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Measuring environmental incomes: System of National Accounts and Agroforestry Accounting System applied to cork oak open woodlands in Andalusia, Spain

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Highlights

Cork oak woodland farmers' extended accounts make up 50% of environmental asset.
Cork oak woodland ecosystem services contribute to 76% of final product consumed.
Cork oak woodland environmental income represents 3% of environmental asset.
Cork oak woodland standard ecosystem services are 30% of extended accounts.
Cork oak woodland standard accounts' gross value added is 37% of extended accounts.

Abstract

This study's objective is to estimate and compare spatially explicit measures of ecosystem services and total environmental incomes for individual activities which occur in 248,015 hectares of cork oak open woodlands in Andalusia, Spain. The activities include timber, cork, firewood, nuts, grazing, conservation forestry, residential accommodation, private amenity, fire services, water supply, mushroom, carbon, free access recreation, landscape conservation and threatened wild biodiversity preservation. Ecosystem service is an economic indicator that informs of nature's contribution to the period's human product consumption, but with an uncertain meaning of ecological sustainability. We show that environmental income is the maximum period consumption of sustainable ecosystem services with both ecological and economic significance only if the benefits and costs involved in sustainable silvicultural management scenarios are accounted for. For measuring environmental incomes, we model sustainable silvicultural management scenarios, considering all the management practices required to maintain cork oak woodlands in perpetuity. Micro farm data is needed to estimate voluntary land and livestock owners' opportunity cost by individual activity as well as for their subsequent transfer to be able to estimate individual's environmental incomes values at social price. We define, for each individual activity, the social price as the basic price plus the voluntary unitary opportunity cost incurred by farmers in the scheduled management. Economic ecosystems indicators are measured using refined standard national accounts and extended environmental-economic accounts. The cork oak open woodlands' ecosystem services and environmental incomes measured by extended accounts at basic prices in 2010 are 1.1 and 1.2 times higher than those estimated at social prices, respectively. The refined standard accounts' ecosystem services and environmental incomes measured at basic prices are, respectively, 0.3 and 0.2 times those estimated by the extended accounts at social prices.

Keywords: Ecosystem services, own intermediate consumption, game grazing, change of environmental net worth, environmental assets.

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1. Introduction

Improving the System of National Accounts and building environmental-economic ecosystem accounting are two current challenges towards the extension of standard accounts' economic activity boundary (European Commission et al., 2009). This extension applies to the omission of environmental valuation of non-priced products within markets and the hidden ecosystem changes of ecosystem environmental net worth (Atkinson and Obst, 2017; Krutilla, 1967; Stone, 1984). An agreement on the new framework is expected no later than 2021, linking ecosystems services[1] and their environmental assets with the natural degradation adjusted net domestic product calculated in standard national accounts (European Commission, 2011). However, there is no consensus yet, as "the precise description of the relationships between economic assets, ecosystem services and the associated production, consumption, and balance sheet data in the standard national accounts is subject to ongoing discussion" (Atkinson and Obst, 2017: p.11).

In this context, focusing on terrestrial ecosystems and in particular cork oak open woodlands (COW), the objectives of this study are: (i) First to estimate and compare the individual activities' geo-referenced ecosystem services and environmental incomes using extended environmental-economic accounts (henceforth extended accounts) and refined standard System of National Accounts (henceforth refined standard accounts). The activities include timber, cork, firewood, nuts, grazing, conservation forestry, residential accommodation, private amenity, fire services, water supply, mushroom, carbon, free access recreation, landscape conservation and wild threatened biodiversity preservation, occurring in 248,015 hectares of cork oak open woodlands in Andalusia (Spain) in the period 2010; and (ii) Second, to link environmental-economic indicators of the extended accounts at social prices with those at producer and basic prices in the refined standard accounts.

Our extended accounts are presented as a modified version of Model B of the ongoing System of Environmental Accounting-Experimental Ecosystem Accounting

[1] The definitions of ecosystem and landscape are still points of discussion between the scientific disciplines and individual researchers. From our economic perspective of syncretic reasoning, we accept that the terms "ecosystem" and "landscape" are equivalent, then integrating the human activities of investment and consumption as constituent components of the ecosystem (Council of Europe, 2000: art.1.a; MEA, 2003: p. 210). This also goes in line with the concept of Coupled Human and Natural System (CHANS) that is receiving increased attention in environment-related research (Liu et al., 2015).

(SEEA-EEA) (United Nations et al., 2014a, 2014b, United Nations, 2017). In our framework, the values of ecosystem services embedded in the period's individual products consumed and the environmental gains accrued from environmental (ecosystem) assets have been based upon economic rationalities of owners (in our context 'farmers'), the government and households (consumers). These economic actors are the ones making decisions on investment and consumption, subject to current and planned (in the long run) social institutional frameworks. We assume that both public farmers (acting as collective owners of land) and the general government (acting as collective economic institutional unit responsible for the free supply of public final products) have intentions of conserving the COW environmental assets in their scheduled ecosystem sustainable managements.

We contribute to the ecosystem accounting debate in two main ways: (i) we calculate the gross value added (GVA) of cork oak woodlands' individual activities at social prices, overcoming the overvaluation problem inherently incurred in the estimates of standard GVA at producer and basic prices due to the omission of the private farmers' voluntary opportunity costs. These costs are considered as auto-consumed and/or donated own non-commercial intermediate consumption of services, thus, we define, for each individual activity, the social price as the basic price plus the voluntary unitary opportunity cost incurred by farmers in the scheduled management; (ii) we link the period's environmental income (EI) of the refined standard and extended accounts with ecosystem services (ES) by the estimation of the change of environmental net worth (CNWe). Environmental income informs of the expected future ecological-economic enhancement or degradation of environmental assets due to deviations on the scheduled biophysical scenarios.

2. Literature review on experimental monetary ecosystem accounting

Governmental and academic institutions are currently developing methodological guidelines and experimental applications for the future implementation of the SEEA-EEA in order to complement the gross domestic product (GDP) of the SNA. The SEEA-EEA approach proposes as key indicators ecosystem service (ES), environmental asset revaluation (EAr), degradation-adjusted both net value added (NVAad) and net operating surplus (NOSad), and other monetary indicators (United Nations, 2014a, b; United Nations, 2017; Atkinson and Obst, 2017).

The experimental application of extended accounts in this study develops a lightly-refined version of the Model B of the SEEA-EEA. Extended accounts integrate the refined standard accounts including, in this application, the institutional sectors of farmers and governments, furthering upon Campos et al (2019). Other authors have applied the SEEA-EEA to individual goods and services, but they do not integrate production and balance account with ecosystem services and environmental assets of the ecosystems (EFTEC, 2015; Eigenraam and Obst., 2018; Keith et al, 2017; La Notte and Dalmazzone, 2018; La Notte et al., 2019a, 2019b; Ogilvy et al. 2018; Remme et al, 2015; Sumarga et al, 2015).

As discussed above, it is expected to agree the standard framework no later than 2021, linking the ecosystems services and their environmental assets with the natural degradation adjusted net domestic product calculated in standard national accounts (European Commission, 2011). The *Knowledge Innovation Project on an integrated system of natural Capital and ecosystem services Accounting* (KIP INCA) aims to design the European Union SEEA-EA by 2020 (European Commission, 2016).

Experts in developing the monetary accounts of ecosystems start with the concept of sustainability as a criterion that guides the proposal of indicators of monetary environmental flows and assets which are linked to refined standard national accounts (Atkinson and Obst, 2017; Campos et al., 2019; La Notte et al., 2019a, 2019b; United Nations, 2017). However, a standard protocol of ecosystem accounts that proposes a measuring of total environmental income has not still made available. A standard protocol can serve as a reference to measure ecological and economic sustainability of current and future managements of ecosystems' natural and cultural assets.

The extended environmental-economic accounts applied here only add carbon to the set of economic activities valued by standard accounts. Final consumed products without market prices by their simulated exchange value based on the consumers' stated willingness-to-pay. In other words, we substitute the valuation of final non-market products consumptions at production cost applied by standard national accounts, the marginal derived simulated price of consumer simulated demand of these non-market products.

Ogilvy et al. (2018) estimate the grazing lease transaction value of silvopastoral ecosystems in Northern Australia[2], scheduling multiple grazing scenarios, both

[2] Only if there is not farmer silvopastoral manufactured cost, the lease price corresponds with the grazing resource rent.

sustainable and unsustainable. These scenarios generate different values for environmental assets of grazing in the potential land livestock grazing market (Ogilvy et al., 2018: p. 264). The biophysical sustainability of grazing is an external result of the grazing lease through the subjective choice before biological scenarios both sustainable and unsustainable[3]. They note that SNA's implicitly incorporate the degradation (consumption of environmental fixed asset) or enhancement (natural growth productivity improvement) in "other changes in volume". They also notice the Australian Accounting Standard (IAS) integrates the environmental asset degradation or enhancement in its "revaluation loss" concept (Ogilvy et al., 2018). Campos et al. (2016) arbitrarily assumed that environmental assets of grazing biophysical productivity remain indefinitely invariable.

La Notte et al. (2019a, 2019b), in the context of the SEEA experimental design, proposes that the concept of sustainable potential ecosystem services is applicable "if a sustainability threshold can be established" in an indefinite time horizon. This concept is similar to the environmental income[4] established in this study, as we assume that the environmental assets at the closing period correspond with a scenario of undefined biophysical sustainable management of the COW. In this case, the ecosystem services can only coincide with the environmental income if the woody extraction of woody (timber, cork and firewood) products (WPeu) adjusted change of environmental net worth (CNWead) is null.

3. Cork oak open woodlands institutional settings and economic activities reconsidered

This Andalusian cork oak open woodland study has been possible due to the collection of the required data from the RECAMAN project[5] and the literature sources. Our analysis here focuses on the environmental income (EI) accounting identities and their link with the ecosystem services (ES) and the CNWead both in extended and refined standard accounts. We leave out of the detailed analysis presented here the methods used for valuing non-market products (see details of the application of these

[3] In this case the owner of the livestock is obliged to pay the ecological restoration after the termination of the lease contract.
[4] The suggestion that free consumption of environmental goods and services are part of the real income of people was proposed by Krutilla (1967: p.779).
[5] There are available on line five monographs in Spanish of the RECAMAN project: http://libros.csic.es/advanced_search_result.php?tipo_busqueda=sencilla&texto=recaman&x=0&y=0

methods in Campos et al., 2019). In addition, we do not describe the modeling methodology of the biological silvicultures that support this complex environmental-economic ecosystem accounting framework applied to the cork oak open woodlands of Andalusia. The interested readers can find the methods of valuation and silvicultural modeling of the trees applied in Campos et al. (2019), Ovando et al. (in press) and Montero et al. (2015).

3.1. Institutional settings

The measurements at regional and national scales of environmental income, for its incorporation into environmental-economic accounts, is based on the imputation of estimated spatial explicit values, which are depicted by vegetation type at farm scale. This micro data, as well as those obtained at the largest scale of government institutions and produced by the authors, are requirements for the application of extended accounts at social prices in this study.

The estimation of ecosystem services by the accounting residual method gives priority to the economic payments of labor and manufactured capital services[6]. In this study we assume, at farm scale, a normal return to manufactured capital investment of hunting, livestock and agriculture activities. These COW activities are omitted in this study, but they influence the estimations of the ecosystem services of the activities which are included through the value of own auto-consumed and donated non-commercial intermediate consumption of services (SSncoa/d). Thus, our prioritized production factor payment could lead to an undervaluation of labor and manufactured capital services.

In silvopastoral farm case studies literature, the literature and final public good consumption have consistently demonstrated that both in non-industrial private and public farming, farmers could voluntarily accept monetary opportunity cost in the economic managements of forestry, grazing and livestock activities because of private amenity and public product consumption (Campos et al., 2017; Raunikar and Buongiorno, 2006). The reasoning for the omission of private amenity consumption in public cork oak farms is due to auto-consumption's value being restricted to individual persons and cannot be attributed to institutions. This is the largest cause of environmental income loss of private amenity when comparing the public cork oak

[6] The environmental asset of private amenity is the only one not estimated by the accounting residual method.

open woodlands with private ones. The publications that apply the SEEA-EEA and present integrated results of institutional sectors (including the government) are limited. Ogilvy et al. (2018) and Campos et al. (2019) incorporate the government amongst the institutional sectors in their integrated valuation of ecosystem services.

In this study, the minimal spatial unit area of Andalusian COW is polygon surface. However, the area of the farm is the independent economic unit which integrates, consistently the concept of total income, the interdependencies between pertinent economic activities and type of farmers. In contrast, private amenity and public activities offer consumed final products without market prices that require data coming from the relevant areas larger than those of the measured farms. The polygons of the Spanish Forest Map (SFM, Dirección General de Conservación de la Naturaleza, 2008) are the spatial reference for physical and economic data of vegetation and forest uses. Thus, the data is sourced and provided by the farms, the government, and the consumers of products at larger scales (e.g., recreational visitors, general public).

3.2. Cork oak open woodlands' economic activities reconsidered

In this study our interest is centered on the valuation of environmental incomes by the accounting identities that are attached to ecosystem services and the CNWead. These motivations justify the decision to omit the COW activities involving hunting, livestock (this includes beekeeping), and agriculture (this is testimonial). However, these omitted activities are taken into account due to their notable contributions, consisting of SSncoa/d. These values are used as inputs for COW activities valued here, which include private amenity, as well as the public recreation services, the conservation of public landscape services and threatened biodiversity services. However, we have already measured the COW total environmental income[7], on the assumption that the three COW activities omitted have not incorporated ecosystem services. In this integration of SSncoa/d, we are able to estimate the environmental income of COW consistent with the theory of factorial allocations of total income at social prices (see details in Campos et al., 2017, 2019; Supplementary texts S1-S2).

The activities of COW valued and managed by the farmers and government are timber, cork, firewood, nuts, grazing, conservation forestry, residential, private amenity,

[7] Except for the tourist guide services and accommodation-meal services of companies located in the COW area and its surroundings.

fire services, water[8], mushroom collection, carbon services, recreation, landscape conservation and wild biodiversity preservation. The concepts and valuations of these activities which are integrated with revised standard accounts can be consulted to in published scientific literature (Campos et al., 2016, 2017, 2019; Caparrós et al., 2017; Martínez-Jauregui et al., 2016; Ovando et al., 2016; Oviedo et al., 2017). The final products consumed in regards to the landscape and biodiversity are valued by the total cost (government ordinary cost and public farmers SSncod) plus the simulated exchange value based on the consumers' stated willingness to pay. These final products are maintained, without future variation, no matter what type of intermediate cost is considered.

The COW of Andalusia are associated with other oaks (*Quercus faginea* and *Quercus canariensis*) and broadleaves tree species (*Olea europaea* and *Ceratonia siliqua*). The browses of bushes and shrubs, specifically in times of persistent Mediterranean drought, are of critical relevance for browses animal fodder. With the exception of cork and holm oak acorn products, the fruits consumed by wild fauna and managed animals (livestock and game) are not estimated due to a lack of data. The consumption of acorns in COW is estimated by the acorn biological functions of production of cork and holm oaks, applied to trees inventories within the COW polygons (Fernández-Rebollo et al., 2008; Montero et al., 2015) (Table 1). Our estimations of grass and browse consumption in livestock activity are obtained by the residual value derived from total acorn production, calculated by the biological production function of individual trees upscaled to the existing stand, minus the period total foraged units consumed. Our results for the grazing of grass, browse, and other fruits should be taken with caution and, as opposed to our assumption of future stability of grazing productivity, overgrazing could exist locally. This is due to the fact that the livestock is supplemented in notable proportions, with respect to their total consumptions of fodder, because of the year-round permanence of the herds in the farms, as this COW ecosystem is a natural environment characterized by the absence of grass growth in the summer period and, often, depending on irregular rainfall, the grazing may also be scarce in the winter.

[8] Used for agricultural irrigation (85% of the physical quantity consumed) and other water consumption (15%).

Table 1. Cork oak open woodlands physical indicators in Andalusia (2010).

Class	Unity	Indicators		
		Useful land (ha)	Quantity	Quantity/ha
Timber				
Stock	m^3	12,036	6,927,442	575.6
Natural growth	m^3	12,036	29,298	2.4
Extraction	m^3	12,036	4,137	0.3
Cork				
Stock	t	248,015	192,657	77.7(*)
Natural growth	t	248,015	80,662	32.5(*)
Extraction	t	248,015	17,873	7.2(*)
Firewood				
Stock	m^3	89,189	2,178,039	24.4
Natural growth	m^3	89,189	39,589	0.4
Extraction	m^3	89,189	605	0.0
Acorn	t	248,015	17,569	7.1(*)
Commercial	t	248,015	5,790	2.3(*)
Free	t	248,015	11,779	4.7(*)
Grazing	FU	248,015	148,568,023	599.0
Livestock grazing	FU	248,015	60,229,866	242.8
Game grazing	FU	248,015	88,338,158	356.2
Hunting captures				
Red deer	he	247,826	4,832	1.9(*)
Wild boar	he	247,826	2,020	0.8(*)
Spanish ibex	he	247,826	19	0.0(*)
Fallow deer	he	247,826	749	0.3(*)
Mouflon	he	247,826	345	0.1(*)
Roe deer (*)	he	247,826	171	0.1(*)
Red partridge	he	247,826	12,083	4.9(*)
Rabbit	he	247,826	22,594	9.1(*
Others(*)	he	247,826	62,179	25.1(*)
Residential	m^2	248,015	88,549	35.7(*)
Recreation	vi	248,015	1,077,028	4.3
Mushrooms	kg	248,015	917,909	3.7
Carbon				
Fixation	t CO_2	248,015	1,303,936	5.3
Woody product natural growth	t CO_2	248,015	701,384	2.8
Shrub natural growth	t CO_2	248,015	602,551	2.4
Emissions	t CO_2	248,015	210,203	0.8
Woody product extractions	t CO_2	248,015	37,266	0.2
Shrub cutting	t CO_2	248,015	172,936	0.7
Net fixation	t CO_2	248,015	1,093,733	4.4
Woody products	t CO_2	248,015	664,118	2.7
Shrubs	t CO_2	248,015	429,615	1.7
Threatened species	nº	248,015	128	0.1
Water physical balance	m3	88,665	2,213,428,392	24,963.9
Intermediate products	m^3	88,665	1,119,958,329	12,631.3
Evapotranspiration	m^3	88,665	1,120,189,153	12,633.9
Negative variation	m^3	88,665	230,824	2.6
Final product	m^3	88,665	1,093,470,063	12,332.6
Runoff stored in basins dams	m^3	88,665	671,257,891	7,570.7
Ecologic	*m^3*	*88,665*	*512,333,772*	*5,778.3*
Economic supply	*m^3*	*88,665*	*158,924,119*	*1,792.4*
Deep aquifer recharge	m^3	88,665	384,647,942	4,338.2
Positive variation	m^3	88,665	37,564,230	423.7

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.

4. Extended accounts experimental application in Andalusian cork oak open woodlands

4.1. Cork oak open woodlands intermediate products and own intermediate consumptions

Government compensation and the monetary opportunity cost incurred by non-industrial farmers require that their measurements be on an individual farm scale. A farm is the independent economic unit in which the private farmer and the government make decisions about the efforts of some individual activities that offer intermediate services that affect the intermediate consumption of other activities in the same spatial unit (in this case the Andalusian COW area). This does not occur in a polygon, whose results come from data given by farm activities. The gathering of regional statistically-representative aggregate results is a commitment delegated to offices of statistics, due to both the high costs and time constraints of data accumulation and processing. In this study we have applied extended accounts to five private and two public cork oak farms to estimate their production of non-commercial intermediate services (ISSnca/d) along with own non-commercial intermediate consumption of services (SSncoa/d) in activities of hunting, grazing and agriculture. We have imputed the estimated average per-hectare values of ISSnca/d supplied in these omitted activities for the seven cork oak farms for the public and private aggregate surfaces of Andalusian COW polygons (see Supplementary texts S1-S2). This ISSnca/d imputation as the SSncoa/d goes after an experimental aim and because of this, the presentation of measured monetary results of COW polygons at social prices should be taken with caution. The COW maps show economic results at producer prices and eliminate the uncertainties presented by the social prices of this study. This however comes with its potential error in own producer price valuation, as the ecosystem services of amenity and of the landscape activities are overvalued at producer prices. However, we present the tables and figures of economic results of COW at social and basic prices to show results of ecosystem services free of overvaluation bias for the aim of illustrative figures, though this maintains the uncertainty with the said estimates. The valuations at social prices allow for a complete analysis of the results of economic activities that are derived from economic rationalities of farmers and government managements of Andalusian COW.

The valuation of ecosystem services by individual activities confront the challenges of identification, measurement, and linking intermediate services on the

supply side and the average own intermediate consumption of services on the cost side of the production account. The double accounting, within the total product (TP), of the intermediate products (IP) is eliminated in the estimation of the net value added (NVA) of the ecosystem, since it is instead registered as own intermediate consumption (ICo), provided that the totality of activities is summed up.

