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Ecosystem Accounting: Application to Holm Oak Open Woodlands in Andalusia-Spain[1]

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Highlights

Private amenity is the largest ecosystem service in mixed holm oak open woodlands.
Landscape ecosystem service (ES) accounts for 29% of sAAS ordinary final product.
Farmer and government sAAS ecosystem services present similar values.
Changes in environmental assets are positive for all activities except the amenity asset.
Ecosystem services of activities are lower than environmental incomes, except in the case of amenity.

Abstract

The scientific debate on how to make visible the linkages between the standard System of National Accounts (SNA) and its ongoing satellite System of Environmental Economic Accounting-Experimental Ecosystem Accounting (SEEA-EEA) is a challenge which is still pending. In previous publications we measured selected ecosystem accounting variables associated with Mediterranean forests and woodlands at market prices and simulated exchange prices in terms of ordinary net value added (NVA), ecosystem services (ES), environmental asset (EA), changes in environmental asset (CEA) and environmental income (EI) based on the experimental Agroforestry Accounting System (AAS). In this study, we applied 'own refined SNA' (rSNA) and SEEA-EEA (rSEEA-EEA) and a simplified AAS (sAAS) to measure the aforementioned environmental variables at basic and social prices for 15 economic activities considered in 1,408 thousand hectares of the predominantly mixed Holm oak open woodlands (HOW) in Andalusia-Spain. We incorporate the government institutional sector and environmental income in the rSNA and rSEEA-EEA. The government is perceived as the collective owner of public economic activities. Our objectives are to measure and discuss consistencies in total environmental incomes accruing from the results of the ecosystem accounting frameworks applied to HOW. The discrepancies in government institutional sector ecosystem services between rSEEA-EEA and sAAS are due to the omission in the former ecosystem accounting approach of the public farmer voluntary opportunity cost and government manufactured costs incurred in the supply of public final products enjoyed free by the consumers. The most relevant findings of this study are, firstly, that the EI of individual products for the period valued at social prices corresponds with the sustainable economic ecosystem services (except for private amenity), and according to the HOW scheduled modeling of future resource management, the EI also shows physical sustainability of individual natural base products. The ES and the EI of individual market products have the same values, whichever the ecosystem accounting framework applied. This is not the case with the ecosystem services of public products without market prices, due to the fact that rSNA estimates these products at production cost and rSEEA-EEA do not consider the total manufactured costs of the free final public products consumption.

Keywords: Ordinary environmental net operating margin, ecosystem services, changes in environmental asset, environmental net worth, environmental income.

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1. Introduction.

The concept of ecosystem services is defined using diverse, often controversial interpretations (Horwart and Farber, 2002). Most natural as well as social science disciplines include free (non-economic)[2] products of nature in what they term 'physical ecosystem service measurements' (Gamfeldt et al., 2013). Other authors with an economic perspective have considered the ecosystem as a non-human independent self-regenerating environmental asset in a given spatial unit, which produces non-economic and economic products (goods and services) consumed by humans in the current period[3]. Other authors with a more "sociecological" perspective add to the latter concept of ecosystem services the condition of being "direct and indirect contributions to sustainable human wellbeing" (Costanza et al., 2017: p. 8). These holistic ecosystem service definitions present a `polysemic labyrinth´, complicating the measurement of economic ecosystem services in a manner consistent with total social income theory (Campos et al., 2017, 2019a, 2019b; McElroy, 1976). This study defines the ecosystem services from a narrower economic perspective as the contribution of nature to the transaction value of ordinary[4] total product directly and indirectly consumed by people in the accounting period (Campos et al., 2019a, 2019b; European Commission et al., 2009; United Nations et al., 2014a, 2014b; United Nations, 2017).

