISSncc). The latter is measured as the normal ordinary net operating margin (NOMon) of the activity less the ordinary net operating margin at producer prices ($NOMo_{pp}$) and auto-consumed non-commercial intermediate service (ISSnca):

$$ISSncc = NOMon - NOMo_{pp} - ISSnca \qquad \text{(eq. 1)}$$

We estimate the NOMon based on the subjective assumption of what is considered to be a normal real private operating profit rate[2] for the mean ordinary manufactured capital invested during the period.

Having verified the existence of an ISSncc value > 0 based on the WTP, the owner can legitimately claim a compensation from the government (in representation of the beneficiaries of HOW public service consumption) estimated in accordance with the ISSncc, as long as WTP ≥ ISSncc in the absence of threat of extinction of a habitat or unique species. If this situation occurs, tolerable social cost will be the criterion of the government in order to pay compensation to an owner where this is not approved by

[2] We have adopted a rate of 3% for the HOW.

current generations of public consumers, if the case were to arise where the WTP ≤ ISSncc.

An initial corollary of the arguments expressed on the estimation of the ISSncc is that it is necessary to know the value of the ISSnca according to the management type of each individual activity. A second corollary is that the consumers and the owners must reveal/declare their WTP/ISSnca in order to determine whether it equals or exceeds the ISSncc which would maintain and/or improve the sustainability of the HOW management.

A critical aspect when agreeing on a compensation for maintaining/improving sustainability is the legitimacy of the payment according to the initial economic property rights of the owners and public consumers prior to the agreement. The public compensation is legitimate if it is based on reciprocity for the loss of economic value of a previous legal use which is lost in the future and/or the loss of profit from private investment in a new action of improvement or mitigation of potential abandonment, which favours the future supply of ordinary public products.

2.1.3. Scheduled sustainability in holm oak open woodlands

The physical sustainability of the HOW is forecasted based on scheduled future natural/induced regeneration. The biological cycles are as prescribed by forestry legislation on the management of *quercus* genus species in Andalusia and felling of holm oaks is only permitted where there is a government authorized land use change. Commercial harvesting rotations are not regulated in the case of Conifers and broadleaf wood producing species (eucalyptus and poplar mainly) and management plans for these species include stand persistence without land use change, except where unforeseen destruction occurs (e.g. catastrophic forest fires).

Although the landowners are not obliged to replant the trees, in this HOW study it has been assumed that the scheduled future conservation silviculture applied will renew the current area of woodland in Andalusia where holm oak woodland predominates (Campos et al., 2019a; Montero et al., 2015).

2.2. Summary of the AAS applied to holm oak open woodlands

The System of National Accounts (SNA) allows economic science conceptualizations of the products, costs and capitals, which allows us to estimate the net value added and the capital gains that integrate the coherent definition of the total income of individual products. In practice, the SNA applied by nations is limited to the measurement of net values added at market price for the economic activities of corporations and the government activities valued at production cost, in this case lacking conceptual consistency with the principle of valuation at market price, since it impedes the existence of a positive ordinary net operating margin.

The AAS and rSNA methodologies have been applied with the above described characteristics to forests and other wooded land in the region and at farm scale in Andalusia and Extremadura (Campos et al., 2008, 2009, 2016, 2017a, 2017b, 2019a, 2019b, 2019e; Caparrós et al., 2017; Ovando et al., 2016; Oviedo et al., 2017). The applications of the AAS and rSNA methodologies adapted to this HOW studies are briefly described in the supplementary texts S3 and S4. In the next section we simply conceptualize the sequence of accounts developed in the HOW applications, which allow us to estimate the total capital, the ecosystem services, total income and environmental income. In the conceptual description of the variables when referring to the individual activities and products it is not necessary to make the distinctions of the accounting methodologies.

2.2.1. Background to income and ecosystem service concepts

In the awards ceremony of the 1984 Nobel Prize for economics, Robert Stone said that the controversy among experts with regard to national accounts had to do with difficulties in their application. However, this point of view was associated with a concept of income limited to the production of goods, without considering the point of view of John K. Krutilla[3] (1967), who advocated the extension of the concept of national income to include nature based public products consumed freely by people and valued according to a market simulation of the marginal willingness to pay declared by the beneficiaries and other procedures revealed by the consumers. However, the opinion of Richard Stone was conditioned by the state of the art at that moment with respect to the valuation methods for products without market price, and he stated that

[3] "When the existence of a grand scenic wonder or a unique and fragile ecosystem is at stake, their preservation and continued availability form a significant part of the real income of many individuals" (Krutilla, 1967: p. 779).

environmental issues constituted one of the mainstays for the development of society accounts (Stone, 1984)[4].

To date, the notable advances achieved in the techniques for valuing the final products consumed without market price have not been incorporated into the standard System of National Accounts applied by nations in their estimations of gross domestic product (GDP), which, as we will see, is still an incomplete measure of the total income for the period, generated within the territory of the different nations (European Commission et al., 2009; European Communities, 2000).

While Stone (1984) favoured the exclusion of the revaluation of manufactured capital from the measurement of national income (hereafter net value added), other authors do include it (Eisner, 1989; Hicks, 1946; McElroy, 1976). The situation in which we currently find ourselves is that the concept of total income is not objective of the SNA measurements, at least for most of the public and private products consumed, even though the regulations for national accounts in the United States of America and European Community accept the theoretical coherence of the concept of total income (BEA, 2017; European Communities, 2000). The BEA explicitly recognizes that the GDP does not measure total income: "Some economic theorists have broadly defined income as the maximum amount that a household, or other economic unit, can consume without reducing its net worth; [..]. In the NIPAs [National Income and Product Accounts], the definition of income is narrower, reflecting the goal of measuring current production" (BEA, 2017: chapter 2, pp. 6-7). The satellite accounts of the SNA for silviculture and agriculture (including animal activities) explicitly accept the concept of total income even though measuring it is not their purpose: "Income can be defined as the maximum amount which the beneficiaries can consume over a given period without reducing the volume of her/his assets. It can also been defined as the total of the consumption and change in value of assets held over a given period, all else being equal, as income represents what *could have been consumed*" (European Communities, 2000: p. 87).

The measurement of total income is the principle which governs the organization of the records for the whole accounting system of an economic unit, which should abide

[4] "Environmental issues, such as pollution, land use and non-renewable resources, offer plenty of scope for accounting. However, I have done little work in this area and so I shall do no more than mention what I called at the beginning of my lecture the third pillar on which the study of society should rest" (Stone, 1984: p. 23).

by the economic principle that the real capital values at the opening and closing of the period in which the total income produced in the territorial unit is measured remain the same.

Measuring the total income requires the type of production and balance accounts described in the AAS methodology (see details in supplementary texts S3 and S4). The production account gives the net value added (NVA) and its distribution among the production factors of labor (LC), manufactured investment (NOMm) and environmental asset (NOMe):

$$NVA = LC + NOMm + NOMe \quad \text{(eq. 2)}$$

The balance account gives the capital revaluation (Cr). Following specific accounting adjustments applied to avoid double counting of the natural growth in HOW applications, the Cr allows us to estimate the capital gain (CG). In accordance with the factorial distribution of the NVA, the CG is divided into manufactured investment (CGm) and environmental asset (EAg) of each individual product:

$$CG = CGm + EAg \quad \text{(eq. 3)}$$

Thus, having estimated at the end of the period the real values registered and the residual virtual values of the production and balance accounts, we have the NVA and the CG, which together give the total income of the HOW for the period and its factorial distribution among remuneration for labor (LC), income from manufactured capital (CIm) and environmental income (EI):

$$TI = NVA + CG \quad \text{(eq. 4)}$$
$$TI = LC + CIm + EI \quad \text{(eq. 5)}$$

The procedures for estimating the CGm and the EAg are the same. Here we describe the EAg as it has more novel aspects. The environmental asset at the closing of the previous period is taken to be the same as the environmental asset at the opening (EAo) of the current period. Entries (EAe) and outputs (EAw) occur during the period. Among other EAe, both real and instrumental, is that of natural growth (NG) for the period valued at environmental price discounted at the closing of the period. As regards the EAw, the extractions of work in progress valued at environmental price (WPeu) are recorded among others, both real and instrumental (WPeu). At the end of the period the closing environmental asset (EA) is estimated, discounting the indefinite flow of resource rents, assuming all else remains constant except for the expected variations in biological productivity which are modelled in advance. The revaluation of the environmental asset (EAr) is the residual variable (balancing item) in the balance account. The EAr incorporates the change in the environmental asset in the period (CEA) and the net EAw of EAo:

CEA = EAc – EAo (eq. 6)

EAr = CEA + EAw – EAe (eq. 7)

The abovementioned identities from the production and balance accounts provide the elements which correspond to the environmental income. These components of the environmental income (EI) are the NOMe and the EAg. The EI represents the total contribution of nature (ecosystems) to the total income of the HOW. The environmental income (EI) is the core variable which gives the values of the ecosystem services (ES) and the changes in the environmental assets for the period (CEA). In the case of some products these CEA must be adjusted to avoid double counting, these adjustments leading to the new variable of changes in environmental net worth adjusted (CNWead) according to WPeu. After certain instrumental adjustments the EI can be presented in it ES and CNWead components:

EI = NOMe + EAg (eq. 8)

ES = WPeu +NOMeo (eq. 9)

EI = ES + CNWead (eq.10)

EI = ES + CEA, if there is no instrumental adjustment (eq.11)

2.2.2. Prices of stocks and harvested products

The environmental timber, cork and firewood stocks at the opening of the period and total products consumed are valued at their environmental, stumpage and farm gate prices. The prices of the stocks of timber, cork and firewood produced are derived from the net current value of the physical quantities times their discounted environmental price at the opening of the period. The products consumed are valued based on the willingness-to-pay of the economic agents, depending on the stage they are at prior to their consumption as a final product.

The environmental price of a harvested product corresponds to the unitary resource rent. The harvested stumpage price of a product represents the transaction price before the product is harvested, and the farm gate price at the harvest price of the road gate.

Producer prices are market prices plus the production costs of commercial intermediate services (ISSc) without market prices (e. g., conservation forestry and fire services). Commercial intermediate products with formal markets are valued at their imputed market prices (e. g., grazing and residential service).

Embedded in the value of the total product at social price are the individual values of its total production costs and the net operating margin. The latter is measured in this HOW as the net operating margin at basic price less the own non-commercial intermediate consumption of amenity and donation services (SSncoa/d). These SSncoa/d, which come from the omitted hunting, livestock and agricultural activities, are valued at the monetary opportunity cost voluntarily accepted by the farmers.

The basic price is the producer price plus the non-commercial intermediate product of compensation for services (ISSncc). The latter is the unit value of the government compensations (annualized capital and net operating subsidies of taxes on production). We assume that the individual compensation is based on loss of profit to the owner due to the additional product offer generated by the agreement reached between farmers and government in relation to the offer which would be expected in the absence of compensation. In this study of the HOW, the activities valued do not incorporate ISSncc, but they do include own non-commercial intermediate consumption of services compensation (SSncc), which is used by the amenity and landscape activities, and which comes from the ISSncc of the omitted HOW activities of hunting, livestock and agriculture.

The fact that products are valued at producer, basic and social prices does not influence the aggregate estimate for the considered HOW activities as a whole. Thus, the valuation of the economic variables at social price is consistent with the total income from HOW activities as a whole. However, the different types of prices *do* influence the estimates of ecosystem services and the gross value added of the farmer, government, HOW activities valued, and those of individual activities where input of SSncoc/a/d is involved.

The revised System of National Accounts (rSNA) applied to the HOW estimates ecosystem services, ordinary environmental net operating margin and gross value added at both producer and basic prices. However, the ISSnc are not considered in this application to HOW economic activities, hence the rSNA producer and basic prices coincide. In the Agroforestry Accounting System (ASS), ecosystem services and incomes are valued at social prices. The reason for this difference is that the AAS considers the SSnco accruing from the HOW hunting and livestock activities omitted.
The maps of geo-referenced monetary income results show values at producer price. In this case the amenity and landscape activities are overvalued with respect to their social prices due to the omission of the SSncoa/d.

2.3. Integration of the refined SNA in the AAS applied to holm oak open woodlands

The statistics for the net value added (NVA) of the economic activities at national level apply the refined System of National Accounts, which does not include natural growth (NG) in own account gross capital formation (GCF) and omits the environmental work in progress used (WPeu) from the intermediate consumption. These omissions lead to a bias associated with the timing of the measurement of the NVA in the SNA, which is avoided in this study as the refined SNA includes their measurement in the NVA (see Tables S1-S2).

The AAS and rSNA applied to the HOW coincide with regard to the quantities estimated. They differ in the prices of the ordinary final products without market price, the valuation of the rSNA at basic price and of the AAS at social price. Furthermore, the AAS includes the carbon activity.

We are interested in linking the net operating margin at social prices in the AAS ($NOM_{sp,AAS}$) with the net operating margin at basic prices in the rSNA ($NOM_{bp,rSNA}$). This linkage is achieved in the HOW application by applying the following criteria: (i) subtracting own non-commercial intermediate consumption of services from the amenity auto-consumption and donation valued at voluntary opportunity cost ($SSncooa/d_{oc,F,G,AAS}$); ii) adding the difference from the price of the private amenity derived from farmers' willingness-to-pay ($\Delta FPaa_{wtp;AAS}$) to the amenity final products consumed valued by the refined System of National Accounts (rSNA) at the private amenity service production cost price; (iii) adding the difference from the price of the final product of water derived from the revealed environmental market price ($\Delta FPwa_{pp,G,AAS}$) to the water supply used by the industry and service sectors valued by the refined System of National Accounts(rSNA) at null manufactured production cost price;(iv) adding the difference from the revealed marginal consumer willingness-to-pay ($\Delta FPnc_{wtp,G,AAS}$) to the cost price of the consumption of public goods and services without market prices (recreational service, landscape conservation service and existence of the threatened wild biodiversity service), (v) adding the carbon final product consumption ($FPca_{pp,G,AAS}$) and (vi) subtracting the carbon consumption from environmental fixed asset ($CFCeca_{pp,AAS} = SSeca_{pp,AAS}$):

$$GVA_{sp,AAS} = GVA_{bp,rSNA} - SSncoo_{oc,F,G,AAS} + \Delta FPaa_{wtp,F,AAS} + \Delta FPw_{pp,G,AAS} + \Delta FPnc_{wtp,G,AAS} + FPca_{pp,G,AAS} - CFCeca_{pp,G} \quad \text{(eq.12)}$$

Equation 12 shows that the SNA and the AAS contain consistent integrated accounting structures which allow homogeneous comparisons of their gross added values as well as any other indicator of ecosystem service, income manufactured capital and environmental asset.

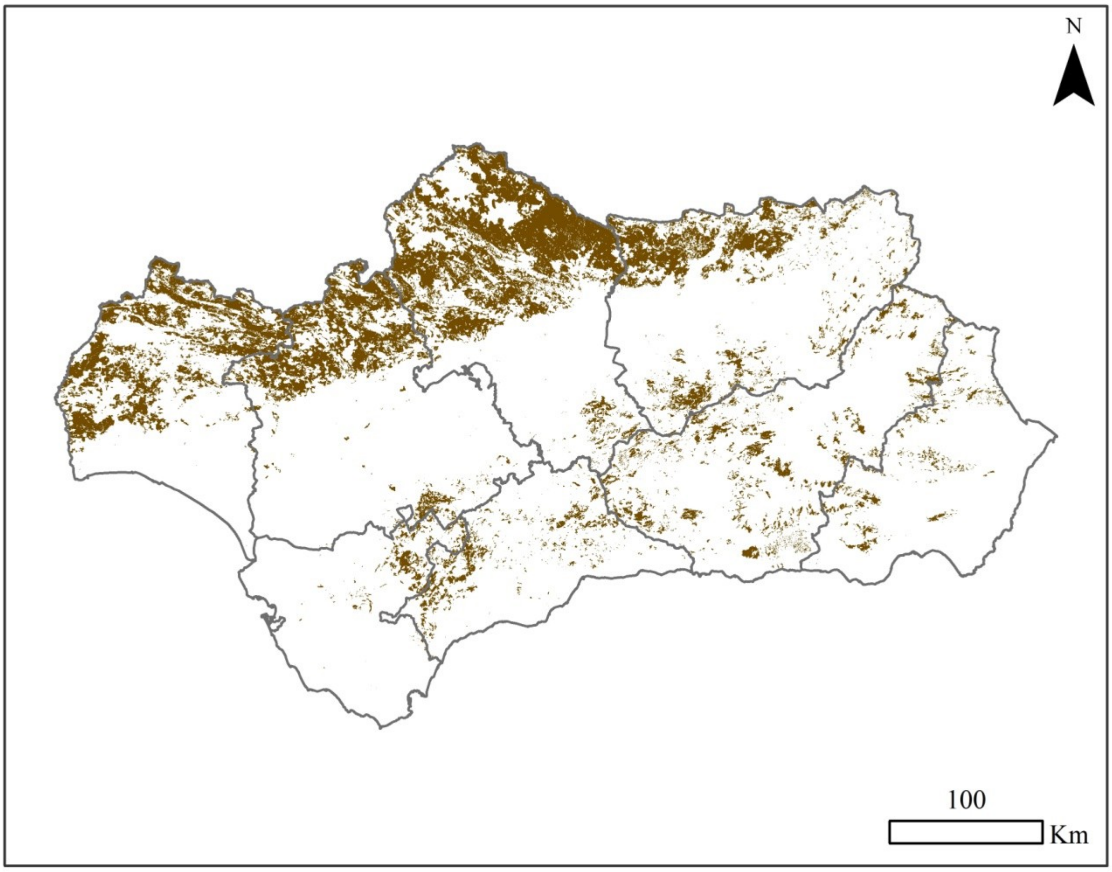
3. Results

3.1. Bio-physical indicators

The bio-physical indicators of the stocks and flows refer to the 2010 period and their respective units and useful agrarian land according to the land-use tiles of Andalusia in which HOW are present. For several of the products the indicators show non-economic flows which are considered in the estimates of economic flows.

The area of the Andalusian land-used tiles in which holm oak open woodlands are predominant covers 1,408,170 ha (Fig 1 and Table S3). The HOW comprise 22,281 tiles with an average size of 63.2 ha (Table S4).

The activities valued in this study of HOW can be considered an extension of the standard Economic Account for Forestry (European Communities, 2000). Thus, the standard Economic Account for Agriculture (EEA) has been left out. The latter includes the hunting, livestock and agriculture activities. It is estimated that the labor demand of government activities in the HOW is slightly greater than that of farmer activities and that the hourly remunerations are double that of the farmers. The greatest demand is for



Holm oak open woodlands (1,408,170 hectares)

Figure 1. Map of tiles with predominant holm oak woodlands in Andalusia.

fire services, followed by residential service and grazing activities, although the demand is far lower in the latter two activities. (Table S5, Figs. S1-S2).

The HOW activities valued require an annual work unit (AWU) per 562.5 ha area. In a sample of predominantly holm oak open woodland farms (*dehesas*) in Andalusia, the animal activities require 1.6 times more labor than all HOW activities valued in this studio combined (Campos et al., 2019d). As an illustration, if we transfer the demand for labor in the animal activities of the HOW *dehesa* sample, the demand would be one AWU per 165.2 ha area.

3.1.1. Provisioning products

Timber-yielding conifer species are present in 7% of the HOW area and the natural growth of wood in the period far exceeds the extractions. The presence of Stone pine is rare among holm oak trees, and although timber extraction may take place, the pine nuts produced by this species are its main use. Cork oak trees cover 16% of the

HOW area and natural growth of cork in the period exceeds extractions. The only product extracted from the holm oak trees is firewood and these extractions are minimal (Table 1).

Grazing in the HOW refers to direct consumption in the field of grasses, wild fruit and browse from trees and bushes by livestock and game species. The consumption of forage units has been estimated residually by simulating the total needs of livestock and game species in the period according to the management characteristics, subtracting supplementary fodder from this total consumption (see details in Campos et al., 2016).

The real productivity as regards acorn production estimated in the field has scarcely been studied (Fernández-Rebollo and Carbonero-Muñoz, 2008). The biological production of acorns is the only component of grazing which has been simulated from real measurements in the field, using a function which depends on the normal diameter of the stem of the holm oak tree (Campos et al., 2019a: supplementary text S13.1). The low average canopy cover fraction (32%) of holm oak open woodlands (see supplementary text S1.1) leads to an average acorn yield of 39.4 kg/100ha. We estimate that the livestock consume 30% of the biological production in the period. The rest of the production is consumed by wild game and other species or reintegrated into the natural regeneration cycles and biological decomposition (Table 1).

Our estimates of grazing consumption are divided between livestock and game species; 70 % and 30%, respectively. The estimated grazing consumption per hectare by livestock in the HOW is lower than the amount estimated in a case study of private *dehesas* since the latter study included grassland consumption (Campos et al., in progress).

There is a generalized use of HOW for recreational hunting, which represents a complementary production of goods and services as a whole, although in cases where this involves deer within fenced estates, this may be the main product. However, the main importance of hunting services, along with meat and trophies (antlers etc.), is for general economic uses (Herruzo et al., 2016). Many different species are captured although the economic value of commercial captures is mainly limited to nine species. Among the six big game species, captures of red deer and wild boar are the most abundant (Table 1).

Table 1. Holm oak open woodlands bio-physical indicators in Andalusia (2010).

Class	Unity	Indicators		
		Useful land (ha)	Quantity	Quantity/ha
Timber				
Stock	m^3	98,692	14,329,399	145.2
Natural growth	m^3	98,692	296,882	3.0
Extraction	m^3	98,692	25,565	0.3
Cork				
Stock	t	225,271	22,379	9.9(*)
Natural growth	t	225,271	7,994	3.5(*)
Extraction	t	225,271	632	0.3(*)
Firewood				
Stock	m^3	1,408,170	68,763,210	48.8
Natural growth	m^3	1,408,170	1,223,810	0.9
Extraction	m^3	1,408,170	36,454	0.0
Nuts	kg	26,742	1,127,063	42.1
Commercial	kg	26,742	155,047	5.8
Free	kg	26,742	972,016	36.3
Acorn	t	1,408,170	554,175	39.4(*)
Livestock	t	1,408,170	167,093	11.9(*)
Game and others uses	t	1,408,170	387,082	27.5(*)
Grazing	FU	1,408,170	843,764,165	599.2
Livestock grazing	FU	1,408,170	592,531,694	420.8
Game grazing	FU	1,408,170	251,219,107	178.4
Hunting captures				
Red deer	he	1,402,309	19,110	1.4(*)
Wild boar	he	1,402,309	10,862	0.8(*)
Spanish ibex	he	1,402,309	125	0.0(*)
Fallow deer	he	1,402,309	1,411	0.1(*)
Mouflon	he	1,402,309	1,166	0.1(*)
Roe deer	he	1,402,309	32	0.0(*)
Red partridge	he	1,402,309	95,407	6.8(*)
Rabbit	he	1,402,309	97,612	7.0(*)
Others	he	1,402,309	532,269	38.0(*)
Residential	m^2	1,408,170	545,141	38.7(*)
Recreation	vi	1,408,170	2,816,138	2.0
Mushrooms	kg	1,402,309	3,972,590	2.8
Carbon				
Fixation	t CO_2	1,408,170	4,286,973	3.0
Wooded	t CO_2	1,408,170	2,369,425	1.7
Shrubland	t CO_2	1,408,170	1,917,548	1.4
Emissions	t CO_2	1,408,170	1,358,029	1.0
Wooded	t CO_2	1,408,170	900,684	0.6
Shrubland	t CO_2	1,408,170	457,344	0.3
Net fixation	t CO_2	1,408,170	2,928,944	2.1
Wooded	t CO_2	1,408,170	1,468,741	1.0
Shrubland	t CO_2	1,408,170	1,460,204	1.0
Threatened wild species	nº	1,408,170	159	
Water	m^3	729,913	12,154,849,160	16,652.5
Intermediate product	m^3	729,913	5,927,078,336	8,120.3
Evapotranspiration	m^3	729,913	5,928,174,621	8,121.8
Negative variation	m^3	729,913	1,096,285	1.5
Final product	m^3	729,913	6,227,770,824	8,532.2
Runoff	m^3	729,913	3,949,483,378	5,410.9
Ecological	*m^3*	*729,913*	*2,907,639,768*	*3,983.5*
Economic	*m^3*	*729,913*	*1,041,843,610*	*1,427.4*
Deep aquifer recharge	m^3	729,913	2,095,960,796	2,871.5
Positive variation	m^3	729,913	182,326,650	249.8

Abbreviations: m^3 is cubic meter; t is ton; kg is kilogram; FU is forage unit (metabolic energy of a kg of barley); he is head; m^2 is square meter; vi is free recreational visit; nº is number; t CO_2 is tons of carbon dioxide.

(*) These indicators are expressed in their unity per 100 hectares.

Mushroom picking is widespread and as occurs with other wild plant and animal species collected such as asparagus, cardoons ("tagarnina") and snails ("cabrillas"), they are not valued here (Martínez-Peña et al., 2015) (Table 1).

We estimate that 51% of precipitation falling in the area of the HOW corresponds to the final product which is not consumed within the HOW (intermediate product) but is runoff water which reaches the river basins, deep aquifer recharge and positive change in the water balance over final consumption for the period (Table 1). The runoff water retained in reservoirs, hence with economic use, accounts for 26% of the runoff and is used by economic activities and households (Beguería et al., 2015).

3.1.2. Regulating products

HOW areas and the economic activities associated with them are considered by many citizens as well as the government as natural capital, the value of which should be conserved for use by future generations, without disregarding the sustainable demands of current generations. As a consequence of this perception of HOW conservation services, there is a conceptualization of the public economic activity of landscape conservation in the HOW as a passive option value, regardless of the other current uses which represent the value enjoyed by current generations motivated by the wish to assure the future continuity of the natural environmental assets constructed through human intervention in the HOW.

The presence of 71% of the 224 inventoried threatened wild forest, woodland, shrubland and grassland species in Andalusia has been documented in the HOW (Campos et al., 2019a; Díaz et al., 2019) (Table 1).

The net accumulation of carbon is positive and divided equally among trees and scrub (Table 1).

3.1.3. Cultural products

The commercial recreational services of hunting, accommodation and restaurants provided by the owners to consumers, nature tourism Company services and ecosystem services which occur outside the HOW in the form of consumption by recreational visitors in restaurants and accommodation are not estimated in this study. The main commercial recreational product of the HOW farmers is big game hunting, mainly of deer and wild boar (Herruzo et al., 2016)

Auto-consumption of amenities by private owners (mainly non-industrial) is the main reason for the existence of family residential dwellings and the latter provide clear evidence of the unique lifestyle associated with the non-industrial ownership of HOW (Table 1). In return for the important private amenity consumption, the owners maintain the HOW as scattered woodland with low canopy cover fractions, grazed by both domestic and wild animals.

Public recreational uses of the HOW are of lower intensity than those of the Andalusian forests since they tend to be located on undulating landscapes and at the foot of the sierra (Table 1). Furthermore, there is much more livestock farming in the holm oak open woodlands than in the forests, which are generally located in the upper reaches of the river basins. Also, the perceived greater degree of "naturalness" of the forests means that they are more attractive to tourists (Campos et al., 2019a).

3.2. Results for AAS ecosystem services, incomes and capitals

The production and balance accounts of the AAS methodology applied to the eight farmer and seven government HOW activities valued are those for which we have complete information at Andalusia regional scale in order to elaborate the results of the economic flows and stocks for individual and aggregate activities of the farmers, government and the fifteen HOW activities considered.

3.2.1. Selected flows and stock prices

Table 2 shows a selection of four possible prices that we have applied to the stocks and flows of products consumed in the HOW.

The discounted environmental price (accounting price) of the timber stock produced is 32 times lower than the work in progress used (WPeu) of timber. The price of timber WPeu equates with its stumpage price because no silvicultural costs are applied to conifer species. The farm gate price of harvested timber is 1.56 times its stumpage price (Table 2).