The standard accounts (S), although recognizing the IP of economic activities, in practice only estimate the standard net added value (NVA_S) of the region and/or the nation. This is not the case of the individual estimate of the net value added in extended accounts (E), which is estimated for each individual product j ($NVAj_E$) at the farm scale (independent economic unit) and then is transferred to scale of the polygons of predominantly cork oaks of the Spanish Forest Map (SFM). The circumstance at the scale of an individual product in which the IPj and its own intermediate consumption (ICoj) do not coincide obliges to obtain its estimations by individual products in order to be able to estimate its net value added ($NVAj_E$), ecosystem service ($ESj_{ep,E}$) and any other monetary indicators of the production account as residual values.

In this study we apply the refine standard accounts (Sr) in order to make possible the estimate of the net value added of every individual product ($NVAj_{Sr}$), the ecosystem service (ESj_{Ss}) and the change of environmental net worth adjusted ($CNWeadj_{Sr}$). Extended accounts distinguish between non-industrial private physic person and public farmers. In this study, we estimate the incurred voluntary opportunity cost by both types of non-industrial farmers. We consider this cost to be an ISSnca of the non-industrial private farmer and, in the case of public farmer, we record the opportunity cost as an ISSncd. The ISSnca is registered simultaneously as an SSncoa of the private amenity activity, and the ISSncd is registered as a SSncod of the public landscape activity.

In our application of extended accounts, we also take into account intermediate commercial services (ISSc) and its own intermediate consumption of services (SSco) of the individual activities.

Due to the omission of COW manufactured activities of hunting, livestock, and agriculture, the intermediate product (IP) and own intermediate consumption (ICo) of the cork oak open woodlands do not have the same value in our application. Commercial intermediate raw materials (IRMc) and intermediate commercial services (ISSc) are produced by grazing activity (IRMcg), residential (ISScre), conservation forestry (ISSccf) and fire services (ISScfs) activities. In the activities considered in this COW study, there is not own intermediate consumption of raw materials (RMco). The

own intermediate consumption of services (SSo) is classified as commercial (SSco) and non-commercial (SSnco) and both are inputs of the intermediate consumption of private amenity activities (SScoa and SSncoa), recreation (SScore), landscape (SScod and SSncod) and biodiversity (SSncod) (Table S1, Fig. S1). The SSnco's derives from the omitted activities of cork oak open woodlands, and consequently the ISSnccc/a/d have not been incorporated into the supply of intermediate services (ISS) of COW activity valued in this COW study.

4.2. Prices applied to cork oak open woodland stocks and harvested products

The opening period environmental timber, cork and firewood inventories produced stocks and total products consumed are valued at their farm environmental, stumpage and road prices. The prices of produced stocks of cork, timber and firewood are referred to net present value of the physical quantities times their environmental price at the opening period. The consumed products can be valued depending upon the state they are in before their consumption as a final product.

The environmental price of a consumed product corresponds with the unitary resource rent. The product consumed stumpage price represents the transaction price before the product is harvested, and the farm road price is the harvest price of the stockpiled product.

The value of the extended accounts total product at social price ($TP_{sp,E}$) contains within itself the individual values of its total production costs ($TC_{sp,E}$) and the net operating margin ($NOM_{sp,E}$). The $NOM_{sp,E}$ of the COW is measured as the sum of the net operating margin at basic price ($NOM_{bp,E}$) minus the SSncoa/d. These latter services are valued at the monetary opportunity cost voluntarily accepted by the farmers in this COW study, which omits hunting, livestock and agricultural activities. The basic price (price at factor cost) represents the producer price (market price) plus the unit value of the government compensations (operating subsidies net of taxes on products).

The valuations of products at different prices do not influence aggregated estimates of the COW if full activities had been considered. Thus, the valuation at social price of the economic variables is the reference consistent with the total income of COW full activities. However, the different types of prices do influence the estimates of ecosystem services and the gross value added of the farmer, government, COW activities valued, and those of the individual activities implicated by the input of SSncoa/d. COW revised standard accounts estimate ecosystem services, ordinary

environmental net operating surplus and gross value added at both producer and basic prices. Extended accounts address these indicator values at social prices.

4.3. Ecosystem services

We have to explicitly use the word "service" as a synonym to immaterial products, or on the contrary, its meaning is also referred as an income service from labor, manufactured (man-made) capital and nature (resource rent), deriving from the latter its SEEA-EEA use as an ecosystem service. In the latter, it holds that the ecosystem service ($ESj_{ep,E}$) is not produced (except in the absence of manufactured investment and/or paid human labor in its production function). Thus, $ESj_{ep,E}$ is the gross operating environmental income (if it includes $WPeuj_{ep,E}$) or the ordinary environmental net operating margin ($NOMej_{ep,E}$) (if it does not include $WPeuj_{ep,E}$).

The standard definition of ecosystem service ($ESj_{ep,E}$) is the residual contribution of nature to the exchange value of a total product consumed ($TPcj_{sp,E}$) by people (United Nations, 2017). Thus, the ecosystem services represent the residual monetary value from the TPcj after subtracting its ordinary manufactured total cost ($TCmoj_{sp,E}$) and the normal ordinary manufactured net operating margin ($NOMmoj_{sp,E}$). Thus, the ecosystem service at social price of extended accounts ($ESj_{ep,E}$) is the contribution of nature to the economic exchange value of total product consumed ($TPcj_{sp,E}$). The components making up the $ESj_{ep,E}$ are the environmental work-in-progress-used ($WPeuj_{ep,E}$) and the ordinary environmental net operating margin ($NOMeoj_{ep,E}$):

$$TCmoj_{sp,E} = ICmoj_{sp,E} + LCoj_{sp,E} + CFCmoj_{sp,E} \quad \text{(eq. 1)}$$

$$TPcj_{sp,E} = TCmoj_{sp,E} + NOMmoj_{sp,E} + ESj_{ep,E} \quad \text{(eq. 2)}$$

$$ESj_{ep,E} = WPeuj_{ep,E} + NOMeoj_{ep,E} \quad \text{(eq. 3)}$$

4.4. Environmental income

We estimate the total environmental income by taking into account that the production factors services of labor and manufactured capital are paid when the first observed or simulated product transactions occur.

The extended production and balance accounts of a product j allow for an estimation of environmental income ($EIj_{ep,E}$) embedded in the total income at environmental price ($TIj_{ep,E}$). The $EIj_{ep,E}$ is made up of the residual variables of the net

environmental operating margin ($NOMej_{ep,E}$) and the environmental asset gain ($EAgj_{ep.E}$):

$$EIj_{ep,E} = NOMej_{ep,E} + EAgj_{ep.E} \quad \text{(eq. 4)}$$

Our goal is to show the $EIj_{ep,E}$ as an equivalent indicator of the potential maximum sustainable consumption of ecosystem services in the period. The connection between the $ES_{sp,E}$ and $EIj_{ep,E}$ is obtained by adding and subtracting the $WPeuj_{ep,E}$ from the eq. 4, which leads to the component linking the $EIj_{ep,E}$ with the $ESj_{ep,E}$ and the $WPeu_E$-adjusted change of environmental net worth ($CNWeadj_{ep,E}$). We assume that the change of environmental net worth ($CNWej_{ep,E}$) is produced with consideration to individual economic activities and their respective individual environmental assets, which are estimated from the recorded capital balances of extended accounts:

$$EIj_{ep,E} = ESj_{ep,E} + CNWeadj_{ep,E} \quad \text{(eq. 5)}$$

The $EIj_{ep,E}$ differs from the total income ($TIj_{sp,E}$) as it does not contain income from labor (LCj) and manufactured capital ($CImj_{sp,E}$). Thus, it is necessary to resort, generally, to the estimation of the $TIj_{sp,E}$ of the ecosystem to make possible the residual measurement of its $EIj_{ep,E}$.

Future scenarios are assumed for the modeling of the silvicultures that are expected to be physically and economically sustainable and to meet the following assumptions: (i) government institutions do not modify their policies, (ii) technologies do not change, (iii) current tree and wild animal populations (stocks) are maintained indefinitely, , (iv) the full cycle productivity of natural assets does not vary, (v) current prices do not vary and (vi) undefined future flows of natural resource rent are discounted at the real private rate of 3%.

In this study we use physical data from the cork oak open woodland experimental plots of the third National Forestry Inventory of Spain (IFN3) and they are transferred to the full Andalusian COW polygons of the Spanish Forest Map (SFM). The valuation of the environmental assets of the COW woody and grazing activities is comprised of the current uses recognized by the land market that generate future resource rents, regardless of whether the current farmer does not make extractive use, during the period, some of these expected uses in the future. The woody environmental

asset has been estimated by the resource rent which offers future extractions of the resources, which simulate the long-term scheduled sustainable conservation silvicultures of cork oaks and other vegetation, including trees, bushes, shrubs and herbaceous growths associated to the polygons of the SFM of the Andalusian COW.

We directly estimate the environmental income of an individual product j ($EIj_{ep,E}$) from the environmental net operating margin ($NOMej_{ep,E}$), measured as a residual value from the production account plus the environmental asset gain ($EAgj_{ep,E}$). The latter accrues from the environmental asset revaluation ($EArj_{ep,E}$) added to the environmental asset adjustment ($EAadj_{ep,E}$). The environmental net operating margin ($NOMej_{ep,E}$) is measured from the ordinary environmental net operating margin ($NOMeoj_{ep,E}$) of the total product consumed j ($TPcj_{sp,E}$) plus the investment environmental net operating margin ($NOMeij_{ep,E}$) both valued at closing period. $NOMeoj_{ep,E}$ can be found embedded in the total consumed product ($PTcj_{sp,E}$). The $NOMeij_{ep,E}$ corresponds with the consumption of fixed environmental capital ($CFCej_{ep,E} = SSeca_{ep,E}$) subtracted from the natural growth ($NGj_{ep,E}$) accumulated in the ecosystem at closing period:

$$NOMej_{ep,E} = NOMeoj_{ep,E} + NOMei_{ep,E} \quad \text{(eq. 6)}$$

$$NOMeij_{ep,E} = NGj_{ep,E} - CFCej_{ep,E} \quad \text{(eq. 7)}$$

$$EIj_{ep,E} = NOMej_{ep,E} + EAgj_{ep,E} \quad \text{(eq. 8)}$$

$$NOMej_{ep,E} = NOMeoj_{ep,E} + NOMij_{ep,E} \quad \text{(eq. 9)}$$

$$NOMij_{ep,E} = NGj_{ep,E} - CFCej_{ep,E} \quad \text{(eq. 10)}$$

$$EAgj_{ep,E} = EArj_{ep,E} + EAadj_{ep,E} \quad \text{(eq. 11)}$$

$$EAadj_{ep,E} = EAwrcj_{ep,E} \quad \text{(eq. 12),}$$

where $NGj_{ep,E}$ is closing period produced natural growth at environmental price, $SSeca_{ep,E}$ is the consumption of the fixed environmental asset of carbon and $EAwrcj_{ep,E}$ is environmental asset withdrawal reclassification valued at opening environmental prices.

The environmental asset gain ($EAgj_{ep,E}$) reflects the revaluation of environmental assets minus instrumental accounting adjustments described below, which gets rid of the double counting of environmental income. The period opening expected work in progress environmental asset ($WPeeow_{ep,E}$) incorporates, among other future growths, the present discounted value at the environmental price of the period

expected natural growth ($NGw_{ep,E}/(1+r)$) of the woody products (timber, cork and firewood). The latter is not registered as an environmental intermediate consumption of the period, and it is embedded in the period produced natural growth ($NGw_{ep,E}$) accumulated at closing period in the ecosystem. The extended and refined standard production accounts register the $NGw_{ep,E}$ as own account gross environmental work in progress capital formation ($NGw_{ep,E}$). However, the $NGw_{ep,E}$ is also registered as an own environmental asset entry ($EAeow_{ep,E}$) in the period environmental asset balance account. Consequently, the extended and refined standard accounts, through inclusion of the $NGw_{ep,E}$ in the supply of the period in the production account, introduce an overvaluation bias of the net environmental operating margin of woody investment ($NOMeiw_{ep,E}$), with the latter overvalue bias represented by $NGw_{ep,E}/(1+r)$. We have corrected this bias in extended and refined standard accounts by adjusting the period environmental asset gain of woody environmental work in progress ($WPegw_{ep,E}$). The setting in $WPegw_{ep,E}$ is applied by subtracting the revaluation ($WPerw_{ep,E}$) from the reclassification output ($WPwrcw_{ep,E}$) of the environmental asset balance account (Tables 2-S2-S3-S4):

$$WPwrcw_{ep,E} = NGw_{ep,E}/(1+r) \quad \text{(eq. 13)}$$

$$WPegw_{ep,E} = WPerw_{ep,E} - NGw_{ep,E}/(1+r) \quad \text{(eq. 14)}$$

In the extended production accounts carbon fixation is a final product ($FPca_{ep,E}$). The asset balance of environmental fixed asset of carbon (EFAlca) registers carbon emission ($EFAlwotca_{ep,E}$) as a withdrawal and carbon fixation ($EFAleotca_{ep,E} = FPca$) as an entry. In this case the adjustment of carbon environmental gain ($EFAlgca_{ep,E}$) is applied by subtracting the carbon withdrawals reclassification ($EFAlwrcca_{ep,E} = FPca/(1+r)$) from the carbon environmental revaluation ($EFAlrca_{ep,E}$):

$$EFAlgca_{ep,E} = EFAlrca_{ep,E} - EFAlwrcca_{ep,E} \quad \text{(eq. 15)}$$

Below we summarize the estimate of full COW environmental gain ($EAg_{ep,E}$):

$$EAg_{ep,E} = EAr_{ep,E} - EAwrc_{ep,E} \quad \text{(eq. 16)}$$

$$EAwrc_{ep,E} = NGw_{ep,E}/(1+r) + FPca_{ep,E}/(1+r) \quad \text{(eq. 17)}$$

Table 2. Cork oak open woodlands extended capital account: environmental asset and manufactured capital in Andalusia, Spain (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 (1.1 + 1.2)	17,278.6		74.4	72.2	146.6	85.3			142.3	11.6	239.3	14.6	17,200.5
1.1 Farmer	8,604.9		74.4		74.4	85.3			72.3		157.6	-15.4	8,506.3
1.1.1 Timber	17.3		0.2		0.2	0.2			0.2		0.4	1.3	18.4
1.1.2 Cork	3,614.0		74.2		74.2	85.1			72.1		157.1	287.8	3,818.9
1.1.3 Firewood	30.8		0.1		0.1	0.0			0.0		0.1	1.3	32.0
1.1.4 Nuts	1.6											0.0	1.7
1.1.5 Grazing	1,010.3											0.2	1,010.6
1.1.5.1 Livestock grass and browse grazed	701.8												701.8
1.1.5.2 Livestock acorn grazed	8.6											0.2	8.9
1.1.5.3 Game grazed fodder	299.9												299.9
1.1.6 Amenity	3,930.8											-306.1	3,624.7
1.2 Government	8,673.7			72.2	72.2				70.1	11.6	81.7	30.0	8,694.1
1.2.1 Recreation	1,434.7												1,434.7
1.1.2 Mushrooms	903.9												903.9
1.1.3 Carbon	907.9			72.2	72.2				70.1	11.6	81.7	30.0	928.3
1.1.4 Landscape	3,993.7												3,993.7
1.1.5 Biodiversity	278.5												278.5
1.1.6 Water	1,155.0												1,155.0
2. Manufactured (2.1 + 2.2)	676.0	0.6	12.3		12.9			0.0			0.0	-38.1	650.8
2.1 Farmer	563.8		3.9		3.9							-28.9	538.8
2.1.1 Plantations	45.8		3.9		3.9							0.2	49.9
2.1.2 Constructions	518.0											-29.1	488.9
2.2 Government	112.2	0.6	8.4		9.0			0.0			0.0	-9.2	112.0
2.1.1 Plantations			0.0		0.0							0.0	0.0
2.1.2 Constructions	94.4		6.7		6.7							-7.7	93.5
2.1.3 Equipments	3.4	0.6			0.6			0.0			0.0	0.0	4.0
2.1.4 Others	14.4		1.6		1.6							-1.5	14.5
Total (1 + 2)	17,954.6	0.6	86.7	72.2	159.5	85.3		0.0	142.3	11.6	239.3	-23.5	17,851.2

Cork oak open woodlands surface: 248,015 hectares.

We are interested to know if the ecosystem services consumed in the period do not exceed their maximum sustainable potential value from the economic perspective given by a period null variation of the adjusted environmental net worth ($CNWeadj_{ep,E}$). The $CNWeadj_{ep,E}$ is estimated after a varied sequence of asset linkages and environmental flows of the production and asset balance accounts. The first account offers the $NOMeij_{ep,E}$, and the second, the $EAgj_{ep,E}$. The j product $CNWeadj_{ep,E}$ is estimated by subtracting the woody environmental work-in-progress used ($WPeuj_{ep,E}$) from the $CNWej_{ep,E}$:

$$CNWej_{ep,E} = NOMeij_{ep,E} + EAgj_{ep,E} \quad \text{(eq. 18)}$$

$$NOMeij_{ep,E} = NGj_{ep,E} - SSej_{ep,E} \quad \text{(eq. 19)}$$

$$CNWeadj_{ep,E} = NGj_{ep,E} - SSej_{ep,E} + EAgj_{ep,E} - WPeuj_{ep,E} \quad \text{(eq. 20)}$$

The revaluation of the environmental asset ($EArj_{ep,E}$) integrates the closing period environmental assets ($EAcj_{ep,E}$), which are subtracted from opening assets ($EAoj_{ep,E}$), and the environmental withdrawals ($EAwj_{ep,E}$) minus the environmental entries ($EAej_{ep,E}$). The $EAcj_{ep,E}$ responds to the net present value of the resource rent derived from the scheduled sustainable biophysical and economic management of the current uses, maintained indefinitely without decay of the biophysical productivity and the natural and cultural resources.

We have only explicitly estimated the consumption of fixed environmental asset ($CFCej_{ep,E}$) in the COW for the carbon emission from greenhouse effects ($SSeca_{ep,E}$) which come from the extractions of woody products (including the shrub cutting) in the period (see detail of the Methodology of the carbon accounts in Campos et al., 2019: Supplementary text S1.7, pp. 7-9).

4.5. Integrating refined standard and extended accounts' net operating margin

In this study, we apply the system of standard national accounts (SNA or S) without the presence of mixed income in the activities of the COW studied[9]. The standard net operating surplus at producer price ($NOSj_{pp,S}$) presents the timing bias of its measurement through the absence of the total product at producer price ($TPj_{pp,S}$) in

[9] This is not a minor circumstance. It avoids considering the separation of the mixed income between the potential remunerations of the independent work (self-employed), the income of manufactured capital and the environmental income of the activities employing non-salaried work (Ovando et al., 2016; Oviedo et al., 2017).

the estimates of its natural growth ($NGj_{ep,E}$). This bias invalidates the meaning of $NOSj_{pp,S}$ as a concept of capital operating income (McElroy, 1976). In addition, the $NOSj_{pp,S}$ overvalued the capital operating income by not including in the period the $WPeuj_{ep,E}$. If we know the environmental price, we directly estimate the WPeu from the physical amount of the product consumed, and we can, in the COW, separate the $WPeuj_{ep,E,}$ leaving the rest of the $NOSj_{pp,S}$ as the standard net operating margin ($NOMj_{pp,S}$). The absence in the $NOSj_{pp,S}$ of natural growth ($NGj_{ep,E}$) undervalues the $NOSj_{pp,S}$ understood as operating capital income. It is of interest to link the COW standard and extended accounts separate the standard ordinary environmental net operating margin at environmental price ($NOMeoj_{ep,S}$) and the ordinary standard manufactured operating margin at producer price ($NOMmoj_{pp,S}$)[10]:

$$NOSj_{pp,S} = WPeuj_{ep,E} + NOMj_{pp,S} \quad \text{(eq. 21)}$$

$$NOMj_{pp,S} = NOMeoj_{ep,S} + NOMmoj_{pp,S} \quad \text{(eq. 22)}$$

The timing bias of the $NOMj_{pp,\,S}$, due to the exclusion of the environmental net operating margin of investment ($NOMeij_{pp,\,Sr}$), can be resolved in the refined standard accounts (hereinafter Sr) by incorporating the $NGj_{ep,Sr}$ and subtracting the $WPeuj_{ep,Sr}$ in the $NOSj_{pp,\,S}$. By not recording the carbon activity in standard accounts, the $NGj_{\,pp,Sr}$ corresponds to the $NOMei_{ep,\,Sr}$:

$$NOMej_{pp,Sr} = NGj_{ep,Sr} + NOMeoj_{ep,Sr} + NOMmoj_{pp,S} \quad \text{(eq. 23)}$$

$$NGj_{ep,Sr} = NOMeij_{ep,Sr} \quad \text{(eq. 24)}$$

$$NOMe_{ep,Sr} = NOMei_{ep,Sr} + NOMeo_{ep,S} \quad \text{(eq. 25)}$$

$$NOM_{pp,Sr} = NOMe_{ep,Sr} + NOMmo_{pp,S} \quad \text{(eq. 26)}$$

$$NOM_{pp,Sr} = NOMei_{ep,Sr} + NOMeo_{ep,S} + NOMmo_{pp,S} \quad \text{(eq. 27),}$$

where the subscript ep is environmental price, the subscript pp is producer price, $NOMeo_{ep,S}$ is net ordinary environmental operating margin, $NOMe_{ep,Sr}$ is net environmental operating and $NOM_{pp,Sr}$ is refined net operating margin.