The scientific debate over how to make visible the connections between the standard System of National Accounts (SNA) and its satellite Environmental Economic Ecosystem Accounting - Experimental Ecosystem Accounting (SEEA-EEA) is a challenge which is still pending. Mainstream proposals for discussions on the institutional sectors that should form the structure of the SEEA-EEA accounts have ignored the government institutional sector. The ongoing SEEA-EEA proposes the institutional sectors of corporations (farmers), households and ecosystems (Obst et al., 2019). We have been advocating that consistent measurement of ecosystem services (ES) and environmental assets (EA) require a refined SEEA-EEA by substituting the ecosystem for the government institutional sectors (Campos, 2019a, 2019b). In addition to the change in environmental asset (CEA), we propose the measurement of the change

[2] These non-economic values are null because of the lack of willingness to pay by people and/or entities for their consumption and or appropriation.
[3] As an example of this perspective, ecosystem services have been defined as "all the goods and services provided by an ecosystem (e.g. a forest) which benefit people" (Masiero et al., 2019: p. 12).
[4] Ordinary products exclude the final product of own-account gross capital formation, both manufactured and natural growth. The latter is incorporated when measuring the environmental income of the period.

in the environmental net worth (CNWead) adjusted in accordance with the environmental work in progress utilized (WPeu), inventoried at the opening of the period in order to estimate the EI consistently. In addition, the consequence of ignoring the ongoing SEEA-EEA manufactured costs incurred to produce final public products consumption is the overvaluation of ordinary net value added and ecosystem services. The environmental income (EI) omission in the ongoing EEAS-EEA is an odd convention. The EI offers a reference synthetic environmental-economic indicator that shows the maximum value of sustainable ecosystem services that can be embedded in consumed total products in the period without depleting and degrading the opening environmental assets at the closing of the period.

Due to the absence of an applicable complete reference framework of economic accounts for ecosystems it is important that we provide a summary of our methodological approach which is intended to be consistent with the spirit of the SEEA-EEA in revealing the hidden economy of nature which is embedded in our current and future goods and services consumptions, addressing our consumption through sustainable management of the natural and cultural resources of silvopastoral landscapes (Atkinson and Obst, 2017).

Simultaneous application of the SEEA-EEA guidelines to the total products consumption of the different types of ecosystem which comprise the silvopastoral landscape at national/regional scales, in which the SNA measurements are integrated, is still unusual in scientific literature. At regional scale, applications by Ogilvy et al. (2018), Remme et al. (2015) y Sumarga et al. (2015) are some of the most notable exceptions as regards agrarian landscapes. As far as we know, the application of our experimental Agroforestry Accounting System (AAS) to the forests of Andalusia are the only exception to the absence of publications of a complete framework for production and balance accounts for forests at regional scale incorporated in the SNA and beyond (Campos et al., 2019a).

Other authors follow the approach of wealth accounting to estimate concepts such as “value added” or “ecosystem income”, referring to the change in environmental assets of ecosystems in a period from the theoretical perspective of welfare economics. In other words, by incorporating the concept of wealth accounting the consumer surpluses in the estimation of “profits” and environmental asset gains will not be

consistent with the change value applied by the SNA (Narita et al., 2018)[5]. In practice, in wealth accounting applied to forests, the authors accept that the "value added" estimated by the change in the environmental asset is consistent with its integration in the SNA where there are only small changes in the ecosystem assets[6]. In this aspect of wealth accounting, "value added" becomes environmental income or "ecosystem [total] income" (Fenichel et al., 2018) for individual assets in some ecosystem accounting frameworks (this is the case of carbon in this HOW study). As regards relating the ecosystem service with the change in the environmental asset Notte et al. (2019a, 2019b) suggest that, given a "threshold" for future sustainable scheduled bio-physical management of environmental assets, the conditioned resource rent flows for the future period represent the expected sustainable flow of ecosystem services ("potential flow"). This "potential flow" can be interpreted as the maximum environmental income from the environmental asset in a period which guarantees that, consumed in its totality; the value of the environmental asset does not decline at the closing of that period[7].