The accounting price of the cork stock produced is 21 times lower than the cork WPeu. Furthermore, the silvicultural cost of cork trees is incorporated into the conservation forestry, and as with timber, the cork WPeu and stumpage prices are the same. The farm gate price of cork is 1.21 times its stumpage price (Table 2).

Table 2. Holm oak open woodlands selected stocks and harvests prices in Andalusia (2010: €/unity.)

Class	Unity	Environmental price of produced stock	Environmental price of harvest	Stumpage price of harvest	Farm road price of harvest
1. Timber	m^3	0.35	11.29	11.29	17.66
2. Cork	t	233.23	1,259.36	1,259.36	1,524.26
3. Firewood	m^3	0.41	8.74	8.74	58.32
4. Grazing fodder	100 FU		3.57	4.51	
4.1 Livestock grazing	100 FU		3.13	4.46	
4.2 Game grazing	100 FU		4.62	4.62	
5. Residential	m^2				37.85
6. Recreation	visits		10.79		15.50
7. Mushrooms	kg		6.31		6.37
8. Carbon	tCO_2		13.73		13.73
9. Economic water	m^3	0.12	0.12	0.12	0.12

The accounting price of the stock of firewood produced from holm trees is 5.4 times lower than the WPeu of firewood. As the holm oak silviculture is included in conservation forestry, the firewood WPeu and stumpage prices are the same. The farm gate price for firewood is 6.67 times its stumpage price (Table 2).

Due to the low costs of ordinary grazing management the stumpage price is 1.26 times the environmental price of the intermediate product of grazing (IRMg) (Table 2).

We have attributed the local leasing price to the residential dwellings used by the owners and registered this commercial intermediate service in the residential activity and its corresponding intermediate consumption is attributed to the amenity activity (Table 2).

The literature concerning recreational services generally assumes the absence of manufactured costs in the production of free-access public services in the simulated estimates of consumer surplus of visitors. In our publications we have included the government costs in the services provided to visitors (Campos et al., 2019a, Caparrós et al., 2003, 2017). In this study of HOW, the final consumption price declared by the visitors is 1.44 times the environmental price of the visit (unitary resource rent) (Table 2).

The management cost to the government of mushroom activity is minimal, which explains the fact that the market price of the mushrooms at the farm gate is similar to the environmental price. Mushrooms have no harvesting cost in this study as it is assumed that recreational mushroom picking visitors do not incur opportunity cost for the time they spend on the visit (Table 2).

Carbon has no manufactured costs in the HOW and for this reason the environmental price and the simulated final consumption price are the same.

The final water supply has no production cost at HOW sites. It is important to distinguish between the accounting price of water as an environmental asset and (stock price) and the price of the economic water consumed (flow) in the period. The stock price of the water is the present net unit price of the resource rent of the indefinite flows of water consumed. Berbel and Mesa (2007) estimate a hedonic stock price for water of 4.04€/m^3 (own updating to 2010). If we accept a profitability rate of 3% of the water environmental asset, the environmental price of a cubic metre of water consumed in the period is 0.1212 €/m^3. We have estimated the environmental price of the water for two micro basins at 0.162 y 0.170 €/m^3 using the residual valuation method (Beguería et al., 2015). Using the aforementioned method, Berbel et al. (2011) estimate the mean environmental price at 0.31 €/m^3. If water supply is stored in reservoirs by the water authority beyond the period, the water supply is ready for consumption in the period; therefore this water stock does not have a discounted price (Table 2).

3.2.2. Residual NOM and Cr results for the AAS production and balance accounts

The final objective pursued in the production and balance accounts is to estimate the factorial distribution of the total income (TI) into labor cost (LC), manufactured capital income (CIm) and environmental income (EI).

The purposes of the production and balance accounts in the AAS methodology are to estimate the net operating margin (NOM) and capital revaluation (Cr) balancing items, respectively. The net value added (NVA) is measured by adding the labor cost (LC) to the NOM. The capital gain (Cg) is measured by adding the capital adjustment (Cad) to Cr according to accounting register convention to avoid double counting. The TI is estimated by adding the NVA and the CG.

3.2.2.1. The net operating margin

The ultimate aim guiding the accounting structure of the AAS production account records is the measurement of the ordinary net values added (NVAo), of investment (NVAi) and total (NVA) of the individual farmer, government and

HOW activities, along with the factorial distribution among the labor costs (LC), environmental assets (NOMe) and manufactured capital (NOMm) (Table 3, S6 and S7).

The only intermediate raw material in the HOW is grazing (IRMg) (Table S6). In this study of HOW, the IRMg are not used as own intermediate consumption of raw materials (RMog) as the hunting and livestock activities have been omitted (Table S6). The absence of RMog means that they are not embedded in the final product consumed (FPc). For this reason it is necessary to adjust the final product consumed of the farmers ($FPcad_F$) and the HOW ($FPcad_{HOW}$) by adding the IRMg. Thus, the $FPcad_F$ and $FPcad_{HOW}$ incorporated all the ecosystem services embedded in the products of the HOW economic activities without incurring double counting (Table S6):

$$FPcad_F = FPc_F + IRMg = 379.2\ €/ha \quad \text{(eq.13)}$$

$$FPcad_{HOW} = FPc_{HOW} + IRMg = 680.9€/ha \quad \text{(eq.14)}$$

where subscript F is farmers and subscript HOW is holm oak open woodlands.

Own non-commercial intermediate consumption of services (SSncoc) comprising compensations (SSncoc), auto-consumption of amenity by private owners (SSncoa) and donations by public owners (SSncod) stemming from intermediate production of the HOW hunting and livestock activities not valued in this study have been incorporated. The SSncoc allow the estimation of the net value added at basic price (NVA_{bp}) and by adding the SSncooa/d it can be valued at social price (NVA_{sp}).

If the HOW activities of hunting and livestock omitted here had been included in the production accounts, their non-commercial intermediate services (ISSnc) would have been counted in the intermediate product (IP), in which case, the IP and own intermediate consumption would have coincided.

Table 3. AAS production account at social prices of holm oak open woodlands in Andalusia (2010: €/ha).

Class	Timber	Cork	Fire-wood	Nuts	Grazing	Conserv. forestry	Residen-tial	Amenity	Farmer	Fire services	Recrea-tion	Mush-rooms	Carbon	Land-scape	Bio-diversity	Water	Govern-ment	Holm oak open woodlands
	1	2	3	4	5	6	7	8	∑1-8	9	10	11	12	13	14	15	∑9-15	∑1-15
1. Total product (TP_{sp})	0.4	2.2	1.8	0.1	33.9	4.5	14.7	342.7	400.2	41.3	31.8	18.0	41.8	110.8	12.2	89.7	345.7	745.9
1.1 Intermediate product (IP_{sp})					33.9	2.8	14.7		51.3	38.1							38.1	89.4
1.2 Final product (FP_{pp})	0.4	2.2	1.8	0.1		1.7		342.7	348.9	3.2	31.8	18.0	41.8	110.8	12.2	89.7	307.5	656.5
1.2.2 Final product consumption (FPc_{pp})	0.3	0.7	1.5	0.1				342.7	345.3		31.0	18.0	41.8	110.2	11.2	89.7	301.7	647.0
1.2.2 Gross capital formation (GCF)	0.1	1.5	0.3			1.7			3.6	3.2	0.8	0.1		0.7	1.1		5.8	9.4
1.2.2.1 Manufactured (GCFm)						1.7			1.7	3.2	0.8	0.1		0.7	1.1		5.8	7.5
1.2.2.2 Natural growth (NG)	0.1	1.5	0.3						1.9									1.9
2. Intermediate consumption (IC_{sp})	0.6	0.6	0.4	0.1	0.6	1.6	0.8	137.9	142.6	12.4	3.2	0.1		74.4	1.8		91.9	234.5
2.1 Manufactured intermediate consumption (ICm)	0.4	0.0	0.2	0.1	0.6	1.6	0.8	137.9	141.6	12.4	3.2	0.1		74.4	1.8		91.9	233.5
2.1.1 Bought (ICmb)	0.4	0.0	0.2	0.1	0.6	1.6	0.8		3.7	12.4	1.6	0.1		1.9	1.8		17.9	21.5
2.1.2 Own ($ICmo_{sp}$)								137.9	137.9		1.6			72.5	0.0		74.0	211.9
2.1.3 Manufactured work in progress used (WPmu)																		
2.2 Environmental intermediate consumption (ICe)	0.2	0.6	0.2						1.0									1.0
2.2.1 Environmental work in progress used (WPeu)	0.2	0.6	0.2						1.0									1.0
3. Consumption of fixed capital (CFC)	0.0		0.0	0.0	1.1	0.1	5.6		6.8	2.8	1.6	0.0	13.2	0.7	0.6		19.0	25.8
4. Net value added (NVA_{sp}) (TP_{sp}-IC_{sp}-CFC)	-0.2	1.6	1.4	-0.1	32.3	2.9	8.3	204.8	250.8	26.2	27.0	17.9	28.6	35.7	9.8	89.7	234.8	485.6
4.1. Labour cost (LC)	2.5	0.1	0.3	0.9	3.4	2.8	3.1		13.1	26.1	4.1	0.1		4.0	3.8		38.2	51.3
4.2. Net operating margin (NOM_{sp})	-2.7	1.5	1.1	-0.9	28.9	0.0	5.1	204.8	237.7	0.0	22.9	17.8	28.6	31.7	5.9	89.7	196.6	434.3
4.2.1 Manufactured net operating margin ($NOMm_{sp}$)	-2.9	0.0	0.8	-0.9	0.6	0.0	5.1		2.7	0.0	1.3	0.0		0.2	0.2		1.7	4.4
4.2..2 Environmental net operating margin (NOMe)	0.1	1.5	0.3		28.3			204.8	235.0		21.6	17.8	28.6	31.5	5.8	89.7	194.9	429.9

This is not the case in this HOW study given that as a result of including the IRMg and the SSnco it is not possible to guarantee that the IP and ICo will coincide[5]. In our estimation of the IP and ICo of the HOW activities valued, an IP_{HOW} value is produced which accounts for 42.2% of the ICo_{HOW} value (Tables 3 and S6). This result clearly shows that the HOW animal activities omitted have a decisive influence on the economic results of the amenity, landscape and aggregate activities of the how (see details in supplementary text S4).

The economic irrelevance of natural growth of woody products, namely timber and cork, is normal in the HOW, where timber-yielding conifer species and cork oaks account for around 16% and 7% respectively of the land-use tiles in which HOW predominates (Table S3). Firewood from holm oaks is a sub product of cultural pruning as well as that extracted from dead holm oak trees. With the exception of dead wood, the environmental price of the work in progress used has generally dissipated and therefore the value of natural growth at discounted environmental price is null or minimal (Tables 2 and S6).

Table S6 shows the details of the total product (TP) and total cost (TC) records for the individual activities, which in turn allow us to estimate their respective net operating margins at social price (NOM_{sp}) and their factorial distribution among the operating services of manufactured capital (NOMm) and the environmental asset (NOMe). Table S6 shows the separation of the total cost into ordinary total cost (TCo) and total investment cost (TCi). This classification of the costs allows us to distinguish the origin of the NOMe as total products consumed (ordinary) (NOMeo) and net investment in environmental assets (NOMei). The NOMei is estimated according to the natural growth less the consumption of environmental fixed capital (CFCe). The manufactured investment is represented by own account gross fixed capital formation (GFCF) and does not generate manufactured investment margin as it has been valued at production cost.

Table S6 of the AAS gives the variables for the (WPeu) and the ordinary environmental net operating margin (NOMeo), which added together provide the ecosystem service (ES) estimates. Tables 3 and S7 provide a detailed description of the components which make up the value of a product consumed, among which are the

[5] Except where by chance both ítems have the same value, registered on opposite sides of the production account.

ecosystem services. Finally, Table S6 gives the net value added (NVA) represented by the operating income which remunerates the labor cost (LC) and the capital (NOM).

It may seem strange that countries do not know the income of their national territories when the economic statistic most universally used by governments is that known as the gross domestic product (GDP). The GDP is a synonym for the gross value added (GVA) and in fact the income for the national territory, which in practice is estimated by the government offices for statistics through the SNA, is represented by the net domestic product (NDP), which is synonymous with net value added (NVA). We have devised the AAS production account for the purpose of estimating the NVA and excluding the capital gain (CG) in the gross capital formation (GCF)[6]. We need to estimate the CG from the balance account and thus provide a value for the total income of the HOW.

3.2.2.2. Capital revaluation

The purpose of the balance account is to estimate the residual value of the capital revaluation (Cr).

Table 4 shows the opening capital for the period of the fifteen HOW economic activities valued, separated into manufactured (Cmo) and environmental (EAo). Three of the fifteen HOW activities valued do not contribute to the environmental assets. The most important individual environmental assets are the private amenity, stored surface water, grazing and landscape (Table 4). The Cm mainly correspond to the farmer activities and the EAo are divided in similar proportions between farmers and government (Table 5).

The HOW maintain a minimal value stock of environmental work in progress (WP) (Tables S8-S9) due to the dissipation of the resource rent from firewood and scarce representation of the associated species of wood-yielding conifers and cork oaks. Although the resource rent from grazing is tending to decline, it is still the second environmental asset for farmers in terms of value after the amenity (Tables 4 and 5).

[6] The SNA also excludes capital gain from the GCF, except for that which corresponds to the livestock activity.

Table 4. AAS opening capital of holm oak open woodlands in Andalusia (2010: €/ha).

Class	Opening environmental asset			Opening manufactured capital			Opening capital		
	Farmer	Government	Total	Farmer	Government	Total	Farmer	Government	Total
Timber	10.3		10.3	0.7		0.7	11.1		11.1
Cork	38.1		38.1	1.0		1.0	39.1		39.1
Firewood	210.8		210.8	0.1		0.1	210.9		210.9
Nuts	0.3		0.3	0.0		0.0	0.3		0.3
Grazing	1,051.0		1,051.0	18.5		18.5	1,069.5		1,069.5
Grass and browse	*727.7*		*727.7*	*18.5*		*18.5*	*746.1*		*746.1*
Acorn	*74.0*		*74.0*				*74.0*		*74.0*
Game grazing	*249.3*		*249.3*				*249.3*		*249.3*
Conserv. forestry				10.0		10.0	10.0		10.0
Residential				455.1		455.1	455.1		455.1
Amenity	3,521.6		3,521.6				3,521.6		3,521.6
Fire services					44.6	44.6		44.6	44.6
Recreation		892.9	892.9		40.5	40.5		933.3	933.3
Mushrooms		591.0	591.0		1.2	1.2		592.2	592.2
Carbon		346.5	346.5					346.5	346.5
Landscape		1,056.1	1,056.1		2.7	2.7		1,058.8	1,058.8
Biodiversity		198.0	198.0		3.8	3.8		201.8	201.8
Water		1,467.9	1,467.9					1,467.9	1,467.9
Total	4,832.2	4,552.4	9,384.6	485.4	92.9	578.2	5,317.6	4,645.2	9,962.8

Table 5. AAS balance account of holm oak open woodlands in Andalusia (2010: €/ha).

Class	1. Opening capital	2. Capital entry				3. Capital withdrawal						4. Reva-luation	5. Closing capital
		2.1 Bought	2.2 Own	2.3 Other	2.4 Total	3.1 Used	3.2 Sales	3.2 Destruc -tions	3.3. Recla-sification	3.4 Other	3.5 Total		
	(Co)	(Ceb)	(Ceoo)	(Ceot)	(Ce)	(Cwu)	(Cws)	(Cwd)	(Cwrc)	(Cwot)	(Cw)	(Cr)	(Cc)
1. Environmental asset	9,384.6		1.9	41.8	43.7	1.0			42.4	13.2	56.7	-136.6	9,235.0
1.1 Farmer	4,832.2		1.9		1.9	1.0			1.9		2.9	-150.4	4,680.9
1.1.1 Timber	10.3		0.1		0.1	0.2			0.1		0.3	0.7	10.9
1.1.2 Cork	38.1		1.5		1.5	0.6			1.4		2.0	2.7	40.3
1.1.3 Firewood	210.8		0.3		0.3	0.2			0.3		0.5	9.3	219.8
1.1.4 Nuts	0.3											0.0	0.3
1.1.5 Grazing	1,051.0											2.0	1,053.0
1.1.5.1 Grass and browse	*727.7*												*727.7*
1.1.5.2 Acorn	*74.0*											*2.0*	*76.0*
1.1.5.3 Game grazing	249.3												249.3
1.1.6 Amenity	3,521.6											-165.1	3,356.6
1.2 Government	4,552.4			41.8	41.8				40.6	13.2	53.8	13.8	4,554.1
1.2.1 Recreation	892.9												892.9
1.1.2 Mushrooms	591.0												591.0
1.1.3 Carbon	346.5			41.8	41.8				40.6	13.2	53.8	13.8	348.3
1.1.4 Landscape	1,056.1												1,056.1
1.1.5 Biodiversity	198.0												198.0
1.1.6 Water	1,467.9												1,467.9
2. Manufactured	578.2	0.4	7.5		7.9			0.0			0.0	-34.4	551.8
2.1 Farmer	485.4		1.7		1.7							-27.9	459.3
2.1.1 Plantations	10.2		1.7		1.7							-0.2	11.8
2.1.2 Constructions	475.2											-27.7	447.5
2.2 Government	92.8	0.4	5.8		6.2			0.0			0.0	-6.6	92.5
2.1.1 Plantations			0.0		0.0							0.0	0.0
2.1.2 Constructions	75.6		4.1		4.1							-5.0	74.8
2.1.3 Equipments	2.8	0.4			0.4			0.0			0.0	-0.1	3.1
2.1.4 Others	14.4		1.7		1.7							-1.4	14.6
Total (1 + 2)	9,962.8	0.4	9.4	41.8	51.7	1.0		0.0	42.4	13.2	56.7	-171.0	9,786.8

The balance accounts in Tables S8-S9 show the capital revaluation (Cr), distinguishing between the revaluation of manufactured capital (Cmr) and environmental assets (EAr). Working with the accounting adjustments (CGad) which avoid double counting due to the *ad hoc* procedures used in the measurement of the NG and fixed capital consumption (CFCm) we arrive at estimates for the capital gain (GC) and its separation into manufactured (CGm) and environmental (EAg) as shown in Fig. S3 and Table S10.

The negative result for the CG of the HOW in the 2010 period is due to the drop in land prices and the manufactured capital of machinery and buildings not forecast at the opening of the period. The volatility of the land price in the short term is of little relevance given the long-term investment-consumption rationale of the land owners. The real rate of variation in the price of HOW land over the period 1994-2010 was more than 3% (Ovando et al., 2016).

Table S10 and Figs. S3-S4 presents the simplified sequence of AAS production and balance accounts which allow the estimation of the total income and its factorial distribution as the sum of the NVA and the GC. It is important to note that the simplified structures of the data in Table S10 and Fig. S3 are derived from the complete primary data of Tables S8 and S6.

The factorial distributions of the total income are consistent with the results of the opening capital, where the environmental assets make up most of the total opening capital and therefore at the closing of the period the environmental income makes up most of the total income of the HOW. In the 2010 period the circumstance arose of the manufactured capital income being negative.

The primary production and balance accounts of the AAS contain all the information to estimate the environmental income (EI) as the sum of the environmental net operating margin (NOMe) and the environmental asset gain (EAg). Table S10 and Fig. S3 show the detailed estimates of the NOMe and the EAg.

3.2.3. Simplified accounts for integrating ecosystem services and incomes

We have described the structured results of the complete production (Table S6) and balance accounts (Tables 5, S8 and S9) for the holm oak open woodlands (HOW) which allow us to reorganize and simplify the data in the instrumental sequence of accounts which show the estimates of the net values added, ecosystem services, total income and environmental income. The results for these variables are presented per individual, farmer, government and total activities in the HOW of Andalusia.

3.2.3.1. Net value added

Tables 3, S6 and S7 present the total values added estimates (NVA) and separated into ordinary (NVAo) and investment (NVAi), both aggregate and for individual activities.

Table S7 integrates the own-account environmental net operating margin (NOMei) in the GCF, this being a component of the change in the environmental assets for the period. The NOMei is integrated into the estimate of the environmental income in its component of change in the environmental net worth for the period (CNWe).

Table 3 incorporates the products, costs and values added from Table S7 and shows the separation of the operating services of the manufactured capital, represented by the manufactured net operating margin (NOMm) and the environmental operating income, represented by the environmental net operating margin (NOMe).

Figs. 2 and 3 show the added values of the individual, farmer, government and total activities of the HOW separated into labor cost (LC) and net operating margin (NOM).

3.2.3.2. Total and environmental incomes

Table S7 shows in detail the measurement of the ecosystem services (ES) valued at social prices based on separating the estimates for net value added of the total products consumed (TPc) and own-account gross capital formation (GCF) for the period of the individual HOW activities. Only the TPc contains the ecosystem services (ES) embedded in its two possible components of intermediate consumption of environmental work in progress used (Wpeu) and ordinary operating income of the environmental asset represented by the ordinary environmental net operating margin (NOMeo).

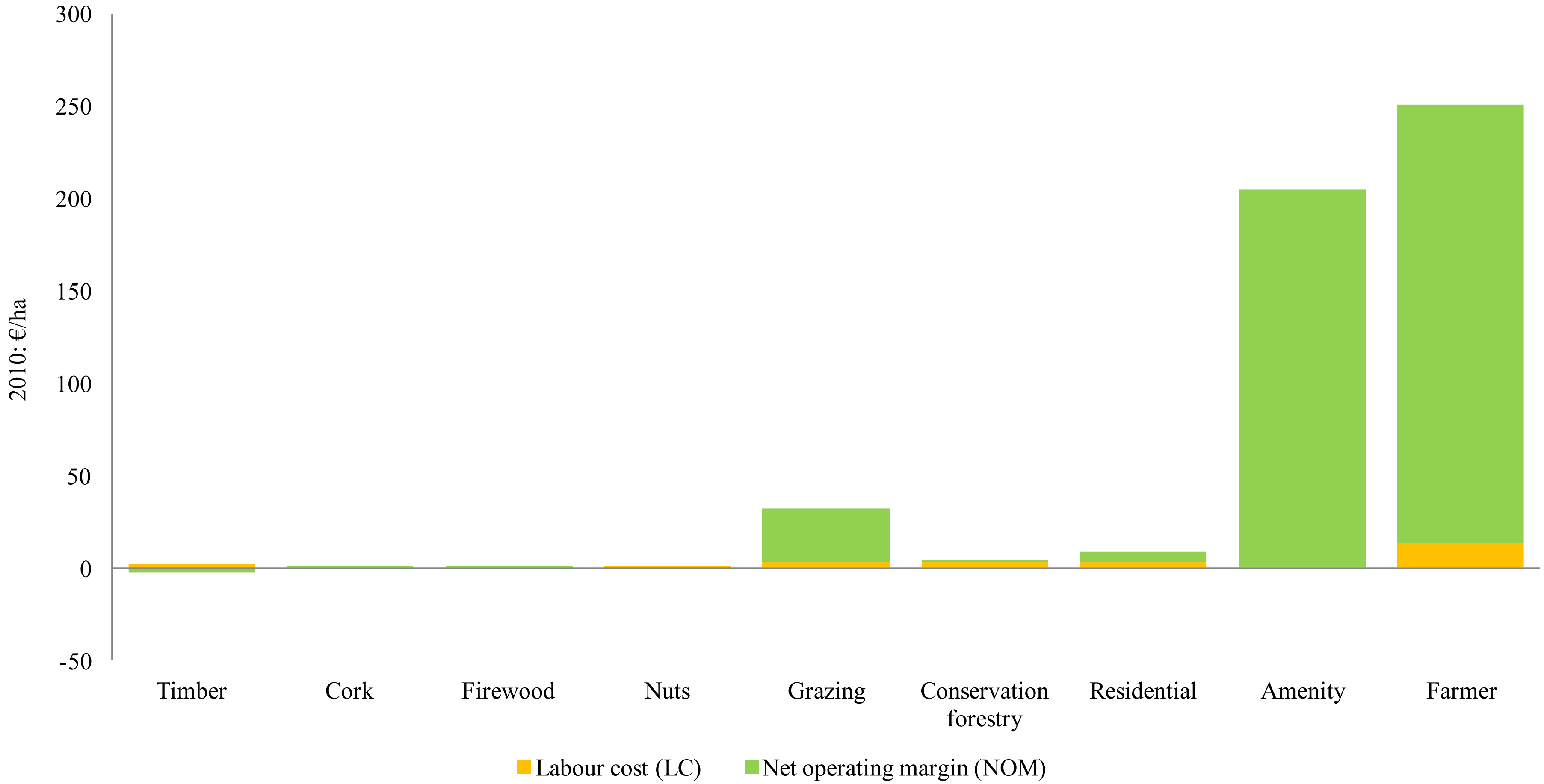


Figure 2. AAS farmer net value added at social prices of holm oak open woodlands in Andalusia (2010: €/ha)

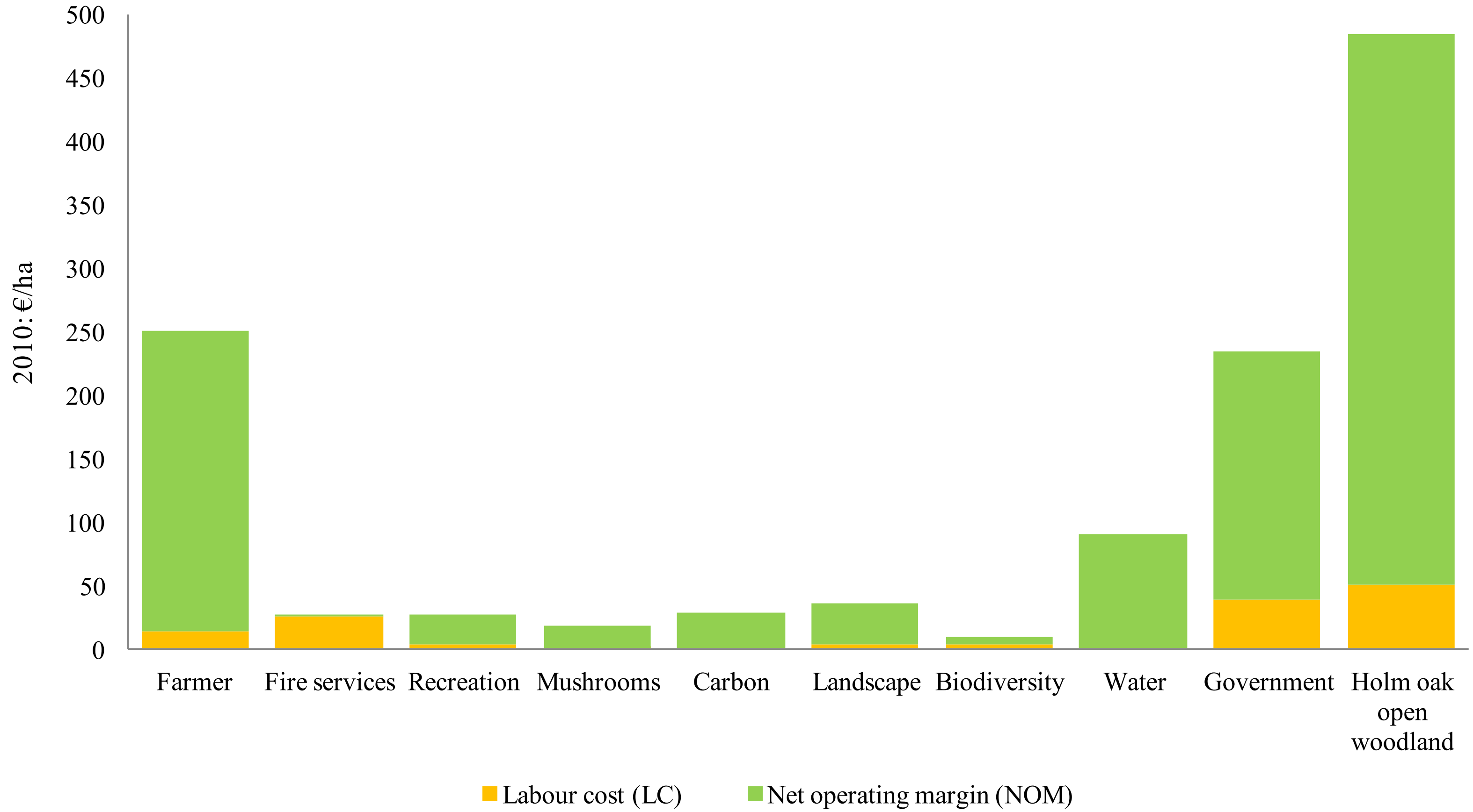


Figure 3. AAS total net value added at social prices of holm oak open woodlands in Andalusia (2010: €/ha).