The net operating margin at basic prices of the refined standard accounts ($NOM_{bp,Sr}$) in this study is obtained by subtracting the own intermediate consumption of

[10] There is no standard investment margin for the valuation of the manufactured investment at production cost.

compensated non-commercial services (SSncoc)[11] from the $NOM_{pp,Sr}$. We have refined the standard accounts, avoiding the timing bias by estimating the $NOM_{bp,Sr}$:

$$NOM_{bp,Sr} = NOM_{pp,Sr} - SSncoc \quad \text{(eq. 28)}$$

We are interested in linking the $NOM_{bp,Sr}$ with the net operating margin at social prices of the extended accounts ($NOM_{sp,E}$). This linkage is achieved in the application of the COW through the following criteria: (i) subtracting the SSncoa/d from the $NOM_{bp,Sr}$, ii) by adding the difference with the price of the private amenity derived from farmer willingness-to-pay ($\Delta FPaa_{ep;E}$), to the values of the final products consumed valued by the refined standard accounts at cost price of the private amenity service, (iii) adding the revealed marginal (water) consumers´ willingness-to-pay difference ($\Delta PGS_{ep,E}$) to the cost price of the consumption of public goods and services without market prices (a part of the economic forest water, recreational service, landscape conservation service and existence service of the threatened wild biodiversity), (iv) adding the carbon final product consumption ($FPca_{ep,E}$) and subtracting the carbon consumption of environmental fixed asset($CFCeca_{ep,E} = SSeca_{ep,E}$):

$$NOM_{sp,E} = NOM_{bp,Sr} - SSncoa/d + \Delta FPaa_{ep;E} + \Delta PGS_{ep,E} + FPca_{ep,E} - \\ - SSeca_{ep,E} \quad \text{(eq. 29)}$$

The records of the revised standard accounts are summarily presented in Tables S5-S6, classified in a manner compatible with the records of the extended accounts in Tables 3-S1-S7-S8. Tables 4-5 show the results of the refined standard and extended accounts comparison from ecosystem services and environmental income.

[11] We have referred before that the activities considered by the COW in this research do not record non-commercial intermediate services.

Table 3. Cork oak open woodlands extended account total product consumption, gross capital formation, and ordinary and investment net valued added in Andalusia, Spain (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	Cork oak open woodlands
	1	2	3	4	5	6	7	8	9=∑1-8	10	11	12	13	14	15	16	17=∑11-16	18=9+17
1. Total product consumption (TPc_{sp})	0.5	98.3	0.1	0.8	33.6	6.7	14.7	351.5	506.2	42.7	52.0	27.3	72.2	223.6	14.1	77.7	509.6	1,015.8
1.1 Intermediate product (IP_{sp})					33.6	6.7	14.7		54.9	42.7							42.7	97.6
1.2 Final product consumption (FPc_{pp})	0.5	98.3	0.1	0.8				351.5	451.3		52.0	27.3	72.2	223.6	14.1	77.7	466.9	918.1
2. Intermediate consumption ($ICmo_{sp}$)	0.3	3.2	0.0	0.2	0.5	2.1	0.7	116.0	123.0	12.4	4.1	0.0		98.7	1.6		116.9	239.8
2.1 Bougth (ICmob)	0.3	3.2	0.0	0.2	0.5	2.1	0.7		7.0	12.4	1.6	0.0		1.7	1.6		17.4	24.4
2.2 Own ($ICmo_{sp}$)								116.0	116.0		2.4			97.0	0.0		99.5	215.4
2.3 Manufactured work in progress used (WPmuo)																		
3. Compensation of employees (LCo)	0.6	18.4	0.0	1.3	2.6	4.1	2.9		29.8	27.0	4.4	0.1		4.2	3.5		39.2	69.0
4. Consumption of fixed capital (CFCmo)	0.0		0.0	0.0	1.2	0.4	5.2		6.8	3.2	1.9	0.0		0.8	0.6		6.5	13.4
5. Manufactured net operating margin ($NOMmo_{sp}$)	-0.7	-8.4	0.1	-0.7	0.7	0.0	5.9		-3.1	0.1	1.7	0.0		0.2	0.2		2.2	-0.8
6. Ecosystem services (ES_{sp})	0.2	85.1	0.0		28.7			235.6	349.6		40.0	27.1	72.2	119.7	8.1	77.7	344.8	694.4
6.1 Environmental work in progress used (WPeu)	0.2	85.1	0.0						85.3									85.3
6.2 Environmental net operating margin ($NOMeo_{sp}$)					28.7			235.6	264.3		40.0	27.1	72.2	119.7	8.1	77.7	344.8	609.0
7. Net value added ($NVAo_{sp}$) (TPc_{sp}–ICo_{sp}-WPeu-CFC)	0.0	10.1	0.1	0.6	32.0	4.1	8.8	235.6	291.1	27.1	46.1	27.2	72.2	124.0	11.9	77.7	386.2	677.2
8. Gross capital formation (GCF)	0.2	74.2	0.1			3.9			78.3	5.7	0.9	0.0		0.7	1.1		8.4	86.7
8.1 Manufactured (GCFm)						3.9			3.9	5.7	0.9	0.0		0.7	1.1		8.4	12.3
8.2 Natural growth (NG)	0.2	74.2	0.1						74.4									74.4
9. Manufactured intermediate consumption (ICmi)						1.3			1.3	1.8	0.2	0.0		0.2	0.3		2.6	3.9
9.1 Bougth (ICmib)						1.3			1.3	1.8	0.2	0.0		0.2	0.3		2.6	3.9
9.2 Work in progress used (WPmui)																		
10. Compensation of employees (LCi)						2.5			2.5	3.9	0.7	0.0		0.5	0.8		5.8	8.4
11. Consumption of fixed capital (CFCi)													11.6				11.6	11.6
11.1 Consumption of fixed manufactured capital (CFCmi)																		
11.2 Consumption of fixed environmental asset (SSe)													11.6				11.6	11.6
12. Net operating margin (NOMi)	0.2	74.2	0.1						74.4	0.0	0.0		-11.6	0.0			-11.6	62.8
12.1 Manufactured (NOMmi)										0.0	0.0			0.0			0.0	0.0
12.2 Environmental (NOMei)	0.2	74.2	0.1						74.4				-11.6				-11.6	62.8
12.2.1 Natural growth (NG)	0.2	74.2	0.1						74.4									74.4
12.2.2 Less carbon emission (SSe)													11.6				11.6	11.6
13. Net value added (NVAi) (GCF-ICmi-CFCi)	0.2	74.2	0.1			2.5			77.0	3.9	0.7	0.0	-11.6	0.5	0.8		-5.8	71.2

Note: $TPc_{sp} = ICmo_{sp} + LCo + CFCmo + NOMmo_{sp} + NOMeo_{sp} + WPeu$

$ES_{sp} = WPeu + NOMeo_{sp}$

Table 4. Cork oak open woodlands extended and refined standard accounts measurements at producer, basic and social prices of ecosystem services and incomes (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	Govern-ment	Cork oak open woodlands
	1	2	3	4	5	6	7	8	9=∑1-8	10	11	12	13	14	15	16	17=∑11-16	18=9+17
Agroforestry Accounting System (AAS)																		
AAS *at social prices*																		
Ecosystem services (ES_{sp})	0.2	85.1	0.0		28.7			235.6	349.6		40.0	27.1	72.2	119.7	8.1	77.7	344.8	694.4
Gross value added (GVA_{sp})	0.2	84.3	0.1	0.6	33.1	7.1	13.9	235.6	374.9	34.2	48.6	27.3	72.2	125.3	13.3	77.7	398.5	773.4
Gross operating margin (GOM_{sp})	-0.4	65.9	0.1	-0.7	30.6	0.5	11.1	235.6	342.5	3.2	43.6	27.2	72.2	120.7	9.0	77.7	353.5	696.0
Environmental income (EI_{sp})	1.3	290.0	1.3	0.0	28.9			-70.5	251.1		40.0	27.1	20.4	119.7	8.1	77.7	293.0	544.1
AAS *at basic prices*																		
Ecosystem services (ES_{bp})	0.2	85.1	0.0		28.7			331.3	445.4		40.0	27.1	72.2	119.7	8.1	77.7	344.8	790.1
Gross value added (GVA_{bp})	0.2	84.3	0.1	0.6	33.1	7.1	13.9	331.3	470.6	34.2	48.6	27.3	72.2	143.4	13.3	77.7	416.6	887.2
Environmental income (EI_{bp})	1.3	290.0	1.3	0.0	28.9			25.3	346.8		40.0	27.1	20.4	119.7	8.1	77.7	293.0	639.8
AAS at *producer prices*																		
Ecosystem services (ES_{pp})	0.2	85.1	0.0		28.7			331.3	445.4		40.0	27.1	72.2	119.7	8.1	77.7	344.8	790.1
Gross value added (GVA_{pp})	0.2	84.3	0.1	0.6	33.1	7.1	13.9	331.3	470.6	34.2	48.6	27.3	72.2	180.9	13.3	77.7	454.1	924.8
Environmental income (EI_{pp})	1.3	290.0	1.3	0.0	28.9			25.3	346.8		40.0	27.1	20.4	119.7	8.1	77.7	293.0	639.8
System of National Accounts refined																		
SNAr at basic prices																		
Ecosystem services (ES_{bp})	0.2	85.1	0.0		28.7				114.0			27.1			0.0	66.0	93.1	207.2
Gross value added (GVA_{bp})	0.2	84.3	0.1	0.6	33.1	7.1	13.9		139.3	34.2	6.9	27.3		5.5	4.9	66.0	144.8	284.1
Gross operating margin (GOM_{bp})	-0.4	65.9	0.1	-0.7	30.6	0.5	11.1		106.9	3.2	1.9	27.2		0.8	0.6	66.0	99.8	206.8
Environmental income (EI_{bp})	1.3	290.0	1.3	0.0	28.9			-306.1	15.5			27.1			0.0	66.0	93.1	108.6
SNAr at producer prices																		
Ecosystem services (ES_{pp})	0.2	85.1	0.0		28.7				114.0			27.1			0.0	66.0	93.1	207.2
Gross value added (GVA_{pp})	0.2	84.3	0.1	0.6	33.1	7.1	13.9		139.3	34.2	6.9	27.3		5.5	4.9	66.0	144.8	284.1
Environmental income (EI_{pp})	1.3	290.0	1.3	0.0	28.9			-306.1	15.5			27.1			0.0	66.0	93.1	108.6

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

Table 5. Cork oak open woodlands extended and refined standard accounts ecosystem services and gross valued added indexes comparisons (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	Cork oak open woodlands
	1	2	3	4	5	6	7	8	9=∑1-8	10	11	12	13	14	15	16	17=∑11-16	18=9+17
Ecosystem services																		
$ES_{pp,E}/ES_{sp,E}$	1.0	1.0	1.0	0.0	1.0			1.4	1.3		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1
$ES_{bp,E}/ES_{sp,E}$	1.0	1.0	1.0	0.0	1.0			1.4	1.3		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1
$ES_{bp,Sr}/ES_{sp,E}$	1.0	1.0	1.0	0.0	1.0				0.3			1.0				0.9	0.3	0.3
$ES_{pp,Sr}/ES_{pb,Sr}$	1.0	1.0	1.0	0.0	1.0				1.0			1.0				1.0	1.0	1.0
Gross value added																		
$GVA_{pp,E}/GVA_{sp,E}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.4	1.3	1.0	1.0	1.0	1.0	1.4	1.0	1.0	1.1	1.2
$GVA_{bp,E}/GVA_{sp,E}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.4	1.3	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.1
$GVA_{bp,Sr}/GVA_{sp,E}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0		0.4	1.0	0.1	1.0		0.0	0.4	0.9	0.4	0.4
$GVA_{pp,Sr}/GVA_{bp,Sr}$	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

5. Andalusian cork oak open woodlands results and comments

The economic results are discussed giving priority to the environmental income (EI) and its components of ecosystem services (ES) and the CNWead. We take, as a basis of the analysis of the environmental variables, the estimations at social price of the extended accounts and the refined standard accounts at basic price. The analysis of the variation sensitivity of the results to the types of prices and accounting systems will refer to ecosystem services, gross value added and environmental income. We focus the comments of the environmental results on the social price estimates of the extended accounts and at the basic price of the refined standard accounts. The description of results, with preference, takes into account the individual activities of cork, grazing and amenity, and briefly we review the seven activities managed by the government. Additionally, we consider the aggregate results of the eight activities of the farmers and the seven activities of the government, and in all of the cork oaks woodlands of Andalusia. Our analysis of physical results highlights the differences between growths and extractions of woody products, and biological productivity and physical indicators that show other goods and services produced and used by the fifteen activities taken into account in this case study of the COW of Andalusia in 2010 (Tables 1-6-S9).

Table 6. Cork oak open woodlands selected stocks and harvests prices in Andalusia, Spain (2010: €/unity).

Class	Unity	Environmental price of stock	Environmental price of harvest	Stumpage price of harvest	Farm road price of harvest
1. Timber	m^3	0.13	13.44	13.44	29.74
2. Cork	t	259.64	1,180.64	1,180.64	1,364.17
3. Firewood	m^3	0.41	8.74	8.74	46.66
4. Grazing fodder	100 FU		4.56	5.38	
4.1 Livestock grazing	100 FU		7.08	9.09	
4.2 Game grazing	100 FU		2.84	2.84	
5. Residential	m^2				41.06
6. Recreation	visits		9.21		11.98
7. Mushrooms	kg		7.33		7.37
8. Carbon	tCO_2		13.73		13.73
9. Economic water supply	m^3	0.12	0.12		0.12

Abbreviations: m^3 is cubic meters; t is ton FU is forage unit; m^2 is square meters; vi is visits; kg is kilograms; tCO_2 is tons of carbon dioxide.

The values of the farmers' environmental assets coincide with the refined standard and extended accounts (Tables 2-S2-S3-S4). The environmental assets of the final products consumed without market prices of the government are null, since these products are in this case valued at manufactured production cost.

5.1. Cork oak open woodlands' physical indicators

The SFM in Andalusia register 4,095 polygons with a canopy cover between 5% and 75% from cork oaks (Table S10). The average size of the polygons is 60.6 ha and varies between minimum values, which do not reach 0.05 ha and a maximum of 817.9 ha. Of the 248,015 hectares of the COW polygons of the SFM of Andalusia, 207,839 belong to private farmers and 40,175 belong to public farmers. The COW of Andalusia are associated with various tree vegetation among which are predominantly holm oaks, Portuguese oaks and stone pines (Fig. 1, Tables S10-S11). Vegetation of bushes and shrubs also has a relevant presence as undergrowth in the polygons of cork oak open woodlands.

Grazing and cork are the main products harvested, the first as an intermediate product grazed by the game species and livestock, and the second as a multi-period final product harvested for sale. The firewood has no use in the cork oak because it is not the subject of habitual pruning and, although it is registered with the consumption of wood pruning of holm oak, this consumption in this study offers a negligible final economic value. The carbon emissions of shrubs have a considerable importance in the environmental cost of the cork oak open woodlands, although this raw material has no use as firewood in the COW of Andalusia (Table 1).

Andalusian forest law aims to conserve the cultural cork oak open woodlands as a unique economic multi use landscape. Cork-stripping is mandatorily regulated by cycles of nine or more years in Andalusia while the cork harvests are repeated circa fifteen periods of stripping though the cork oak stripping will become non-profitable. The physical natural growths of cork, timber and firewood are, respectively, 4.5, 7.0 and 65.4 times of those of their extractions in the period (physical environmental work in progress used). Thus, from an ecological perspective, there are no over-extractions of woody products in the period.

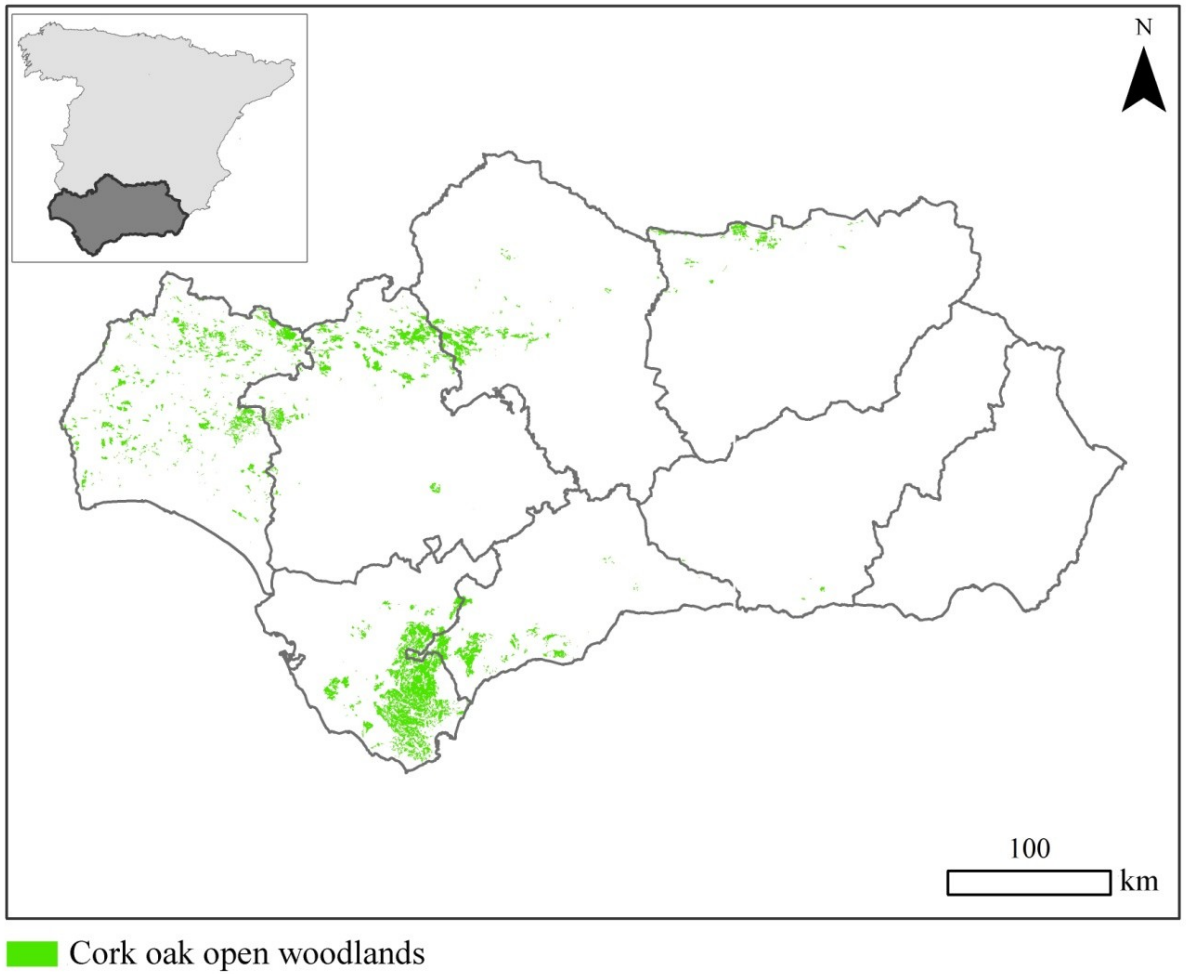

Fig. 1. Map of cork oak open woodlands in Andalusia.
Surface: 248,015 hectares

The total consumption of grazing of the game species exceeds that of the livestock in the Andalusian cork oak open woodlands (Table 1). The estimated hunting captures per square kilometer in 2010 are 3.2 heads for captures of big game and 39.1 heads for those of small game (Table 1).

Andalusian holm oak woodlands house 128 threatened wild species that are managed by the government and subjected to preservation programs that guarantee their long-term preservation.

Carbon fixations are 6.6 times higher than emissions, with the positive contributions of the shrubs surpassing the positive net fixations of the trees by 1.6 times (Table 1).

The varied forest landscapes of Andalusia surpass 44,000 km^2, favoring a recreational use by the visitors of free access. The cork oak open woodlands contributed 4.3 vi/ha in 2010. Private non-industrial property farmers of cork oak open woodlands usually have residential homes whose services are imputed as own commercial intermediate consumption of services of private amenity activity (Table 1).

The physical balance of the water shows that 30.3% of the precipitated water is regulated in the public reservoirs basins. 76.3% of the reservoir water has an ecological use (evaporation, ecological flow, flood management drains and others). The remaining 23.7% of the reservoir water has economic use for agricultural irrigators (85%) and industrial, service and household uses (15%).