The ultimate objective of ecosystem accounting should be to estimate the total economic contributions given by nature in the form of environmental intermediate consumption costs (WPeu), consumption of environmental fixed assets (CFCe) and environmental incomes (EI) to the consumption by people of natural based economic products in the current period as well as indefinite future periods.

In this study, we aim to contribute to the ongoing SEEA-EEA framework through the application of refined SNA (henceforth rSNA), refined SEEA-EEA (henceforth rSEEA-EEA) and simplified AAS (henceforth sAAS) frameworks to 1,408 thousand hectares of mixed, predominantly holm oak open woodlands (HOW) in the region of Andalusia-Spain, for the year 2010. The total products consumption (TPc_{HOW}) measured include: timber, cork, firewood, nuts, grazing (by game species and livestock), conservation forestry, landowner residential services, private amenity, fire services, water supply, mushrooms, carbon, free access recreation, landscape conservation and threatened wild biodiversity preservation.

Our objectives are to measure and discuss consistencies accruing from the results of the ecosystem accounting frameworks applied to HOW. We focus on selected

[5] "our method is not directly compatible with GDP estimates but in return allows us to evaluate sustainability of the economy and the environment in relation to forest services" (Narita et al., 2018: p. 189).
[6] "The [value added] could, in principle, be incorporated into the national accounting (specifically, [in the] Net Domestic Product, NDP)" (Narita et al., 2018: p. 190-191).
[7] "If a sustainability threshold can be established, it becomes possible to calculate what we can call "potential flow" (or sustainable flow). If the actual flow of the service (the use) is equal or below the potential flow, then the capacity to provide the same (or enhanced) amount of ecosystem service is guaranteed (La Notte et l., 2019b: p. 160).

ecosystem indicators such as ordinary net valued added (NVAo), ecosystem service (ES), change in environmental asset (CEA), change in environmental net worth (CNWead) adjusted in accordance with environmental work in progress used (WPeu) and environmental income (EI) from the aforementioned eight farmers and seven government ordinary total products consumption (TPc).

Campos et al. (2019a) develop the methodology for the measurement at producer (market) prices of the above cited selected variables of Andalusian forests applying the AAS framework. In this HOW study the source of data is the AAS application to Andalusian HOW (Campos et al., in progress). It is assumed that we have the physical quantities and valuations at observed market prices for the commercial products and the simulated exchange values for the final public products consumption with no market prices (Campos et al., 2016, 2017, 2019a; 2019b, Campos et al., in progress; Caparrós et al., 2017; Ovando and Campos, 2016; Oviedo et al., 2017). This starting point allows us to focus on our conceptualization of the structures of the accounts systems compared and consistent measurements of the 12 ecosystem services (ES), changes in the environmental assets (CEA) and environmental net worth (CNWead) adjusted according to WPeu along with the environmental income (EI) to which the 15 economic activities considered in the Andalusian HOW contribute.

2. Economic rationale and accounting frameworks

2.1 Non-industrial private and public farmer economic rationale

The mixed character of private and public assets (Koop and Smith, 1993), assigned respectively to the institutional sectors of farmers and government, indicate the condition of joint productions internalized in HOW activities by intermediate products and own intermediate consumptions. Thus, it is the entire aggregate results which ultimately underlie the rationale of the HOW sustainable resource base management. Although farmer activities are independent of government activities, farmer management activities are conditioned by government regulations and compensations.

The type of ownership conditions the self-consumption of private amenities as well as own-intermediate consumption due to the farmers' voluntary opportunity cost (Campos et al., 2019b; Masiero et al., 2018; Raunikar and Buongiorno, 2006). Institutional farmers do not consume private amenities. In consequence, the latter do not generate private amenity ecosystem services. However, these public farmers do generate

environmental income from the private amenity activity originating from the changes over the period in the environmental asset of the private amenity embedded in the market price of the land (Campos et al., 2019a; Oviedo et al., 2017).