The production account (Table 3, S6 and S7) and balance account (Tables 5, S8 and S9) of the AAS allow a simplified sequence of identities of the total income measurements in Figs S3-S4 shows the sequence of identities which permit the total income to be estimated as the sum of the net value added at social price (NVA_{sp}) and the capital gain (CG). Fig. S4 shows the sequence of identities which, by reorganizing the components of the NVA_{sp} and the CG, give the results for the total income as the aggregate values of total product consumption at social price (TPc_{sp}) and the change in net worth (CNW) less the intermediate consumption (IC).

Labor cost only contributes minimally to the total income of the HOW activities valued since the HOW animal activities omitted are those which generate most of the demand for employment.

The NOMm/NOMe comprise one of the two components required to estimate the manufactured capital income (CIm) and the environmental income respectively (EI). The other two components of the CIm and the EI are the manufactured capital gain (CGm) and the environmental asset gain (EAg).

The environmental income is presented in Figs. S3 and S4 as the sum of the operating margin (NOMe) and environmental asset gain (EAg) components. By reorganizing the elements which integrate the NOMe and the EAg we get the identity of the environmental income (EI) which links the environmental variables of the AAS production (ES) and balance (CNWead) accounts (Table S10 and Fig. 4). Fig 5 shows the individual and aggregate values for the AAS ecosystem services, change in environmental net worth adjusted according to WPeu and environmental incomes at social prices for holm oak open woodlands in Andalusia.

The briefly described sequences of accounts for the AAS are repeated in the application of the rSNA to the holm oak open woodlands of Andalusia (Tables S1-S2-S11).

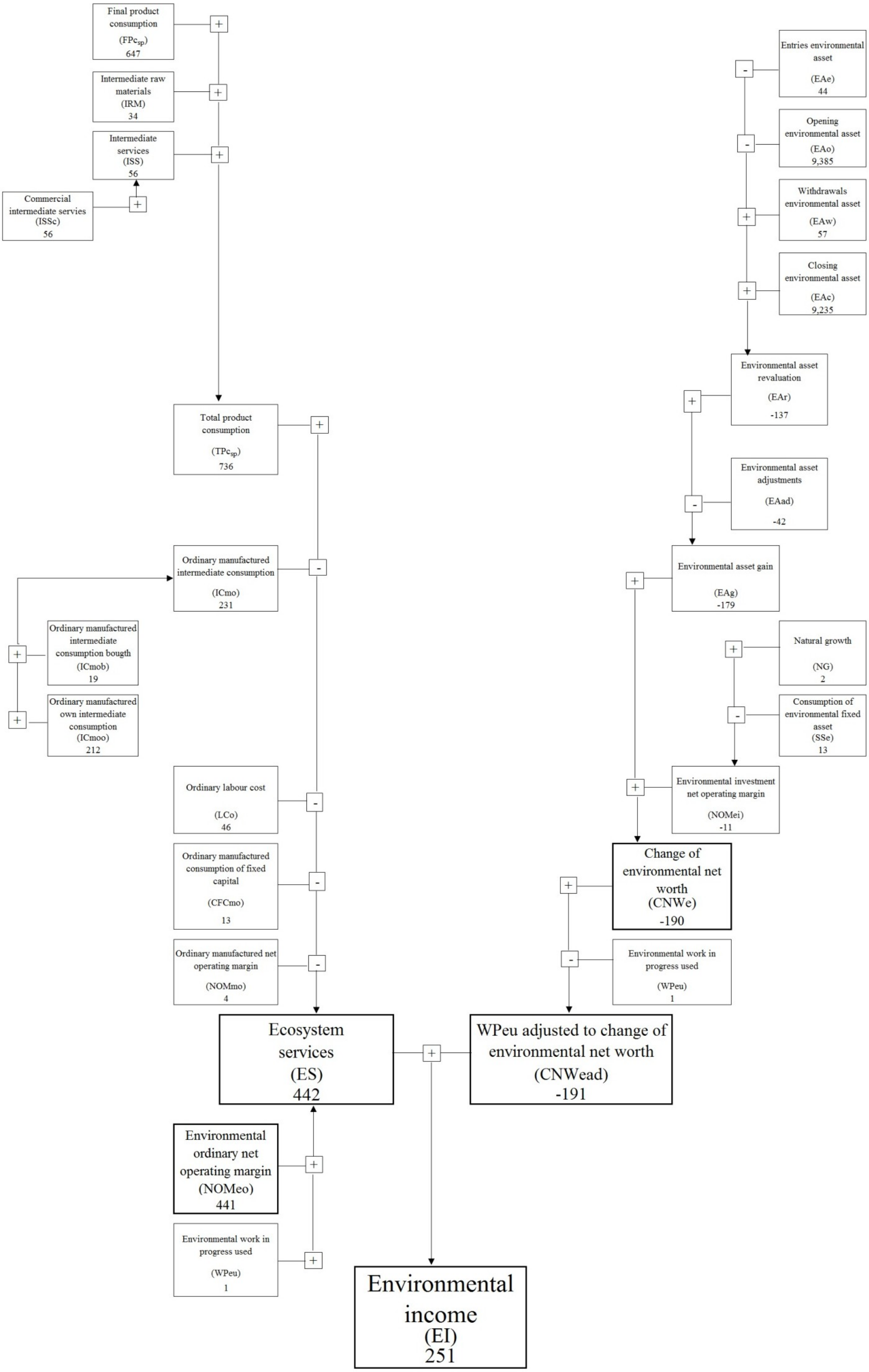


Figure 4. AAS environmental income at social prices for holm oak open woodlands in Andalusia (2010: €/ha).

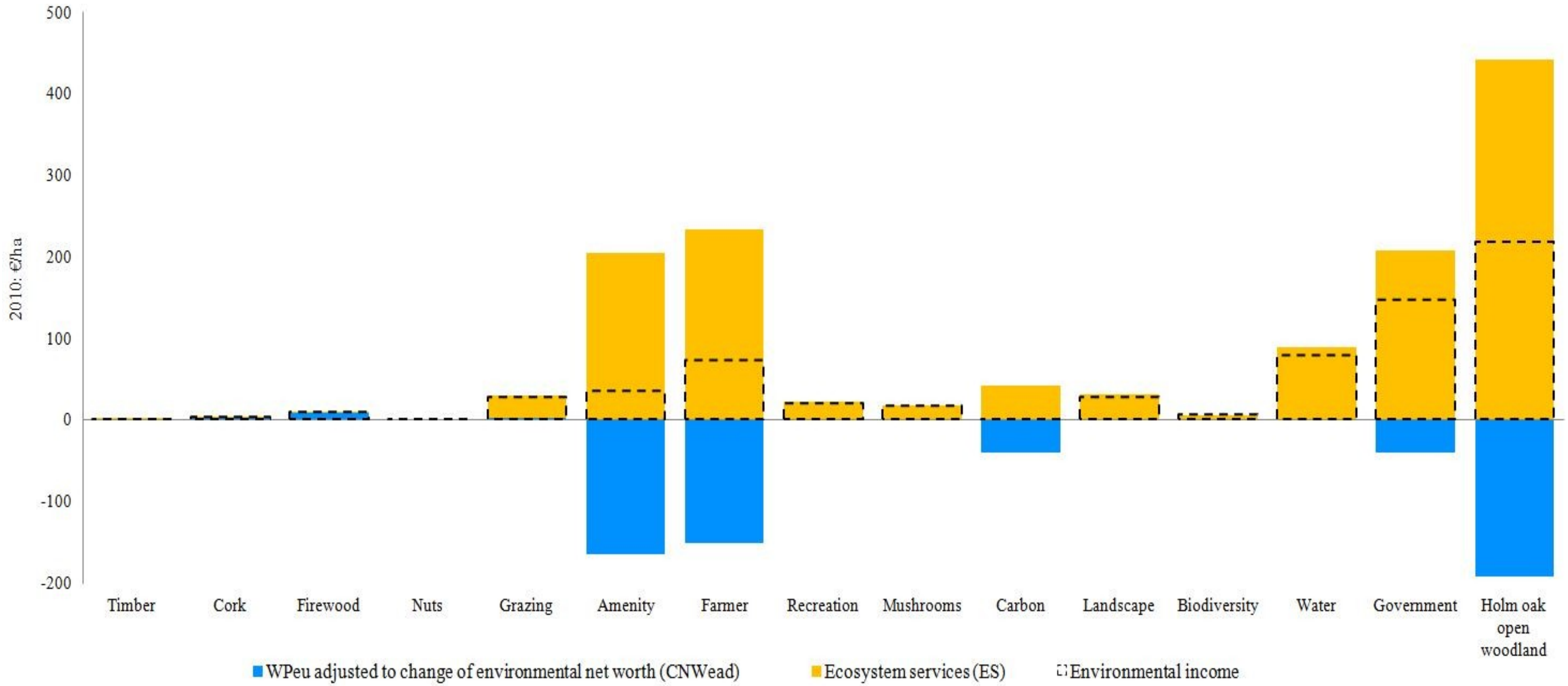


Figure 9[5]. AAS ecosystem services, change in environmental net worth adjusted according to WPeu and environmental incomes at social prices for holm oak open woodlands in Andalusia (2010: €/ha).

3.2.4. Geo-referenced results

The ecosystem services and the total and environmental incomes at producer prices[7] for the Andalusian HOW activities valued by the AAS methodology are presented in the maps of Figs. 6, 7 and S5, geo-referenced at the scale of the tiles in the Spanish Forest Map of Andalusia. Figs. S6 and S7 present the ecosystem services and the environmental income of the individual products consumed and the total for the HOW of Andalusia.

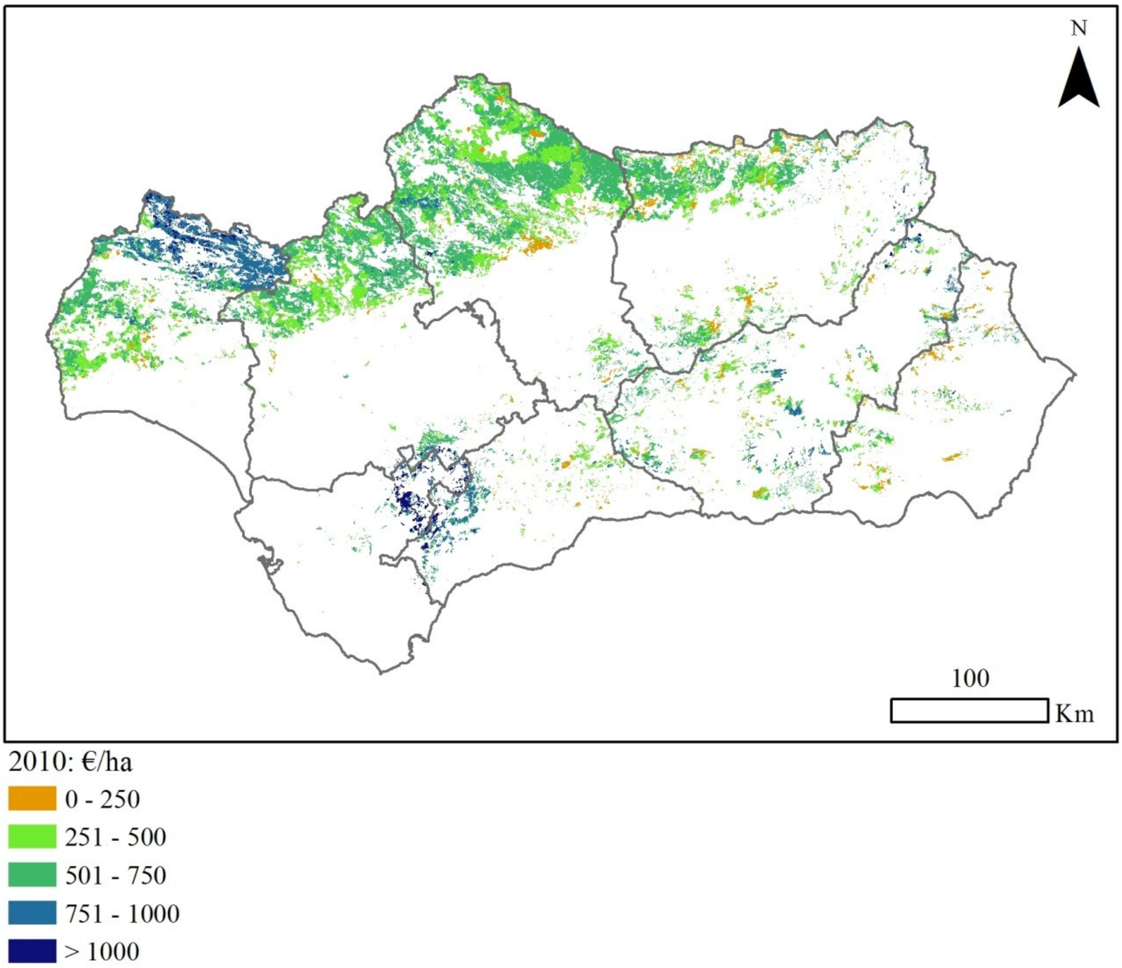


Figure 6. Map of AAS total ecosystem services at producer prices for holm oak open woodlands in Andalusia.

[7] The AAS estimates at producer price in the HOW overvalue the ES and the EI of the amenity activity. At tile scale we think it is unwise to present the data at social price for the amenity activity given the uncertainty of having imputed the SSnco according to the ISSnc of the hunting and livestock activities in sixteen private and six public HOW farm (*dehesa*) case studies respectively.

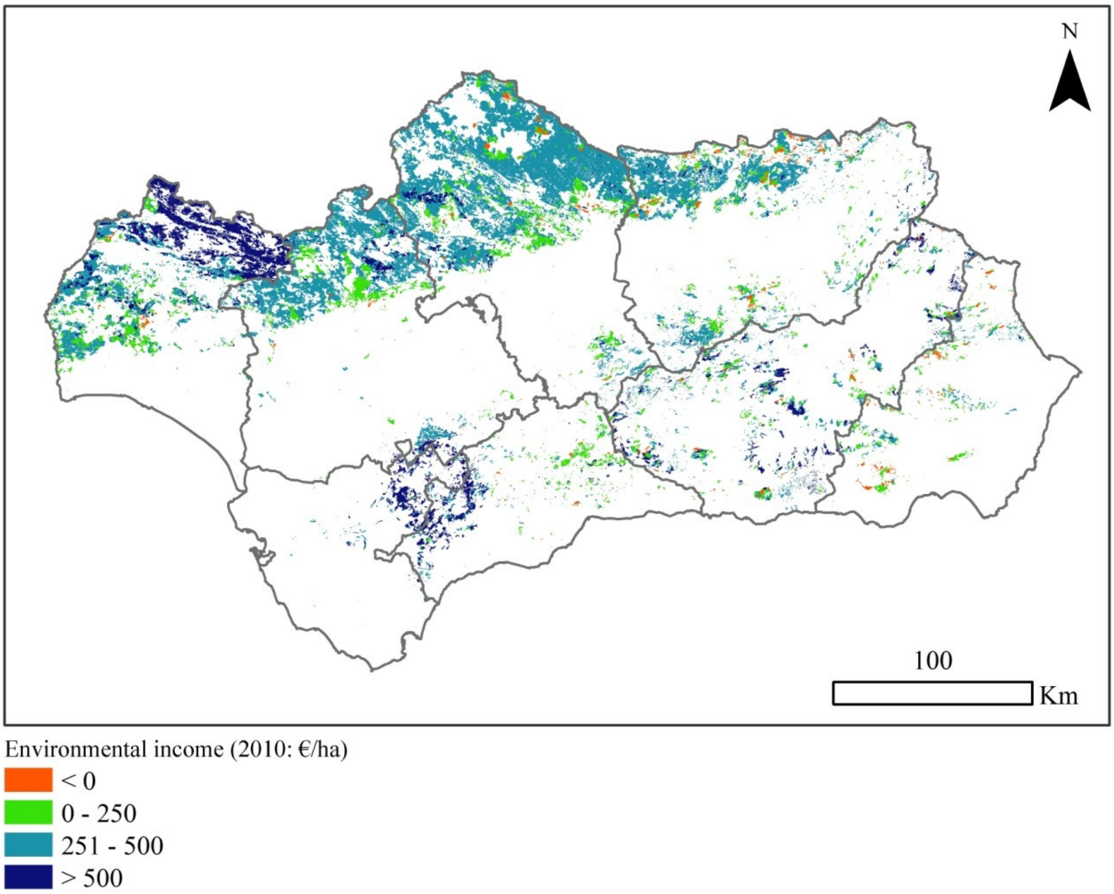


Figure 7. AAS total environmental income at producer prices for holm oak open woodlands in Andalusia.

3.2.5. Price comparisons and rSNA versus AAS results

3.2.5.1. Price comparison

The advantage of producer prices is that they can be observed directly and indirectly in formal and simulated markets in the case of final products consumed (ordinary) without market prices according to consumer willingness to pay, and they include the valuations imputed at production cost price. The disadvantage of producer prices is that they give biased valuations, which normally undervalue the operating margins of the activities which produce own ordinary non-commercial intermediate services (ISSnc) and in contrast overvalue the operating margins of the activities which demand the own ordinary non-commercial intermediate consumption of services (SSnco). The basic prices partially correct the bias in the valuations by incorporating the intermediate services of compensations (ISSncc) and their respective intermediate consumptions (SSncoc). The total correction of the valuation biases is achieved by applying the social price. In this study of the HOW we have added the valuations imputed at basic prices and social price to the results at producer prices. Due to the problem of lack of statistical representative of the basic and social price valuations, conclusions with regard to the results at basic and social prices for the only two individual activities affected, namely amenity and landscape, should be drawn with caution (see supplementary text S4). Furthermore, having estimated the willingness to pay for landscape and threatened biodiversity activities as a value additional to their total costs, whatever the type of cost, the ecosystem services of these activities will not vary. It can be observed in Tables 6 and S12 that the price comparisons in the same accounting methodologies present unitary indices, indicating the absence of variation with types of price applied. Given these results, we lean towards presenting the results at producer prices in this incomplete study of the HOW activities in Andalusia. However, for illustrative purposes we comment on some of the variations in the results for ecosystem incomes and services of the amenity activity, the farmers, and the HOW activities as a whole.

The HOW ecosystem services and the gross values added at producer prices and social prices for the farmers and the total for the activities vary due to the omission of the livestock and hunting activities (see Tables 6 and S12). The variation in ecosystem services (ES) depending on the type of prices applied is slightly greater for the amenity activity than for the farmer activities as a whole due to the greater weight of the amenity in the ES and because the rest of the farmer activities are not affected by the inclusion of the SSnco. There are notable variations in the valuations of farmer ES and gross added values, which indicates that in the presence of auto-consumption of amenities by the owners the social price more reliably reflects the individual and aggregate economic valuations derived from the economic rationales of the owners.

Table 6. AAS and rSNA ecosystem services and gross value added index comparisons for holm oak open woodlands in Andalusia (2010).

Class	Timber	Cork	Fire-wood	Nuts	Gra-zing	Conserv. forestry	Residen-tial	Amenity	Farmer	Fire services	Recrea-tion	Mush-rooms	Carbon	Land-scape	Bio-diversity	Water	Govern-ment	Holm oak open woodlands
	1	2	3	4	5	6	7	8	∑1-8	9	10	11	12	13	14	15	∑9-15	∑1-15
Ecosystem services																		
$ES_{pp,AAS}/ES_{sp,AAS}$	1.0	1.0	1.0	0.0	1.0			1.6	1.5		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.3
$ES_{bp,AAS}/ES_{sp,AAS}$	1.0	1.0	1.0	0.0	1.0			1.6	1.5		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.3
$ES_{bp,rSNA}/ES_{sp,AAS}$	1.0	1.0	1.0	0.0	1.0			0.0	0.1			1.0				0.9	0.5	0.3
$ES_{pp,rSNA}/ES_{pb,rSNA}$	1.0	1.0	1.0	0.0	1.0			0.0	1.0			1.0				1.0	1.0	1.0
Gross value added																		
$GVA_{pp,AAS}/GVA_{sp, AAS}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.6	1.5	1.0	1.0	1.0	1.0	1.9	1.0	1.0	1.1	1.3
$GVA_{bp,AAS}$ /$GVA_{sp,AAS}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.6	1.5	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.2
$GVA_{bp,rSNA}/GVA_{sp,AAS}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0		0.2	1.0	0.2	1.0		0.1	0.4	0.9	0.5	0.4
$GVA_{pp,rSNA}/GVA_{bp,rSNA}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0

Abbreviations: subscript sp is social prices, subscript bp is basic prices, subscript pp is producer prices.

The estimates of ecosystem services for the government activities in this HOW study do not vary depending on the type of prices applied, although gross added values for landscape and the aggregate total for the government activities *do* vary.

As regards HOW activities as a whole, comparisons of ES and GVA evaluations reveal substantial overvaluations when estimating at producer prices in comparison to social prices (Tables 6 and S12).

3.2.5.2. rSNA versus AAS results

Comparison of the Agroforestry Accounting System (AAS) and the refined System of National Accounts (rSNA) reveals that their results coincide for activities with market price and that there are large differences between the results for activities without market price as regards the private and public amenity products. The rSNA only include valuations at producer and basic prices. Here we only compare the estimates at basic price in the rSNA and at social price in the AAS.

In the HOW activities valued using the rSNA; the ES and GVA estimates are 28% and 37% respectively of the respective values in the AAS (Tables 6 and S12).

Figure 8 shows that the amenity, carbon and landscape are the ecosystem services which present the greatest differences in the comparisons between the rSNA at basic price and the AAS at social price. Figure 9 reveals an important loss of environmental income for the amenity caused by the fall in the price of land in 2010. The rest of the activities show almost zero or positive environmental incomes.

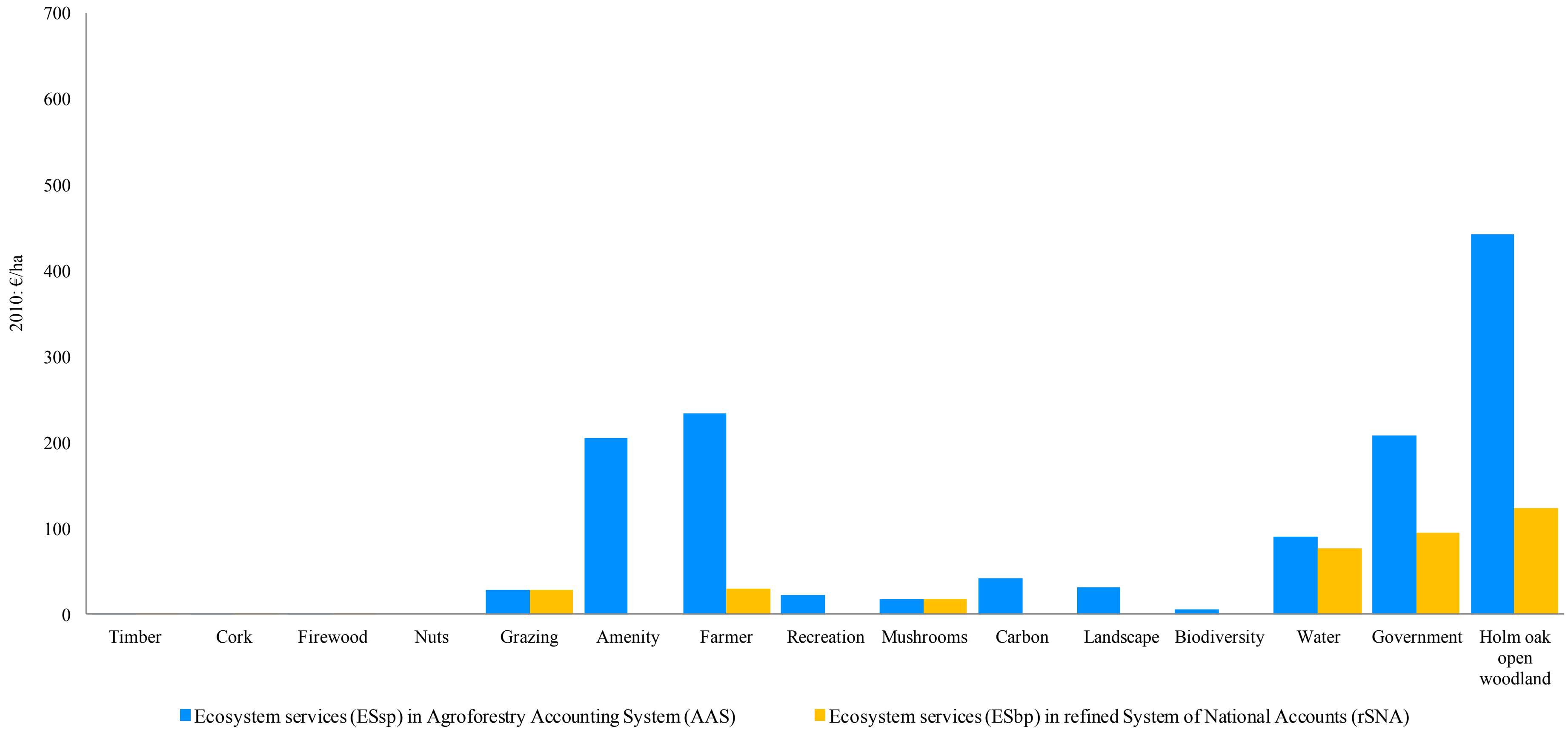


Figure 8. AAS and rSNA ecosystem services at social and basic prices comparison for holm oak open woodlands in Andalusia (2010: €/ha).

Figure 9. Comparison of AAS and rSNA environmental income at social and basic prices for holm oak open woodlands in Andalusia (2010: €/ha)

4. Discussion

4.1. We cannot consume the ecosystem services but rather their ordinary final product

In this article, as regards the economic analysis of ecosystem services we have referred exclusively to the renewable products appropriated by farmers and the government. It has been accepted that the economic production functions can only employ inputs (intermediate consumptions) and cost of environmental capital[8] use (natural); their physical contribution being sufficient for their inclusion (Campos et al., 2019a, 2019e). Consequently, the economic analysis of the ecosystem services goes beyond their economic value and from our perspective, the final product consumed (ordinary) is at the centre of the analysis of the contribution of nature to the value of the nature based products consumed.

The production functions of an ordinary final product in the SNA ignore the zero price natural inputs but in contrast, admit the residual values, regardless of sign, for net mixed income and net operating surplus in a consistent manner. Thus, we can consider that it is consistent with the SNA methodology to take into account the zero value natural intermediate consumptions so as to make the physical quantities of the production factors consistent with their final products consumed. The fact that the ecosystem service is an income from the gifted natural resource (environmental asset) means that its residual economic value will be greater than or equal to zero[9].

The SEEA-EEA implicitly accept that products without manufactured costs can be integrated in the economic activities since "the production boundary is expanded relative to the SNA reflecting that the supply of goods and services by ecosystems is considered additional production" (United Nations, 2017: p. 88). Here, in order to fulfil the additional products with respect to those of the SNA, the ecosystem institutional sector must only refer to government public products without manufactured costs.

The AAS maintain the dependency on the nature based ordinary final products, even where the resource rent is zero, since people enjoy the consumption of these products without knowing the remunerations of the production factors which contribute to their market or simulated price. In other words, we cannot consume the ecosystem

[8] The capital use cost is defined in this case as the sum of the fixed capital consumption and the normal income from capital invested in the ordinary final production.