5.2. Prices applied in valuing cork oak open woodlands flows and stocks

The environmental prices of the stocks of cork oak open woodlands are varied depending on the type of individual asset valued. The stocks of various cork turns in progress produced have a discounted price subject to their respective future harvest average value from the opening period, with a value of 259.64 €/t (Table 6). The woody work-in-progress used (WPeuw) has the same environmental and stumpage prices. This equality is because it does not generate commercial forestry manufactured costs because the manufactured costs of their silviculture have been attributed entirely to the conservation forestry activity of the farmers (Table 6). The prices of the woody products after harvests deposited at farm road differ logically from the respective stumping prices by incorporating the extraction costs and the ordinary manufactured net operating margin (Table 6).

The existence value of the different genetic varieties for a consumer should be assumed to be equal the degree of threat of permanent disappearance of the threatened species. The current welfare that a passive consumer perceives to be guaranteed over the next 30 years, one in which wild threatened species does not disappear during that time frame, is the same for all species, due to the existence of such service.

The environmental and stumpage prices of the grazed forage unit of livestock differ slightly due to the reduced costs manufactured by the grazing silvopastoral works in the COW (Table 6). The stumpage price of the forage units of livestock grazing comes from the leases paid by the livestock keepers and in the case of the environmental price of game grazing, it has been estimated by the environmental price of the period hunting captures.

5.3. Extended accounts' environmental income

The Figs. 2-S2-S3 shows the total environmental-economic records of the extended accounts at social prices, leading to the estimation of the environmental income at environmental price ($EI_{ep,E}$) as the maximum sustainable economic value accrued from the COW environmental assets in 2010. The $EI_{ep,E}$ represents the period potential sustainable ecosystems service of the COW of Andalusia. The values of the variables are shown in Figs. 2-S2-S3 with a per hectare average of the totality of the 248.015 ha of cork oak open woodlands of Andalusia (Fig. 1, Table S10).

The ecosystem services reach the 76% of COW total final product consumed at social price ($TPc_{sp,E}$). This percentage is 77.5% for farmers and 73.8% for government (Table 3). The value of €694/ha for the ecosystem services came in 87.8% of the ordinary environmental net operating margin at environmental price ($NOMeo_{ep,E}$) and the remaining 12.2% of the value of the extractions of woody products at environmental price ($WPeuw_{ep,E}$) (Figs. 2-3, Tables 3-S7-S8-S12). In the COW we believe that their contributions, in not very different proportions, to the ecosystem services are provisioning, regulating and cultural services. However the participation of these three classes of services is very different from the activities of farmers and the government.

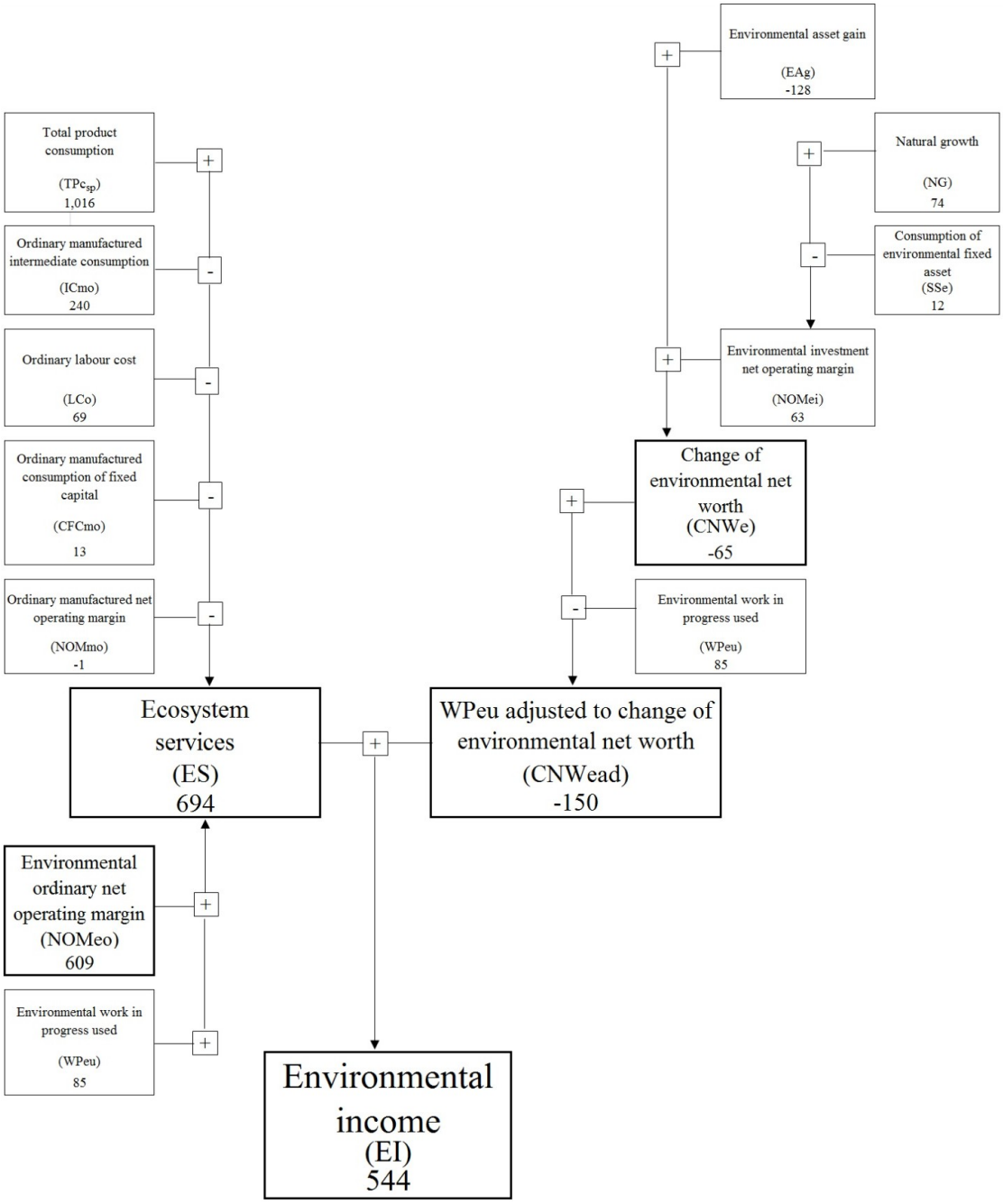

Fig. 2. Cork oak open woodlands extended accounts environmental income at social prices (2010: €/ha).

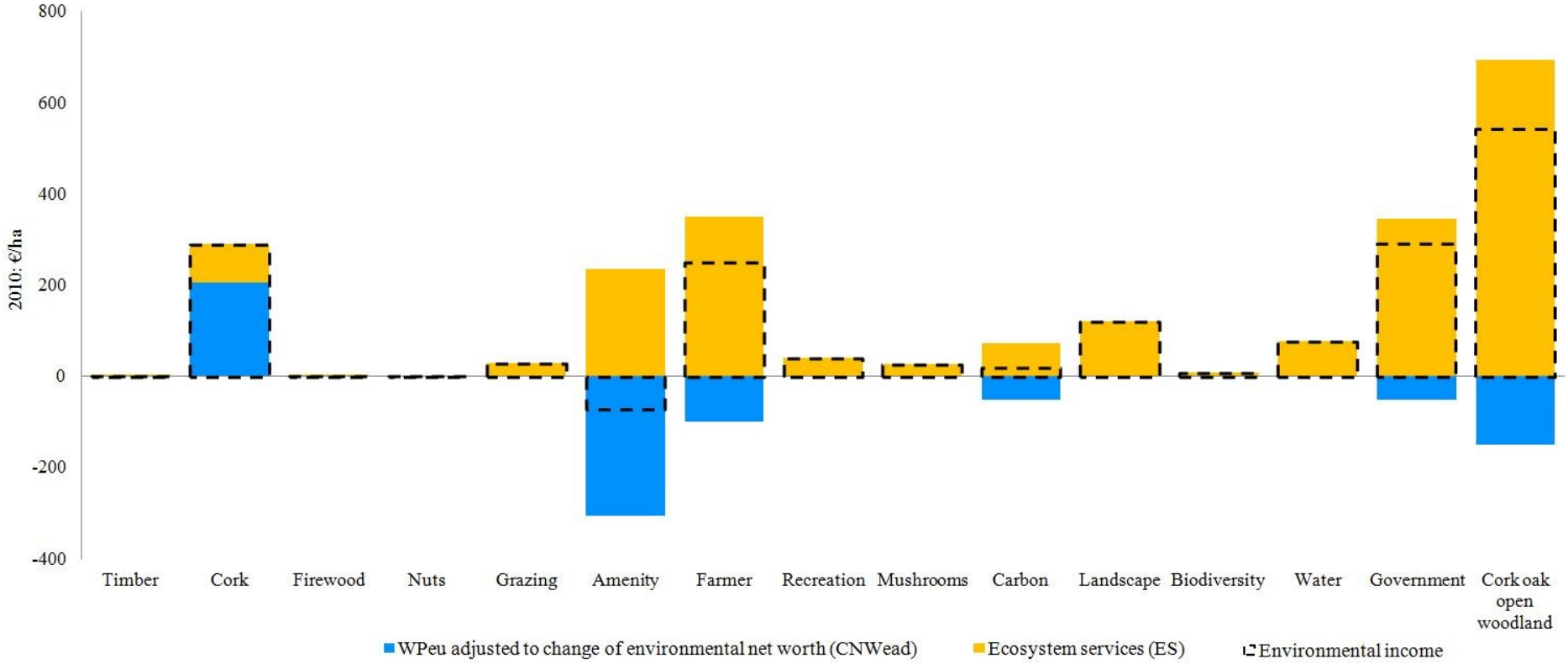

Fig. 3. Cork oak open woodlands extended accounts economic activities environmental incomes at social prices: ecosystem services and adjusted for change of environmental net worth (2010: €/ha).

We estimate a negative result for the whole of the COW studied activities of the $CNWead_{ep,E}$, indicating an economic over-consumption of ecosystem services ($ES_{ep,E}$) in the period exceeding the value of the environmental income (Fig. 2). This would not be the case with the ecological sustainability of the COW, which is insured in the period to overcome natural physical growths to extractions of cork, wood and firewood while there has been no extraordinary destruction of environmental stocks.

In 2010 the cork oak open woodlands obtained their principal environmental income from the activities of cork, landscape and water (Fig. 3, Table 4). The environmental income of the private amenity offers significant oscillations between years motivated by the variations in the price of the land, with the last negative variation taking place in 2010, and this being the cause of the $CNWeada_{ep,E}$ exceeding the remarkable positive value of its ecosystem service (Fig. 3, Table 4). However, in the period 1994-2010 the real annual cumulative rate variation of the land price has been 3.4% (Ovando et al., 2016), so the environmental asset gains of the amenity activity in the period 1994-2010 presented remarkable positive values. The Figs. 4-5 shows the distribution of the ecosystem services consumed and the environmental income, respectively, at producer prices, by activities in Andalusia.

5.4. Results sensibility to prices and accounting frameworks

Gross value added results (GVA), of the Andalusian COW do not vary when producer, basic and social prices are applied, if full economic activities were considered. This is not the case of this study, which has omitted the Andalusian COW hunting, livestock and agricultural activities that provide SSncoc/a/d to private amenity and landscape conservation activities. In this study, the estimations of the GVA, ES and EI concerned with the COW private amenity and landscape activities are sensitive to the type of price applied in this study and, also cause variations of the aggregate results of the farmers, government and the set of activities of what COW considered.

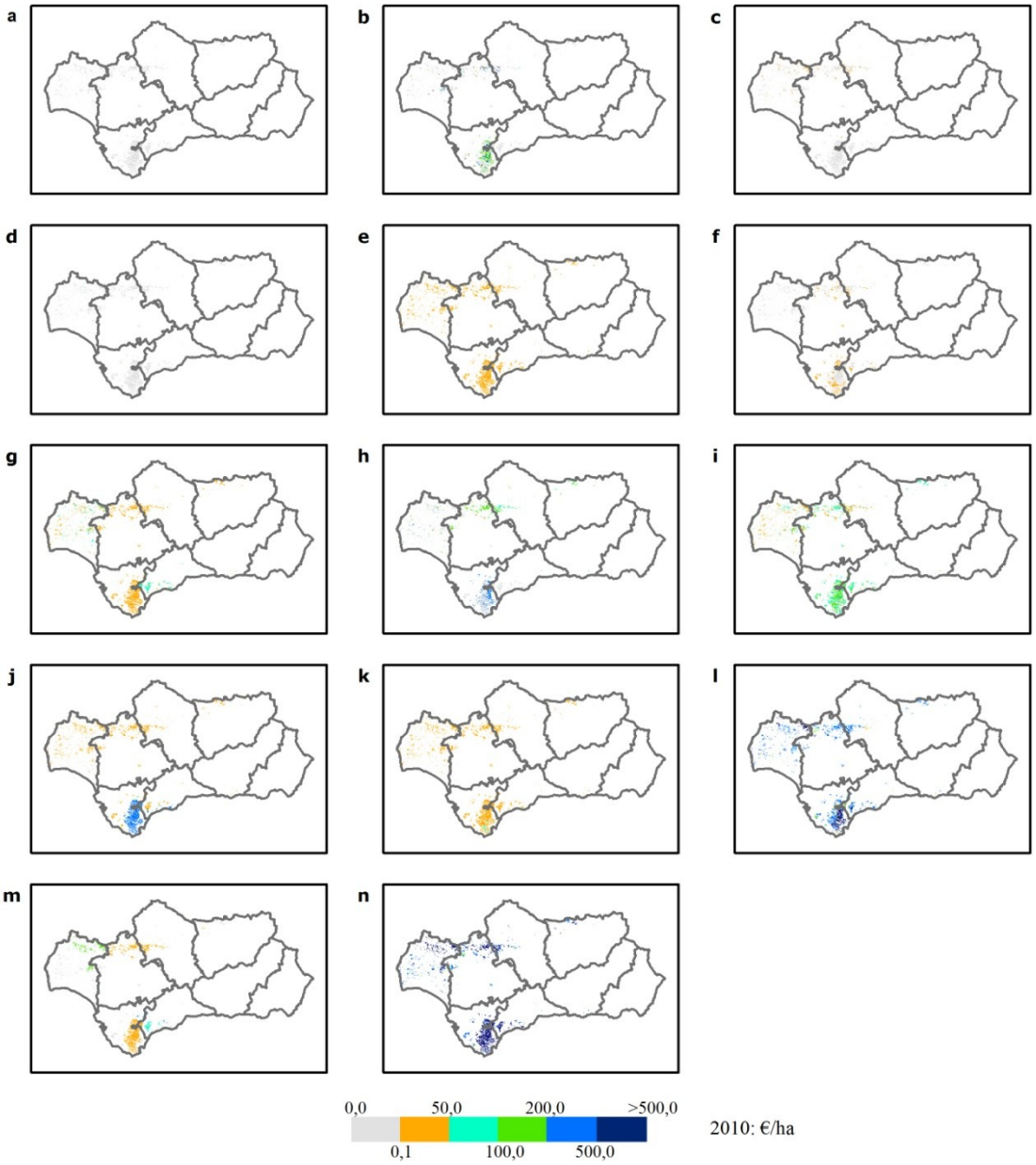

Fig. 4. Cork oak open woodlands ecosystem services consumed at producer prices by activities in Andalusia, Spain (2010: €/ha).
(a) timber; (b) cork; (c) firewood; (d) nuts; (e) livestock grazing; (f) game grazing; (g) mushrooms; (h) water; (i) carbon; (j) landscape; (k) biodiversity; (l) amenity; (m) recreation; (n) total ecosystem services consumed.

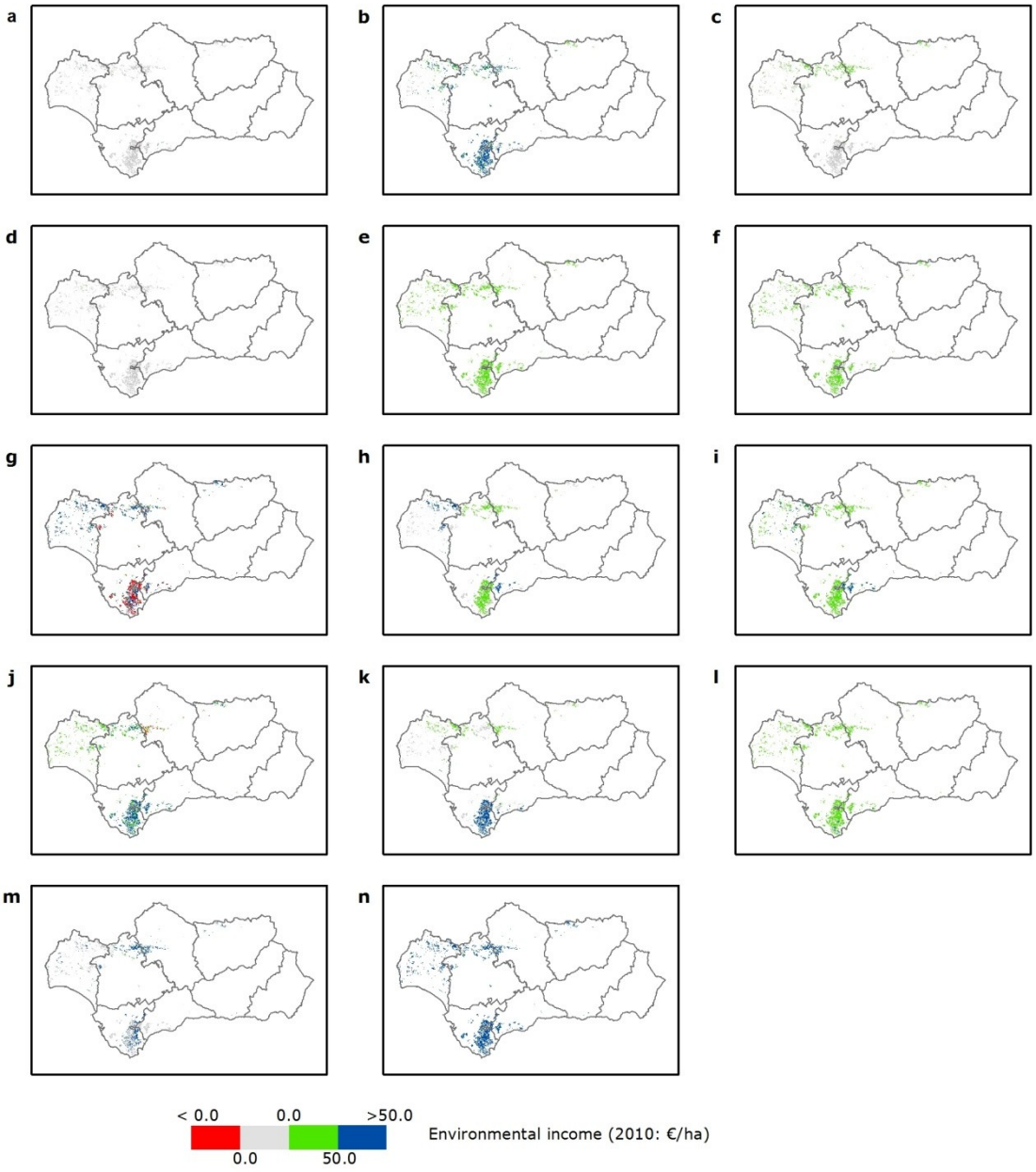

Fig. 5. Cork oak open woodlands environmental income at producer prices by activities in Andalusia, Spain (2010: €/ha).
(a) timer; (b) cork; (c) firewood; (d) nuts; (e) livestock grazing; (f) game grazing; (g) amenity; (h) recreation; (i) mushrooms; (j) carbon; (k) landscape; (l) biodiversity; (m) water; (n) total environmental income.

In this study, the valuations of the SSnco are based on the estimates of five private farms and two public cork oak open woodlands of Andalusia (Supplementary text S1). This small number of farms justifies a cautious use of the results at basic and social prices in this study transferred to all of the surfaces of the cork oak polygons of Andalusia. Being aware of the uncertainty of the results of the valuations at basic and social prices, we have preferred to maintain the focus of the analysis of the aggregate results based on these prices for the total surface of the polygons of the cork oak open woodlands of Andalusia. We believe that the transfer at the scale of the SSnco estimated in this study should be carried out even with the potential fault, which would come from the small number of farms in which their estimates are based.

We present the spatial estimates at the scale of polygons of cork oaks of Andalusia at producer price of ecosystem services, environmental income and total income (Figs. 5-S4). Despite the fact that the refined standard accounts consider the same activities (with the sole exception of carbon excluded) as the extended accounts, the differences in the valuations between both accounting systems of the final products consumed without market prices have an effect of eliciting significantly different results from ecosystem services, gross value added and environmental income in the COW of Andalusia. The refined standard accounts do not estimate the ecosystem services nor the CNWead of the final products consumed without market prices, with the provision of the revaluation of the environmental fixed assets of the amenity activity. The latter depends on the in-period changes of the implicit environmental price of the COW land market (Tables S5-S6).