The rationale which motivates this voluntary opportunity cost incurred by the farmers of the land and controlled animals is conditioned by the type of ownership. We assume that the farmers who are non-industrial natural persons incur opportunity costs in various individual activities in order to satisfy their private amenity consumption preferences. In other words, the opportunity cost of an activity of a non-industrial owner is registered simultaneously as a self-consumed non-commercial intermediate service product (ISSnca) of the activity which generates it and as own non-commercial intermediate consumption of the service (SSncoa) of private amenity activity. The opportunity costs of the public farmers register the products of the non-commercial intermediate services as donations (ISSncd) of the activities which generate them and as own non-commercial intermediate consumptions of the public activity services (SSncod) which utilize them.

2.2. Background to the accounting frameworks

We do not present here the estimates of the sequence of allocation/use income accounts and flows of the capital of the draft SEEA-EEA accounts in Obst et al. (2019: Table 6, p. 33). These accounts are justified by the register of flows which link the institutional sectors of farmers, ecosystems and government with the household institutional sector. We do not need to take into account the household institutional sector for the purposes of this HOW study. Our objective focuses on comparing measurements of ordinary net values added (NVAo), ordinary net operating surpluses (NOSo), ecosystem services (ES), changes in environmental assets (CEA), changes in environmental net worth (CNWead) adjusted according to WPeu and environmental incomes (EI). In Campos et al. (2019b) these variables are estimated from production account records and from the changes in the balance account in cork oak open woodland farm case studies.

2.2.1. System of National Accounts

The standard System of National Accounts (SNA) constitutes the starting conceptual framework for the theory and measurement of total income[8]. In the SNA, public spending on HOW is misplaced in the government general institutional sector. The SNA does not estimate, in practice, the balance accounts of commercial activities. The final products consumption is valued in the SNA at basic price. This price is the sum of the producer price (market) and price of compensations (operating and annualized capital subsidies).

The SNA does not estimate results at individual corporation scale. However, in the rSEEA-EEA and sAAS we require economic data on the flows and stocks of the activities and products of individual farms in order to associate the results of microeconomic management with the aggregated classifications of the different types of vegetation and land uses. In other words, the SNA limits the valuation of aggregated activities to their basic prices. The SNA and AAS coincide in the valuation of commercial flows and stocks at market prices but differ in the valuation of final products with no market price, the AAS estimating them according to the simulated exchange value whereas they are estimated in the SNA by the manufactured production cost.

2.2.2. Agroforestry Accounting System

We have previously applied the SNA and AAS to the Andalusia HOW and estimated their respective total social incomes from the activities valued (Campos et al., in progress). The factorial distribution of the total income gives the environmental income as the residual component (balancing item) in the SNA and AAS.

2.2.2.1. Social total income

The AAS aim to measure the extended social total income from the individual activities of agrosilvopastoral landscapes at any territorial scale of economic unit or area. Our AAS differ from the SNA in the organization of the accounting records, the redefinition of economic activities, the inclusion of new variables linked to the individual environmental assets, the measurement of social total income and the

[8] In practice the SNA measures the total income from livestock rearing, by incorporating the change in the inventory as a manufactured gross capital formation, the latter net of livestock purchases. The revaluation of manufactured capital is implicitly incorporated in the net value added through the estimation of manufactured consumption of fixed capital at replacement cost (McElroy, 1976; European Commission et al., 2009).

presentation of georeferenced accounts using the minimum scale of vegetation provided by the national forest inventory polygons and the government land use maps available. The estimation of the social total income from individual activities requires the incorporation of ordinary non-commercial intermediate service products originating from the farmers' voluntary opportunity cost. The latter can only be measured on individual farms.