[9] Since the farmers and government do not incur manufactured production costs in their appropriation.

service of an economic activity but we can consume the ordinary final product to which it contributes physically and/or economically. It is inconsistent from the perspective of consumption of an ordinary product to conclude that "if no [resource] rent is earned [embedded], the concept of [net] value added will represent no more than that which could be earned in alternative employment, and will as such not reflect any dependency on the natural resource" (Sjaastad et al., 2005: 41). The zero value of the resource rent does not nullify the ecological dependence which makes it possible to obtain a manufactured net value added embedded in the value of the product consumed, the existence of which is only viable due to the physical consumption of the environmental intermediate input supplied by the ecosystem. This would be the case of grazing, if it is considered as an environmental input consumed by the HOW game species which, even though it has a zero transaction price, gives rise to the existence of a resource rent for market transactions of game captures and which, in the case of the HOW, allows us to match the resource rent for game captures to the value of the grazing consumed, and to the net value added due to the absence of manufactured costs.

The supply of stored water with commercial economic use is another example where the resource rent coincides with the value of the product in the HOW due to the absence of manufactured costs.

In the case of harvesting wild products with free access to the products, the net mixed income must be estimated and the factorial distribution of the net mixed income must be derived from the local markets and the motivation of the picker. In the HOW, the recreational mushroom pickers do not incur intermediate consumptions or cost for manufactured capital use, and it is assumed that they do not incur opportunity costs for the time employed on the visit; therefore the values of the ordinary product, the ecosystem service and the net value added coincide.

In all the examples described there is a constant in the ecosystem service estimates for an individual product which consists of starting from the first possible transaction value of the ordinary product. This criterion is followed by the estimates of intermediate consumptions and the capital use cost, and finally the ecosystem service is estimated as residual value. All types of relationship are possible among the values of the product, the ecosystem service resource rent and the net value added of a product, but all equivalence must be consistent with the concept of total income. In short, the existence of an ecosystem institutional sector is an instrumental construction, the justification for which lies more in political convention than a scientific necessity derived from the production function.

4.2. Ecosystem service and income valuations: producer versus social prices

In this article the AAS methodology is applied to fifteen economic activities (hunting, livestock and agriculture activities are omitted) at regional scale in holm oak open woodlands in Andalusia in 2010, with the novelty of comparing producer prices (market and simulated) and social prices. The results reveal notable overvaluations at producer prices in comparison to social prices of the net/gross added values of the private amenity and landscape economic activities, as well as of the aggregate farmer, government and total HOW activities. The ecosystem services and the environmental income of the private amenity, along with their aggregate values for farmers and total for the HOW are affected. The results for the ecosystem services and the environmental incomes of the individual activities of the government are not affected by the change in the type of price used in the valuations.

The comparison of the results for the valuations of ecosystem services and incomes at producer price in the rSNA reveals notable undervaluation compared to the AAS estimates at social price. The differences revealed in the comparisons of environmental assets estimated by the AAS and rSNA are due to the valuation at production cost of the final products consumed without market prices in the rSNA and at simulated revealed/declared price in the AAS, as well as to the omission of the carbon activity in the rSNA.

4.3. Lack of investment in conservation forestry in holm oak woodlands

The commercial products of the HOW do not generally give competitive monetary profits at producer (market) prices; the justification for the market price of the HOW can only be found in the auto-consumption of amenities (recreation) by non-industrial owners. In other words, the private family owners pay themselves the monetary opportunity cost of the production of amenity services auto-consumed exclusively in their properties, when they incur voluntarily accepted monetary opportunity costs. The public administration also recognizes this economic value of the dehesa owner’s amenities. Spanish land law establishes that to buy or expropriate a rural property, it is possible to pay up to a maximum of twice what it would be worth if only the profits from its commercial exploitation are considered, since the legislators recognize that the other half of its market price is due to the benefit from the non-commercial flow of private amenities of the owner.

It is unusual for owners to invest in order to benefit the consumption of future generations without receiving government compensations, given that the competitive profitability results are mainly due to the amenities, and these are not affected in the short and medium term by the current rate of degradation of the HOW, taking into account the historical variations in the price of land (Ovando et al., 2016)[10]. The private owner prefers to invest in land and livestock, which contribute in the short to medium term to increasing the available monetary profitability (Ovando et al., 2015, 2016; Oviedo et al., 2015, 2017). Plantations do not provide monetary benefits for the generation of the owner who undertakes the plantation. The high level of uncertainty associated with the generation of future profits from the plantation is the main factor underlying the uncertainty of the gain in net worth in the present for the future yield. However, the future owner who harvests the products of the historical plantations will be the beneficiary of the largest ordinary environmental operating margins since the historical costs of the conservation forestry will have been amortized. In other words, the conservation of the HOW can be considered a public service, which is represented in this study by the landscape activity. In this context, the words of the editor of the influential publication 'Our Common Future' are of relevance with respect to the need for government to have consistent information on sustainable management and contributions of natural resources to the total income of the HOW when drawing up their policies: "Politics that disregard science and knowledge will not stand the test of time. Indeed, there is no other basis for sound political decisions than the best available scientific evidence. This is especially true in the fields of resource management and environmental protection" (Brundtland, 1997: p. 457).

4.4. Does the SEEA-EEA provide concepts for measuring environmental income?

From our perspective of the conceptualization of ecosystem accounting, it is necessary to admit the nature based government activities both direct and indirect. It is difficult to understand an economic rationale that is admissible in the farmer activities and not the government public activities affected in their management and regulations by manufactured costs. The SEEA-EEA criterion which refers to the fact that "the

[10] It is worth noting the modest investment in conservation forestry by a group of large private dehesa operations (Campos et al., in revision[b]).

production boundary is expanded relative to the SNA reflecting that the supply of goods and services by ecosystems is considered additional production" (United Nations, 2017: p. 88) is consistent from the perspective of including an ecosystem institutional sector only for public products consumed without regulations and without government costs. In return, a strange limitation is incurred, namely the exclusion of the government sector which, in the case of the HOW, is an ecosystem service provider of similar importance to the farmers. Furthermore, it renders unnecessary the inclusion of a non-human institutional sector which provides free ordinary economic products to humans, independently of the farmers (Obst et al., 2019).

Our response to the question that provides the heading to this section is that we cannot know whether the SEEA-EEA in their current incipient stage of development will include standard guidelines for the nature based government activities as a whole. If they were not included, the SEEA-EEA would not be able to measure the environmental income of ecosystems of the type valued at national level which are produced with government manufactured costs.

The debate concerning the conceptual design of ecosystem accounting has so far centred on the valuations of ecosystem services and their respective environmental assets derived from the prices of transactions observed in formal or simulated markets based on consumer preferences. Although a detailed development of the SEEA-EEA accounting structure is not available, the reference of Obst et al. (2019: Table 6, p. 33) allows us to outline a provisional interpretation of the concept of extending the economic activities with respect to the SNA. These authors take into consideration the institutional sector of corporations (timber) the (timber) and add the ecosystem public services produced without manufactured costs (air filtration). ¿Should we understand, therefore, that the SNA valuation of public goods and services of nature based government services is maintained at production cost and therefore the value of their ecosystem services is zero? This interpretation does not appear to be coherent and we understand from what the authors state in the above cited reference they are referring to an example of the application of the SEEA-EEA to two specific products, which cannot be generalized to embrace public products with manufactured production costs. It would also not make sense to present the values for products of the corporations and only the ecosystem services for the public products with and without manufactured production costs.

Since the purpose of the SEEA-EEA is to explicitly specify the valuations of the ecosystem services of ordinary individual products and their respective environmental assets it can be concluded that the ultimate aim of the SEEA-EEA is the estimation of the environmental incomes of the individual economic activities valued for the ecosystem types of the spatial unit considered.

To date, the SEEA-EEA does not explicitly mention the environmental income of the ecosystems, but gives the measurements separately for the ecosystem services (ES) and the change in environmental asset (CEA) of the individual product. These two variables added together give the value of the environmental income, and depending on the specific accounting conventions of the environmental production and balance accounts, the CEA is adjusted in the case of certain individual products in order to give the change in environmental net worth adjusted (CNWead) according to the environmental work in progress used (WPeu), as we have shown in section 2 and supplementary text S3. Thus, we arrive at the general expression of the environmental income (EI) as the sum of the ES and the CNWead of the individual product. All the information that we require to measure the environmental income is provided by the variables ES and EAg proposed by the authors SEEA-EEA discussion papers (Fenichel and Obst, 2019: section 4.1, pp. 20-23; Obst et al., 2019: Table 6, p.33). Other authors also implicitly estimate the environmental income, the value of the environmental assets depending on the discounted benefits (ecosystem services) and the capital gain (change in environmental asset (Fenichel et al., 2016; Narita et al., 2018).

We can simplify the definition of the concept of environmental income as the value of the ecosystem service of a stationary state nature based activity, given that in this situation the value of the CEA/CNWead is zero. Beyond the stationary state of the ecosystem activity, the EI represents the maximum possible consumption of the ES of the individual ecosystem product which we can permit without reducing its value at the opening of the period.

It seems strange that no SEEA-EEA applications have so far been produced by other authors which include measurements of ecosystem services for one or various ecosystem types and the respective changes in the environmental assets of the products incorporated in a single indicator such as the environmental income of the ecosystems and integrated in the standard SNA at national/regional scale. In Campos et al. (2019b) a simplified AAS application is presented comparing the results with our refined version of the SEEA-EEA sequence of accounts proposed by Obst et al. (2019: Table 6,

p. 33). The application in Campos et al. (2019b) is based on the data from the production and balance accounts in this HOW study to develop the format of the sequences in Obst et al. (2019), the purpose of which is to compare the refined rSNA, rSEEA-EEA and simplified sAAS systems.

The AAS and rSNA applications in this study reveal that the measurement of environmental incomes in the HOW may be derived directly based on the total products that are generated by the activities valued in the HOW territory of Andalusia by the institutional sectors of the farmers and the government, the latter including the ecosystem sector of the SEEA-EEA.

The consistency of the comparisons of the AAS and rSNA results based on the theoretical concept of total income shows that the SNA can be extended with the ultimate aim of estimating the environmental income, modifying on the one hand (i) the inconsistent application of the production cost in the valuation of products without market prices, substituting it for the marginal price of the simulated demand of active and passive consumers: and on the other, (ii) extending the measurement of society total income by incorporating the capital gain to the net value added (operating income).

4.5. Valuing the ecosystem service as a residual value

In the SEEA-EEA, independent estimates (not linked to the total income accounts) of ecosystem services and changes in the environmental assets risk incurring bias towards inconsistency as regards remunerations for the manufactured incomes generated in the type of ecosystem valued. The fact that the ecosystem service is a residual value together with other operating incomes of a consumed product means that prior estimation is necessary of the priority remunerations for manufactured incomes of the individual ecosystem product valued. Ecosystem service estimates using non-residual procedures are common, and in these cases the situation may arise where the arbitrarily assigned value of the ecosystem service of a consumed product exceeds the value of its net value added, which would be a conceptually inconsistent result. For example, Campos et al. (2008) estimate that if family-scale shepherds in Iteimia (Tunisia) with free access to grazing attributed themselves a remuneration for their self-employed work equal to 81% of that received by a local forestry worker, the ecosystem service of grazing would be dissipated. If the shepherds in Itemia were willing to work as employees, earning 60% of the current earnings of forest workers, the ecosystem service of grazing would be 0.07€/UF o 36.95€/ha. Other authors estimate the grazing resource rent as the energy substitute of the market price of barley, which would mean paying the self-employed wage rate at 38% of the forestry employee wage rate of 0:37€/hour at the time of the Iteimia study.

5. Policy implications

5.1. Do governments want to extend the accounts of society to include nature incomes?

In a world where the property rights over global goods and damages tend to be regulated, the divide as regards free public goods is diminishing. In other words, the economic accounts for global society should incorporate public products and costs appropriated directly or indirectly by the government, without market price and produced within the national territory in the period, valuing them at simulated marginal prices derived from the active and passive consumer demand globally. However, the government institutions specialized in the regulations of the System of National Accounts (SNA) oppose the extension of the economic activities and the substitution of valuations of public and private products without market price at production cost for the simulated marginal value according to consumer demand. This situation has ultimately led to the public debate which has given rise to the satellite proposal in the process of the System of Environmental Economic Accounting-Experimental Ecosystem Accounting (SEEA-EEA) (United Nations et al., 2014, United Nations, 2017). This subsidiarity of the SEEA-EEA with respect to the SNA can be avoided by extending the SNA with the ultimate goal of measuring the total income. The economic accounts of the global society make the existence of a satellite SEEA-EEA unnecessary as the former directly provides consistent measurements of the environmental income of the ecosystem types which exist in the national territory and the planet as a whole. In the absence of global compensations among governments for appropriated environmental products and assets of the ecosystems, the design and application of environmental accounts for ecosystem types such as the HOW studied in this article can be applied at national scale and multinational regional scales such as the European Union.

5.2. Towards a government compensation policy for HOW conservation

In the new paradigm, public consumers demand that farmers and governments maintain/improve the offer of public goods and services. This demand will continue increasing, although we will continue to see a process of internalization through the market for public goods and services in which the rights of economic use will change to a private property regime. In this double process of growth of government and market supply of nature based products there are technical and institutional factors which determine the local division of economic activities between corporations and government. The government will continue to take exclusive responsibility in cases where consumer exclusion is highly costly or where consumer exclusion is impossible due to the nature of the product, hence such products will continue to be consumed freely by citizens (Mäler et al., 2008). In these circumstances the government, in representation of the public consumers, compensates the owners of the unwanted loss of profit involved in meeting the demands of the public consumers, previously agreed with the government.

The payment of compensation should be linked to the existence of sustainable management practices with regard to renewable natural resources. Continual management which is often necessary for grazing land in the Mediterranean (scrub control, pruning, periodical sowing etc.) is one of the necessary conditions for the conservation of the HOW cultural landscape. From this perspective, ¿should payment be extended to owners where loss of profit occurs through any cultural practice favouring the many nature based products such as game species, firewood from thinning/pruning, apiculture products and free-access products such as wild mushrooms and asparagus? Government compensations with the ultimate goal of HOW conservation should be based on the concept of cultural landscape, for example, as defined by the Council of Europe (2000), and payment to the owner should be legitimized having previously determined the consumers' willingness to pay a tax for the services of cultural landscape conservation to a degree assumed bio-physically sustainable in the long term.

The government could use the landscape tax to finance the loss of profit not accepted by the owners of the land and livestock for HOW activities which produce intermediate services used as inputs in the production of additional public service provision. Thus, the thinning/pruning undertaken as part of landscape management should be compensated given the public benefits associated with cultural landscape conservation. Honey production should also be compensated for the intermediate services which it produces in the landscape, but only for the loss of profit not accepted by the hive owner. Compensation could be paid to owners where wild mushroom and asparagus picking takes place, on the condition that a plan agreed with the government is put in place which is proved to encourage future production for commercial or recreational picking.

According to the local institutional agreements reached, the owners may receive compensation without having to make additional investment for allowing mushroom/asparagus pickers access to the farm, although in such cases there would be no loss of commercial profit to the owner but there could be a loss of private amenity service for the non-industrial owner.

An illustrative example of the complexity involved in implementing agreed compensation policies is that of the exclusion from compensations of most of the areas of woody grazing in Spain. Compensations under the Common Agricultural Policy (CAP) of the European Union continue to suffer from its philosophy based around livestock and crops, without conditioning these compensations to the sustainability of the management practices employed for renewable natural resources on the farms. This commercial principle in the CAP of dealing with the final agricultural and livestock products results in the intermediate outputs of managed wild grazing (fruit, leaves and twigs) being ignored, as is the case of holm oak open Woodland (HOW), where the fruit (acorns) and leaves/twigs from regeneration, pruning etc. are consumed by game species, cattle and other wild animals. This situation of "commodity tragedy" under the CAP means that silvopastoral landscape grazing does not form part of the CAP, except indirectly through compensations for extensive husbandry. Grazing is also invisible in the net value added estimated in the government economic accounts for agriculture and forestry (European Communities, 2000).

In a recent report analysing the limitations of CAP direct payments for areas of woody pasture, the authors consider that the current guidelines of the CAP, which under certain circumstances recognize the right of HOW to compensation for livestock grazing, present limitations which should be mitigated by generalizing the compensations paid for woody grazing. The justification for this recommendation is that such a policy would clearly have favourable social, economic and environmental effects (Ruiz et al., 2015).

The design of the CAP still does not explicitly include the payment of compensations for non-commercial intermediate products of the HOW which contribute to public goods and services which are consumed freely by European citizens. It would seem that the compensations under the CAP which indirectly affect the production of grazing in the HOW do not fulfil the criteria of equity and mitigation of the "free rider" behaviour of the active and passive consumers of HOW public products, while at the same time the standard of living of owners and employees is negatively impacted. The paradox of this decline in the commercial products of their farms is that it is taking place at the same time as the public products derived from the economic activities in the HOW are increasingly valued by public consumers. ¿What will society as a whole lose if the HOW cultural landscape continues to decline due to the loss of appropriate cultural practices and this tendency is not mitigated through adequate compensations, whichever the controlled animal species in question? In the future, insufficient regeneration of the HOW will lead to a decline in the natural variety and even greater loss of cultural diversity and employment income. Rural depopulation will continue and the demand for cultural landscape recreation services will decrease. The rate at which wild and domestic biological diversity is lost will increase.

Conclusions

The first conclusion which can be drawn from the results given in this article is that the valuations of ecosystem services and gross values added vary in those activities affected by the change in the type of valuation from producer prices to social price. The second conclusion is that the omission of the valuations of corporation activities producing non-commercial intermediate services (ISSnc) used by activities which *are* valued as own non-commercial intermediate consumption (SSnco) also leads to variations in the aggregate values added of the farmer and government activities.

A general policy conclusion is that the challenge to be addressed by the government, as collective landowner in the name of current society and especially of future generations, is to overcome the current limitations in the functioning of market forces which make the investment by non-industrial private owners profitable, mainly through auto-consumption of amenities, without long term investment in woodland regeneration taking place, along with the policy of government compensations for extensive husbandry set apart from the public environmental income in silvopastoral landscapes, so that the aforementioned future generations are able to inherit the cultural and biological environmental assets of the HOW in good condition. Therefore, it is the government that must take care of landscape conservation with the purpose of avoiding the deterioration and/or complete disappearance of the natural and cultural variety of the HOW in all its different aspects, whether biophysical, anthropological, built historical patrimony and testimonial uses of traditional skills which are attributed as being bearers of heritage values recognized by global society. In this case, the reference to ‘global society’ goes beyond Spanish society and should include at least the European Union member countries.

For this task of defending the conservation of world silvopastoral landscapes it is necessary that the best available scientific knowledge for decision making is at the service of government, consumers and landowners according to G.H. Brundtland, and a methodology such as the Agroforestry Accounting System can contribute to informing governments on the ultimate goal of implementing policies with greater efficiency and equity in terms of preserving threatened nature and associated human culture without failing to meet the needs of current generations or deteriorating the non-reproducible environmental assets of our planet.

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Appendix: Supplementary material

Agroforestry Accounting System for measuring environmental incomes at social prices: application to holm oak open woodlands in Andalusia-Spain

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This appendix includes:

Supplementary text for

Agroforestry Accounting System for measuring environmental incomes at social prices: application to holm oak open woodlands in Andalusia-Spain

List of contents:

S1. Background to holm oak open woodlands in West and South-West Spain

S1.1. Extent of holm oak open woodlands

The holm oak open woodlands defined in this study as having a canopy cover fraction (CCF) of between 5% and 75% are mainly found in the west and southwest of five Spanish autonomous regions, with pure and mixed stands covering an area of 4,845,798 ha which account for 72.1% of the total woodland area and 44.7% of the areas of forest and open Woodland in the five regions (Table ST1). The 22,281 tiles in which HOW predominate in Andalusia have an average area of 63 ha, ranging from less than a hectare up to 730 ha (Table S4). Andalusia, with 1,408,170 ha, is the region with the largest area of tiles in which holm oak open woodlands (HOW) predominate, accounting for 29.1% of the total, followed by Extremadura with 28.7% and Castilla-La Mancha with 24% (Table ST1, Figs. 1 and ST1)[1]. The HOW make up 47.6% of the total area of forests and open woodlands in Andalusia. The average CCF of the HOW in Andalusia is 32%, which is similar to that of the HOW area in the five regions. This CCF is considerably lower than the 49% for tiles in Andalusia with a predominance of timber-yielding conifers.

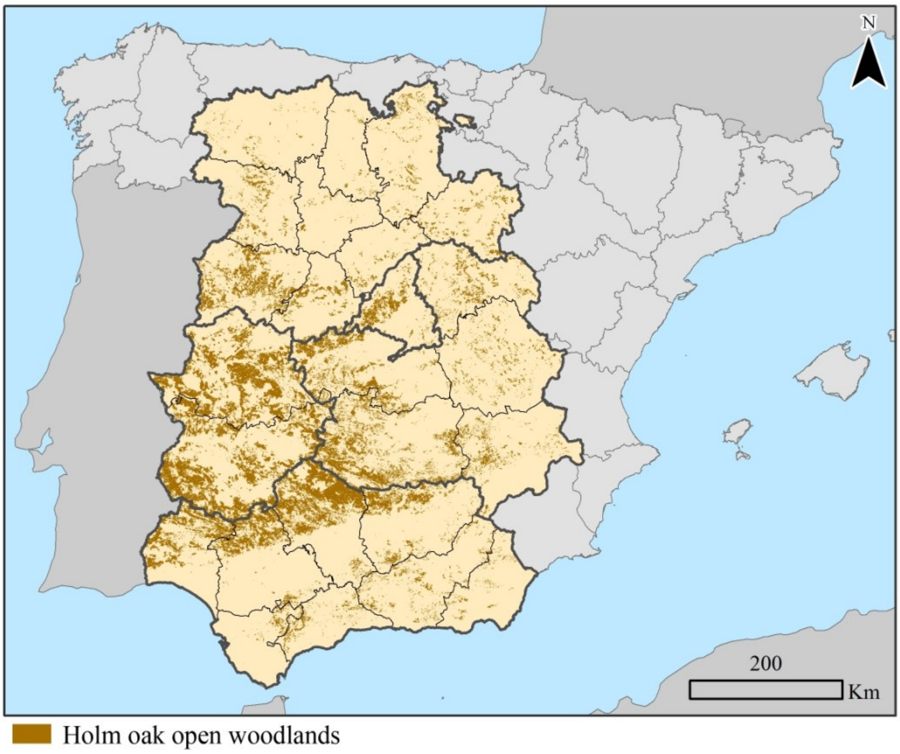
Table ST1. Open woodlands* in tiles with a predominance of hardwood species in West and Central Spain (hectares).

Class	Andalucía	Castilla-La Mancha	Castilla-León	Extremadura	Madrid	Total (ha)
Holm oak	1,408,170	1,165,064	750,459	1,390,896	13,.209	4,845,798
Cork oaks	248,015	24,493	7,059	151,786	190	431,543
Other oaks	28,992	175,383	745,760	94,995	24,260	1,069,390
Others	127,476	113,202	113,536	8,270	12,918	375,402
Total	1,812,654	1,478,142	1,616,815	1,645,946	168,576	6,722,133

*Open woodlands correspond to tiles with a canopy cover fraction ranging from FCC ≥5% to FCC ≤75% (including all standing tree “developments”).

Source: Eloy Almazan based on the DGCN (2008).

[1] According to preliminary information from the NFI6 (February 2013), holm oak as the dominant species covers a total area of 331,790 in Portugal. This area also includes, among others, areas of holm oak which constitute “dense holm oak woodland” (Pinto-Correia et al., 2013: p. 15)



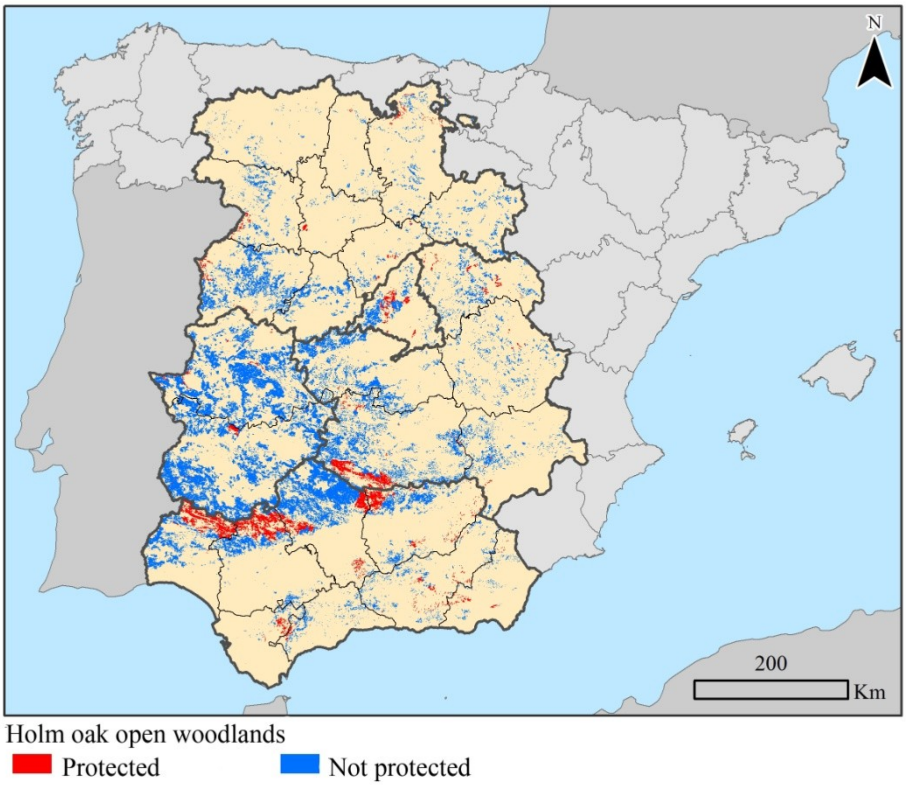
Source: Eloy Almazan based on the DGCN (2008).

Figure ST1. Open woodlands in tiles with a predominance of holm oak species in West and Central Spain

S1.2. Holm-oak open woodland institutional settings

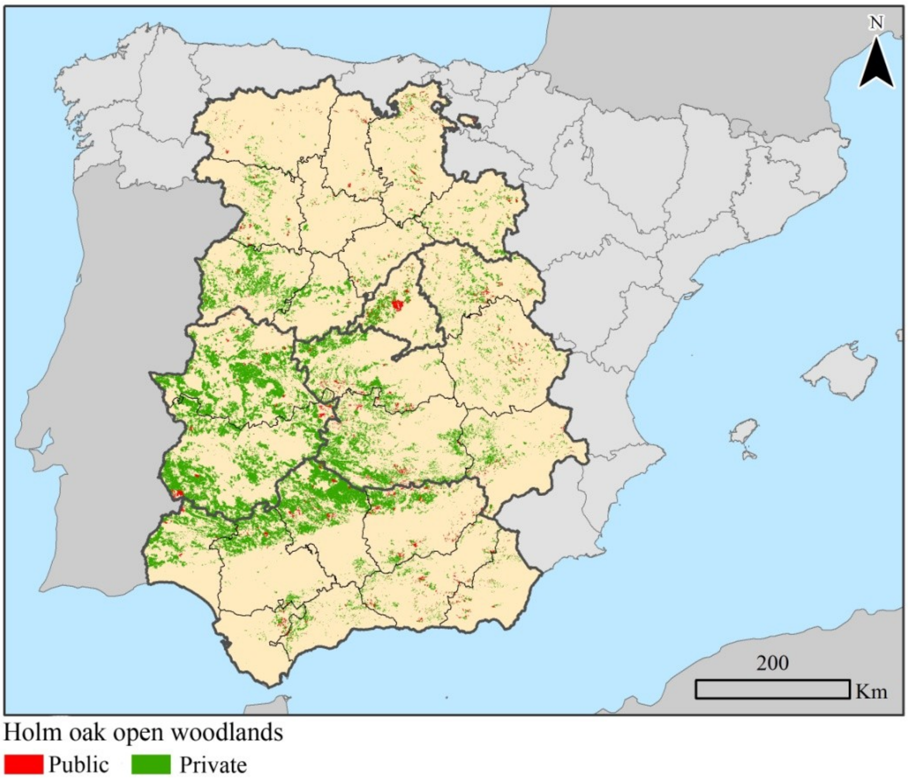
The regulations for protected areas[2] affect 27.5% of the HOW area in Andalusia, while 38.2% of forest falls under protected areas and this figure rises to 46.2% in the case of timber yielding conifer forest (Fig. ST2). The predominant location of forests in areas at the head of the watersheds has favoured greater government regulation in order to provide greater protection as part of the implementation of ongoing policies for historical repopulation aimed at mitigating damage to the environment and to infrastructures caused by occasional intense precipitation episodes downstream. The private owners, in the main part non-industrial, manage 92% of the total area of tiles with a predominance of HOW in the five regions, a share which is similar to that of the private HOW in Andalusia (Fig. ST3).