In the refined standard accounts, the gross value added (GVA_{Sr}) and ecosystem services (ES_{Sr}) do not vary with the applications of producer and basic prices, because the final products consumed from the amenity activities ($FPca_{Sr}$) and landscape ($FPcl_{Sr}$) are valued at production cost (Tables 4-S6). On the other hand, the extended accounts value the $FPca_{E}$ and $FPcl_{E}$, respectively, by the marginal willingness-to-pay of farmers and consumers. Thus, for the considered activities of COW, the estimations of the extended accounts of the gross value added at producer prices ($GVA_{pp,E}$) overvalue the estimate at the social price of the $GVA_{sp,E}$ by 1.2 times. The activities of the farmers and the government offer overvaluations of the $GVA_{pp,E}$ which are , respectively, of 1.3 and 1.1 times the valuations at the social price of the $GVA_{sp,E}$ (Tables 4-5).

As a sum of all the considered activities of the COW, the estimations of the ecosystems services at producer price ($ES_{pp,E}$) overestimate, by 1.1 times, the estimate at

social price of the $ES_{sp,E}$. The $ES_{pp,E}$ of the farmers are 1.3 times the estimations of the $ES_{sp,E}$, signaling another overestimation, and do not vary the ES_E of the government (Tables 4-5). The $ES_{pp,E}$ of the amenity activity overvalues the $ES_{sp,E}$ estimates by 1.4 times however the ES_E of landscape activity doesn´t change.

The added values and ecosystem services, when compared to the refined standard and extended accounts applied to the activities and the cork oak open woodlands, offer a notable undervaluation of the former (Fig. S5). The results at basic prices of the refined standard accounts of the $GVA_{bp,Sr}$ and $ES_{bp,Sr}$ of the COW farmers and government are, respectively, 0.4 and 0.3 times the $GVA_{sp,E}$ and $ES_{sp,E}$ estimated by the extended accounts (Tables 4-5).

The refined standard accounts incorporate the environmental incomes of the final products consumed at market prices (timber, cork, firewood, nuts, grazing, water and mushroom) and the incomplete environmental income of the amenity by price revaluation of implicit market price of its environmental fixed asset (Tables S5-S6).

The remarkable range of inter-period variation in the revaluation of the amenity environmental assets can influence the compared results of the refined and extended standard accounts, due to the omission of the first ecosystem service in the final amenity product consumed. The number of COW activities that provide environmental incomes is eight in the application of the refined standard accounts and eleven in the application of the extended accounts (Tables 3-S5-S6-S7-S8).

The two accounting methodologies offer data to be able to measure the environmental income of the farmers of the commercial activities, and the incorporation of the environmental income of amenity in both methodologies sink the environmental income of the refined standard accounts to only 0.1 times the amount of value of those estimated by the extended accounts (Tables 3-4-S5-S6-S7-S8, Fig. 6). The environmental incomes of the government activities measured by the refined standard accounts are 0.3 times those estimated by extended accounts. In totality of all COW activities valued in this study, the environmental incomes offered by the refined standard accounts are 0.2 times those estimated by the extended accounts (Tables 3-4-S5-S6-S7-S8, Fig. 6). If we exclude the environmental income from the consumed private amenity product, then the refined standard accounts show an environmental income that is still only 0.7 times of those estimated y the extended accounts..

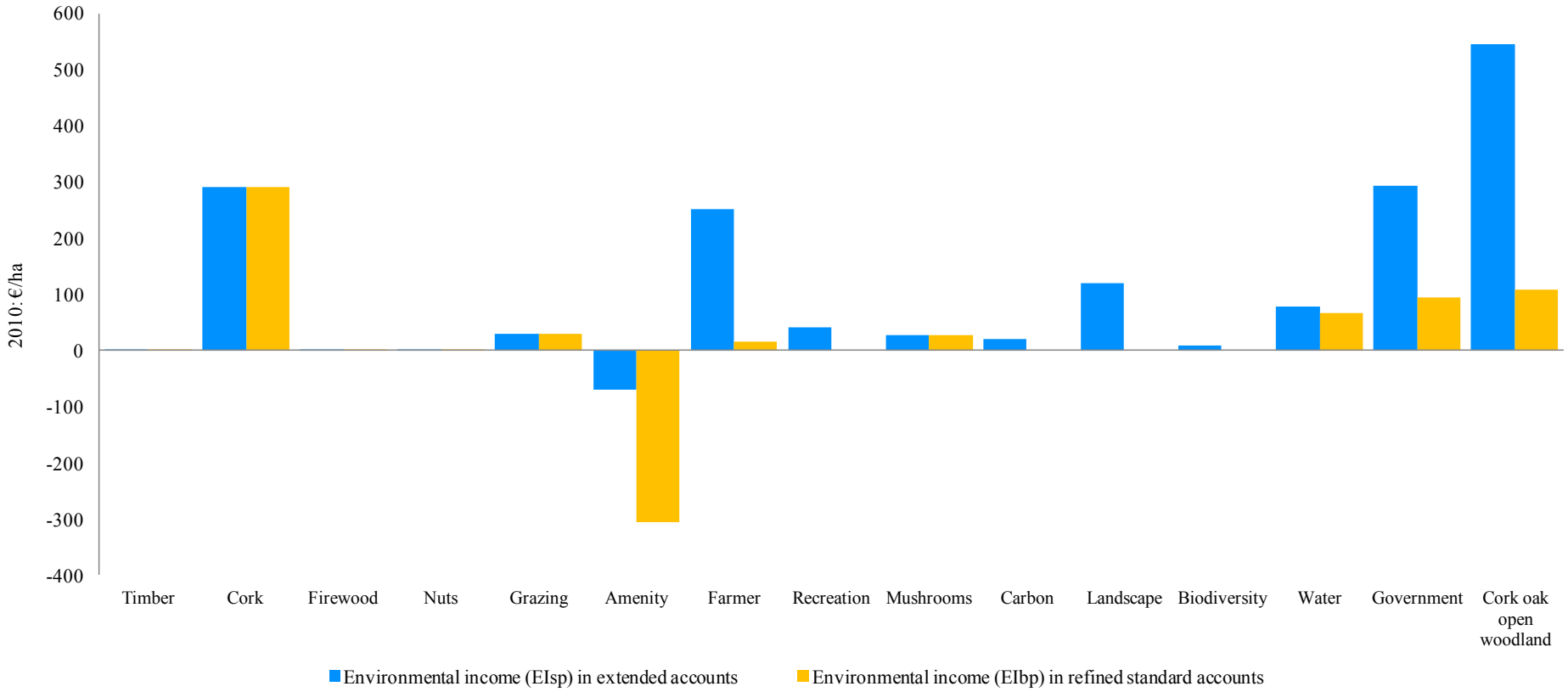

Fig. 6. Cork oak open woodlands extended and refined standard accounts comparisons of environmental income at social prices and basic prices in Andalusia, Spain (2010: €/ha).

6. Discussion

6.1. On the environmental income as potential sustainable ecosystem service

Environmental assets show the net present value of the expected future ecosystem services consumption without accounting a link with the period ecosystem services visible. The visible link between the ecosystem services and the environmental assets of the ecosystems is provided by the CNWead. Ecological sustainability is taken out of economic valuation through the scheduled future silvicultures that ensure that there will be no degradation of the biophysical endowments of natural resources (including wildlife biodiversity), nor over-extractions during the complete cycles of plant and game species. In other words, ecological sustainability is a political purpose assumed prior to the generation of the environmental income of the period. In this study, the future endowments of the biophysical environmental stocks are programmed to repeat indefinitely the uses and assuming that other circumstances of the present remain equal. In other words, the valuation of an environmental asset at the closing of the period represents a subjective expectation in which we try to minimize its degree of uncertainty in our application to the Andalusian COW. In the COW, every service of the ecosystem, in its complete cycle, repeats itself, regenerating in indefinite complete cycles. Ecosystem services and environmental income from environmental assets vary from one period to another, without the need or guarantee in advance that environmental income unequivocally informs in regards to the biophysical sustainability of the ecosystem. This is due to the asymmetry between the physical and economic metrics. In the latter the data is monetary, reflecting the quantity product times its price. Period variations between physical productivity and product environmental prices may offer environmental income values that vary, in opposite directions, to variations of physical productivity.

On this occasion, we omit the content of the sustainable biological modeling build that supports this complex study applied to Andalusia cork oak open woodlands (for detail see Campos et al., 2019; Campos et al., 2017). Our claim that environmental income represents the maximum potential sustainable consumption of ecosystem service is consistent with the concept of ecological sustainability of the ecosystem on the basis of schedule future conservationist scenarios applied to Andalusian COW.

6.2. Policy matters on building environmental-economic extended ecosystem accounts

The application of the extended accounts to a complex ecosystem, i.e. the COW, allows a reflection on the general public utility of the implementation of the environmental-economic ecosystem accounting. Public policies for the preservation of natural and culturally threatened varieties are based on the precautionary principle and government policy restricted by the tolerable social cost of avoiding and/or mitigating their unique varieties losses forever.

Among the possible motivations for governments to implement new environmental- economic statistics of ecosystems are the following: (i) governments are responsible for the design and implementation of the policies to avoid or mitigate the loss of the legacy of environmental assets received by current generations, which are to be transmitted to future generations on the basis of principles of inter-generational public legacy, (ii) the normalization of the measurement of biophysical sustainability requires a scientific subjective consensus of the critical bio-physical thresholds of environmental assets, in which they are recognized as carriers of non-reproducible natural diversities, which are industrially and culturally unique, (iii) standardized scientific data on the goods and services of ecosystems that contribute to human well-being should be visible in order to provide data that contributes to improving the design of environmental policies and the enhancement the human wellbeing, (iv) the future implementation of the extended environmental-economic accounts of ecosystems are perceived by governments as key statistics for "ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies" (Mountford, 2011: p. 3), (v) the accounts of the physical stocks and environmental assets of the ecosystems at the global, national, regional and local scales are the tools to generate data that favors the design and practices of international conventions, (vi) environmental accounts must be implemented by governments according to types of ecosystems at the global, national, regional and local scales to ensure the mitigation of losses of threatened and shared biological and cultural varieties, and (vii) new technologies are key production factors in the improvement of economic growth and their impact on environmental assets must be incorporated in the valuation of economic progress, in both its effects on benefits and environmental costs with new indicators such as environmental income, and others that can be incorporated into the refined standard national accounts and the extended accounts.

7. Concluding remarks

Our study presents a systematic conceptualization and application of the extended environmental-economic accounts to the ecosystems of Andalusian region cork oak open woodlands. This application shows that the integration of the varied basket of products, both consumed and accumulated, is feasible, with theoretical consistency, from a single indicator of environmental income integrated with the measurement of the COW total income. The measurement has been shown to be the joint result of multiple physical and monetary indicators that link the contribution of ecosystem services to the current consumption of cork oak open woodland products, with an adjustment of the CNWead.

The environmental income is key, among other relevant indicators, for reporting on the sustainable economy of ecosystems. However, in the presence of individual biophysical endowments from the critical threshold of physical ecosystem stocks, environmental income is not an indicator that can unequivocally report on ecological sustainability in the management of individual ecosystem assets. In these circumstances, it requires the design of biophysical managements beyond economic sustainability.

Acknowledgments

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Appendix: Supplementary material

Measuring environmental incomes: System of National Accounts and Agroforestry Accounting System applied to cork oak open woodlands in Andalusia, Spain

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This Appendix file includes:

Supplementary text for

Measuring environmental incomes: System of National Accounts and Agroforestry Accounting System applied to cork oak open woodlands in Andalusia, Spain

List of contents:

S1. Results of non-commercial intermediate services in the cork oak open woodland farms

In the case studies of the studied cork oak open woodland farms, the activities of private landowners (grazing, hunting, livestock, and agriculture) uniquely produce non-commercial intermediate services. The activities of silvicultural conservation, government foresting, and residential services produce the commercial intermediate services (ISSc).

S1.1 Private cork oak open woodland farms

The landowner activities in private cork oak open woodland farms that produce non-commercial intermediate services (ISSnc) are grazing, hunting and livestock. There are 5 private farms utilized in the imputation, consisting of a total area of 5,512 hectares.

Grazing contributes 11.3 €/ha to own consumed, non-commercial intermediate services while hunting activity provides 47.7 €/ha. These results show the significant implication of the management and hunting of hunted species in the amenity consumption of family-owned cork oak open woodlands (Table ST1 and Fig. ST1). Livestock contributes 41.4 €/ha to compensated non-commercial intermediate services (ISSncc) and 55.2 €/ha to auto-consumed non-commercial intermediate services (ISSnca). The latter shows that the landowner also participates in livestock due to a better enjoyment of amenities (Table ST1 and Fig. ST1).

In summary, adding up all of the prior activities, private landowners of cork oak open woodland farms provide 114.3 €/ha to own consumed non-commercial intermediate services and 41.4 €/ha to compensated non-commercial intermediate services (Table ST1 and Fig. ST1).

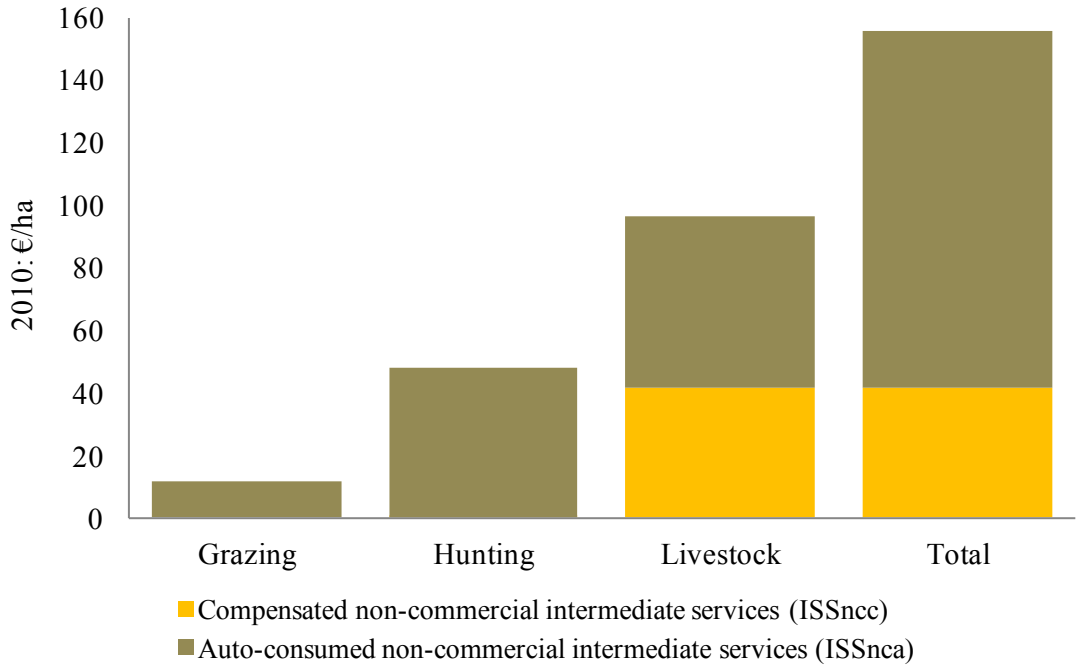

Fig. ST1. Compensated and auto-consumed non-commercial intermediate services in private cork oak open woodland farms (2010: €/ha).

S1.2 Public cork oak open woodland farms

In summary, the public cork oak open woodland farms provides 17.9 €/ha to compensated non-commercial intermediate services (ISSncc), 77.1 €/ha to the donated (ISSncd), and 34.3 €/ha to the auto-consumed (ISSnca) (Table ST1 and Fig. ST1).

The public cork oak open woodland farms activities that produce non-commercial intermediate services are hunting, livestock, and agriculture. The hunting contributes to ISSncc and ISSncd. Agriculture contributes to compensate non-commercial intermediate services and livestock work, carried out by own employed ranchers, supports ISSnca. The case study uses 2 public farms for its imputation, which consist of a total area of 12,520 hectares. Hunting activity, livestock, and agriculture respectively provide 0.6 €/ha, 16.0 €/ha and 1.3 €/ha towards compensated non-commercial intermediate services (ISSncd) (Table ST1 and Fig. ST2). The donated non-commercial intermediate services (ISSncd) receives a contribution of €77.1/ha from the hunting activity a, while the ISSnca receives €34.3/ha from stockbreeding amounts. These results show the important implication of the landowner´s involvement in the management and hunting of hunting species, while the ranchers have a component of amenity when carrying out livestock activities. (Table ST1 and Fig. ST2)

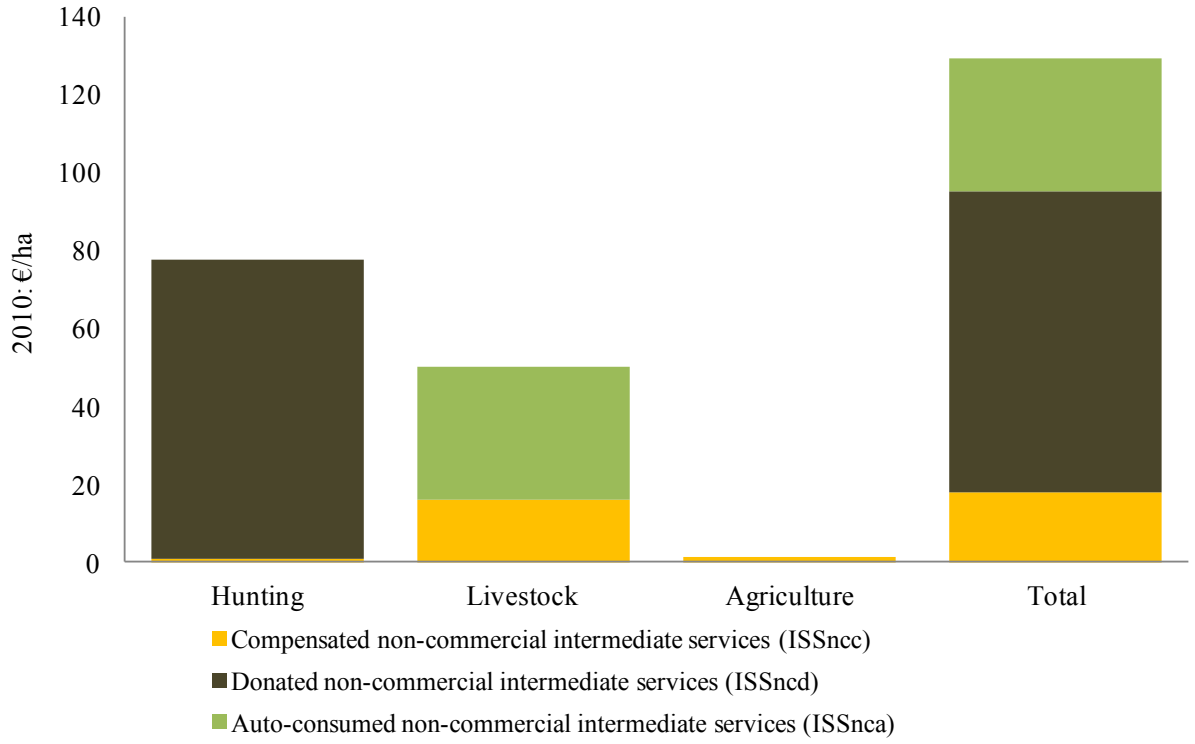

Fig. ST2. Compensated, donated and auto-consumed non-commercial intermediate services in public cork oak open woodland farms (2010: €/ha).

Table ST1. Non-commercial intermediate services (ISSnc) by type of cork oak open woodland farms, landowner and activity (2010: €/ha).

Classification	Grazing	Hunting	Livestock	Agriculture	Landowner
Private cork oak open woodlands(*)	11.3	47.8	96.5	0.0	155.7
Compensated		*0.1*	*41.3*		*41.4*
Auto-consumed	*11.3*	*47.7*	*55.2*		*114.3*
Donated					*0.0*
Public cork oak open woodlands(**)	0.0	77.7	50.2	1.3	129.3
Compensated		*0.6*	*16.0*	*1.3*	*17.9*
Auto-consumed			*34.3*		*34.3*
Donated		*77.1*			*77.1*

(*) Number of private cork oak open woodlands: 5. Total area: 5,512 hectares.
(**) Number of public cork oak open woodlands: 2. Total area: 12,520 hectares.

S2. Imputation of own intermediate services consumption (SSo) in the cork oak open woodland of Andalusia

The imputation of own services for the Andalusian cork oak open woodlands (COW) is due to information available is at the producer price, and the objective is to obtain economic

indicators at social price. The Andalusian cork oak open woodlands omit hunting, livestock and agriculture activity.

The own intermediate services consumption (SSo) estimate is made from the information available in the seven case studies farms. To impute the SSo of the corks oak open woodlands in Andalusia; we use information available from the private and public property owners of cork oak open woodlands. The Forest Map of Spain provides the per tile public and private hectare proportions, hence the use of both public and private farm owner information.

An own intermediate consumption value (SSo), which comes from the intermediate services both compensated (ISSncc) and donated (ISSncd), is imputed for activities of biodiversity and landscape to the public hectares of the polygons. For the private hectares, own intermediate consumption services (SSo) are imputed in landscape activities, which come from the compensated non-commercial intermediate services (ISSncc), and amenity activity, which is derived from the auto-consumed non-commercial intermediate services (ISSnca).