In the AAS the social price is due to the incorporation as non-commercial intermediate products the non-SNA services (ISSnca/d) of amenity and donation originating from the voluntary opportunity costs of the individual activities, voluntarily incurred by the farmers of the land and controlled animals. We define the social price of an individual product according to the sum of the basic price and the price derived from the unit opportunity cost. Both the basic price and the social price are dissipated in the aggregated results of the whole HOW activities so as to arrive at a market price, provided that the intermediate products and own intermediate consumption of agrosilvopastoral landscape activities coincide if the HOW full activities are valued. In this circumstance, the valuations of social total income added to the social price of the farmers' commercial products correspond to the estimates at observed and/or simulated market price.

The voluntary opportunity costs incurred by the farmers in the economic activities can only be observed at farm (corporation) and individual owner scale. Consequently, in this study it was necessary to measure the voluntary opportunity costs to estimate firstly the social total income and derived from the latter, the total environmental income of the HOW at social price (Campos et al., in progress).

2.2.2.2. Total products and costs

The classification of a product as intermediate is based on the criterion that this product is re-employed as an intra-consumption in the same or other economic activity within the HOW during the current period in which its production takes place. This is the case of intermediate services (ISS), which are re-employed as inputs of private and public activities that take place in the HOW (Campos et al., 2008, 2016, 2017; 2019b; European Commission et al., 2009; Ovando et al., 2016; Oviedo et al., 2017). Final products are goods and services produced (not used up as own intermediate consumption) consumed (sold, auto-consumption, payment in kind, donations, finished goods stored) or accumulated at the closing of the current period as own gross capital

formation (final work in progress and durable finished goods for future consumption as work in progress used or consumption of fixed capital on the same farms).

The SNA manufactured total cost (TCm) of bought intermediate consumption (ICb), labour cost (LC) and consumption of manufactured fixed capital (CFCm) are registered in the activities that produce them. The main hidden products of SNA are the manufactured intermediate products of commercial services (ISSc), by contrast, the AAS register the ISSc in the activities that produce them, and their counterpart, as own commercial intermediate consumption of services (SSco) in the activities that use them.

2.2.2.3. Net value added

The production account of the AAS estimates the net value added (NVA) at aggregate social price as the sum of the ordinary net value added (NVAo) and investment net value added (NVAi) that accrues from the own-account gross capital formation (GCF). The NVAo is incorporated in the value of the total products consumption for the period. The NVA includes labour cost (LC), manufactured net operating margin (NOMm) which remunerates the manufactured capital services and the environmental net operating margin (NOMe) as the operating return of the environmental assets:

$$NVA = LC + NOMm + NOMe \quad \text{(eq. 1)}$$

The NVA is a key indicator of manufactured operating income that can indicate their dependence from nature physical inputs (intermediate consumptions) contribution to total product consumption in the case that economic ecosystem services have been dissipated.

2.2.2.4. Capital gain

The social total income (TI) is estimated in the AAS from the aggregation of the NVA and the capital gains (GC), the latter being adjusted (Cad) for avoiding double counting of natural growth and manufactured fixed capital consumption in measuring the NVA (Campos et al., 2017, 2019a, 2019b). The balance account of the AAS presents the opening capital (Co) and closing capital (Cc) along with entries (Ce) and withdrawals (Cw) in the accounting period, with the revaluation of capital (Cr) as the balancing item:

$$TI = NVA + CG \quad \text{(eq. 2)}$$

$$GC = Cr - Cad \quad \text{(eq. 3)}$$

$$Cr = Cc - Co + Cw - Ce \quad \text{(eq. 4)}$$

2.2.2.5. Environmental income

The sustainable environmental income (EI) from a silvopastoral landscape (a delimited area) is the maximum possible contribution of its ecosystem services that could be embedded in the total products consumption by people in a period (eg a year) without diminishing the environmental asset at the closing (EAc) in relation to its value at the opening of the period (EAo). Estimating the environmental income from an individual product (EI) is done by aggregating the environmental net operating margin (NOMe) and the environmental asset gain (EAg). By adding both variables we obtain the EI which links the ecosystem service (ES) and the change in environmental net worth adjusted (CNWeadj) according to the environmental intermediate consumption of work in progress used (WPeu). In the AAS the CNWead coincides with the change in the environmental asset (CEA), except in the case of carbon due to the absence of a value for emissions in the final product consumption (fixation):