[2] Areas not included in the types of protected spaces of HOW in the regions: Community Importance Zone ZIC (ZEPA/ZEC), Regional Interest Zone and Zone belonging to the European Ecological Network Natura 2000.



Source: Eloy Almazan based on the DGCN (2008).

Figure ST2. Protected and non-protected open woodlands in tiles with a predominance of holm oak species in West and Central Spain.



Source: Eloy Almazan based on the DGCN (2008)

Figure ST3. Private and publicly owned open woodlands in tiles with a predominance of holm oak species in West and Central Spain.

In the past, government reforestation and induced natural regeneration in the HOW were concentrated on public properties and mainly involved plantation of timber-yielding conifers. These protective reforestations carried out in the past by the government justified the exclusion from sale in public auction of public forests at the heads of the watersheds during the process of disentitlement of the land belonging to public properties and the church between the second third of the 19th century and the first third of the 20th century. This government policy of mitigating soil erosion in the steepest mountain areas explains the fact that the public owners maintain the ownership in 52% and 57% of the forested areas in the five regions and in Andalusia as a whole, respectively.

HOW areas are mainly concentrated on large private farms where they generally share much of the total area (although the share varies considerably) and where other uses within these properties include scrubland, pasture and agriculture. On these farms, the traditional silvicultural practice of creating open woodland is orientated towards the livestock and game species activities. This type of farm with typically open HOW is known as a *dehesa* in Spain and *montad*o in Portugal.

In the case of owners of *dehesas* of more than 200 ha, the average size of the *dehesas* is 502 ha, which account for 62% of the area of open woodland and 64% of the total *dehesa* area of 3,606,154 ha in the five regions of the West and South-West of Spain most of the *dehesas* are found (Table ST2). In Andalusia, the characteristics of the *dehesas* larger than 200 ha are similar to those in the five regions, with the average area of the *dehesas* being 460 ha, open woodlands making up 63% of the total area of the all farms and 68% of the total area of the *dehesas* (Table ST2).

The extensive livestock husbandry in the *dehesas* comprises a wide range of autocthonous species (part of the livestock registered in geneological registers regulated by the government) in the main producing offspring crossed with foreign breeds which are sold once weaned for fattening up in stables, usually outside the farms themselves. More than two thirds of the livestock population is bovine or ovine in similar proportions, followed by goats and pigs of the Iberian breed and crosses with duroc-jersey (Campos et al., in progress). Grazing by large game species and migrating birds is of importance in areas where these species settle (Campos et al., in progress).

Table ST2. *Dehesas* area extend and open woodland vegetation cover in five autonoous rgions in West and South-West of Spain by size classification.

Farms size (hectares)	Number of farms		Surfaces			
			Open woodlands		Farms	
	Nº	%	ha	%	ha	%
Andalucía	4,408	100	462,240	100	743,775	100
E* ≤ 200	3,309	75	171,369	37	238,670	32
E > 200	1,099	25	290,871	63	505,105	68
Castilla-La Mancha	27,881	100	486,916	100	1,048,713	100
E ≤ 200	26,765	96	158,621	33	326,187	31
E > 200	1,116	4	328,295	67	722,526	69
Castilla y León	41,819	100	392,317	100	687,408	100
E ≤ 200	40,913	98	175,535	44	317,195	46
E > 200	906	2	216,782	56	370,213	54
Extremadura	37,692	100	828,460	100	1,065,189	100
E ≤ 200	36,318	97	314,079	38	400,833	37
E > 200	1,374	3	514,381	62	664,356	63
Madrid	587	100	33,069	100	61,069	100
E ≤ 200	507	86	15,309	46	27,351	45
E > 200	80	14	17,760	54	33,718	55
Spain	112,387	100	2,203,002	100	3,606,154	100
S ≤ 200	107,812	96	834,913	38	1,310,236	36
E ≤ 10	87,395	78	102,611	5	152,867	4
10 < E ≤ 50	12,015	11	183,203	8	287,939	8
50 < E ≤ 100	4,612	4	209,429	10	330,672	9
100 < E ≤150	2,322	2	177,758	8	285,042	8
150 < E ≤ 200	1,468	1	161,912	7	253,716	7
E > 200	4,575	4	1,368,089	62	2,295,918	64
200 < E ≤ 300	1,698	2	265,382	12	416,935	12
300 < E ≤ 500	1,521	1	373,223	17	582,026	16
500 < E ≤ 1000	979	1	394,791	18	658,528	18
E > 1000	377	0	334,693	15	638,429	18

Source: own elaboration after MAPA (2008)

S1.3. Background to the decline of holm oak open woodlands

The scarce data available based on real measurements of the ages of dead holm oaks in the HOW of Andalusia and Extremadura reveal that there are very few individuals more than 250 years old (Campos et al., 2017). If it were possible to generalize these data, the conclusion drawn would be that the current HOW are relatively recent. The hypothesis which seems the most plausible is that almost all the HOW that existed prior to the 19th century have disappeared due to natural death and commercial felling. Hence, without regeneration of the trees destroyed there was a gradual change in land use in areas of HOW which were replaced by permanent natural pasture and agricultural crops.

However, this biological-cultural process of creation and destruction of the HOW up to the end of the Modern age was in part countered from the 19th century onwards by the growth of the local population and immigration to Extremadura and western Andalusia from Castile and Leon, giving rise to the clearance of scrubland and thinning of the dense "virgin" woodland, transforming the landscape into holm oak open woodland, resulting in much of the HOW in West and South-West Spain which exist today (Alagona et al., 2013; Linares and Zapata, 2003). Once livestock grazing commences following the thinning and establishment of pre-existing natural regeneration, the absence of the usual regeneration cycles accompanied by fencing off of grazing and/or protection of individual seedlings leads to the existing trees reaching maturity, then declining and eventually the natural death of the holm oaks.

The apparent paradox is that the secular trend towards decline and depletion of the trees has not led to the disappearance of the HOW in the area of the five regions in West and South-West Spain where HOW predominate. Silviculture in holm oak open woodlands has traditionally consisted of thinning the trees which come from natural regeneration along with recurrent pruning in rotation periods which vary considerably, in the past depending on firewood prices whereas today such treatments are carried out more for health reasons to mitigate loss of large branches from over-mature trees, formed through "olivado" (pruning as it donen in olive tree) type pruning treatments carried out in the past to encourage acorn production and to allow sunlight to penetrate below the crowns of the trees (Pulido and Picardo, 2010). This past silviculture of HOW creation-destruction based on clearance of the natural regeneration by the private owners in Spain has been complemented for the first time by government intervention through compensation for ceasing of grazing over a 20 year period and financing of reforestation using European Union funds through the program for voluntary setting aside of agricultural land. In the HOW area of the five regions, 197,600 ha were reforested with holm oaks over the period 1993-2000 (Ovando et al., 2007). A new phenomenon in recent decades has been the expansion of large game species (mainly deer and wild boar) in the HOW, especially in upland areas and mixed woodland, where livestock grazing has either ceased or is decreasing in intensity.

The long term tendencies outlined above, the government policies of HOW landscape protection and reforestation, explain the complex phenomenon of the falling numbers of adult trees in the HOW of West and South-West Spain. The concern for the decline in holm oaks is shared by owners, scientists, government and other interested parties and has been confirmed by case studies in scientific publications (Alejano et al., 2011; Pinto-Correía et al., 2011, 2013; Pulido and Picardo, 2010; Urbieta et al., 2011) and in the information available from the public administrations (BOJA, 2010; MAPA, 2008; Senado, 2010).

In the Third National Forest Inventory research plots in the five communities where *dehesas* predominate, null or scarce natural regeneration in the HOW ranges from 46% – 75% (Table ST3). These data are explained in general by uninterrupted livestock grazing, consuming the new natural generation of trees during periods of seasonal drought, since continuous grazing is only compatible with the protection of individual trees against grazing of leaves and twigs by controlled animals. Plantation and natural regeneration by plots of woodland requires temporary and/or seasonal exclusion measures to be put in place against grazing in the regeneration area so that, based on the biological life cycle of the holm oak (generally more than 200 years), rotational regeneration plots can be programmed in the HOW of the *dehesas* (Alejano et al., 2011; Campos et al., 2017).

Table ST3. Plot regeneration density classes for plant development categories in open holm oak woodland in West and South-West Spain (%).

Class	Null	Scarse	Normal	Abundant	Total
Andalucía					
Quercus pyrenaica	*99.92*	*0.00*	*0.04*	*0.04*	*100*
Quercus faginea	*98.06*	*0.41*	*0.62*	*0.91*	*100*
Quercus ilex	*68.97*	*5.90*	*5.31*	*19.82*	*100*
Quercus suber	*93.16*	*2.28*	*1.56*	*3.00*	*100*
Quercus canariensis	*99.29*	*0.38*	*0.08*	*0.25*	*100*
Olea europaea	*89.81*	*3.56*	*2.25*	*4.38*	*100*
Todas	63.47	8.69	6.96	20.88	100
Castilla-La Mancha					
Quercus pyrenaica	*97.86*	*0.55*	*0.50*	*1.09*	*100*
Quercus faginea	*91.12*	*2.94*	*3.25*	*2.69*	*100*
Quercus ilex	*51.04*	*11.54*	*14.49*	*22.93*	*100*
Quercus suber	*98.67*	*0.55*	*0.55*	*0.23*	*100*
Fraxinus angustifolia	*99.56*	*0.19*	*0.19*	*0.06*	*100*
Todas	46.75	13.33	16.17	23.75	100
Castilla y León					
Quercus pyrenaica	*87.22*	*2.71*	*3.58*	*6.49*	*100*
Quercus faginea	*95.62*	*1.91*	*1.01*	*1.46*	*100*
Quercus ilex	*50.84*	*11.92*	*15.89*	*21.35*	*100*
Quercus suber	*99.35*	*0.27*	*0.38*	*0.00*	*100*
Fraxinus angustifolia	*98.97*	*0.66*	*0.23*	*0.14*	*100*
Todas	40.59	15.05	18.57	25.79	100
Extremadura					
Quercus pyrenaica	*97.78*	*0.73*	*0.60*	*0.89*	*100*
Quercus faginea	*99.73*	*0.09*	*0.09*	*0.09*	*100*
Quercus ilex	*52.67*	*15.85*	*13.87*	*17.61*	*100*
Quercus suber	*93.28*	*3.39*	*2.24*	*1.09*	*100*
Fraxinus angustifolia	*99.95*	*0.04*	*0.00*	*0.01*	*100*
Todas	48.28	18.16	15.28	18.28	100
Madrid					
Quercus pyrenaica	*92.32*	*1.70*	*2.07*	*3.91*	*100*
Quercus faginea	*98.83*	*0.51*	*0.51*	*0.15*	*100*
Quercus ilex	*30.97*	*15.31*	*18.71*	*35.01*	*100*
Fraxinus angustifolia	*93.92*	*2.81*	*2.18*	*1.09*	*100*
Todas	22.15	24.07	22.50	31.28	100

Null: There are no trees of category 1, 2 or 3 in the plot. Scarce. From 1 to 4 trees in the plot, extrapolating this data gives 1 – 575 seedlings/ha. Normal. From 5 to 15 trees in the plot, in other words 576 – 1,910 seedlings/ha. Abundant. More than 15 trees in the plot, that is, > = 1,911 seedlings/ha.

Source: MAPA (2008).

S2. Economic activities reconsidered

The conceptualizations of the individual economic activities have been dealt with in Campos et al. (2019a), hence only a brief description is given in this study in order to facilitate the understanding of the text.

The production functions of the individual activities of the Andalusian HOW contain manufactured factors (except for water) and inputs at zero cost for the hours employed by free-access consumers of recreational services and mushroom picking. We have not registered self-employed labor cost in the HOW activities valued. This avoids the presence of mixed income.

S2.1. Conservation forestry

The owners do not normally undertake the conservation of HOW aimed at commercial acorn and wood production along with other products from associated tree such as industrial timber, cork and fruit (pine nuts and chestnuts). We assume that these products incur no silvicultural costs, the only costs considered being those related to the extraction of the products. We conceptualize that in the Andalusian HOW conservation forestry undertaken by private owners is mainly motivated by auto-consumption of amenities and in the case of public owners by landscape conservation.

Conservation forestry activity refers to interventions involving natural regeneration and planting of trees in the period in which they are recorded as own-account manufactured gross capital formation (GCFm). GCFm also includes road and other infrastructures in the ordinary management of the Woodland.

Past GCFm pending amortization generate a consumption of historic manufactured fixed capital at replacement cost (CFCmh) and the ordinary management for the period a manufactured total cost (TCmog), which together make up the ordinary manufactured total cost (TCmo) of the conservation forestry activity.

The products of the conservation forestry activity are the GCFm valued according to their production cost in the period and the intermediate production of amenity commercial services (ISSca) valued according to the TCmo.

Due to lack of available data the government compensations affecting the historical GCFm of the conservation forestry activity have not been considered. This omission is important as substantial reforestation has taken place in the recent past which was not included in the NFI3 (Ovando et al., 2007). As regards the way in which compensations in this activity are dealt with in the accounts, they are annualized in the cycle of their amortization at replacement cost as CFCmh. This CFCmh gives rise to a compensated commercial intermediate service (ISScc) (see details in Campos et al., 2017). In this study, the ISSc of the private HOW are auto-consumed (ISSca) and incorporated into own commercial intermediate consumption of services (SScoa) of the private amenity activity, and those of the public HOW are donated (ISScd) and registered as SScod of the landscape activity.

S2.2. Grazing

The grazing activity in the HOW includes consumption by livestock and game species. Livestock grazing is valued according to the market price of the leaseholds and game species grazing is estimated by the environmental price (unitary resource rent) according to the captures in the period. The stage at which the possible environmental price of a product is estimated is that of the first possible transaction in the local market of the intermediate product and/or the final product consumed (ordinary).

Holm oak open woodlands are cultural landscapes modelled by animals and pruning aimed at favouring the production of acorns. The animals generally graze the whole area at intensities which do not favour the accumulation of palatable bushy forage, although there are plenty of bushes and scrub that are not consumed.

Over recent decades in areas with steep slopes, which tend to be the places with the lowest production of forage species, livestock grazing is being partially replaced by that of large game species. The evolution of game captures and livestock consumptions indicate that grazing by livestock and game species in the holm oak open woodlands of Andalusia is not decreasing.[3]. Our estimates of acorn production consumed by livestock and wild fauna (including game species) suggest that the game species are adding economic value to grazing (including acorns) in increasing proportions, thus mitigating the persistent tendency towards reduction in the market value of the grazing consumed by livestock (Campos et al., 2009a; Campos et al., 2016).

S2.3. Private Amenity

The ordinary final production of the private amenity is implicitly commercial as it is embedded in the market price of the land. Amenity is explicitly accepted in

[3] In the discussion section we address the consequences of this diagnosis in the design of the silvopastoral public policy of compensations from the European Union for the conservation of *dehesa* landscapes.

Spanish land law (BOE, 2011, 2015), which includes it in the estimation of land prices by the government when purchasing/expropriating rural land. In other words, the amenity is conceptually a SNA activity which, by convention is valued at production cost in the SNA. In contrast, it is valued in the AAS according to the owner's willingness to pay (Campos et al., 2009b; Oviedo et al., 2017). Amenities cannot receive remuneration for the manufactured capital employed in the period as the latter is made up exclusively of own ordinary intermediate consumption of services (SSoo). The ISSca and ISSnca of the HOW activities which produce them (and which are omitted here), namely hunting and livestock husbandry, are those which receive the remunerations from the manufactured investment.

S2.4. Fire services

In the HOW of Andalusia, prevention and extinction of forest fires are normally assigned to the owners and government respectively. Among the ordinary costs of the forestry conservation activity is that of fire prevention, meeting government regulations. Once a fire has been observed and detected by the government fire fighting services, the actions required to extinguish the fire are registered in the government fires services activity. This activity is paid for entirely through public spending and this produces both commercial intermediate services (ISSc) and own account manufactured gross fixed capital formation (GCFm) (Ovando and Campos, 2016). The ISSc are registered as the balancing entry of the SSco in the public activities which used them, which in the case is mainly the landscape activity. The valuation criteria for the ISSc are the same as those for the conservation forestry activity.

S2.5. Mushrooms

The mushrooms gathered in the HOW are in fact public economic products as the owners do not exercise access exclusion rights in relation to gathering. In this situation the market price of the land does not embrace hunting related resource rent, which *is* appropriated by free-access pickers. Mushroom picking is undertaken by recreational visitors with free access and by definition the opportunity cost of the leisure time spent gathering is zero and the access costs at the farm gate for pickers are considered not to be incorporated in the market price of the product gathered. However, the government does incur costs related to the regulation and vigilance of appropriate harvesting practices.

The final product consumed for mushrooms is obtained according to the amounts harvested by the trading price (weighted by the product quality) declared in telephone surveys to public mushroom pickers resident in Andalusia (Martínez-Peña et al., 2015).

The condition of mushrooms being a joint product along with recreational service enjoyment is avoided by not incorporating it into the mushroom activity and assuming that the latter is incorporated in the total estimate of visitor willingness to pay for recreational use of the HOW.

S2.6. Public recreation

It is difficult for owners to prevent access to their farms by visitors off the public rights of way for a variety of reasons, such as the huge size of the HOW in Andalusia, the large network of old paths, tracks and bridleways, many of which are all but impassable today, and the policy of many public owners as well as the government to encourage free-access recreational use of the HOW. However, perhaps the majority of the large owners fence their farms and thus manage to exclude visitor access, above all in farms where there are large game species and breeding of fighting bulls.

The government of Andalusia has established an information service for free-access visitors providing them with audio-visual information and services in centres distributed throughout the region. The government also schedules free visits to public farms through agreements with the local councils and the regional administration, including the provision of guide services in protected natural areas.

In this context, a market has been simulated whereby the final product consumed (FPc) of recreational visits is estimated through visitor willingness to pay in order to continue making visits beyond the usual public rights of way, receiving the same services from the public administration as opposed to the alternative of paying an entrance fee which does not allow them entry in the future (Caparrós et al., 2017). Own-account gross formation of manufactured fixed capital (GFCFm) is estimated in accordance with the production cost.

The ordinary manufactured total cost (TCmo) includes the direct management costs for the period and the historic manufactured fixed capital consumption (CFCmh) at replacement cost for the manufactured fixed capital investments applied to the provision of services for public visitors. The TCmo also includes the SSco used by the recreational activity and which stem from the ISSc of the fire services activity.

S2.7. Water supply

In Spain, by government decision, the market price of economic water used by economic activities as input for production and by households as final product is not included in the ecosystem service. In Andalusia little water is retained in reservoirs and for this reason the price of water derived from a market unrestricted by the government would be higher than that for regulated water, so the resource rent is embedded in the products of the economic activities and in the consumer surplus of households due to paying a lower price than that which would be paid under a monopoly water supply situation such as the current one or a competitive one.

In the case of retained water which has fallen within the area of the HOW of Andalusia, the economic use of which is crop irrigation, its ecosystem service (ES) revealed indirectly in the land prices and in fact this could also be the case in the first transaction of corporations which supply the water to the industry and service sectors and to households. Although this would not by right be the case due to water regulation laws not allowing the ecosystem service of natural retained water to be charged in the first transaction.

Since the regulated prices of water exclude the resource rent we have to employ alternative valuation methods to the market prices of water. In Andalusia, since the demand for irrigation has been shown to be the main use of economic water, we resort to the hedonic price method in order to estimate the value of retained water as an environmental asset used in the irrigation of land in the Guadalquivir river basin (Beguería et al., 2015; Campos et al., 2019a; Berbel and Mesa, 2007; Berbel et al., 2011). We assume a rate of return of 3% from the environmental asset estimated for its use in irrigation and having determined the annual water consumption entitlement through the administrative concession we estimate the unitary resource rent of the water resource used on irrigated land (Beguería et al., 2015; Campos et al., 2019a).

85% of the regulated economic water is destined for a normal water consumption use in irrigation for agricultural production and the remaining 15% for economic uses and households. We assume that the marginal productivity of the water used for irrigation is lower than that for the rest of the uses. That being the case, if we take the environmental price estimated according to the unitary resource rent of the irrigation water as the mean environmental price of the total water consumed, this establishes it at the lower limit of the environmental price of the water.

The supply of surface water to the reservoirs has no cost until it reaches the natural course of the rivers, which is where the resource rent is estimated in this HOW study. The resource rent of the forest surface water is its positive residual value obtained after subtracting the ordinary operating costs (intermediate consumption and labor), the fixed capital consumption and the normal remuneration of immobilized manufactured capital from the inputs of the supply company at producer prices. In other words, the resource rent of the water is its economic value as a natural raw material prior to the Company incurring any costs for storage, treatment and transport to the site where it is consumed. The concessionary companies and the public water agencies do not transfer the resource rent of the water revealed by the market for products from irrigated farms to the end users. In other words, it is the owner of the irrigated land who appropriates the resource rent for forest water.

S2.8. Landscape conservation

The HOW public landscape activity service is a passive option value incorporated in the marginal willingness to pay declared by consumers to assure the quality and quantity of the offer of current ordinary public assets not threatened with disappearance for at least the next 30 years. Thus, the HOW landscape conservation service excludes the private amenity services used exclusively by the owner as well as the public recreation and threatened wild biodiversity services. In other words, the option value of the landscape represents the simulated payment declared in the experimental choice survey which individuals are willing to incur to assure future use of forest ecosystem economic goods and services for themselves or third parties under the same conditions in which they currently enjoy them (Campos et al., 2019a).

S2.9. Threatened wild biodiversity preservation

In the valuation of the existence of threatened wild biodiversity in the HOW, the same choice of price is assumed for all the threatened species. This criterion is justified by the nature of the service valued. This passive option service of biodiversity consists of assuring the mitigation of extinction risks for an industrially non-reproducible genetic variety, the future asset service of which is unknown. In this situation, there is no public preference for one unique genetic variety over another, not having another equivalent asset service through which a price they are equal to can be determined. Hence, all the unique genetic varieties are equivalent in the period in which they are valued as their future utility to human consumers is unknown, thus the choice of the same price for all is justified. Thus, we assume in this study of the HOW that the passive consumer of the existence of threatened wild biodiversity service has the same willingness to pay for any unique genetic variety (species) threatened with extinction. Threatened biological variety can also provide other values consumed by people (apart from the biodiversity existence value) which are included in its total economic value, such as free-access recreation services and the landscape conservation service (Campos et al., 2019a).

S2.10. Carbon

Forest carbon possesses characteristics of economic activity given the fact that it offers physical flows of fixation (production) and emission (consumption) as well as liability as it leads to possible loans/debts if physical standards have previously been contractually regulated which must be met by the end of the established term. As the owners have no contractual agreement entailing a financial loan/debt, we have assumed the character of the economic activity of carbon. The practical consequence of this option is the possible generation of a negative carbon environmental asset, which is inconsistent with the economic definition of environmental asset. It is assumed that the government makes implicitly transactions for flows of fixation and emission of carbon among its forest and atmospheric environmental assets.

S3. Accounting methods applied to holm oak open woodlands in Andalusia

S3.1. Refined System of National Accounts

Social accounting (national) registers the values of the transactions for products generated in a period, some of which are revealed by the formal markets and others, implied, which are simulated with the theoretical aim of estimating the total income of the territory, usually at national/regional scale. In practice, the national accounting does not reach its ultimate purpose and is limited to non-geo-referenced measurement of a list of private commercial final products and government spending on free consumption public goods and service production. The products are grouped into activity sectors and institutional sectors.

The activities of mixed holm oak open woodlands (HOW) are divided into, on the one hand, the silviculture (Economic Account for Forstry-EAF) and service sectors, and on the other hand, the institutional sectors of corporations (farmers) and government. In other words, the total product and cost of the HOW remain invisible in national accounting and as a consequence, the absence of geo-referenced data per ecosystem type makes the measurement of gross/net value added of the HOW impossible.

The net value added (NVA) estimated by the Standard National Accounts (SNA) is a net operating income which hides the revaluation of stockbreeding capital incorporated in the gross formation of capital and which originates from the net variation in the livestock inventory. It also hides the revaluation of manufactured fixed capital embedded in the consumption of fixed capital estimated at replacement cost. Furthermore, the SNA ignores possible net operating surpluses (NOS) and revaluations of capital coming from public products with no market price.

All accounting systems are obliged to fulfil the principle of double entry, but their structure is subsidiary to the ultimate objective pursued. In our case the objective is to measure the concept of environmental income of the HOW in a coherent way, integrating it into the total income at social price and assuming that in the future the expected management of resources will be sustainable from both ecological and economic perspectives.

In Campos et al. (2019a) we have developed the conceptualizations and measurements of the total incomes derived from the Agroforestry Accounting System (AAS) and the refined System of National Accounts (rSNA) at producer price for the Andalusian forests, woodlands, shrubland and grasslands as a whole. The new aspect presented in this study is the valuation of the Andalusian holm oak open woodland (HOW) ecosystem at social price. In the following sub-sections we briefly describe the different accounting identities of the total income at social price. The identity of most interest for this article is that which shows the factorial distribution of the total income, which makes visible the link between the total income and the environmental income of the Andalusian how (see development of accounting identities in Campos et al., 2017, 2019a, 2019b; 2019c).

The organization of the accounts and indicators in the refined System of National Accounts (rSNA) is the same as that of the AAS. The refinement of the SNA (henceforth S) consists of adding the natural growth (NG_{rSNA}) for the period to the gross capital formation (GCF_{rSNA}) and subtracting the environmental work in progress used ($WPeu_{rSNA}$) from the gross operating surplus (GOS_S) and incorporating it into the intermediate consumption of the rSNA in order to estimate the gross operating margin

(GOM_{rSNA}). These changes resolve the problem of timing of the gross value added (GVA_S) in the SNA by estimating it in the period in which it is consumed and not in which it is produced, as in the rSNA measurement of the gross value added (GVA_{rSNA}):

$$GVA_{rSNA} = GVA_S + NG_{rSNA} - WPeu_{rSNA} \quad \text{(SM eq. 3.1)}$$
$$GOM_{rSNA} = GOS_S + NG_{rSNA} - WPeu_{rSNA} \quad \text{(SM eq. 3.2)}$$

Other modifications introduced in the rSNA are due to the incorporation of the intermediate production (IP_{rSNA}) and own ordinary intermediate consumption ($ICoo_{rSNA}$) as well as the reclassification of compensations which are taken from the final product consumed in the SNA (FPc_S) and incorporated into the IP_{rSNA} as non-commercial intermediate product of compensation service (ISSncc). These modifications affect the results of the individual activities and as they are double entered they cancel each other out in the aggregate gross value added result of the standard (S) and refined (rSNA) methods of the SNA:

$$GVA_{bp,HOW,S} = FPc_{bp,S} + GCF_S - IC_S \quad \text{(SM eq. 3.3)}$$
$$GVA_{bp,HOW,rSNA} = IP_{rSNA} + FPc_{bp,rSNA} + GCF_{rSNA} - IC_{rSNA} \quad \text{(SM eq. 3.4)}$$
$$IP_{rSNA} = IPc_{rSNA} + ISSncc_{rSNA} \quad \text{(SM eq. 3.5)}$$
$$FPc_{bp,rSNA} = FPc_{bp,S} - ISSncc_{rSNA} \quad \text{(SM eq. 3.6)}$$
$$TPc_{rSNA} = IP_{rSNA} + FPc_{bp,rSNA} \quad \text{(SM eq. 3.7)}$$
$$GCF_{rSNA} = GCF_S + NG_{rSNA} \quad \text{(SM eq. 3.8)}$$
$$IC_{rSNA} = IC_S + WPeu_{rSNA} + ICoo_{rSNA} \quad \text{(SM eq. 3.9)}$$
$$ICoo_{rSNA} = ICcoo_{rSNA} + ICncooc_{rSNA} \quad \text{(SM eq.3.10)}$$
$$GVA_{bp,HOW,rSNA} = TPc_{rSNA} + GCF_{rSNA} - IC_{rSNA} \quad \text{(SM eq.3.11)}$$

where subscript bp is basic price, subscript S is standard SNA, subscript rSNA is refined SNA, $ICcoo_{rSNA}$ is own ordinary commercial intermediate consumption of rSNA, $ICncooc_{rSNA}$ is own ordinary non-commercial intermediate consumption compensation of rSNA and TPc_{rSNA} is total product consumption of rSNA.