Only the SSo from the intermediate non-commercial services (ISSnc) are imputed, since in the Andalusian cork oak open woodlands, the commercial intermediate services (ISSc) that are produced in the activities of forestry of conservation, residential service and forest government are estimated and integrated, both in the production and in the cost.

S2.1 How are own intermediate services consumption (SSo), generated by non-commercial intermediate services (ISSnc), estimated?

From the cork oak open woodland farms data, we estimate, per hectare, the own intermediate services consumption (SSo), which corresponds with the following non-commercial intermediate services (ISSnc): those of amenities (ISSnca) (publicly and privately owned), those that are compensated (ISSncc) (publicly and privately owned, as well as those that are donated (ISSncd) (once again both publicly and privately owned). For cork oak open woodlands, three SSo values will be imputed, each of which corresponds with an ISSnc, adding the corresponding activity, be it amenity, landscape, or biodiversity, which already include SSo, produced as a commercial intermediate service (ISSc) by activities of silviculture conservation, residential service, and government forestry. The SSo values imputed, which are incorporated in landscape or biodiversity activity, will see an increase in

production equal to the carried-out imputation, so that their production is equal to the total ordinary cost (TCo) plus the consumer willingness-to-pay.

S2.2 Data imputed for cork oak open woodlands

For the imputation of the own intermediate consumption (SSo), the aggregate information available in the five private farms (with a total area of 5,512 hectares) and two public farms (with a total area of 12,520 hectares) is used; whose main vegetation is the cork oak. In Table ST2, the rows show that activities generate compensated and auto-consumed non-commercial intermediate services (ISSncd and ISSnca) in private owner farms while the columns show the destination of private hectares in polygons of the cork oak open woodlands of Andalusia as own intermediate consumption. Table ST3 is similar to Table ST2, but the indicated results would apply to the public hectares of cork oak open woodlands, since the rows indicate compensated and donated non-commercial intermediate services (ISSncc and ISSncd) which come from the farms of public property.

Table ST2. Own intermediate services consumption (SSo) imputed for the private cork oak open woodlands in Andalusia (2010: €/ha).

Classification	Amenity	Landscape
Compensated		41.4
Hunting		*0.1*
Livestock		*41.3*
Auto-consumed	114.3	
Grazing	*11.3*	
Hunting	*47.7*	
Livestock	*55.2*	
Total	114.3	41.4

Private cork oak open woodlands: 5. Total area: 5,512 hectares.

Table ST3. Own intermediate services consumption (SSo) imputed for the public cork oak open woodlands in Andalusia (2010: €/ha).

Classification	Amenity	Landscape
Compensated		17.9
Hunting		*0.6*
Livestock		*16.0*
Agriculture		*1.3*
Donated		*77.1*
Hunting		*77.1*
Auto-consumed	34.3	
Livestock	*34.3*	
Total	*34.3*	95.0

Public cork oak open woodlands: 2. Total area: 12,520 hectares.

Taking into account that the total area of the cork oak open woodlands in Andalusia (248,015 hectares), it can be observed that 207,839 hectares are private and 40,175 are public. Table ST4 indicates the intermediate consumption (SSo) imputation's value for cork oak open woodlands in Andalusia. According to Table ST4, 25,125,320 Euros and 12,420,050 Euros are incorporated as amenity activity cost to the landscape activity.

Fig. ST3 shows the per hectare value of the imputations of the intermediate services consumed by amenity and landscape activities in the cork oak open woodlands of Andalusia.

Table ST4. Own intermediate services consumption (SSo) imputed for the cork oak open woodlands in Andalusia (2010: €).

Classification	Amenity	Landscape
Private area	23,749,192	8,602,916
Compensated		8,602,916
Hunting		*9,786*
Livestock		*8,593,130*
Auto-consumed	23,749,192	
Grazing	*2,356,772*	
Hunting	*9,923,099*	
Livestock	*11,469,321*	
Public area	1,376,128	3,817,134
Compensated		718,338
Hunting		*23,029*
Livestock		*641,465*
Agriculture		*53,844*
Donated		3,098,796
Hunting		*3,098,796*
Auto-consumed	1,376,128	
Livestock	*1,376,128*	
Total	25,125,320	12,420,050

Note: Cork oak open woodlands total area in Andalusia: 248,015 hectares, 207,839 of which are private and 40,175 are public.

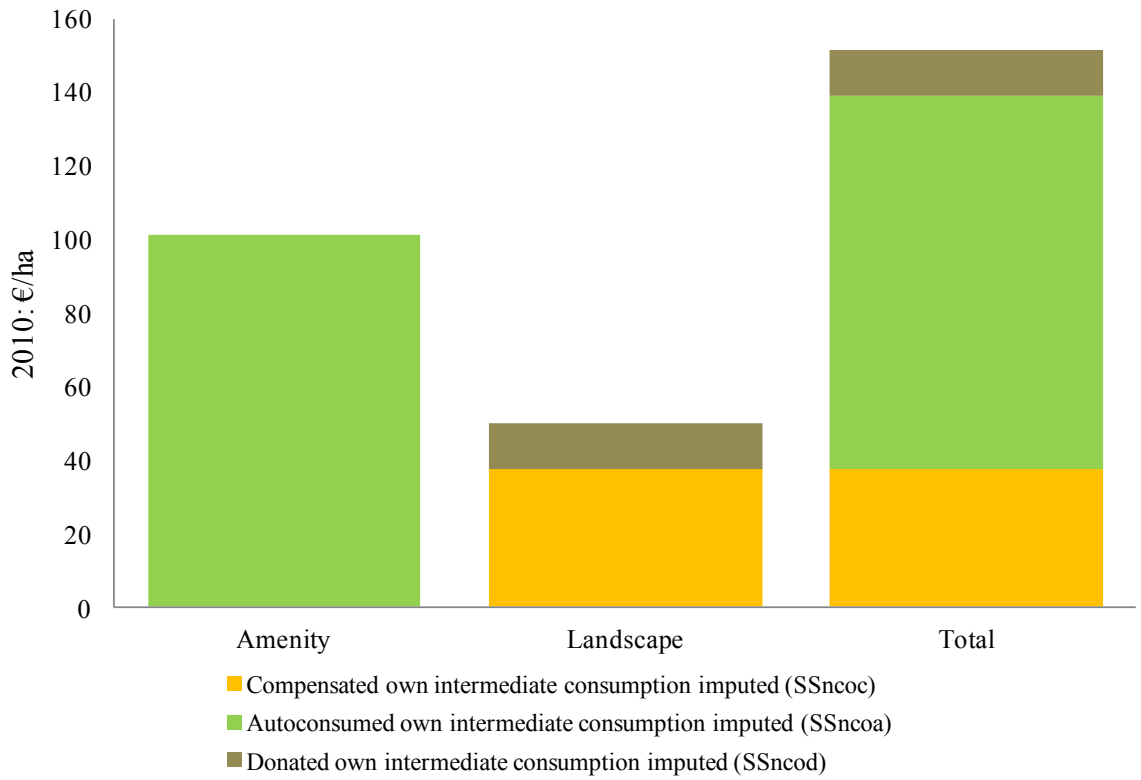

Fig. ST3. Own intermediate services consumption (SSo) imputed for cork oak open woodlands of Andalusia (2010: €/ha).

Supplementary tables for

Measuring environmental incomes: System of National Accounts and Agroforestry Accounting System applied to cork oak open woodlands in Andalusia, Spain

Table S1. Cork oak open woodlands extended production account at social prices in Andalusia, Spain (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	Cork oak open woodlands
	1	2	3	4	5	6	7	8	9=∑1-8	10	11	12	13	14	15	16	17=∑10-16	18=9+17
1. Total product (TP)	0.7	172.5	0.2	0.8	33.6	10.5	14.7	351.5	584.5	48.4	52.9	27.3	72.2	224.3	15.2	77.7	518.0	1,102.5
1.1 Intermediate product (IP)					33.6	6.7	14.7		54.9	42.7							42.7	97.6
1.1.1 Raw materials (IRM)					33.6				33.6									33.6
1.1.1.1 Livestock grass and browse grazed (IRMglg)					22.1				22.1									22.1
1.1.1.2 Livestock acorn grazed (IRMgla)					1.4				1.4									1.4
1.1.1.3 Game grazed fodder (IRMgg)					10.1				10.1									10.1
1.1.2 Services (ISS)						6.7	14.7		21.3	42.7							42.7	64.0
1.1.2.1 Commercial (ISSc)						6.7	14.7		21.3	42.7							42.7	64.0
1.1.2.2 Non-commercial (ISSnc)																		
1.2 Final product (FP)	0.7	172.5	0.2	0.8		3.9		351.5	529.6	5.7	52.9	27.3	72.2	224.3	15.2	77.7	475.3	1,004.9
1.2.1 Final product cosumed (FPc)	0.5	98.3	0.1	0.8				351.5	451.3		52.0	27.3	72.2	223.6	14.1	77.7	466.9	918.1
1.2.1.1 Sales (FPs)	0.5	98.3	0.1	0.8					99.7									99.7
1.2.1.2 Autoconsumption (FPa)			0.0					351.5	351.6									351.6
1.2.1.3 Other final product (FPo)																		
1.2.1.4 Public goods and services (PGS)											52.0	27.3	72.2	223.6	14.1	77.7	466.9	466.9
1.2.2 Gross capital formation (GCF)	0.2	74.2	0.1			3.9			78.3	5.7	0.9	0.0		0.7	1.1		8.4	86.7
1.2.2.1 Gross capital formation manu. (GCFm)						3.9			3.9	5.7	0.9	0.0		0.7	1.1		8.4	12.3
1.2.2.1.1 Gross fixed capital formation manu. (GFCFm)						3.9			3.9	5.7	0.9	0.0		0.7	1.1		8.4	12.3
1.2.2.1.1.1 Plantations (GFCFmp)						*3.9*			*3.9*	*0.0*							*0.0*	*3.9*
1.2.2.1.1.2 Construction (GFCFmc)										*5.1*	*0.7*	*0.0*		*0.1*	*0.8*		*6.7*	*6.7*
1.2.2.1.1.3 Others (GFCFmo)										*0.6*	*0.2*	*0.0*		*0.6*	*0.3*		*1.6*	*1.6*
1.2.2.2 Natural growth (NG)	0.2	74.2	0.1						74.4									74.4
1.2.2.2.2 Environmental gross fixed capital (GWPFe)	*0.2*	*74.2*	*0.1*						*74.4*									*74.4*
1.2.2.2.2.1Woody gross natural growth (GWPFew)	*0.2*	*74.2*	*0.1*						*74.4*									*74.4*
2. Total cost (TC)	1.2	106.7	0.1	1.5	4.2	10.5	8.8	116.0	248.8	48.3	11.3	0.1	11.6	104.4	6.9		182.6	431.5
2.1 Intermediate consumption (IC)	0.5	88.2	0.0	0.2	0.5	3.5	0.7	116.0	209.6	14.2	4.3	0.0		98.9	2.0		119.5	329.1
2.1.1 Raw materials (RM)	0.1	0.7	0.0	0.1	0.3	0.0	0.2		1.4	0.1	0.1	0.0		0.1	0.0		0.3	1.7
2.1.1.1 Bought raw materials (RMb)	0.1	0.7	0.0	0.1	0.3	0.0	0.2		1.4	0.1	0.1	0.0		0.1	0.0		0.3	1.7
2.1.1.2 Own raw materials (RMo)																		
2.1.2 Services (SS)	0.2	2.5	0.0	0.1	0.2	3.4	0.6	116.0	122.9	14.1	4.2	0.0		98.9	1.9		119.2	242.1
2.1.2.1 Bought services (SSb)	0.2	2.5	0.0	0.1	0.2	3.4	0.6		7.0	14.1	1.8	0.0		1.9	1.9		19.7	26.7
2.1.2.2 Own services (SSo)								116.0	116.0		2.4			97.0	0.0		99.5	215.4
2.1.3 Environmental work in progress used (WPue)	0.2	85.1	0.0						85.3									85.3
2.1.3.1 Timber harvested (WPuet)	0.2								0.2									0.2
2.1.3.2 Cork stripping (WPuec)		85.1							85.1									85.1
2.1.3.3 Firewood pruning (WPuef)			0.0						0.0									0.0
2.2 Labor cost (LC)	0.6	18.4	0.0	1.3	2.6	6.6	2.9		32.4	30.9	5.0	0.1		4.6	4.3		45.0	77.4
2.3 Consumption of fixed capital (CFC)	0.0		0.0	0.0	1.2	0.4	5.2		6.8	3.2	1.9	0.0	11.6	0.8	0.6		18.2	25.0
2.3.1 Plantations (CFCp)	0.0					0.4			0.4									0.4
2.3.2 Constructions (CFCc)	0.0			0.0	1.1		5.2		6.3	1.7	1.7	0.0		0.2	0.2		3.8	10.1
2.3.3 Equipments (CFCeq)	0.0		0.0	0.0	0.0		0.0		0.1	0.3	0.0	0.0		0.1	0.0		0.5	0.6
2.3.4 External environmental (CFCe)													11.6				11.6	11.6
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)	-0.5	65.9	0.1	-0.7	29.4	0.0	5.9	235.6	335.7	0.1	41.7	27.2	60.5	119.9	8.4	77.7	335.4	671.0
3.1. Environmental net operating margin (NOMe)	0.2	74.2	0.1		28.7			235.6	338.7		40.0	27.1	60.5	119.7	8.1	77.7	333.1	671.9
3.1.1.Ordinary net operating margin (NOMeo)					28.7			235.6	264.3		40.0	27.1	72.2	119.7	8.1	77.7	344.8	609.0
3.1.2. Investment net operating margin (NOMei)	0.2	74.2	0.1						74.4				-11.6				-11.6	62.8
3.2. Manufactured net operating margin (NOMm)	-0.7	-8.4	0.1	-0.7	0.7	0.0	5.9		-3.1	0.1	1.7	0.0		0.2	0.2		2.2	-0.8
4. Net value added (NVA = LC + NOM)	0.1	84.3	0.1	0.6	32.0	6.6	8.8	235.6	368.0	31.0	46.7	27.3	60.5	124.5	12.7	77.7	380.3	748.4
5. Ordinary total cost (TCo)	1.2	106.7	0.1	1.5	4.2	6.6	8.8	116.0	245.0	42.6	10.3	0.1		103.7	5.8		162.6	407.6
6. Investment total cost (TCi)						3.9			3.9	5.7	0.9	0.0	11.6	0.7	1.1		20.1	23.9

Table S2. Cork oak open woodlands extended capital account: work in progress and fixed capital in Andalusia, Spain (2010: €/ha).

Class	1.	2. Capital entries				3. Capital withdrawals						4.	5.
	Opening capital (Co)	2.1 Bought (Ceb)	2.2 Own (Ceo)	2.3 Others (Ceot)	2.4 Total (Ce)	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)	Revaluation (Cr)	Closing capital (Cc)
1. Capital (C=WP+FC)	17,954.6	0.6	86.7	72.2	159.5	85.3		0.0	142.3	11.6	239.3	-23.5	17,851.2
2. Work in progress (WP)	462.8		74.4		74.4	85.3			72.3		157.6	107.6	487.3
Timber (WPt)	12.2		0.2		0.2	0.2			0.2		0.4	1.1	13.1
Cork (WPc)	446.4		74.2		74.2	85.1			72.1		157.1	106.3	469.7
Firewood (WPf)	4.3		0.1		0.1	0.0			0.0		0.1	0.2	4.5
3. Fixed capital (FC)	17,491.7	0.6	12.3	72.2	85.1			0.0	70.1	11.6	81.7	-131.1	17,363.9
3.1 Land (FCl)	13,759.1			72.2	72.2				70.1	11.6	81.7	-271.2	13,478.4
3.1.1 Commercial (FCco)	1,154.6											4.9	1,159.5
Timber (FClt)	4.9											0.2	5.1
Cork (FClc)	133.1											4.3	137.4
Firewood (FClf)	12.1											0.4	12.4
Nuts (FCln)	0.3											0.0	0.3
Livestock grass and browse grazed (FClg)	701.8												701.8
Livestock acorns grazed (FCla)	2.4											0.1	2.5
Game grazed fodder (FClh)	299.9												299.9
3.1.2 Environmental (FCle)	12,604.5			72.2	72.2				70.1	11.6	81.7	-276.1	12,318.9
Amenity (FClea)	3,930.8											-306.1	3,624.7
Recreation (FCler)	1,434.7												1,434.7
Mushrooms (FClem)	903.9												903.9
Carbon (FClec)	907.9			72.2	72.2				70.1	11.6	81.7	30.0	928.3
Landscape (FClel)	3,993.7												3,993.7
Biodiversity (FCleb)	278.5												278.5
Water (FClew)	1,155.0												1,155.0
3.2 Biological resources (FCbr)	3,056.7											178.1	3,234.8
Timber (FCbrt)	0.2											0.0	0.2
Cork (FCbrc)	3,034.5											177.2	3,211.8
Firewood (FCbrf)	14.4											0.7	15.1
Nuts (FCbrn)	1.3											0.0	1.3
Acorns (FCbra)	6.2											0.2	6.4
3.3 Plantations (FCp)	45.8		3.9		3.9							0.2	49.9
3.4 Infrastructure (FCco)	612.4		6.7		6.7							-36.8	582.4
3.5 Equipments (FCe)	3.4	0.6			0.6			0.0			0.0	0.0	4.0
3.9 Others (FCo)	14.4		1.6		1.6							-1.5	14.5

Table S3. Cork oak open woodlands extended capital account: produced and expected work in progress in Andalusia, Spain (2010: €/ha).

Class	1.	2. Capital entries				3. Capital withdrawals						4.	5.
	Opening capital (Co)	2.1 Bought (Ceb)	2.2 Own (Ceo)	2.3 Others (Ceot)	2.4 Total (Ce)	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)	Revaluation (Cr)	Closing capital (Cc)
1. Work in progress (WP)	462.8		74.4		74.4	85.3			72.3		157.6	107.6	487.3
Timber (WPt)	12.2		0.2		0.2	0.2			0.2		0.4	1.1	13.1
Cork (WPc)	446.4		74.2		74.2	85.1			72.1		157.1	106.3	469.7
Firewood (WPf)	4.3		0.1		0.1	0.0			0.0		0.1	0.2	4.5
1.1 Produced (WPp)	209.0		74.4		74.4	85.3					85.3	21.1	219.3
Timber (WPt)	3.8		0.2		0.2	0.2					0.2	0.2	3.9
Cork (WPc)	201.7		74.2		74.2	85.1					85.1	20.8	211.6
Firewood (WPf)	3.6		0.1		0.1	0.0					0.0	0.1	3.7
1.2 Expected (WPe)	253.8								72.3		72.3	86.5	268.0
Timber (WPt)	8.4								0.2		0.2	0.9	9.1
Cork (WPc)	244.7								72.1		72.1	85.5	258.1
Firewood (WPf)	0.7								0.0		0.0	0.1	0.7

Table S4. Cork oak open woodlands extended account opening capital in Andalusia, Spain (2010: €/ha).

Class	Opening environmental asset			Opening manufactured capital			Opening capital		
	Farmer	Government	Total	Farmer	Government	Total	Farmer	Government	Total
Timber	17.3		17.3	1.5		1.5	18.8		18.8
Cork	3,614.0		3,614.0	40.5		40.5	3,654.5		3,654.5
Firewood	30.8		30.8	0.0		0.0	30.8		30.8
Nuts	1.6		1.6	0.0		0.0	1.6		1.6
Grazing	1,010.3		1,010.3	21.3		21.3	1,031.7		1,031.7
Livestock grass and browse grazed	701.8		701.8	21.3		21.3	723.2		723.2
Livestock acorn grazed	8.6		8.6				8.6		8.6
Game grazed fodder	299.9		299.9				299.9		299.9
Conservation forestry				45.2		45.2	45.2		45.2
Residential				455.3		455.3	455.3		455.3
Amenity	3,930.8		3,930.8				3,930.8		3,930.8
Fire services					49.6	49.6		49.6	49.6
Recreation		1,434.7	1,434.7		53.4	53.4		1,488.2	1,488.2
Mushrooms		903.9	903.9		1.2	1.2		905.1	905.1
Carbon		907.9	907.9					907.9	907.9
Landscape		3,993.7	3,993.7		2.8	2.8		3,996.4	3,996.4
Biodiversity		278.5	278.5		5.1	5.1		283.6	283.6
Water		1,155.0	1,155.0					1,155.0	1,155.0
Total	8,604.9	8,673.7	17,278.6	563.8	112.2	676.0	9,168.7	8,785.9	17,954.6

Table S5. Cork oak open woodlands farmer refined standard accounts summary of production, income generation, accumulation and adjusted for change of environmental net worth in Andalusia, Spain (2010: €/ha).