$$EI = NOMe + EAg \quad \text{(eq. 5)}$$

$$EI = ES + CNWead \quad \text{(eq. 6)}$$

$$CNWead = CEA, \text{ except carbon} \quad \text{(eq. 7)}$$

$$CEA = EAc - EAo \quad \text{(eq.8)}$$

2.2.2.5.1. Ecosystem services

The economic ecosystem services "are flows measured as the amount of ES that are actually mobilized (used) in a specific area and time: actual flow**"** **(**Vallecillo et al., 2019a: p. 4)**.** Thus, in this HOW study the ecosystem services (ES) are the contribution of nature embedded in the value that people give to the total product consumption measured as a residual value after having paid all ordinary manufactured costs and the eligible of the farmer activity return for ordinary manufactured immobilized capital (IMCmo) (for details see Campos et al., 2019b).

The total product consumption (TPc) is defined as the observed and/or simulated exchange value of a good or service produced in an ecosystem (delimited area) and

destined for direct or indirect consumption by people in the current accounting period. The transaction value of a TPc is made up of the contributions from ordinary manufactured intermediate consumption (CImo), the environmental work in progress used (WPeu), the ordinary labour cost (LCo), the consumption of ordinary manufactured fixed capital (CCFmo), the ordinary manufactured net operating margin (NOMmo) and the ordinary environmental net operating margin (NOMeo). Among these TPc components, both the WPeu, as ordinary environmental intermediate cost, and the NOMeo as the ordinary environmental operating income, are the contributions of nature to the TPc. In other words, these two TPc environmental componenets are the ecosystem services embedded in the the TPc:

$$TPo = ICmo + WPeu + LCo + CFCmo + NOMmo + NOMeo \quad \text{(eq. 9)}$$

$$TPo = TCmo + NOMmo + ES \quad \text{(eq. 10)}$$

$$TCmo = CImo + LCo + CFCmo \quad \text{(eq. 11)}$$

$$ES = WPeu + NOMeo \quad \text{(eq. 12)}$$

where TCmo is the ordinary manufactured total cost.

2.2.2.5.2. Changes in environmental net worth adjusted according to WPeu

We estimate the change in environmental net worth (CNWead) adjusted according to the environmental work in progress used (WPeu). The aim of this adjustment is to avoid double counting of the latter in the environmental income. The change in environmental net worth (CNWe) is estimated as the aggregate value of the environmental net operating margin investment (NOMei) plus the environmental asset gain (EAg):

$$CNWead = CNWe - WPeu \quad \text{(eq. 13)}$$

$$CNWe = NOMei + EAg \quad \text{(eq. 14)}$$

$$EAg = EAr - EAwd - EAwad \quad \text{(eq. 15)}$$

$$EAr = EAc - EAo + EAw - EAe \quad \text{(eq. 16)}$$

$$NOMi = NG - CFCe \quad \text{(eq. 17)}$$

where EAr is the revaluation of the environmental asset, EAwd is the extraordinary destruction of the environmental asset, EAwad is the withdrawals due to adjustment in

the environmental asset, EAw is the withdrawals of the environmental asset, EAe is the entry of the environmental asset, NG is natural growth and CFCe is consumption of fixed environmental asset.

2.2.3. SEEA-Experimental Ecosystem Accounting

The System of Environmental Economic Ecosystem Accounting-Central Framework (SEEA-CF) is the standard guideline for valuing market environmental assets (United Nations et al., 2014a). This market boundary of the SEEA-CF environmental assets is extended by the ongoing satellite guidelines of the SEEA-Experimental Ecosystem Accounting (SEEA-EEA) (United Nations et al., 2014b; United Nations, 2017).