S3.2. Agroforestry Accounting System

The development and application of the AAS methodology in previous publications by the authors facilitate the simplified description in the present document of the accounting identities of total income and environmental income of the HOW as a whole.

The structure of the production and balance accounts in the Agroforestry Accounting System fulfils the purposes of estimating the total income (TI) of the economic activities of the owners and government as well as their factorial distribution. We assume the absence of financial liabilities and credits from/to third parties, so that the change in net worth (CNW) is due exclusively to the real flows derived from the production and balance accounts. Our interest is to make the flows and stocks of the land (hence forth environmental) visible in the total product function and factorial distribution of the total income.

S3.2.1. Net value added

In Campos et al. (2019a: p. 221) the total product (TP) function (f) explicitly incorporates the environmental intermediate consumption of work in progress used (WPeu) and the environmental fixed assets (EFA) as production factors:

$$TP \equiv f(WPeu, ICm, LC, EFA, FCm) \qquad \text{(SM eq.3.12)}$$

where ICm is manufactured intermediate consumption, LC is labor costs, and FCm is manufactured fixed capital.

Total product (TP) components are: on the one hand, (i) total cost (TC) of manufactured intermediate consumption (ICm) both bought (ICb) and own (ICo) and work in progress used (WPmu), intermediate consumption of environmental work in progress used (WPeu), labor cost (LC) and consumption of fixed capital (CFC) and, on the other hand, (ii) net operating margin (NOM) of ordinary manufactured net operating margin (NOMmo), ordinary environmental net operating margin (NOMeo) and environmental net operating margin investment (NOMei):

$$TP = ICb + ICo + WPmu + WPeu + LC + CFC + NOMmo + NOMeo + NOMei \qquad \text{(SM eq.3.13)}$$

$$TP = TC + NOM \qquad \text{(SM eq.3.14)}$$

$$TC = ICm + WPeu + LC + CFC \qquad \text{(SM eq.3.15)}$$

$$ICm = ICb + ICo + WPmu \qquad \text{(SM eq.3.16)}$$

$$NOM = NOMmo + NOMeo + NOMei \qquad \text{(SM eq.3.17)}$$

NOMe = NOMeo + NOMei (SM eq.3.18)

The net value added (NVA) is the indicator which represents the operating income of the HOW economic activities valued. The operating remunerations for production factors embedded in the total product (TP) are the LC and the NOM. The latter remunerates the manufactured investments (NOMmo) and the environmental assets (NOMe):

NVA = TP – ICm – WPeu – CFC (SM eq.3.19)

NVA = LC + NOM (SM eq.3.20)

NVA = LC + NOMmo + NOMe (SM eq.3.21)

Among the components of the total product are the WPeu and NOMeo, and the NOMei accumulated in the environmental asset at the closing of the period comprising natural growth (NG) net consumption of environmental fixed asset (CFCe). The first two correspond to the contribution of the ecosystem services (ES) to the total product (TP) and the third is one of the components of the changes in environmental net worth (CNWe):

ES = WPeu + NOMeo (SM eq.3.22)

NOMei = NG – CFCe (SM eq.3.23)

S3.2.2. Capital gain

The concept of capital gain (CG) is one of the most controversial in the definition of total income. In this application of the AAS to the HOW we focus on describing the criteria applied to measure it (for greater detail see Campos et al. 2017, 2019a). We have not forecast variations in the future prices of the manufactured capital and environmental assets, the capital revaluations corresponding to changes in prices at the closing not forecast at the opening of the period. The CG is obtained from the capital revaluation (Cr) less extraordinary capital destruction (Cd) plus instrumental adjustment of capital (Cadj) which avoids double counting of depreciation and natural growth (see details in Campos et al., 2017, 2019a: Supplementary material, p. 45). We divide the GC into manufactured (CGm) and environmental asset gain (EAg).

$$CG = Cr - Cd + Cadj \quad \text{(SM eq.3.24)}$$

$$Cr = Cc - Co + Cw - Ce \quad \text{(SM eq.3.25)}$$

$$CG = CGm + EAg \quad \text{(SM eq.3.26)}$$

where Cc is closing capital, Co is opening capital, Cw is capital withdrawals and Ce is capital entries.

S3.2.3. Total income

The original accounting identity of the total income (TI) is that revealed by its links with the operating income (NVA) and the capital gain (GC). The net value added (NVA) is the balancing item of the production account and the CG is the balancing item of the balance account.

$$TI = NVA + CG \quad \text{(SM eq.3.27)}$$

$$NVA = TP - IC - CFC \quad \text{(SM eq.3.28)}$$

$$TP = IP + FP \quad \text{(SM eq.3.29)}$$

$$FP = FPc + GCF \quad \text{(SM eq.3.30)}$$

where TP is total product, IC intermediate consumption, CFC is consumption of fixed capital, IP intermediate product, FP is final product, FPc is final product consumption, GCF is gross capital formation, Cc is closing capital, Co is opening capital, Cw is capital withdrawals and Ce is capital entries.

Through the rearrangement of SM eq.3.27 (TI = NVA + CG), TI is shown through a new instrumental identity to be total product consumption (TPc) less intermediate consumption (IC) plus change in net worth (CNW). We assume that there are no HOW liabilities and in this case the CNW is the net present value of the changes in the COW total capital for the period, with adjusted capital gain. The estimation of the CNW depends on the investments (GCF), the fixed capital consumptions (CFC) and the capital gain (CG) for the period:

$$TI = TPc - IC + CNW \quad \text{(SM eq.3.31)}$$

$$CNW = GCF - CFC + CG \quad \text{(SM eq.3.32)}$$

$$GCF = GCFm + NG \quad \text{(SM eq.3.33)}$$

$$CFC = CFCm + CFCe \quad \text{(SM eq.3.34)}$$

where GCFmj is own account manufactured gross capital formation, NG is natural growth, CFCm is manufactured consumption of fixed capital and CFCe is environmental consumption of fixed capital.

The TI identity forming the basis for the development of all other aspects of environmental income is the TI factorial distribution, the environmental income (EI) displaying consistent integration with labor cost (LC) and manufactured capital income (CIm) in the HOW application:

$$TI = LC + CIm + EI \qquad \text{(SM eq.3.35)}$$

S3.2.4. Environmental income

The production and balance accounts of the AAS allow the fundamental identify of the environmental income to be estimated as the sum of the environmental net operating margin (NOMe) and the environmntal asset gain (EAg) (Campos et al., 2017, 2019a). The EAg is estimated by the environmental asset revaluation (EAr) less the environmental asset adjustment (EAad) according to natural growth and carbon fixation valued at the opening of the period. The change in environmental net worth (CNWe) is estimated as the environmental net operating margin investment (NOMei) plus the environmental asset gain (EAg):

$$EI = NOMe + EAg \qquad \text{(SM eq.3.36)}$$

$$EAg = EAr + EAad \qquad \text{(SM eq.3.37)}$$

$$EAr = EAc – EAo + EAw – EAe \qquad \text{(SM eq.3.38)}$$

$$CNWe = NOMei + EAg \qquad \text{(SM eq.3.39)}$$

If we rearrange SM eq.3.40 by adding and subtracting WPeu on the right side of the equation, we obtain the EI links with ecosystem services and the change in net worth adjusted (CNWead) according to WPeu:

$$EI = ES + CNWead \qquad \text{(SM eq.3.40)}$$

S4. Imputed own non-commercial intermediate consumption of services of holm oak open woodlands in Andalusia

In this study of holm oak open woodlands (HOW) the activities valued do not include non-commercial intermediate services (ISSnc), but they do include the own non-commercial intermediate consumption of services (SSnco) of compensation (SSncoc), amenity (SSncoc) and donation (SSncod), which are mainly used by the amenity and landscape activities. These SSnco stem from the ISSnc produced by the omitted HOW hunting and livestock activities.

As regards the imputation of the SSnco in the holm oak open woodlands (HOW) of Andalusia, these should be imputed because the available information is at producer price whereas we wish to present it at basic and social prices. Only the SSnco stemming from non-commercial intermediate services (ISSnc) of animal activities are imputed since, in the activities of the Andalusian HOW, they are estimated and integrated both in the commercial intermediate services (ISSc) which are produced in the conservation forestry, residential and fire service activities, and their balancing entry of own commercial intermediate consumption of services (SSco).

The estimation of HOW SSnco is carried out based on the information available from the private and public owners in the holm oak farm case studies under the RECAMAN project. The Spanish forest map provides the proportion of private and public area by tiles.

SSnco are imputed in the landscape activity in the case of public hectares of the tiles of Andalusian HOW. These SSnco stem from the compensated (ISSncc) and donated (ISSncd) non-commercial intermediate services of the hunting and livestock activities. A SSncoa is also incorporated in the amenity activity, arising from the family livestock breeders present in public holm oak *dehesas*.

SSnco are imputed in the landscape and amenity activities in the case of the private hectares of Andalusian HOW. The former (SSncc) arising from the compensated non-commercial intermediate services (ISSncc) and the latter (SSnca) from the auto-consumed non-commercial intermediate services (ISSnca).

S4.1. Estimation of the SSnco of the holm oak woodlands of Andalusia

Based on the data from the holm oak woodland farms, the SSnco corresponding to the ISSnca (private and public owner), compensated (ISSncc) (private and public owner) and donated (ISSIncd) (public owner) can be estimated. The three values for the

ISSnc of the animal activities are assigned to the HOW tiles as their SSnco corresponding to the landscape and amenity activities, adding them to the SSco produced as commercial intermediate services (ISSc) by the conservation forestry, residential and fire service activities.

The imputed SSnco values which are incorporated in the landscape activity also increase its production by the same amount as the SSnco allocation made, such that its production is equal to the ordinary total cost (CTo) plus the additional willingness to pay of the passive consumers (DAPa)[4].

S4.2. Data imputed to estimate the SSnc of the Andalusian HOW

For the imputation of the SSnc, aggregate information is used from the sixteen private farms (with a total area of 9,032 hectares) and six public farms (with a total area of 13,499 hectares) in which holm oaks comprise the main vegetation. Table ST5 shows the private *dehesa* hunting and livestock activity non-commercial intermediate services (ISSnc) used as own non-commercial intermediate consumption of services (SSnco), compensated (ISSncc) and auto-consumed (ISSnca) by the landscape and amenity activities. These SSnco are imputed to the private areas of the Andalusian HOW tiles in which holm oaks comprise the main vegetation.

Table ST5. Private *dehesas* own non-commercial intermediate consumption of services used by amenity and landscape activities (2010: €/ha).

Class	Amenity	Landscape
Compensated (SSncoc)		33.9
Livestock		*33.9*
Auto-consumed (SSncoa)	135.3	
Hunting	*57.5*	
Livestock	*77.8*	
Total SSncoc/a	135.3	33.9

Private *dehesas*: 16 farms. Total surface: 9,032 hectares.

Table ST6 is similar to table ST5 but the results indicated apply to the hectares of public HOW.

[4] The consumers pay ordinary commercial costs of the landscape and threatened wild biodiversity activities through public spending.

Table ST6. Public *dehesas* own non-commercial intermediate consumption of services used by amenity and landscape activities (2010: €/ha).

Clase	Amenity	Landscape
Compensated (SSncoc)		1.5
Livestock		*1.5*
Donated (SSncod)		23.3
Hunting		*23.3*
Auto-consumed (SSncoa)	2.1	
Livestock	*2.1*	
Total SSncoc/d/a	2.1	24.8

Public *dehesas*: 6 farms. Total surface: 13,499 hectares.

It is estimated that of the total 1,408,170 hectares of HOW in Andalusia, 1,280,684 hectares are private and 127,565 are public. Table ST7 shows the values for the imputation of the SSnco of the Andalusian HOW. The aggregate values in table ST7 show that 173,572,585 euros are imputed to the amenity activity and 46,633,854 euros to the landscape activity.

Figure ST4 shows the value of the imputations per hectare for the SSnco of the amenity and landscape activities in the Andalusian HOW.

Table ST7. Values imputed for own non-commercial intermediate consumption of services in the Andalusian HOW (2010: €).

Clase	Amenity	Landscpae
Private surface	173,305,347	43,473,263
Compensated (SSncoc)		43,473,263
Livestock		*43,473,263*
Auto-consumed (SSncoa)	173,305,347	
Hunting	*73,678,531*	
Livestock	*99,626,817*	
Public surface	267,237	3,160,591
Compensated (SSncoc)		194,409
Hunting		
Livestock		*194,409*
Donated (SSncod)		2,966,182
Hunting		*2,966,182*
Auto-consumed (SSncoa)	267,237	0
Livestock	*267,237*	
Own services (SSo)	173,572,585	46,633,854

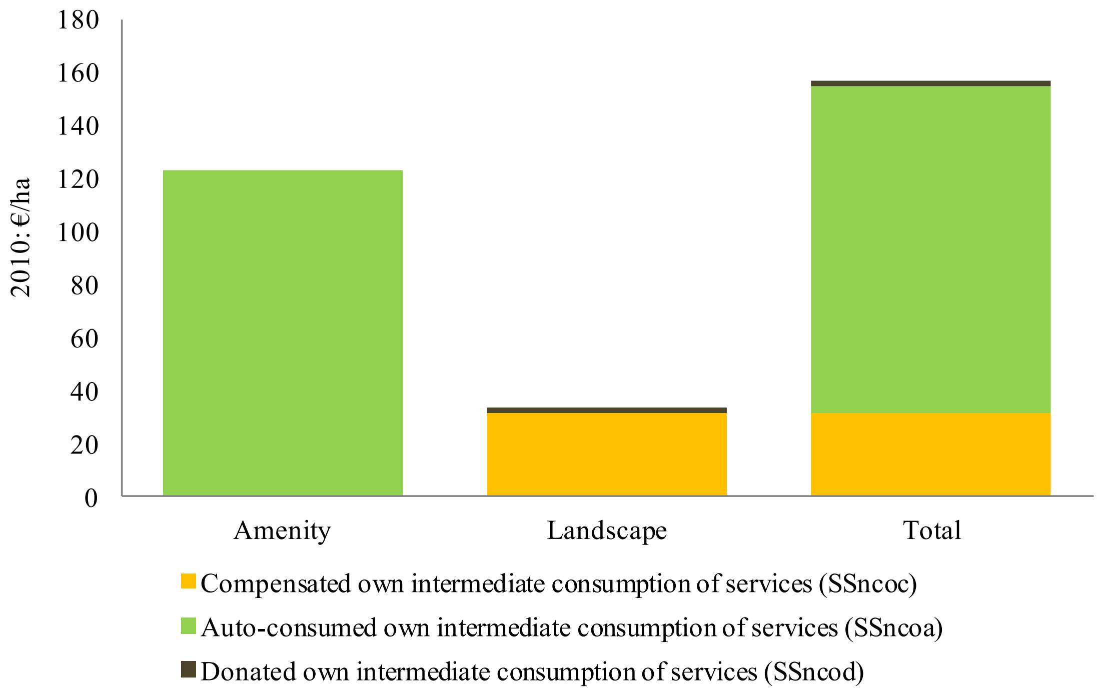


Figure ST4. Values imputed for own non-commercial intermediate consumption of services in the Andalusian HOW (2010: €).

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Supplementary tables for

Agroforestry Accounting System for measuring environmental incomes at social prices: application to holm oak open woodlands in Andalusia-Spain

Table S1. rSNA ordinary and investment production account for holm oak open woodlands in Andalusia (2010: €/ha).

Class	Timber 1	Cork 2	Fire-wood 3	Nuts 4	Grazing 5	Conserv. forestry 6	Residen-tial 7	Amenity 8	Farmer ∑1-8	Fire services 9	Recrea-tion 10	Mush-rooms 11	Carbon 12	Land-scape 13	Bio-diversity 14	Water 15	Govern-ment ∑9-15	Holm oak open woodlands ∑1-15
1. Total product consumption (TPc_{sp})	0.3	0.7	1.5	0.1	33.9	2.8	14.7	14.7	68.5	38.1	8.1	18.0		76.4	5.2	76.2	222.0	290.5
1.1 Intermediate product (IP_{sp})					33.9	2.8	14.7		51.3	38.1							38.1	89.4
1.2 Final product consumption (FPc_{pp})	0.3	0.7	1.5	0.1				14.7	17.2		8.1	18.0		76.4	5.2	76.2	183.9	201.1
2. Intermediate consumption (ICo_{sp})	0.4	0.0	0.2	0.1	0.6	1.0	0.8	14.7	17.7	11.4	3.0	0.0		72.1	1.5		87.9	105.7
2.1 Bought (ICmob)	0.4	0.0	0.2	0.1	0.6	1.0	0.8		3.1	11.4	1.4	0.0		1.7	1.5		16.0	19.1
2.2 Own ($ICmo_{sp}$)								14.7	14.7		1.6			70.4	0.0		71.9	86.6
2.3 Manufactured work in progress used (WPmuo)																		
3. Labour cost (LCo)	2.5	0.1	0.3	0.9	3.4	1.7	3.1		12.0	23.9	3.6	0.1		3.6	3.1		34.2	46.3
4. Consumption of fixed capital (CFCmo)	0.0		0.0	0.0	1.1	0.1	5.6		6.8	2.8	1.6	0.0		0.7	0.6		5.7	12.6
5. Manufactured net operating margin ($NOMmo_{sp}$)	-2.9	0.0	0.8	-0.9	0.6	0.0	5.1		2.7	0.0		0.0		0.0			0.1	2.8
6. Ecosystem services (ES_{sp})	0.2	0.6	0.2		28.3				29.3			17.8				76.2	94.0	123.3
6.1 Environmental work in progress used (WPeu)	0.2	0.6	0.2						1.0									1.0
6.2 Environmental net operating margin (NOMeo)					28.3				28.3			17.8				76.2	94.0	122.3
7. Net value added ($NVAo_{sp}$) (TPc_{sp}–ICosp-WPeu-CFC)	-0.4	0.1	1.1	-0.1	32.3	1.7	8.3		43.0	24.0	3.6	17.9		3.6	3.1	76.2	128.3	171.3
8. Gross capital formation (GCF)	0.1	1.5	0.3			1.7			3.6	3.2	0.8	0.1		0.7	1.1		5.8	9.4
8.1 Manufactured (GCFm)						1.7			1.7	3.2	0.8	0.1		0.7	1.1		5.8	7.5
8.2 Natural growth (NG)	0.1	1.5	0.3						1.9									1.9
9. Manufactured intermediate consumption (ICmi)						0.6			0.6	1.0	0.2	0.0		0.2	0.4		1.8	2.5
9.1 Bought (ICmib)						0.6			0.6	1.0	0.2	0.0		0.2	0.4		1.8	2.5
9.2 Work in progress used (WPmui)																		
10. Labour cost (LCi)						1.1			1.1	2.2	0.5	0.0		0.5	0.7		4.0	5.1
11. Consumption of fixed capital (CFCi)																		
11.1 Consumption of fixed manufactured capital (CFCmi)																		
11.2 Consumption of fixed environmental asset (SSe)																		
12. Net operating margin (NOMi)	0.1	1.5	0.3						1.9	0.0							0.0	1.9
12.1 Manufactured (NOMmi)										0.0							0.0	0.0
12.2 Environmental (NOMei)	0.1	1.5	0.3						1.9									1.9
12.2.1 Natural growth (NG)	0.1	1.5	0.3						1.9									1.9
12.2.2 Less carbon emission (SSe)																		
13. Net value added (NVAi) (GCF-ICmi-CFCi)	0.1	1.5	0.3			1.1			3.0	2.2	0.5	0.0		0.5	0.7		4.0	7.0

Table S2. rSNA production account at basic prices for holm oak open woodlands in Andalusia (2010: €/ha).

Class	Timber	Cork	Fire-wood	Nuts	Grazing	Conserv. forestry	Residen-tial	Amenity	Farmer	Fire services	Recrea-tion	Mush-rooms	Carbon	Land-scape	Bio-diversity	Water	Govern-ment	Holm oak open woodlands
	1	2	3	4	5	6	7	8	∑1-8	9	10	11	12	13	14	15	∑9-15	∑1-15
1. Total product (TP_{sp})	0.4	2.2	1.8	0.1	33.9	4.5	14.7	14.7	72.2	41.3	8.9	18.0		77.0	6.3	76.2	227.8	300.0
1.1 Intermediate product (IP_{sp})					33.9	2.8	14.7		51.3	38.1							38.1	89.4
1.2 Final product (FP_{pp})	0.4	2.2	1.8	0.1		1.7		14.7	20.9	3.2	8.9	18.0		77.0	6.3	76.2	189.7	210.5
1.2.2 Final product consumption (FPc_{pp})	0.3	0.7	1.5	0.1				14.7	17.2		8.1	18.0		76.4	5.2	76.2	183.9	201.1
1.2.2 Gross capital formation (GCF)	0.1	1.5	0.3			1.7			3.6	3.2	0.8	0.1		0.7	1.1		5.8	9.4
1.2.2.1 Manufactured (GCFm)						1.7			1.7	3.2	0.8	0.1		0.7	1.1		5.8	7.5
1.2.2.2 Natural growth (NG)	0.1	1.5	0.3						1.9									1.9
2. Intermediate consumption (IC_{sp})	0.6	0.6	0.4	0.1	0.6	1.6	0.8	14.7	19.3	12.4	3.2	0.1		72.3	1.8		89.8	109.1
2.1 Manufactured intermediate consumption (ICm)	0.4	0.0	0.2	0.1	0.6	1.6	0.8	14.7	18.3	12.4	3.2	0.1		72.3	1.8		89.8	108.1
2.1.1 Bought (ICmb)	0.4	0.0	0.2	0.1	0.6	1.6	0.8		3.7	12.4	1.6	0.1		1.9	1.8		17.9	21.5
2.1.2 Own ($ICmo_{sp}$)								14.7	14.7		1.6			70.4	0.0		71.9	86.6
2.1.3 Manufactured work in progress used (WPmu)																		
2.2 Environmental intermediate consumption (ICe)	0.2	0.6	0.2						1.0									1.0
2.2.1 Environmental work in progress used (WPeu)	0.2	0.6	0.2						1.0									1.0
3. Consumption of fixed capital (CFC)	0.0		0.0	0.0	1.1	0.1	5.6		6.8	2.8	1.6	0.0		0.7	0.6		5.7	12.6
4. Net value added (NVA_{sp}) (TP_{sp}-IC_{sp}-CFC)	-0.2	1.6	1.4	-0.1	32.3	2.9	8.3		46.0	26.2	4.1	17.9		4.0	3.8	76.2	132.3	178.3
4.1. Labour cost (LC)	2.5	0.1	0.3	0.9	3.4	2.8	3.1		13.1	26.1	4.1	0.1		4.0	3.8		38.2	51.3
4.2. Net operating margin (NOM_{sp})	-2.7	1.5	1.1	-0.9	28.9	0.0	5.1		32.9	0.0		17.8		0.0		76.2	94.1	127.0
4.2.1 Manufactured net operating margin ($NOMm_{sp}$)	-2.9	0.0	0.8	-0.9	0.6	0.0	5.1		2.7	0.0		0.0		0.0			0.1	2.8
4.2..2 Environmental net operating margin (NOMe)	0.1	1.5	0.3		28.3				30.2			17.8				76.2	94.0	124.2

Table S3. Tiles with predominant holm oak open woodlands in Andalusia

Class	Surfaces	
	Hectares	Percentage
Without secondary species	750,632	53.3
Quercus suber	225,271	16.0
Without tertiary species	179,301	12.7
With tertiary species	45,970	3.3
Quercus faginea	81,511	5.8
Without tertiary species	49,858	3.5
With tertiary species	31,652	2.2
Quercus cannariensis	743	0.1
Without tertiary species	547	0.0(*)
With tertiary species	196	0.0(*)
Olea europaea	113,378	8.1
Without tertiary species	89,504	6.4
With tertiary species	23,874	1.7
Pinus halepensis	37,176	2.6
Without tertiary species	23,731	1.7
With tertiary species	13,445	1.0
Pinus pinea	25,174	1.8
Without tertiary species	14,938	1.1
With tertiary species	10,236	0.7
Pinus pinaster	16,768	1.2
Without tertiary species	7,374	0.5
With tertiary species	9,394	0.7
Pinus nigra	16,298	1.2
Without tertiary species	11,206	0.8
With tertiary species	5,092	0.4
Pinus sylvestris	3,276	0.2
Without tertiary species	1,057	0.1
With tertiary species	2,219	0.2
Juniperus oxycedrus	32,880	2.3
Without tertiary species	23,228	1.6
With tertiary species	9,652	0.7
Arbutus unedo	26,051	1.8
Without tertiary species	15,367	1.1
With tertiary species	10,684	0.8
Castanea sativa	1,568	0.1
Without tertiary species	795	0.1
With tertiary species	772	0.1
Others	77,444	5.5
Total	1,408,170	100

(*) This value is lower than 0.05

Table S4. Tiles with predominant holm oak open woodlands sizes caracteristic in Andalusia

Class	Surfaces		Statistics			
	Hectares	Percentage	Number of tiles	Minimum	Maximum	Average
Holm oak without other species	750,632	53.3	11,697	0.0(*)	603.3	64.2
Holm oak with secondary species and without tertiary	460,892	32.7	7,381	0.0(*)	730.3	62.5
Holm oak with secondary and tertiary species	196,645	14.0	3,203	0.0(*)	607.3	61.5
Total holm oak open woodlands	1,408,170	100.0	22,281	0.0	730.3	63.2

(*) This value is lower than 0.05

Table S5. Total labor demand for holm oak open woodlands in Andalusia (2010)

Class	Quantity h/ha	Wage rate €/h	Labour cost €/ha
1. Landowner	1.4	9.7	13.1
1.1 Timber	0.3	8.5	2.5
1.2 Cork	0.0(*)	9.8	0.1
1.3 Firewood	0.0(*)	9.8	0.3
1.4 Nuts	0.1	8.7	0.9
1.5 Grazing	0.3	9.7	3.4
1.6 Conservation forestry	0.1	21.1	2.8
1.7 Residential	0.4	7.1	3.1
2. Government	1.8	21.3	38.2
2.1 Fire services	1.2	21.1	26.1
2.2 Recreation	0.2	22.7	4.1
2.3 Mushrooms	0.0(*)	21.5	0.1
2.4 Landscape	0.2	21.3	4.0
2.5 Biodiversity	0.2	21.2	3.8
Total (1+2)	3.2	16.3	51.3

(*) This value is lower than 0.05

Table S6. AAS production account at social prices for holm oak open woodlands in Andalusia (2010: €/ha).