Class	Timber	Cork	Firewood	Nuts	Grazing	Conservation. forestry	Residential	Amenity	Farmer
	1	2	3	4	5	6	7	8	9=∑1-8
1. Total product consumption (TPc_{bp})	0.5	98.3	0.1	0.8	33.6	6.7	14.7	14.7	169.3
1.1 Intermediate product (IP_{bp})					33.6	6.7	14.7		54.9
1.1.1 Raw materials (IRM)					33.6				33.6
1.1.1.1 Grass and browse (IRMgb)					22.1				22.1
1.1.1.2. Acorn (IRMa)					1.4				1.4
1.1.1.3 Game grazing (IRMh)					10.1				10.1
1.1.2 Services (ISS)						6.7	14.7		21.3
1.1.2.1 Commercial (ISSc)						6.7	14.7		21.3
1.1.2.2 Compensated (ISSncc)									
1.2 Final product consumed (FPc_{pp})	0.5	98.3	0.1	0.8				14.7	114.4
2. Refined ordinary intermediate consumption (ICo_{Sr})	0.5	88.2	0.0	0.2	0.5	2.1	0.7	14.7	107.0
2.1 Manufactured bought (ICmob)	0.3	3.2	0.0	0.2	0.5	2.1	0.7		7.0
2.2 Manufactured own (ICmo)								14.7	14.7
2.3 Environmental work in progress used (WPeu)	0.2	85.1	0.0						85.3
3. Ordinary labor cost (LCor)	0.6	18.4	0.0	1.3	2.6	4.1	2.9		29.8
3.1 Employee (LCeor)	0.6	18.4	0.0	1.3	2.6	4.1	2.9		29.8
4. Ordinary consumption of manu. fixed capital (CFCmo)	0.0		0.0	0.0	1.2	0.4	5.2		6.8
5. Ordinary net operating margin ($NOMo_{bp,S}$)	-0.7	-8.4	0.1	-0.7	29.4	0.0	5.9		25.7
5.1 Manufactured net operating margin ($NOMmo_{bp,S}$)	-0.7	-8.4	0.1	-0.7	0.7	0.0	5.9		-3.1
5.2 Environmental net operating margin ($NOMeo_S$)					28.7				28.7
6. Refined ordinary net value added ($NVAo_{bp,Sr}$)	0.0	10.1	0.1	0.6	32.0	4.1	8.8		55.5
7. Refined gross capital formation (GCF_{Sr})	0.2	74.2	0.1			3.9			78.3
7.1 Manufactured (GCFm)						3.9			3.9
7.2 Natural growth (NG)	0.2	74.2	0.1						74.4
8. Investment intermediate consumption (ICmib)						1.3			1.3
9. Investment labor cost (LCi)						2.5			2.5
10. Investment consumption of manu. fixed capital (CFCmi)									
11. Refined investment net operating margin ($NOMi_{Sr}$)	0.2	74.2	0.1						74.4
11.1 Manufactured net operating margin (NOMmi)									
11.2 Environmental net operating margin ($NOMei_{Sr}$)	0.2	74.2	0.1						74.4
12. Refined investment net value added ($NVAmi_{Sr}$)	0.2	74.2	0.1			2.5			77.0
13. Refined total product ($TP_{bp,Sr}$)	0.7	172.5	0.2	0.8	33.6	10.5	14.7	14.7	247.6
14. Refined intermediate consumption (IC_{Sr})	0.5	88.2	0.0	0.2	0.5	3.5	0.7	14.7	108.3
14.1 Bought (ICb)	0.3	3.2	0.0	0.2	0.5	3.5	0.7		8.3
14.2 Own (ICo)								14.7	14.7
14.3 Environmental work in progress used (WPeu)	0.2	85.1	0.0						85.3
15. Labor cost (LC)	0.6	18.4	0.0	1.3	2.6	6.6	2.9		32.4
15.1 Employee (LCe)	0.6	18.4	0.0	1.3	2.6	6.6	2.9		32.4
16. Consumption of manufactured fixed capital (CFCm)	0.0		0.0	0.0	1.2	0.4	5.2		6.8
17. Refined net operating margin ($NOM_{bp,Sr}$)	-0.5	65.9	0.1	-0.7	29.4	0.0	5.9		100.1
17.1 Manufactured net operating margin ($NOMm_{bp,S}$)	-0.7	-8.4	0.1	-0.7	0.7	0.0	5.9		-3.1
17.2 Environmental net operating margin ($NOMe_{Sr}$)	0.2	74.2	0.1		28.7				103.2
18. Refined net value added ($NVAr_{bp,Sr}$)	0.1	84.3	0.1	0.6	32.0	6.6	8.8		132.5
19. Refined gross value added ($GVAr_{bp,Sr}$)	0.2	84.3	0.1	0.6	33.1	7.1	13.9		139.3
20. Refined gross operating margin ($GOMr_{bp,Sr}$)	-0.4	65.9	0.1	-0.7	30.6	0.5	11.1		106.9
21 Refined environmental income ($EI_{bp,Sr}$)	1.3	290.0	1.3	0.0	28.9			-306.1	15.5
21.1 Ecosystem services ($ES_{bp,S}$)	0.2	85.1	0.0		28.7				114.0
21.2 WPeu adjusted for change of environmental net worth (CNWead)	1.1	204.9	1.3	0.0	0.2			-306.1	-98.5

Table S6. Cork oak open woodlands social refined standard accounts summary of production, income generation, accumulation and adjusted for change of environmental net worth in Andalusia, Spain (2010: €/ha).

Class	Farmer	Fire services	Recreation	Mushrooms	Carbon	Landscape	Biodiversity	Water	Government	Cork oak open woodlands
	9	10	11	12	13	14	15	16	17=∑10-16	18=9+17
1. Total product consumption (TPc_{bp})	169.3	42.7	10.3	27.3		91.2	5.8	66.0	243.4	412.7
1.1 Intermediate product (IP_{bp})	54.9	42.7							42.7	97.6
1.1.1 Raw materials (IRM)	33.6									33.6
1.1.1.1 Grass and browse (IRMgb)	22.1									22.1
1.1.1.2. Acorn (IRMa)	1.4									1.4
1.1.1.3 Recreational standing game hunted (IRMh)	10.1									10.1
1.1.2 Services (ISS)	21.3	42.7							42.7	64.0
1.1.2.1 Commercial (ISSc)	21.3	42.7							42.7	64.0
1.1.2.2 Compensated (ISSncc)										
1.2 Final product consumed (FPc_{pp})	114.4		10.3	27.3		91.2	5.8	66.0	200.7	315.0
2. Refined ordinary intermediate consumption (ICo_{Sr})	107.0	12.4	4.1	0.0		86.2	1.6		104.4	211.4
2.1 Manufactured bought (ICmob)	7.0	12.4	1.6	0.0		1.7	1.6		17.4	24.4
2.2 Manufactured own (ICmo)	14.7		2.4			84.5	0.0		87.0	101.6
2.3 Environmental work in progress used (WPeu)	85.3									85.3
3. Ordinary labor cost (LCor)	29.8	27.0	4.4	0.1		4.2	3.5		39.2	69.0
3.1 Employee (LCeor)	29.8	27.0	4.4	0.1		4.2	3.5		39.2	69.0
4. Ordinary consumption of manu. fixed capital (CFCmo)	6.8	3.2	1.9	0.0		0.8	0.6		6.5	13.4
5. Ordinary net operating margin ($NOMo_{bp,S}$)	25.7	0.1		27.2		0.0		66.0	93.3	118.9
5.1 Manufactured net operating margin ($NOMmo_{bp,S}$)	-3.1	0.1		0.0			0.0		0.1	-2.9
5.2 Environmental net operating margin ($NOMeo_S$)	28.7			27.1			0.0	66.0	93.1	121.9
6. Refined ordinary net value added ($NVAo_{bp,Sr}$)	55.5	27.1	4.4	27.2		4.2	3.5	66.0	132.4	187.9
7. Refined gross capital formation (GCF_{Sr})	78.3	5.7	0.9	0.0		0.7	1.1		8.4	86.7
7.1 Manufactured (GCFm)	3.9	5.7	0.9	0.0		0.7	1.1		8.4	12.3
7.2 Natural growth (NG)	74.4									74.4
8. Investment intermediate consumption (ICmib)	1.3	1.8	0.2	0.0		0.2	0.3		2.6	3.9
9. Investment labor cost (LCi)	2.5	3.9	0.7	0.0		0.5	0.8		5.8	8.4
10. Investment consumption of manu. fixed capital (CFCmi)										
11. Refined investment net operating margin ($NOMi_{Sr}$)	74.4									74.4
11.1 Manufactured net operating margin (NOMmi)										
11.2 Environmental net operating margin ($NOMei_{Sr}$)	74.4									74.4
12. Refined investment net value added ($NVAmi_{Sr}$)	77.0	3.9	0.7	0.0		0.5	0.8		5.8	82.8
13. Refined total product ($TP_{bp,Sr}$)	247.6	48.4	11.3	27.3		91.9	6.9	66.0	251.8	499.4
14. Refined intermediate consumption (IC_{Sr})	108.3	14.2	4.3	0.0		86.4	2.0		107.0	215.3
14.1 Bought (ICb)	8.3	14.2	1.9	0.0		1.9	1.9		20.0	28.3
14.2 Own (ICo)	14.7		2.4			84.5	0.0		87.0	101.6
14.3 Environmental work in progress used (WPeu)	85.3									85.3
15. Labor cost (LC)	32.4	30.9	5.0	0.1		4.6	4.3		45.0	77.4
15.1 Employee (LCe)	32.4	30.9	5.0	0.1		4.6	4.3		45.0	77.4
16. Consumption of manufactured fixed capital (CFCm)	6.8	3.2	1.9	0.0		0.8	0.6		6.5	13.4
17. Refined net operating margin ($NOM_{bp,Sr}$)	100.1	0.1		27.2				66.0	93.3	193.4
17.1 Manufactured net operating margin ($NOMm_{bp,S}$)	-3.1	0.1		0.0			0.0		0.1	-2.9
17.2 Environmental net operating margin ($NOMe_{Sr}$)	103.2			27.1			0.0	66.0	93.1	196.3
18. Refined net value added ($NVAr_{bp,Sr}$)	132.5	31.0	5.0	27.3		4.6	4.3	66.0	138.3	270.7
19. Refined gross value added ($GVAr_{bp,Sr}$)	139.3	34.2	6.9	27.3		5.5	4.9	66.0	144.8	284.1
20. Refined gross operating margin ($GOMr_{bp,Sr}$)	106.9	3.2	1.9	27.2		0.8	0.6	66.0	99.8	206.8
21 Refined environmental income ($EI_{bp,Sr}$)	15.5			27.1			0.0	66.0	93.1	108.6
21.1 Ecosystem services ($ES_{bp,S}$)	114.0			27.1			0.0	66.0	93.1	207.2
21.2 WPeu adjusted for change of environmental net worth (CNWead)	-98.5									-98.5

Table S7. Cork oak open woodlands extended account total product and net valued added in Andalusia, Spain (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	Cork oak open woodlands
	1	2	3	4	5	6	7	8	9=∑1-8	10	11	12	13	14	15	16	17=∑11-16	18=9+17
1. Total product (TP_{sp})	0.7	172.5	0.2	0.8	33.6	10.5	14.7	351.5	584.5	48.4	52.9	27.3	72.2	224.3	15.2	77.7	518.0	1,102.5
1.1 Intermediate product (IP_{sp})					33.6	6.7	14.7		54.9	42.7							42.7	97.6
1.2 Final product (FP_{pp})	0.7	172.5	0.2	0.8		3.9		351.5	529.6	5.7	52.9	27.3	72.2	224.3	15.2	77.7	475.3	1,004.9
1.2.1 Final product consumption (FPc_{pp})	0.5	98.3	0.1	0.8				351.5	451.3		52.0	27.3	72.2	223.6	14.1	77.7	466.9	918.1
1.2.2 Gross capital formation (GCF)	0.2	74.2	0.1			3.9			78.3	5.7	0.9	0.0		0.7	1.1		8.4	86.7
1.2.2.1 Manufactured (GCFm)						3.9			3.9	5.7	0.9	0.0		0.7	1.1		8.4	12.3
1.2.2.2 Natural growth (NG)	0.2	74.2	0.1						74.4									74.4
2. Intermediate consumption (IC_{sp})	0.5	88.2	0.0	0.2	0.5	3.5	0.7	116.0	209.6	14.2	4.3	0.0		98.9	2.0		119.5	329.1
2.1 Manufactured intermediate consumption (ICm)	0.3	3.2	0.0	0.2	0.5	3.5	0.7	116.0	124.3	14.2	4.3	0.0		98.9	2.0		119.5	243.8
2.1.1 Bought (ICmb)	0.3	3.2	0.0	0.2	0.5	3.5	0.7		8.3	14.2	1.9	0.0		1.9	1.9		20.0	28.3
2.1.2 Own ($ICmo_{sp}$)								116.0	116.0		2.4			97.0	0.0		99.5	215.4
2.1.3 Manufactured work in progress used (WPmu)																		
2.2 Environmental intermediate consumption (ICe)	0.2	85.1	0.0						85.3									85.3
2.2.1 Environmental work in progress used (WPeu)	0.2	85.1	0.0						85.3									85.3
3. Consumption of fixed capital (CFC)	0.0		0.0	0.0	1.2	0.4	5.2		6.8	3.2	1.9	0.0	11.6	0.8	0.6		18.2	25.0
4. Net value added (NVA_{sp}) (TP_{sp}-IC_{sp}-CFC)	0.1	84.3	0.1	0.6	32.0	6.6	8.8	235.6	368.0	31.0	46.7	27.3	60.5	124.5	12.7	77.7	380.3	748.4
5. Compensation of employees (LC)	0.6	18.4	0.0	1.3	2.6	6.6	2.9		32.4	30.9	5.0	0.1		4.6	4.3		45.0	77.4
6. Net operating margin (NOM_{sp})	-0.5	65.9	0.1	-0.7	29.4	0.0	5.9	235.6	335.7	0.1	41.7	27.2	60.5	119.9	8.4	77.7	335.4	671.0
6.1 Manufactured net operating margin ($NOMm_{sp}$)	-0.7	-8.4	0.1	-0.7	0.7	0.0	5.9		-3.1	0.1	1.7	0.0		0.2	0.2		2.2	-0.8
6.2 Environmental net operating margin (NOMe)	0.2	74.2	0.1		28.7			235.6	338.7		40.0	27.1	60.5	119.7	8.1	77.7	333.1	671.9

Table S8. Cork oak open woodlands extended account summary of production, income generation, accumulation and change of environmental net worth in Andalusia, Spain (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	Govern-ment	Cork oak open woodlands
	1	2	3	4	5	6	7	8	9=∑1-8	10	11	12	13	14	15	16	17=∑11-16	18=9+17
1. Total product (TP_{sp})	0.7	172.5	0.2	0.8	33.6	10.5	14.7	351.5	584.5	48.4	52.9	27.3	72.2	224.3	15.2	77.7	518.0	1,102.5
2 Manufactured intermediate consumption (ICm_{sp})	0.3	3.2	0.0	0.2	0.5	3.5	0.7	116.0	124.3	14.2	4.3	0.0		98.9	2.0		119.5	243.8
2.1 Bought (ICb)	0.3	3.2	0.0	0.2	0.5	3.5	0.7		8.3	14.2	1.9	0.0		1.9	1.9		20.0	28.3
2.2 Own (ICo_{sp})								116.0	116.0		2.4			97.0	0.0		99.5	215.4
2.3 Manufactured work in progress used (WPmu)																		
3. Labor cost (LC)	0.6	18.4	0.0	1.3	2.6	6.6	2.9		32.4	30.9	5.0	0.1		4.6	4.3		45.0	77.4
4. Consumption of fixed capital (CFC)	0.0		0.0	0.0	1.2	0.4	5.2		6.8	3.2	1.9	0.0	11.6	0.8	0.6		18.2	25.0
5. Ordinary manufactured net operating margin ($NOMmo_{sp}$)	-0.7	-8.4	0.1	-0.7	0.7	0.0	5.9		-3.1	0.1	1.7	0.0		0.2	0.2		2.2	-0.8
6. Investment net operating margin (NOMi)	0.2	74.2	0.1						74.4	0.0	0.0		-11.6	0.0			-11.6	62.8
7. Ecosystem services (ES_{sp})	0.2	85.1	0.0		28.7			235.6	349.6		40.0	27.1	72.2	119.7	8.1	77.7	344.8	694.4
7.1 Environmental work in progress used (WPue)	0.2	85.1	0.0						85.3									85.3
7.2 Ordinary environmental net operating margin (NOMeo)					28.7			235.6	264.3		40.0	27.1	72.2	119.7	8.1	77.7	344.8	609.0
8. Net value added (NVA_{sp}) (TP_{sp} – ICm_{sp} - WPue CFC)	0.1	84.3	0.1	0.6	32.0	6.6	8.8	235.6	368.0	31.0	46.7	27.3	60.5	124.5	12.7	77.7	380.3	748.4
8.1 Compensation of employees (LC)	0.6	18.4	0.0	1.3	2.6	6.6	2.9		32.4	30.9	5.0	0.1		4.6	4.3		45.0	77.4
8.2 Net operating margin (NOM_{sp})	-0.5	65.9	0.1	-0.7	29.4	0.0	5.9	235.6	335.7	0.1	41.7	27.2	60.5	119.9	8.4	77.7	335.4	671.0
8.2.1 Manufactured net operating margin ($NOMm_{sp}$)	-0.7	-8.4	0.1	-0.7	0.7	0.0	5.9		-3.1	0.1	1.7	0.0		0.2	0.2		2.2	-0.8
8.2.2 Environmental net operating margin ($NOMe_{sp}$)	0.2	74.2	0.1		28.7			235.6	338.7		40.0	27.1	60.5	119.7	8.1	77.7	333.1	671.9
9. Capital gain (CG)	1.2	214.4	1.2	0.1	0.7	0.6	-21.7	-306.1	-109.6	-3.7	0.6	0.0	-40.1	0.4	0.0		-42.8	-152.4
9.1 Manufactured (CGm)	0.0	-1.4	0.0	0.0	0.5	0.6	-21.7		-21.9	-3.7	0.6	0.0		0.4	0.0		-2.7	-24.7
9.2 Environmental (EAg)	1.1	215.7	1.2	0.0	0.2			-306.1	-87.7				-40.1				-40.1	-127.8
9.2.1 Environmental asset revaluation (EAr)	1.3	287.8	1.3	0.0	0.2			-306.1	-15.4				30.0				30.0	14.6
9.2.2 Growth adjusted to environmental asset (EAad)	-0.2	-72.1	0.0		0.0				-72.3				-70.1				-70.1	-142.3
10. Total income (TI_{sp})	1.3	298.6	1.4	0.6	32.6	7.3	-12.9	-70.5	258.4	27.3	47.3	27.2	20.4	124.9	12.6	77.7	337.5	595.9
10.1 Compensation of employees (LC)	0.6	18.4	0.0	1.3	2.6	6.6	2.9		32.4	30.9	5.0	0.1		4.6	4.3		45.0	77.4
10.2 Capital income (CI_{sp})	0.7	280.2	1.3	-0.6	30.1	0.7	-15.8	-70.5	226.1	-3.6	42.3	27.2	20.4	120.2	8.3	77.7	292.5	518.6
10.2.1 Manufactured capital income (CIm)	-0.6	-9.7	0.1	-0.7	1.1	0.7	-15.8		-25.0	-3.6	2.3	0.0		0.6	0.2		-0.5	-25.5
10.2.2 Environmental income (EI_{sp})	1.3	290.0	1.3	0.0	28.9			-70.5	251.1		40.0	27.1	20.4	119.7	8.1	77.7	293.0	544.1
10.2.2.1 Ecosystem services (ES_{sp})	0.2	85.1	0.0		28.7			235.6	349.6		40.0	27.1	72.2	119.7	8.1	77.7	344.8	694.4
10.2.2.2 WPeu adjusted for CNWe (CNWead)	1.1	204.9	1.3	0.0	0.2			-306.1	-98.5				-51.7				-51.7	-150.3
10.2.2.2.1 Change of environmental net worth (CNWe)	1.3	290.0	1.3	0.0	0.2			-306.1	-13.2				-51.7				-51.7	-65.0
10.2.2.2.2 Less WPeu	0.2	85.1	0.0						85.3									85.3
11. Change of environmental net worth (CNWe)	1.3	290.0	1.3	0.0	0.2			-306.1	-13.2				-51.7				-51.7	-65.0
11.1 Investment of environmental net operating margin (NOMei)	0.2	74.2	0.1						74.4				-11.6				-11.6	62.8
11.2 Environmental asset gain (EAg)	1.1	215.7	1.2	0.0	0.2			-306.1	-87.7				-40.1				-40.1	-127.8

Table S9. Cork oak open woodlands labor demand in Andalusia, Spain (2010).

Class	Quantity h/ha	Wage rate €/h	Labor cost €/ha
1. Landowner	3.1	10.5	32.4
1.1 Timber	0.1	8.5	0.6
1.2 Cork	1.9	9.7	18.4
1.3 Firewood	0.0	9.8	0.0
1.4 Nuts	0.1	8.8	1.3
1.5 Grazing	0.3	9.7	2.6
1.6 Conservation forestry	0.3	21.1	6.6
1.7 Residential	0.4	7.1	2.9
2. Government	2.1	21.3	45.0
2.1 Fire services	1.5	21.1	30.9
2.2 Recreation	0.2	22.7	5.0
2.3 Mushrooms	0.0	21.5	0.1
2.4 Landscape	0.2	21.3	4.6
2.5 Biodiversity	0.2	21.2	4.3
Total (1+2)	5.2	14.9	77.4

Table S10. Cork oak open woodlands surface in Andalusia, Spain (2010).