The objective of the SEEA-EEA is to measure the ecosystem services embedded in the products currently consumed by people and changes in environmental assets which are forecast to accrue from total product consumption in the future. The SEEA-EEA defines the ecosystem service (ES) as the contribution of the ecosystem to the transaction value of a total product consumption (TPc).

Our interest in this section is to refine the stylized sequence of production and generation of income account and balance account environmental indicators considered in the draft SEEA-EEA (SEEA for short) framework in Obst et al. (2019). The SEEA incorporates the new institutional sector of ecosystems (with respect to the institutional sectors considered in the SNA), registering the ecosystem services of the public products consumption ($TPc_{G,SEEA}$) without human manufactured costs and capital return. The possible bias incurred by the SEEA is the overvaluation of ecosystem services embedded in the $TPc_{G,SEEA}$ in the period, the production of which includes contributions from manufactured production factors paid for by the government and public farmers, in the case of the latter, originating from the voluntary opportunity costs incurred to encourage the supply of public products (Campos et al., 2019b).

The main difficulty, initially, with applications consistent with the economic SEEA is the absence of complete and consistent criteria for the structure of the production and balance accounts of the ecosystem accounts integrated in the standard SNA. In the SEEA guidelines an approach to integrate the sequence of SNA accounts that would allow a common procedure to be adopted which would serve as a reference for authors in order to integrate them into the ecosystem accounts has not been developed (Atkinson and Obst, 2017). In this study we develop the application of sAAS

compared with and including the applications of the rSNA and the rSEEA (Campos et al., 2019a, 2019b; Obst et al., 2019; United Nations et al., 2014a, 2014b; United Nations, 2017).

2.3. Ecosystem accounting frameworks applied to HOW

We have refined the SNA (rSNA) and the SEEA-EEA (rSEEA-EEA) by incorporating the government institutional sector and extending the variables of the sequence of accounts, among the most important of which are the ecosystem services (ES), the change in environmental assets (CEA), the change in environmental net worth (CWead) adjusted in accordance with the environmental work in progress used (WPeu) and the environmental income (EI). The results of the rSNA and rSEEA-EEA are compared in the same stylized sequence of production and regeneration of accounts and balance accounts with those obtained using the simplified Agroforestry Accounting System (sAAS).

Our interest focuses on describing the compared results of the rSNA, rSEEA-EEA and sAAS. Our comparisons are of particular interest in that they highlight the shortcomings of the rSNA and rSEEA-EEA valuations in the preliminary development stage of the latter. Based on the results for the production and income generation and balance accounts of the SNA and AAS accounting approaches we developed a stilized sequence of ecosystem accounts for the rSNA and rSEEA-EEA and the sAAS which measure, amongt others, the ecosystem services and the environmental incomes corresponding to the individual activities, the farmers, the government and the aggregate activities of the HOW (Campos et al., 2019a, 2019b; Campos et al., in progress).

The integration of ecosystem accounts within the social total income accounts is a pending challenge yet to be resolved due to a variety of conceptual and instrumental causes. Among the main challenges of the former, the valuations of the consumption of final products without market price and the delimitation of the concept of social total income are those which generate the most academic controversies. Instrumental challenges include the absence of government standardization of a glossary of terms which would mitigate the current polysemic labyrinth along with a lack of development of the structure of the sequence of ecosystem accounts linked to the SNA. In this study we use the terms ‘ecosystem accounting’ in place of ‘environmental accounting’, ‘environmental asset’ as a synonym of ‘ecosystem asset’, ‘ecosystem service’ instead of

‘environmental asset resource rent ’and ‘environmental income’ as an equivalent to ‘ecosystem total environmental income’[9].

The structures of the production and balance accounts of the rSNA, the rSEEA-EEA and the sAAS allow the accounting records of the respective ecosystem accounting frameworks to be structured as subsystems of the SNA and AAS. Once the social total income has been estimated using the SNA and AAS approaches we organize the structure of the stilezed sequence of ecosystem accounts starting with the production and generation of income accounts of the total products consumption (TPc).