Class	Timber	Cork	Fire-wood	Nuts	Grazing	Conservation forestry	Residen-tial	Amenity	Farmer	Fire services	Recrea-tion	Mush-rooms	Carbon	Land-scape	Bio-diversity	Water	Government	Holm oak open woodlands
	1	2	3	4	5	6	7	8	∑1-8	9	10	11	12	13	14	15	∑9-15	∑1-15
1. Total product (TP)	0.4	2.2	1.8	0.1	33.9	4.5	14.7	342.7	400.2	41.3	31.8	18.0	41.8	110.8	12.2	89.7	345.7	745.9
1.1 Intermediate product (IP)					33.9	2.8	14.7		51.3	38.1							38.1	89.4
1.1.1 Raw materials (IRM)					33.9				33.9									33.9
1.1.1.1 Grass and browse (IRMgg)					18.8				18.8									18.8
1.1.1.2 Acorn (IRMga)					6.9				6.9									6.9
1.1.1.3 Game grazing (IRMgh)					8.2				8.2									8.2
1.1.2 Services (ISS)						2.8	14.7		17.4	38.1							38.1	55.6
1.1.2.1 Commercial (ISSc)						2.8	14.7		17.4	38.1							38.1	55.6
1.1.2.2 Non-commercial (ISSnc)																		
1.2 Final product (FP)	0.4	2.2	1.8	0.1		1.7		342.7	348.9	3.2	31.8	18.0	41.8	110.8	12.2	89.7	307.5	656.5
1.2.1 Final product cosumed (FPc)	0.3	0.7	1.5	0.1				342.7	345.3		31.0	18.0	41.8	110.2	11.2	89.7	301.7	647.0
1.2.1.1 Sales (FPs)	0.3	0.7	1.2	0.1					2.3									2.3
1.2.1.2 Autoconsumption (FPa)			0.3					342.7	343.0									343.0
1.2.1.3 Other final product (FPo)																		
1.2.1.4 Public goods and services (PGS)											31.0	18.0	41.8	110.2	11.2	89.7	301.7	301.7
1.2.2 Gross capital formation (GCF)	0.1	1.5	0.3			1.7			3.6	3.2	0.8	0.1		0.7	1.1		5.8	9.4
1.2.2.1 Gross capital formation manu. (GCFm)						1.7			1.7	3.2	0.8	0.1		0.7	1.1		5.8	7.5
1.2.2.1.1 Gross fixed capital formation manu. (GFCFm)						1.7			1.7	3.2	0.8	0.1		0.7	1.1		5.8	7.5
1.2.2.1.1.1 Plantations (GFCFmp)						1.7			1.7	0.0							0.0	1.7
1.2.2.1.1.2 Construction (GFCFmc)										2.7	0.6	0.1		0.0	0.8		4.1	4.1
1.2.2.1.1.3 Others (GFCFmo)										0.5	0.2	0.0		0.6	0.3		1.7	1.7
1.2.2.2 Natural growth (NG)	0.1	1.5	0.3						1.9									1.9
1.2.2.2.2 Gross work in progress formation (GWPFe)	0.1	1.5	0.3						1.9									1.9
1.2.2.2.2.1Environmental woody natural growth (GWPFew)	0.1	1.5	0.3						1.9									1.9
2. Total cost (TC)	3.2	0.7	0.8	1.0	5.0	4.5	9.5	137.9	162.6	41.3	8.9	0.2	13.2	79.1	6.3		149.1	311.6
2.1 Intermediate consumption (IC)	0.6	0.6	0.4	0.1	0.6	1.6	0.8	137.9	142.6	12.4	3.2	0.1		74.4	1.8		91.9	234.5
2.1.1 Raw materials (RM)	0.0	0.0	0.2	0.0	0.2	0.0	0.2		0.6	0.1	0.1	0.0		0.0	0.0		0.2	0.8
2.1.1.1 Bought raw materials (RMb)	0.0	0.0	0.2	0.0	0.2	0.0	0.2		0.6	0.1	0.1	0.0		0.0	0.0		0.2	0.8
2.1.1.2 Own raw materials (RMo)																		
2.1.2 Services (SS)	0.4	0.0	0.1	0.1	0.3	1.6	0.6	137.9	141.0	12.3	3.1	0.1		74.3	1.8		91.7	232.7
2.1.2.1 Bought services (SSb)	0.4	0.0	0.1	0.1	0.3	1.6	0.6		3.1	12.3	1.6	0.1		1.9	1.8		17.6	20.7
2.1.2.2 Own services (SSo)								137.9	137.9		1.6			72.5	0.0		74.0	211.9
2.1.3 Environmental work in progress used (WPue)	0.2	0.6	0.2						1.0									1.0
2.1.3.1 Timber harvested (WPuet)	0.2								0.2									0.2
2.1.3.2 Cork stripping (WPuec)		0.6							0.6									0.6
2.1.3.3 Firewood pruning (WPuef)			0.2						0.2									0.2
2.2 Labor cost (LC)	2.5	0.1	0.3	0.9	3.4	2.8	3.1		13.1	26.1	4.1	0.1		4.0	3.8		38.2	51.3
2.3 Consumption of fixed capital (CFC)	0.0		0.0	0.0	1.1	0.1	5.6		6.8	2.8	1.6	0.0	13.2	0.7	0.6		19.0	25.8
2.3.1 Plantations (CFCp)	0.0					0.1			0.1									0.1
2.3.2 Constructions (CFCc)	0.0			0.0	1.0		5.6		6.6	1.4	1.3	0.0		0.2	0.2		3.1	9.7
2.3.3 Equipments (CFCeq)	0.0		0.0	0.0	0.1		0.0		0.1	0.2	0.0	0.0		0.0	0.0		0.3	0.5
2.3.4 External environmental (CFCe)													13.2				13.2	13.2
2.3.9 Others (CFCo)										1.1	0.2	0.0		0.5	0.4		2.3	2.3
3. Net operating margin (NOM = TP - TC)	-2.7	1.5	1.1	-0.9	28.9	0.0	5.1	204.8	237.7	0.0	22.9	17.8	28.6	31.7	5.9	89.7	196.6	434.3
3.1. Environmental net operating margin (NOMe)	0.1	1.5	0.3		28.3			204.8	235.0		21.6	17.8	28.6	31.5	5.8	89.7	194.9	429.9
3.1.1.Ordinary net operating margin (NOMeo)					28.3			204.8	233.1		21.6	17.8	41.8	31.5	5.8	89.7	208.1	441.2
3.1.2. Investment net operating margin (NOMei)	0.1	1.5	0.3						1.9				-13.2				-13.2	-11.3
3.2. Manufactured net operating margin (NOMm)	-2.9	0.0	0.8	-0.9	0.6	0.0	5.1		2.7	0.0	1.3	0.0		0.2	0.2		1.7	4.4
4. Net value added (NVA = LC + NOM)	-0.2	1.6	1.4	-0.1	32.3	2.9	8.3	204.8	250.8	26.2	27.0	17.9	28.6	35.7	9.8	89.7	234.8	485.6
5. Ordinary total cost (TCo)	3.2	0.7	0.8	1.0	5.0	2.8	9.5	137.9	160.8	38.1	8.1	0.1		78.5	5.2		130.0	290.9
6. Investment total cost (TCi)						1.7			1.7	3.2	0.8	0.1	13.2	0.7	1.1		19.0	20.8

Table S7. AAS ordinary and investment production accounts at social prices for holm oak open woodlands in Andalusia (2010: €/ha).

Class	Timber 1	Cork 2	Fire-wood 3	Nuts 4	Grazing 5	Conserv. forestry 6	Residen-tial 7	Amenity 8	Farmer ∑1-8	Fire services 9	Recrea-tion 10	Mush-rooms 11	Carbon 12	Land-scape 13	Bio-diversity 14	Water 15	Govern-ment ∑9-15	Holm oak open woodlands ∑1-15
1. Total product consumption (TPc_{sp})	0.3	0.7	1.5	0.1	33.9	2.8	14.7	342.7	396.6	38.1	31.0	18.0	41.8	110.2	11.2	89.7	339.9	736.5
1.1 Intermediate product (IP_{sp})					33.9	2.8	14.7		51.3	38.1							38.1	89.4
1.2 Final product consumption (FPc_{pp})	0.3	0.7	1.5	0.1				342.7	345.3		31.0	18.0	41.8	110.2	11.2	89.7	301.7	647.0
2. Intermediate consumption (ICo_{sp})	0.4	0.0	0.2	0.1	0.6	1.0	0.8	137.9	141.0	11.4	3.0	0.0		74.2	1.5		90.0	231.0
2.1 Bought (ICmob)	0.4	0.0	0.2	0.1	0.6	1.0	0.8		3.1	11.4	1.4	0.0		1.7	1.5		16.0	19.1
2.2 Own ($ICmo_{sp}$)								137.9	137.9		1.6			72.5	0.0		74.0	211.9
2.3 Manufactured work in progress used (WPmuo)																		
3. Labour cost (LCo)	2.5	0.1	0.3	0.9	3.4	1.7	3.1		12.0	23.9	3.6	0.1		3.6	3.1		34.2	46.3
4. Consumption of fixed capital (CFCmo)	0.0		0.0	0.0	1.1	0.1	5.6		6.8	2.8	1.6	0.0		0.7	0.6		5.7	12.6
5. Manufactured net operating margin ($NOMmo_{sp}$)	-2.9	0.0	0.8	-0.9	0.6	0.0	5.1		2.7	0.0	1.3	0.0		0.2	0.2		1.7	4.4
6. Ecosystem services (ES_{sp})	0.2	0.6	0.2		28.3			204.8	234.1		21.6	17.8	41.8	31.5	5.8	89.7	208.1	442.2
6.1 Environmental work in progress used (WPeu)	0.2	0.6	0.2						1.0									1.0
6.2 Environmental net operating margin (NOMeo)					28.3			204.8	233.1		21.6	17.8	41.8	31.5	5.8	89.7	208.1	441.2
7. Net value added ($NVAo_{sp}$) (TPc_{sp}–ICosp-WPeu-CFC)	-0.4	0.1	1.1	-0.1	32.3	1.7	8.3	204.8	247.8	24.0	26.4	17.9	41.8	35.2	9.0	89.7	244.1	491.9
8. Gross capital formation (GCF)	0.1	1.5	0.3			1.7			3.6	3.2	0.8	0.1		0.7	1.1		5.8	9.4
8.1 Manufactured (GCFm)						1.7			1.7	3.2	0.8	0.1		0.7	1.1		5.8	7.5
8.2 Natural growth (NG)	0.1	1.5	0.3						1.9									1.9
9. Manufactured intermediate consumption (ICmi)						0.6			0.6	1.0	0.2	0.0		0.2	0.4		1.8	2.5
9.1 Bought (ICmib)						0.6			0.6	1.0	0.2	0.0		0.2	0.4		1.8	2.5
9.2 Work in progress used (WPmui)																		
10. Labour cost (LCi)						1.1			1.1	2.2	0.5	0.0		0.5	0.7		4.0	5.1
11. Consumption of fixed capital (CFCi)													13.2				13.2	13.2
11.1 Consumption of fixed manufactured capital (CFCmi)																		
11.2 Consumption of fixed environmental asset (SSe)													13.2				13.2	13.2
12. Net operating margin (NOMi)	0.1	1.5	0.3			0.0			1.9	0.0		0.0	-13.2	0.0	0.0		-13.2	-11.3
12.1 Manufactured (NOMmi)						0.0			0.0	0.0		0.0		0.0	0.0		0.0	0.0
12.2 Environmental (NOMei)	0.1	1.5	0.3						1.9				-13.2				-13.2	-11.3
12.2.1 Natural growth (NG)	0.1	1.5	0.3						1.9									1.9
12.2.2 Less carbon emission (SSe)													13.2				13.2	13.2
13. Net value added (NVAi) (GCF-ICmi-CFCi)	0.1	1.5	0.3			1.1			3.0	2.2	0.5	0.0	-13.2	0.5	0.7		-9.3	-6.3

Table S8. AAS balance account for holm oak open woodlands in Andalusia (2010: €/ha).

Class	1. Opening capital (Co)	2. Capital entries: 2.1 Bought (Ceb)	2.2 Own (Ceo)	2.3 Others (Ceot)	2.4 Total (Ce)	3. Capital withdrawals: 3.1 Used (Cwu)	3.2 Sales (Cws)	3.2 Destructions (Cwd)	3.3.Recla-sifications (Cwrc)	3.4 Others (Cwo)	3.5 Total (Cw)	4. Revaluation (Cr)	5. Closing capital (Cc)
1. Capital (C=WP+FC)	9,962.8	0.4	9.4	41.8	51.7	1.0			42.4	13.2	56.7	-171.0	9,786.8
2. Work in progress (WP)	40.7		1.9		1.9	1.0			1.9		2.9	3.0	42.8
Timber (WPt)	7.5		0.1		0.1	0.2			0.1		0.3	0.6	7.9
Cork (WPc)	7.3		1.5		1.5	0.6			1.4		2.0	0.9	7.7
Firewood (WPf)	25.9		0.3		0.3	0.2			0.3		0.5	1.5	27.1
3. Fixed capital (FC)	9,922.1	0.4	7.5	41.8	49.7	0.0			40.6	13.2	53.8	-174.0	9,744.0
3.1 Land (FCl)	9,185.3			41.8	41.8				40.6	13.2	53.8	-147.3	9,026.0
Timber (FClt)	*2.8*											*0.1*	*2.9*
Cork (FClc)	*0.9*											*0.0*	*0.9*
Firewood (FClf)	*88.5*											*2.7*	*91.2*
Nuts (FCln)	*0.2*											*0.0*	*0.2*
Grass and browse(FClg)	*727.7*												*727.7*
Acorns (FCla)	*41.8*											*1.3*	*43.1*
Game grazing (FClh)	*249.3*												*249.3*
Amenity (FClea)	*3,521.6*											*-165.1*	*3,356.6*
Recreation (FCler)	*892.9*												*892.9*
Mushrooms (FClem)	*591.0*												*591.0*
Carbon (FClec)	*346.5*			*41.8*	*41.8*				*40.6*	*13.2*	*53.8*	*13.8*	*348.3*
Landscape (FClel)	*1,056.1*												*1,056.1*
Biodiversity (FCleb)	*198.0*												*198.0*
Water (FClew)	*1,467.9*												*1,467.9*
3.2 Biological resources (FCbr)	158.6											7.6	166.3
Timber (FCbrt)	0.0											0.0	0.0
Cork (FCbrc)	29.9											1.8	31.7
Firewood (FCbrf)	96.4											5.1	101.5
Nuts (FCbrn)	0.1											0.0	0.1
Acorns (FCbra)	32.2											0.7	32.9
3.3 Plantations (FCp)	10.2		1.7		1.7							-0.2	11.8
3.4 Infrastructure (FCco)	550.8		4.1		4.1							-32.6	522.3
3.5 Equipments (FCe)	2.8	0.4			0.4			0.0			0.0	-0.1	3.1
3.9 Others (FCo)	14.4		1.7		1.7							-1.4	14.6

Table S9. AAS produced and expected work in progress balance account for holm oak open woodland in Andalusia (2010: €/ha).

Class	1. Opening capital (Co)	2. Capital entries: 2.1 Bought (Ceb)	2.2 Own (Ceo)	2.3 Others (Ceot)	2.4 Total (Ce)	3. Capital withdrawals: 3.1 Used (Cwu)	3.2 Sales (Cws)	3.2 Destructions (Cwd)	3.3.Recla-sifications (Cwrc)	3.4 Others (Cwo)	3.5 Total (Cw)	4. Revaluation (Cr)	5. Closing capital (Cc)
1. Work in progress (WP)	40.7		1.9		1.9	1.0			1.9		2.9	3.0	42.8
Timber (WPt)	7.5		0.1		0.1	0.2			0.1		0.3	0.6	7.9
Cork (WPc)	7.3		1.5		1.5	0.6			1.4		2.0	0.9	7.7
Firewood (WPf)	25.9		0.3		0.3	0.2			0.3		0.5	1.5	27.1
1.1 Produced (WPp)	27.4		1.9		1.9	1.0					1.0	0.3	28.6
Timber (WPt)	3.5		0.1		0.1	0.2					0.2	0.3	3.7
Cork (WPc)	3.7		1.5		1.5	0.6					0.6	-0.7	3.9
Firewood (WPf)	20.2		0.3		0.3	0.2					0.2	0.8	21.1
1.2 Expected (WPe)	13.3								1.9		1.9	2.7	14.1
Timber (WPt)	4.0								0.1		0.1	0.4	4.2
Cork (WPc)	3.6								1.4		1.4	1.6	3.8
Firewood (WPf)	5.7								0.3		0.3	0.7	6.1

Table S10. AAS simplified accounts sequence of total income at social prices for holm oak open woodlands in Andalusia (2010: €/ha).

Class	Timber 1	Cork 2	Fire-wood 3	Nuts 4	Gra-zing 5	Conserv. forestry 6	Residen-tial 7	Amenity 8	Farmer ∑1-8	Fire services 9	Recrea-tion 10	Mush-rooms 11	Carbon 12	Land-scape 13	Bio-diversity 14	Water 15	Govern-ment ∑9-15	Holm oak open woodlands ∑1-15
1. Total product (TP_{sp})	0.4	2.2	1.8	0.1	33.9	4.5	14.7	342.7	400.2	41.3	31.8	18.0	41.8	110.8	12.2	89.7	345.7	745.9
2 Manufactured intermediate consumption (ICm_{sp})	0.4	0.0	0.2	0.1	0.6	1.6	0.8	137.9	141.6	12.4	3.2	0.1		74.4	1.8		91.9	233.5
2.1 Bought (ICb)	0.4	0.0	0.2	0.1	0.6	1.6	0.8		3.7	12.4	1.6	0.1		1.9	1.8		17.9	21.5
2.2 Own (ICo_{sp})								137.9	137.9		1.6			72.5	0.0		74.0	211.9
2.3 Manufactured work in progress used (WPmu)																		
3. Labour cost (LC)	2.5	0.1	0.3	0.9	3.4	2.8	3.1		13.1	26.1	4.1	0.1		4.0	3.8		38.2	51.3
4. Consumption of fixed capital (CFC)	0.0		0.0	0.0	1.1	0.1	5.6		6.8	2.8	1.6	0.0	13.2	0.7	0.6		19.0	25.8
5. Ordinary manufactured net operating margin ($NOMmo_{sp}$)	-2.9	0.0	0.8	-0.9	0.6	0.0	5.1		2.7	0.0	1.3	0.0		0.2	0.2		1.7	4.4
6. Investment environmental net operating margin (NOMei)	0.1	1.5	0.3			0.0			1.9	0.0		0.0	-13.2	0.0	0.0		-13.2	-11.3
7. Ecosystem services (ES_{sp})	0.2	0.6	0.2		28.3			204.8	234.1		21.6	17.8	41.8	31.5	5.8	89.7	208.1	442.2
7.1 Environmental work in progress used (WPue)	0.2	0.6	0.2						1.0									1.0
7.2 Ordinary environmental net operating margin (NOMeo)					28.3			204.8	233.1		21.6	17.8	41.8	31.5	5.8	89.7	208.1	441.2
8. Net value added (NVA_{sp}) (TP_{sp} – ICm_{sp} - WPue CFC)	-0.2	1.6	1.4	-0.1	32.3	2.9	8.3	204.8	250.8	26.2	27.0	17.9	28.6	35.7	9.8	89.7	234.8	485.6
8.1 Labour cost (LC)	2.5	0.1	0.3	0.9	3.4	2.8	3.1		13.1	26.1	4.1	0.1		4.0	3.8		38.2	51.3
8.2 Net operating margin (NOM_{sp})	-2.7	1.5	1.1	-0.9	28.9	0.0	5.1	204.8	237.7	0.0	22.9	17.8	28.6	31.7	5.9	89.7	196.6	434.3
8.2.1 Manufactured net operating margin ($NOMm_{sp}$)	-2.9	0.0	0.8	-0.9	0.6	0.0	5.1		2.7	0.0	1.3	0.0		0.2	0.2		1.7	4.4
8.2.2 Environmental net operating margin ($NOMe_{sp}$)	0.1	1.5	0.3		28.3			204.8	235.0		21.6	17.8	28.6	31.5	5.8	89.7	194.9	429.9
9. Capital gain (CG)	0.7	1.3	8.9	0.0	2.4	-0.1	-21.2	-165.1	-173.1	-1.4	0.2	-0.1	-26.8	0.4	0.0		-27.7	-200.8
9.1 Manufactured (CGm)	0.0	0.0	0.0	0.0	0.4	-0.1	-21.2		-20.9	-1.4	0.2	-0.1		0.4	0.0		-0.9	-21.7
9.2 Environmental (EAg)	0.6	1.3	8.9	0.0	2.0			-165.1	-152.2				-26.8				-26.8	-179.1
9.2.1 Environmental asset revaluation (EAr)	0.7	2.7	9.3	0.0	2.0			-165.1	-150.4				13.8				13.8	-136.6
9.2.2 Environmental asset adjusted for growth and carbon (EAad)	-0.1	-1.4	-0.3		0.0				-1.9				-40.6				-40.6	-42.4
10. Total income (TI_{sp})	0.4	2.8	10.3	-0.1	34.7	2.7	-13.0	39.7	77.7	24.7	27.2	17.9	1.7	36.1	9.8	89.7	207.1	284.8
10.1 Compensation of employees (LC)	2.5	0.1	0.3	0.9	3.4	2.8	3.1		13.1	26.1	4.1	0.1		4.0	3.8		38.2	51.3
10. 2 Capital income (CI_{sp})	-2.1	2.7	10.0	-0.9	31.3	-0.1	-16.1	39.7	64.6	-1.4	23.1	17.8	1.7	32.1	5.9	89.7	168.9	233.5
10.2.1 Manufactured capital income (CIm)	-2.8	0.0	0.8	-0.9	1.0	-0.1	-16.1		-18.2	-1.4	1.5	0.0		0.6	0.2		0.8	-17.3
10.2.2 Environmental income (EI_{sp})	0.7	2.8	9.3	0.0	30.2			39.7	82.7		21.6	17.8	1.7	31.5	5.8	89.7	168.1	250.8
10.2.2.1 Ecosystem services (ES_{sp})	0.2	0.6	0.2		28.3			204.8	234.1		21.6	17.8	41.8	31.5	5.8	89.7	208.1	442.2
10.2.2.2 Change in net worth adjusted for WPeu (CNWead)	0.5	2.2	9.0	0.0	2.0			-165.1	-151.3				-40.1				-40.1	-191.4
10.2.2.2.1 Change of environmental net worth (CNWe)	0.7	2.8	9.3	0.0	2.0			-165.1	-150.3				-40.1				-40.1	-190.4
10.2.2.2.1.1 Investment environmental net operating margin (NOMei)	0.1	1.5	0.3						1.9				-13.2				-13.2	-11.3
10.2.2.2.1.2 Environmental asset gain (EAg)	0.6	1.3	8.9	0.0	2.0			-165.1	-152.2				-26.8				-26.8	-179.1
10.2.2.2.2 Less WPeu	0.2	0.6	0.2						1.0									1.0

Table S11. rSNA simplified accounts sequence of total income at basic prices for holm oak open woodlands in Andalusia (2010: €/ha).

Class	Timber 1	Cork 2	Fire-wood 3	Nuts 4	Gra-zing 5	Conserv. forestry 6	Residen-tial 7	Amenity 8	Farmer ∑1-8	Fire services 9	Recrea-tion 10	Mush-rooms 11	Carbon 12	Land-scape 13	Bio-diversity 14	Water 15	Govern-ment ∑9-15	Holm oak open woodlands ∑1-15
1. Total product (TP_{sp})	0.4	2.2	1.8	0.1	33.9	4.5	14.7	14.7	72.2	41.3	8.9	18.0		77.0	6.3	76.2	227.8	300.0
2 Manufactured intermediate consumption (ICm_{sp})	0.4	0.0	0.2	0.1	0.6	1.6	0.8	14.7	18.3	12.4	3.2	0.1		72.3	1.8		89.8	108.1
2.1 Bought (ICb)	0.4	0.0	0.2	0.1	0.6	1.6	0.8		3.7	12.4	1.6	0.1		1.9	1.8		17.9	21.5
2.2 Own (ICo_{sp})								14.7	14.7		1.6			70.4	0.0		71.9	86.6
2.3 Manufactured work in progress used (WPmu)																		
3. Labour cost (LC)	2.5	0.1	0.3	0.9	3.4	2.8	3.1		13.1	26.1	4.1	0.1		4.0	3.8		38.2	51.3
4. Consumption of fixed capital (CFC)	0.0		0.0	0.0	1.1	0.1	5.6		6.8	2.8	1.6	0.0		0.7	0.6		5.7	12.6
5. Ordinary manufactured net operating margin ($NOMmo_{sp}$)	-2.9	0.0	0.8	-0.9	0.6	0.0	5.1		2.7	0.0		0.0		0.0			0.1	2.8
6. Investment environmental net operating margin (NOMei)										0.0							0.0	0.0
7. Ecosystem services (ES_{sp})	0.2	0.6	0.2		28.3				29.3			17.8				76.2	94.0	123.3
7.1 Environmental work in progress used (WPue)	0.2	0.6	0.2						1.0									1.0
7.2 Ordinary environmental net operating margin (NOMeo)					28.3				28.3			17.8				76.2	94.0	122.3
8. Net value added (NVA_{sp}) (TP_{sp} – ICm_{sp} - WPue CFC)	-0.2	1.6	1.4	-0.1	32.3	2.9	8.3		46.0	26.2	4.1	17.9		4.0	3.8	76.2	132.3	178.3
8.1 Labour cost (LC)	2.5	0.1	0.3	0.9	3.4	2.8	3.1		13.1	26.1	4.1	0.1		4.0	3.8		38.2	51.3
8.2 Net operating margin (NOM_{sp})	-2.7	1.5	1.1	-0.9	28.9	0.0	5.1		32.9	0.0		17.8		0.0		76.2	94.1	127.0
8.2.1 Manufactured net operating margin ($NOMm_{sp}$)	-2.9	0.0	0.8	-0.9	0.6	0.0	5.1		2.7	0.0		0.0		0.0			0.1	2.8
8.2.2 Environmental net operating margin ($NOMe_{sp}$)	0.1	1.5	0.3		28.3				30.2			17.8				76.2	94.0	124.2
9. Capital gain (CG)	0.7	1.3	8.9	0.0	2.4	-0.1	-21.2	-165.1	-173.1	-1.4	0.2	-0.1		0.4	0.0		-0.9	-174.0
9.1 Manufactured (CGm)	0.0	0.0	0.0	0.0	0.4	-0.1	-21.2		-20.9	-1.4	0.2	-0.1		0.4	0.0		-0.9	-21.7
9.2 Environmental (EAg)	0.6	1.3	8.9	0.0	2.0			-165.1	-152.2									-152.2
9.2.1 Environmental asset revaluation (EAr)	0.7	2.7	9.3	0.0	2.0			-165.1	-150.4									-150.4
9.2.2 Environmental asset adjusted for growth and carbon (EAad)	-0.1	-1.4	-0.3		0.0				-1.9									-1.9
10. Total income (TI_{sp})	0.4	2.8	10.3	-0.1	34.7	2.7	-13.0	-165.1	-127.1	24.7	4.3	17.9		4.4	3.8	76.2	131.4	4.3
10.1 Compensation of employees (LC)	2.5	0.1	0.3	0.9	3.4	2.8	3.1		13.1	26.1	4.1	0.1		4.0	3.8		38.2	51.3
10. 2 Capital income (CI_{sp})	-2.1	2.7	10.0	-0.9	31.3	-0.1	-16.1	-165.1	-140.2	-1.4	0.2	17.8		0.4	0.0	76.2	93.2	-47.0
10.2.1 Manufactured capital income (CIm)	-2.8	0.0	0.8	-0.9	1.0	-0.1	-16.1		-18.2	-1.4	0.2	0.0		0.4	0.0		-0.8	-19.0
10.2.2 Environmental income (EI_{sp})	0.7	2.8	9.3	0.0	30.2			-165.1	-122.0			17.8				76.2	94.0	-28.0
10.2.2.1 Ecosystem services (ES_{sp})	0.2	0.6	0.2		28.3				29.3			17.8				76.2	94.0	123.3
10.2.2.2 Change in net worth adjusted for WPeu (CNWead)	0.5	2.2	9.0	0.0	2.0			-165.1	-151.3									-151.3
10.2.2.2.1 Change of environmental net worth (CNWe)	0.7	2.8	9.3	0.0	2.0			-165.1	-150.3									-150.3
10.2.2.2.1.1 Investment environmental net operating margin (NOMei)	0.1	1.5	0.3						1.9									1.9
10.2.2.2.1.2 Environmental asset gain (EAg)	0.6	1.3	8.9	0.0	2.0			-165.1	-152.2									-152.2
10.2.2.2.2 Less WPeu	0.2	0.6	0.2						1.0									1.0

Table S12. AAS and rSNA measurements at producer, basic and social prices of ecosystems services and incomes for holm oak open woodlands in Andalusia (2010: €/ha).