Class	Surface			Statistics			
	Hectares	Canopy cover fraction	Percentage	Polygons	Minimum	Maximum	Average
	ha	%	%	n	ha	ha	ha
Cork oak	34,318	41.7	13.8	969	0.1	293.8	35.4
Cork oak with secondary species and without tertiary	136,967	48.1	55.2	2,050	0.0	617.9	66.8
Cork oak with secondary and tertiary species	76,730	48.8	30.9	1,076	0.0	575.0	71.3
Total	248,015	47.4	100.0	4,095	0.0	617.9	60.6

Note: a 0.0 value denotes a value less than 0.05 ha.

Table S11. Cork oak open woodlands surface by associated species in Andalusia.

Class	Surface	
	Hectares	Percentage
Without secondary species	34,318	13.8
Quercus ilex	*89,189*	*36.0*
Without tertiary species	61,701	24.9
With tertiary species	27,489	11.1
Quercus faginea	*8,865*	*3.6*
Without tertiary species	3,127	1.3
With tertiary species	5,737	2.3
Quercus cannariensis	*38,815*	*15.7*
Without tertiary species	25,567	10.3
With tertiary species	13,248	5.3
Olea europaea	*37,648*	*15.2*
Without tertiary species	26,909	10.8
With tertiary species	10,739	4.3
Pinus halepensis	*719*	*0.3*
Without tertiary species	411	0.2
With tertiary species	308	0.1
Pinus pinea	*5,734*	*2.3*
Without tertiary species	3,217	1.3
With tertiary species	2,517	1.0
Pinus pinaster	*5,583*	*2.3*
Without tertiary species	2,128	0.9
With tertiary species	3,455	1.4
Juniperus oxycedrus	*709*	*0.3*
Without tertiary species	383	0.2
With tertiary species	326	0.1
Arbutus unedo	*15,578*	*6.3*
Without tertiary species	9,502	3.8
With tertiary species	6,075	2.4
Castanea sativa	*4,091*	*1.6*
Without tertiary species	1,081	0.4
With tertiary species	3,010	1.2
Others	6,767	2.7
Total	248,015	100.0

Table S12. Cork oak open woodlands extended account ecosystem services classification at social prices in Andalusia, Spain (2010: €/ha).

Class	Farmer	Government	Cork oak open woodlands
1. Provisioning	114.0	104.8	218.8
1.1 Timber	0.2		0.2
1.2 Cork	85.1		85.1
1.3 Firewood	0.0		0.0
1.4 Nuts	0.0		0.0
1.5 Grazing	28.7		28.7
1.5.1 Livestock grass and browse grazed	*17.2*		*17.2*
1.5.2 Livestock acorns grazed	*1.4*		*1.4*
1.5.3 Game grazed fodder	*10.1*		*10.1*
1.6 Mushrooms		27.1	27.1
1.7 Water		77.7	77.7
2. Regulating		200.0	200.0
2.1 Carbon		72.2	72.2
2.2 Landscape		119.7	119.7
2.3 Biodiversity		8.1	8.1
2.4 Conservation forestry			*n.a*$^{(*)}$
2.5 Government forestry			*n.a*$^{(*)}$
3. Cultural	235.6	40.0	275.6
3.1 Private amenity	235.6		235.6
3.2 Public recreation		40.0	40.0
3.3 Residential			*n.d*$^{(**)}$
Total	349.6	344.8	694.4

na$^{(*)}$: not apply.
nd$^{(**)}$: not data.

Supplementary figures for

Measuring environmental incomes: System of National Accounts and Agroforestry Accounting System applied to cork oak open woodlands in Andalusia, Spain

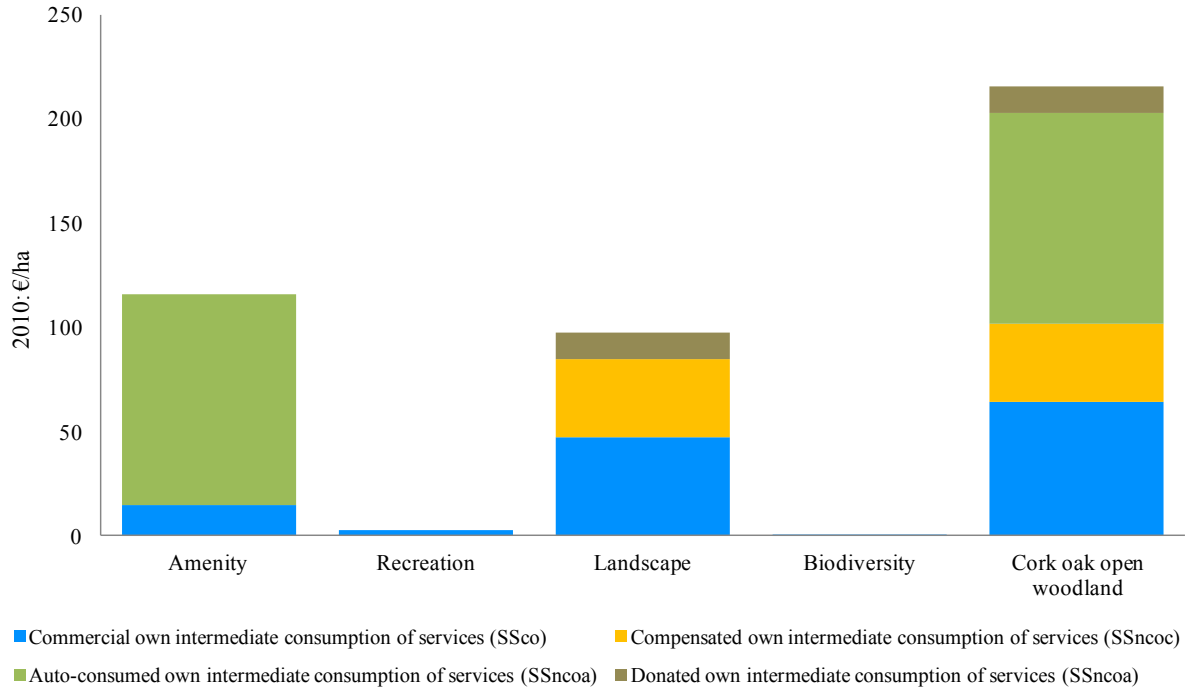

Fig. S1. Cork oak open woodlands extended accounts intermediate consumption of services (2010: €/ha).

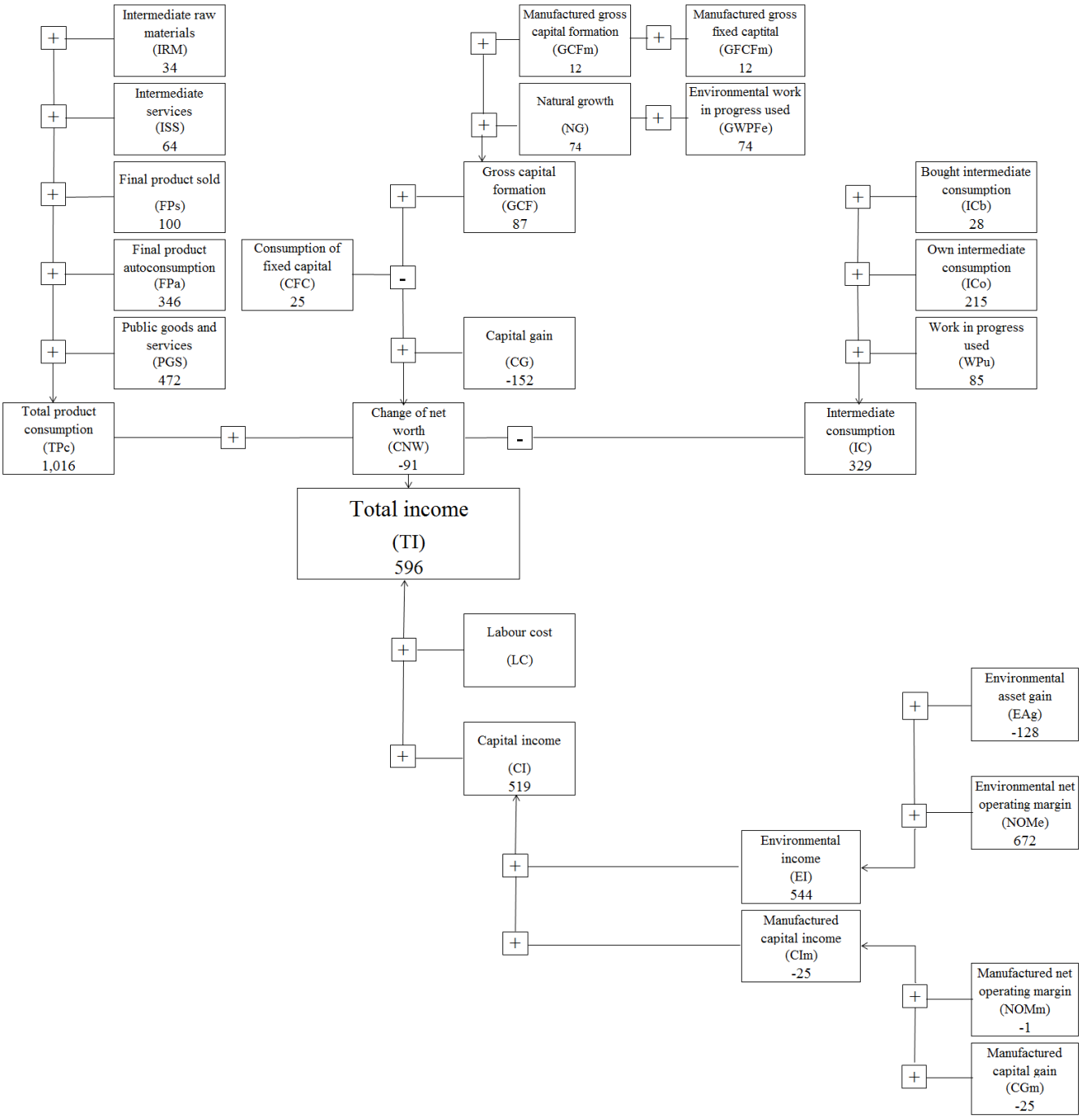

Fig. S2. Cork oak open woodlands extended accounts total income at social prices: net product consumption and change of net worth (2010: €/ha).

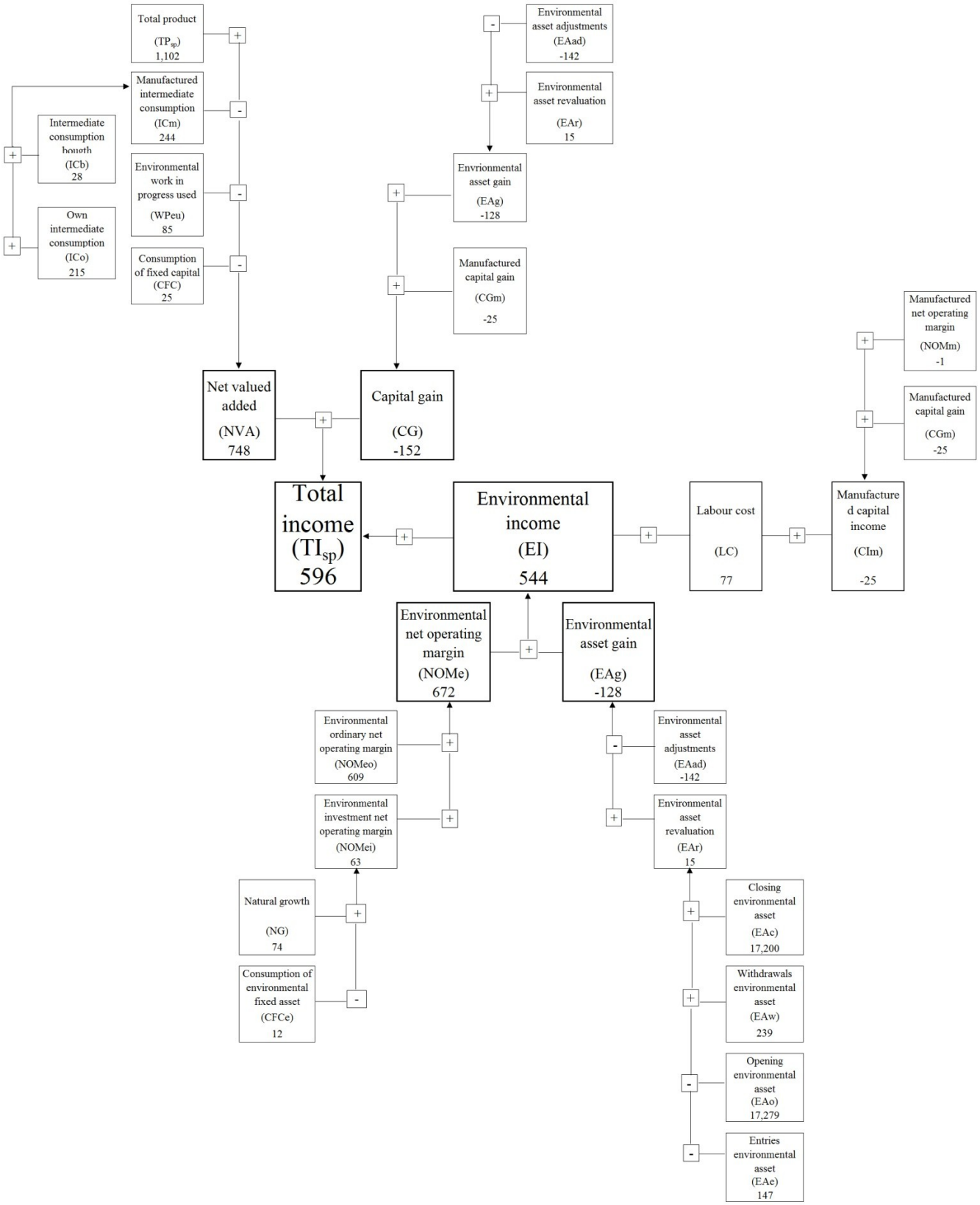

Fig. S3. Cork oak open woodlands extended accounts total income at social prices; net value added and capital gain (2010: €/ha).

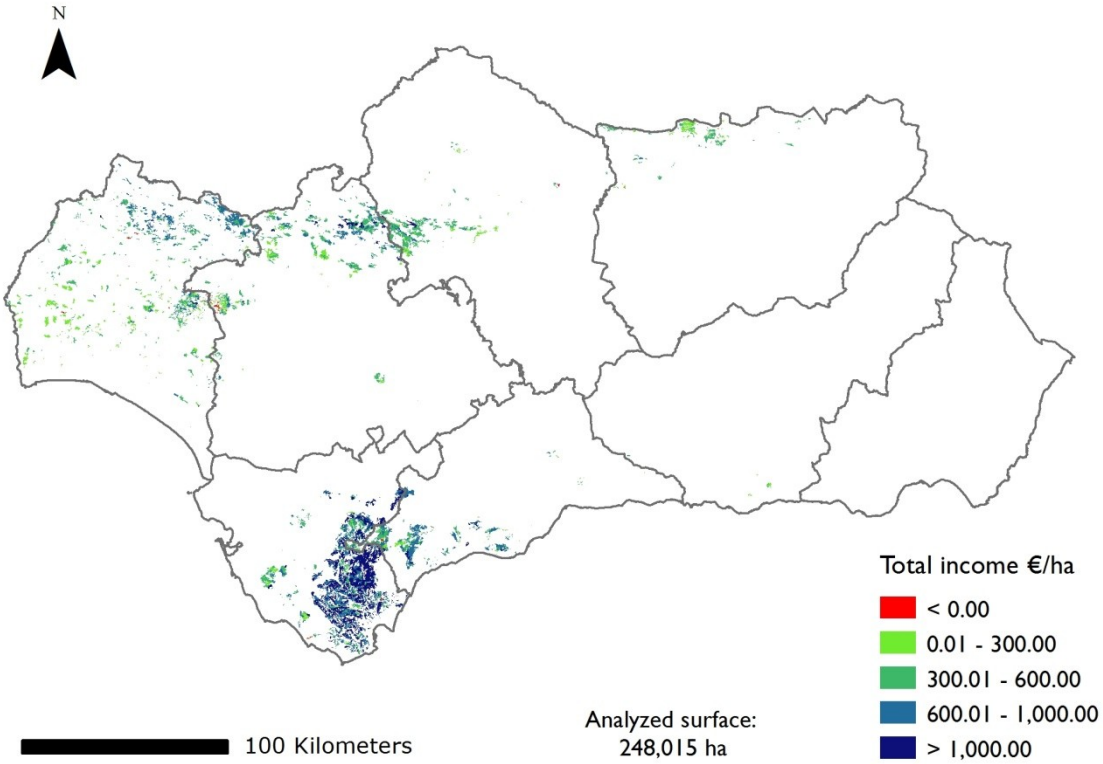

Fig. S4. Cork oak open woodlands total income at producer prices in Andalusia, Spain (2010: €/ha).

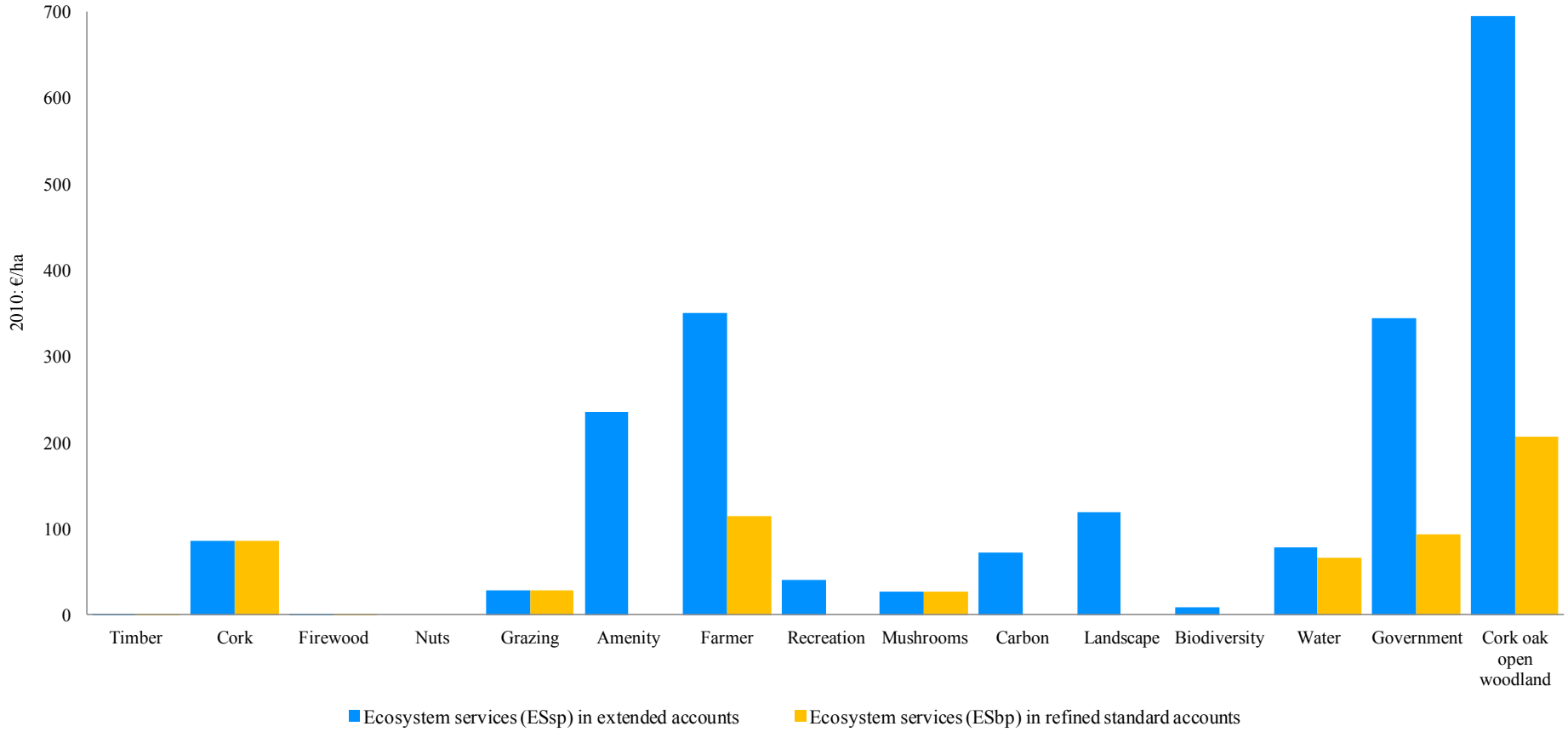

Fig. S5. Cork oak open woodlands extended and refined standard accounts comparisons of ecosystem services at social and basic prices in Andalusia, Spain (2010: €/ha).