Class	Timber	Cork	Fire-wood	Nuts	Gra-zing	Conserv. forestry	Residen-tial	Amenity	Farmer	Fire services	Recrea-tion	Mush-rooms	Carbon	Land-scape	Bio-diversity	Water	Government	Holm oak open woodlands
	1	2	3	4	5	6	7	8	∑1-8	9	10	11	12	13	14	15	∑9-15	∑1-15
Agroforestry Accounting System																		
AAS *at social prices*																		
Ecosystem services (ES_{sp})	0.2	0.6	0.2		28.3			204.8	234.1		21.6	17.8	41.8	31.5	5.8	89.7	208.1	442.2
Gross value added (GVA_{sp})	-0.2	1.6	1.4	-0.1	33.3	2.9	13.9	204.8	257.6	28.9	28.6	18.0	41.8	36.4	10.4	89.7	253.8	511.4
Gross operating margin (GOM_{sp})	-2.7	1.5	1.1	-0.9	30.0	0.1	10.7	204.8	244.5	2.8	24.5	17.9	41.8	32.4	6.6	89.7	215.6	460.1
Environmental income (EI_{sp})	0.7	2.8	9.3	0.0	30.2			39.7	82.7		21.6	17.8	1.7	31.5	5.8	89.7	168.1	250.8
AAS *at basic prices*																		
Ecosystem services (ES_{bp})	0.2	0.6	0.2		28.3			328.1	357.3		21.6	17.8	41.8	31.5	5.8	89.7	208.1	565.5
Gross value added (GVA_{bp})	-0.2	1.6	1.4	-0.1	33.3	2.9	13.9	328.1	380.9	28.9	28.6	18.0	41.8	38.5	10.4	89.7	255.9	636.8
Environmental income (EI_{bp})	0.7	2.8	9.3	0.0	30.2			163.0	206.0		21.6	17.8	1.7	31.5	5.8	89.7	168.1	374.1
AAS at *producer prices*																		
Ecosystem services (ES_{pp})	0.2	0.6	0.2		28.3			328.1	357.3		21.6	17.8	41.8	31.5	5.8	89.7	208.1	565.5
Gross value added (GVA_{pp})	-0.2	1.6	1.4	-0.1	33.3	2.9	13.9	328.1	380.9	28.9	28.6	18.0	41.8	69.6	10.4	89.7	286.9	667.8
Environmental income (EI_{pp})	0.7	2.8	9.3	0.0	30.2			163.0	206.0		21.6	17.8	1.7	31.5	5.8	89.7	168.1	374.1
Refined System of National Accounts																		
rSNA at basic prices																		
Ecosystem services (ES_{bp})	0.2	0.6	0.2		28.3				29.3			17.8				76.2	94.0	123.3
Gross value added (GVA_{bp})	-0.2	1.6	1.4	-0.1	33.3	2.9	13.9		52.8	28.9	5.7	18.0		4.8	4.5	76.2	138.0	190.9
Gross operating margin (GOM_{bp})	-2.7	1.5	1.1	-0.9	30.0	0.1	10.7		39.7	2.8	1.6	17.9		0.7	0.6	76.2	99.8	139.6
Environmental income (EI_{bp})	0.7	2.8	9.3	0.0	30.2			-165.1	-122.0			17.8				76.2	94.0	-28.0
rSNA at producer prices																		
Ecosystem services (ES_{pp})	0.2	0.6	0.2		28.3				29.3			17.8				76.2	94.0	123.3
Gross value added (GVA_{pp})	-0.2	1.6	1.4	-0.1	33.3	2.9	13.9		52.8	28.9	5.7	18.0		4.8	4.5	76.2	138.0	190.9
Environmental income (EI_{pp})	0.7	2.8	9.3	0.0	30.2			-165.1	-122.0			17.8				76.2	94.0	-28.0

Supplementary figures for

Agroforestry Accounting System for measuring environmental incomes at social prices: application to holm oak open woodlands in Andalusia-Spain

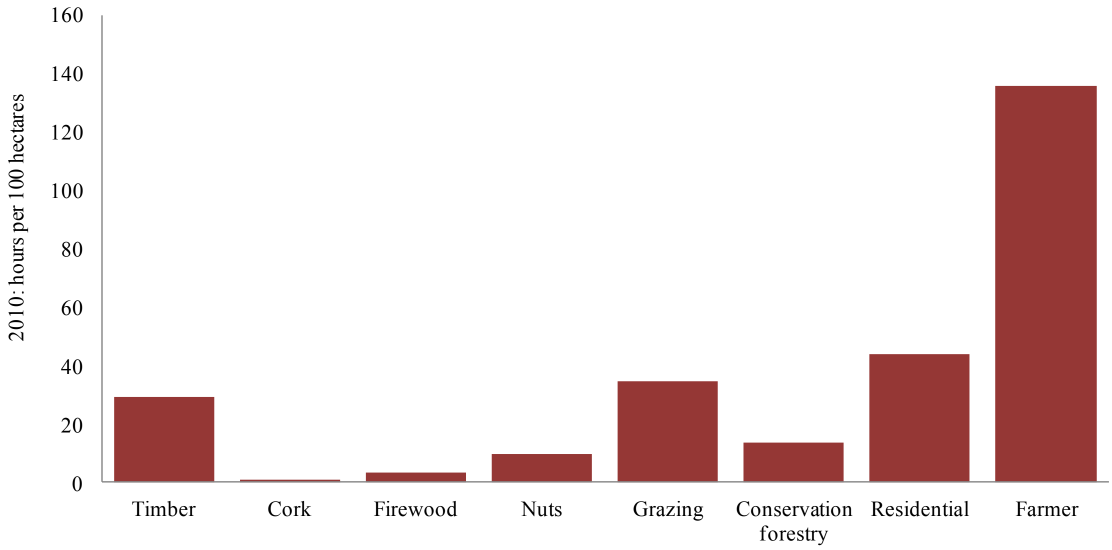

Figure S1. Farmer labor demand for holm oak open woodlands in Andalusia, Spain (2010)

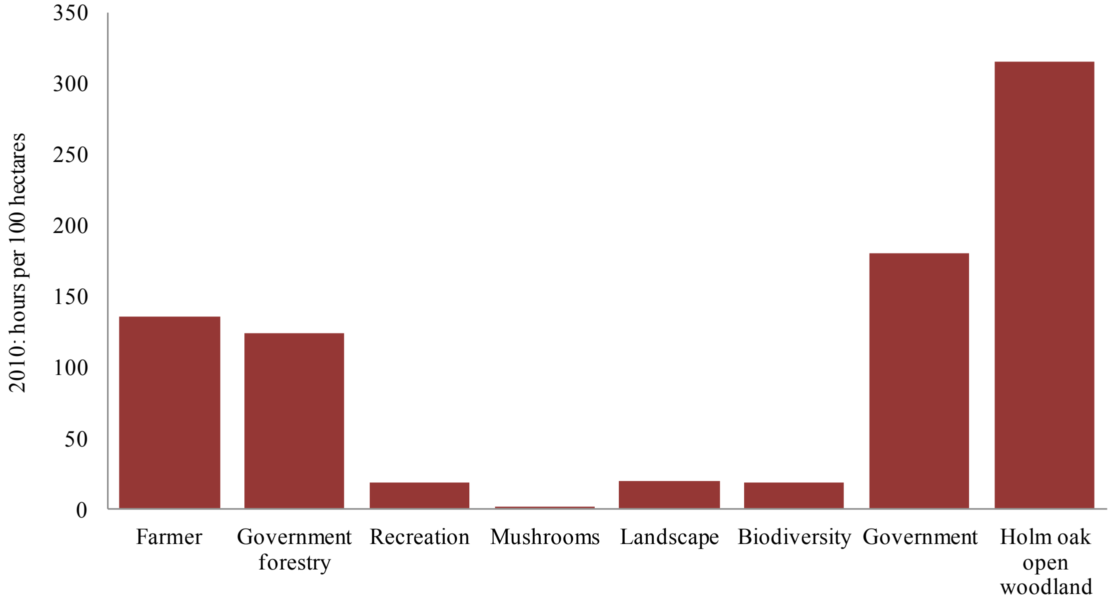

Figure S2. Total labor demand for holm oak open woodlands in Andalusia (2010)

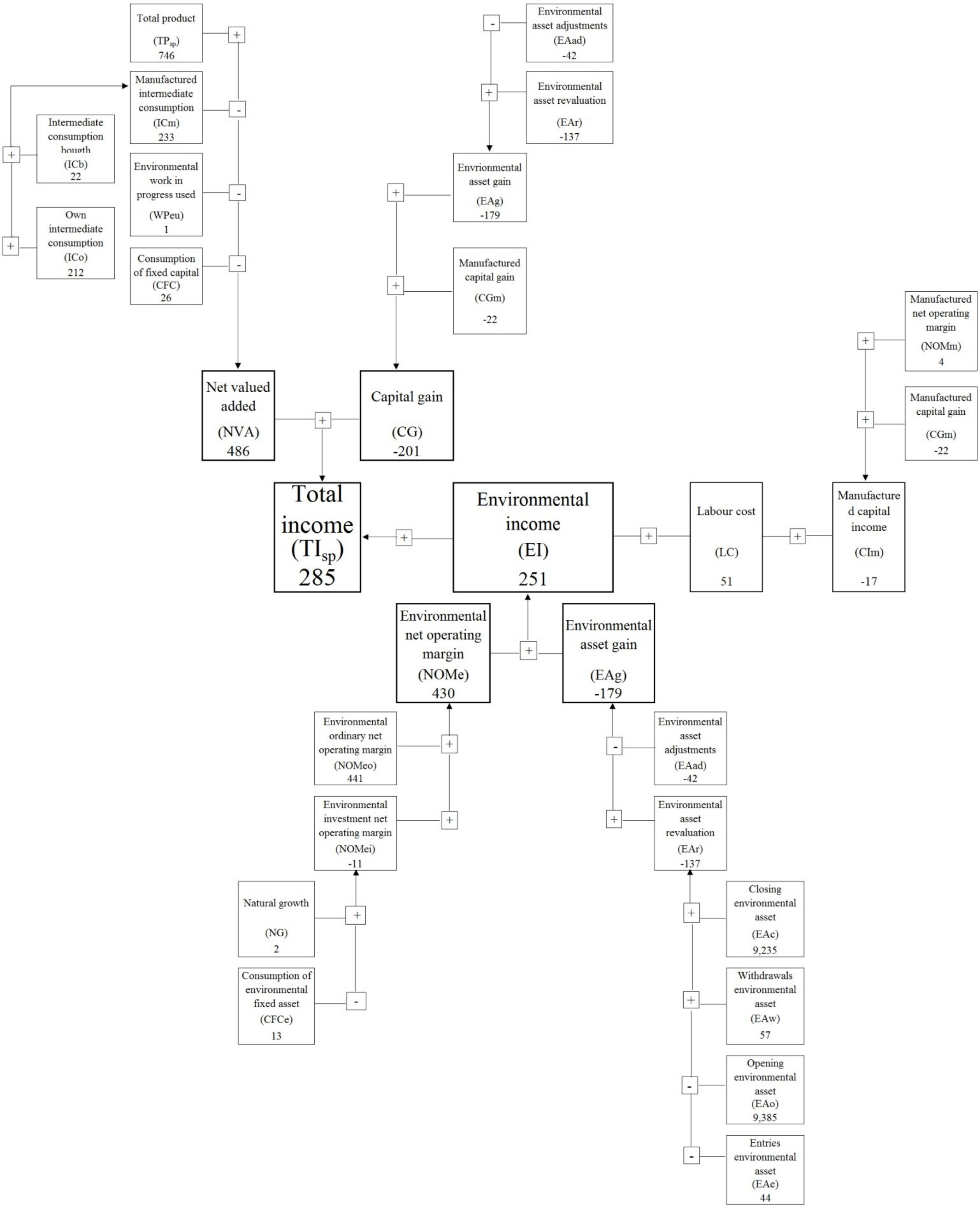

Figure S3. AAS simplified accounts sequence of total income factorial distribution at social prices for holm oak open woodlands in Andalusia-(2010: €/ha).

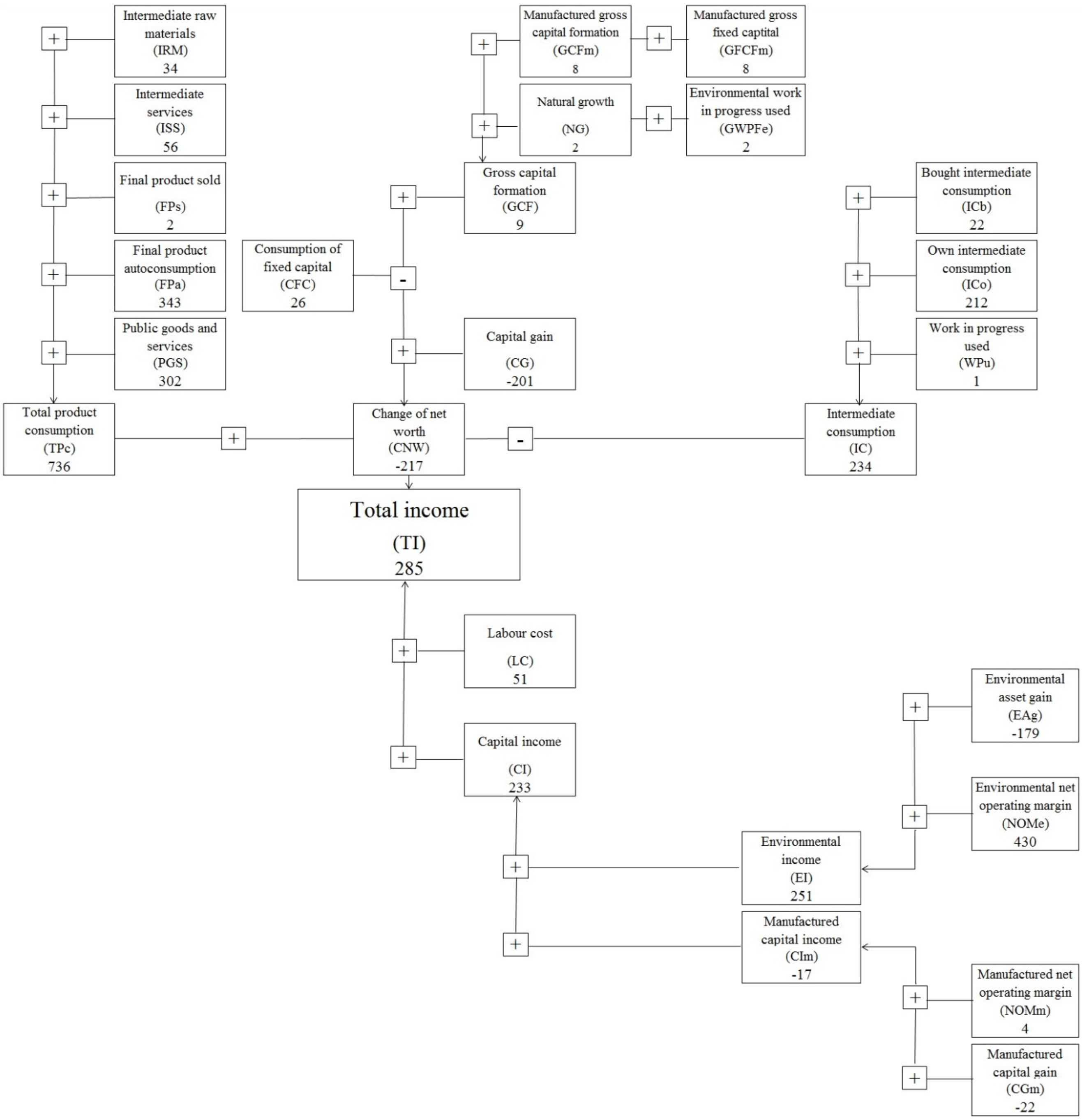

Figure S4. AAS simplified accounts sequence of total income at social prices for holm oak open woodlands in Andalusia, Spain (2010: €/ha).

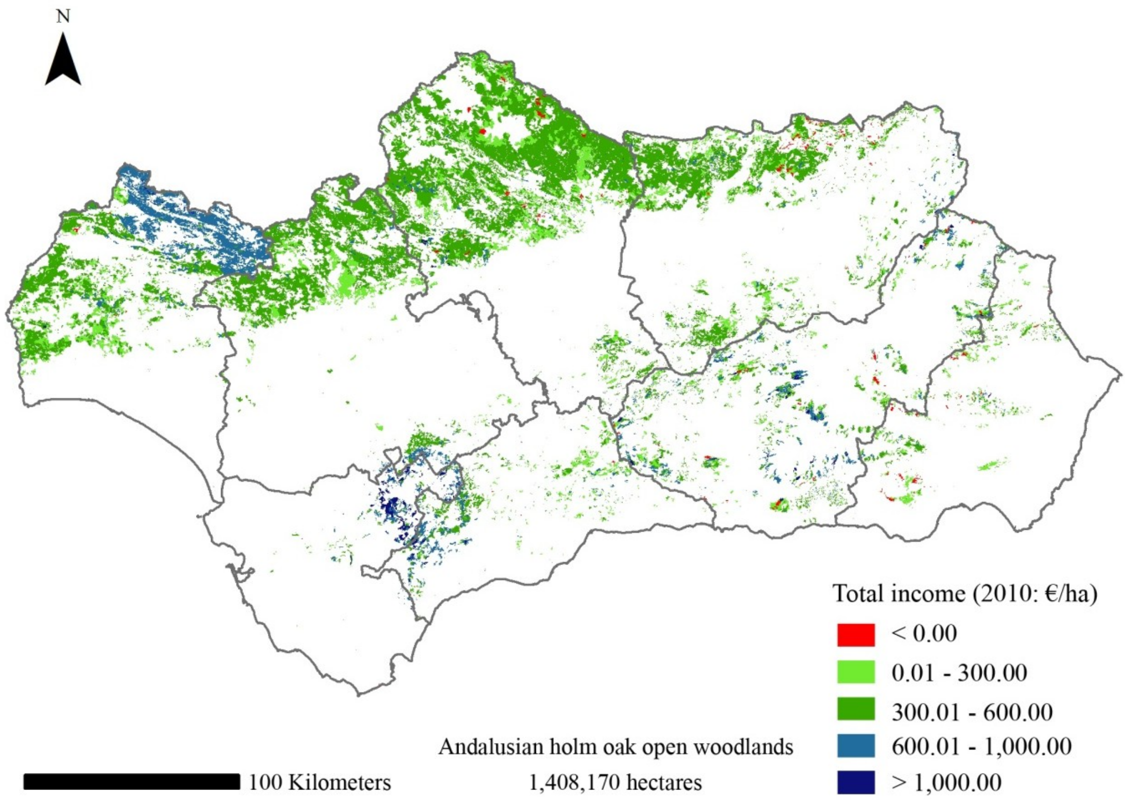

Figure S5. AAS total income at producer prices for holm oak open woodlands in Andalusia (2010: €/ha).

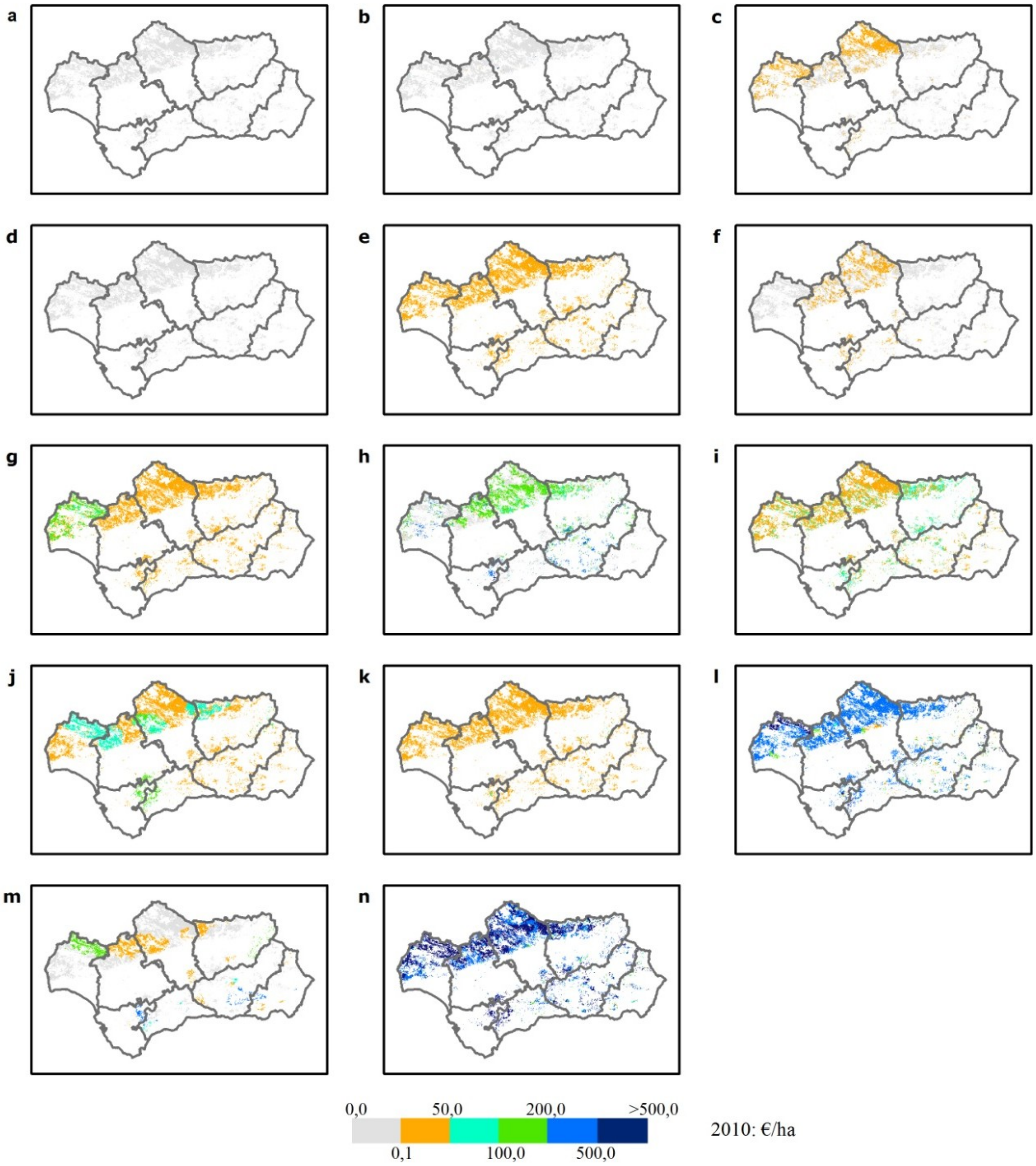

Figure S6. Map of AAS ecosystem services at producer prices by products and total for holm oak open woodlands in Andalusia.

Abreviations: (a) timber; (b) cork; (c) firewood; (d) nuts; (e) livestock grazing; (f) game grazing; (g) mushrooms; (h) water; (i) carbon; (j) landscape; (k) biodiversity; (l) amenity; (m) recreation; (n) total ecosystem services consumed in Holm oak woodlands.

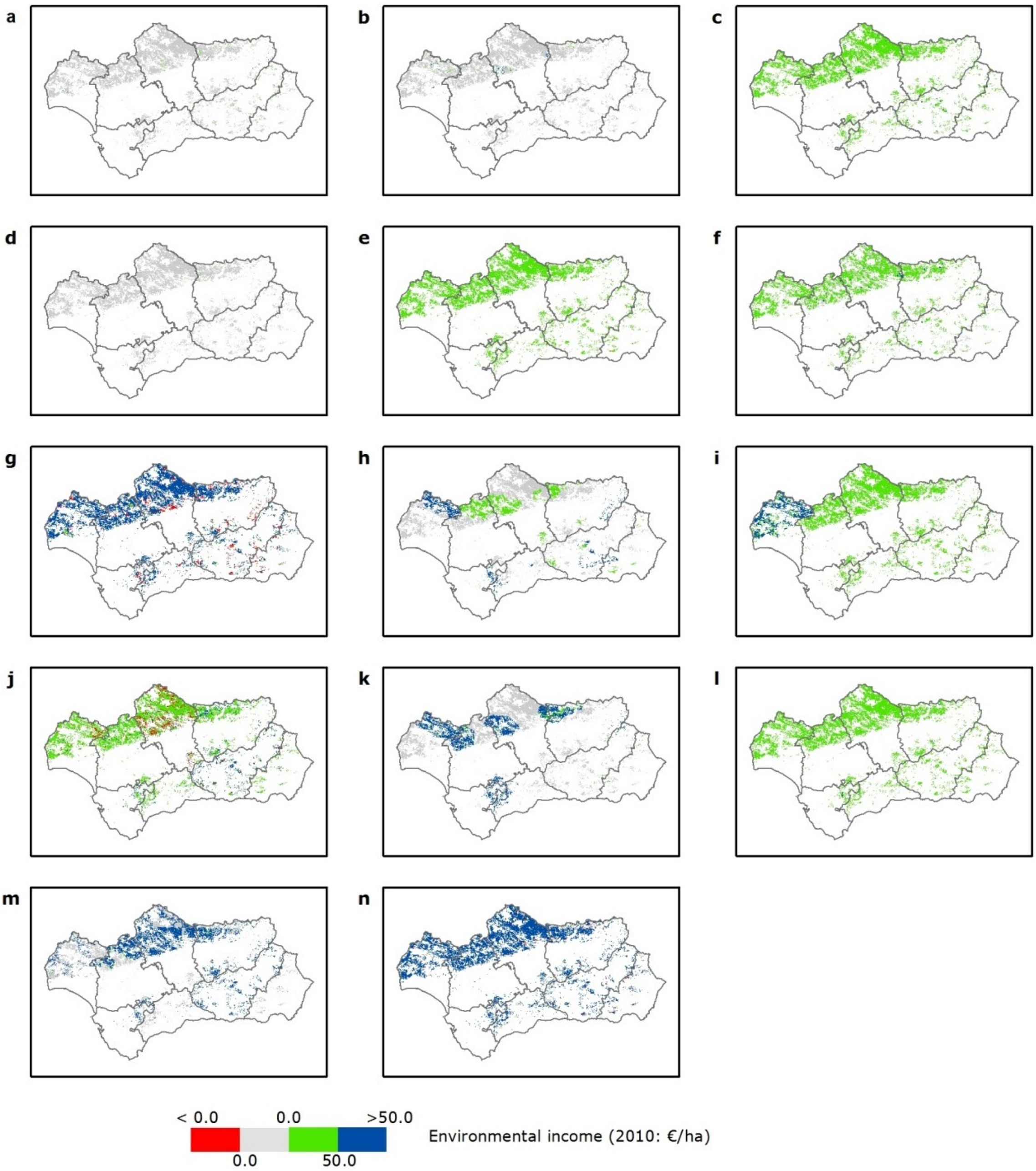

Figure S7. AAS environmental income at producer prices per activity and total for holm oak open woodlands in Andalusia.

Abreviations: (a) timer; (b) cork; (c) firewood; (d) nuts; (e) livestock grazing; (f) game grazing; (g) amenity; (h) recreation; (i) mushrooms; (j) carbon; (k) landscape; (l) biodiversity; (m) water; (n) total environmental income in Holm oak woodlands.