The general accounting identity of the environmental income (EI) is expressed as the sum of the production and balance accounts balancing items of the environmental net operating margin (NOMe) plus the environmental asset gain (EAg) (Campos et al., 2019a, 2019b; Campos et al., inprogress). These components of the EI are equivalent to the sum of the ES plus the change in environmental net worth (CNWead) adjusted according to the WPeu in all HOW products. The CNWead coincide with the change in the environmental asset (CEA), excep carbon product.

The ordinary net operating surplus of the standard ($NOSo_{SNA}$) and refined SNA ($NOSo_{rSNA}$) are the same in this study and differ from the ordinary net operating margin (NOMo) of the rSEEA ($NOMo_{rSEEA}$) and the sAAS ($NOMo_{sAAS}$). This discrepoancy is due to the exclusion of the products of the environmental work in progress used (WPeu) in the NOMo of the latter two approaches.

2.3.1 Simplified Agroforestry Accounting System

The overvaluation of the ES in the rSEEA-EEA is avoided in the sAAS by incorporating own non-commercial intermediate consumption of services originating from the opportunity costs incurred by the public farmers and the government manufactured costs in the public activities with which they are associated. In addition we assume, in contrast to the rSNA and rSEEA, that the sAAS attributes an ordinary manufactured net operating margin ($NOMmo_{G,sAAS}$) to the government activities that could generate consistent value.

The environmental income valuations in the sAAS[10] are derived from the social total income (TI) in the Agroforestry Accounting System (Campos et al., 2017, 2019a,

[9] The precedent for our choice in this instance is the use of the term environmental income in scientific literature. However, if future government standardization of terms used in ecosystem accounting adopted the terms ‘ecosystem service’ and ‘ecosystem asset’, then we consider the terms ‘ecosystem total income’ would be more appropriate than ‘total environmental income’.

2019b; Campos et al., in progress; Cavendish, 2002; McElroy, 1976; Sjaastad et al., 2005; Stone, 1984). This consistency of the sAAS improves the integration of the sequence of ecosystem accounts in the general framework of principles for the transaction value and effective demand of the period by consumers which form the basis of silvopastoral landscape ecosystem accounting.

The ultimate objective of the sAAS is to measure the individual ordinary net value added (NVAo), ecosystem service (ES), changes in the environmental asset (CEA), changes in environmental net worth adjusted (CNWead) according to the WPeu and the environmental income (EI) of the total products consumption and theirs environemntal assets.

2.3.2. Refined System of National Accounts

We incorporate the government institutional sector in the rSNA in order to embrace displaced public spending in the HOW (Campos et al., 2019a; Ovando and Campos, 2016). The objective is to make visible the economic activities of the government institutional sector in the HOW. Although the rSNA extend the economic activities of the HOW with the public activities provided by the government, it does not modify the net value added of the farmers and the nation estimated in the SNA, except for the case, in the government institutional sector, of the final product of economic water from the HOW stored in reservoirs outside the HOW.[11] The novelty in practical terms of the rSNA is that it estimates the balances of environmental asset of famers in the SNA and of the government public activities with market prices (mushrooms and water).

We do not incorporate adjustments of the net value added (NVA) and net operating surplus/margin (NOS/NOM) due to environmental fixed asset consumption (ecosystem degradation) because in this application they are not embedded in the total product consumption. However, they *are* recorded in the ecosystem degradation, implicitly integrated in the change in environmental asset (CEA) estimated for the period. We classify the NOS_{rSNA} into manufactured net operating margin ($NOMm_{rSNA}$) and environmental net operating margin ($NOMe_{rSNA}$), and into ordinary ($NOSo_{rSNA}$) and

[10] We remind the reader that the refinement of the SEEA consists of including the government institutional sector in place of the ecosystem institutional sector of public products with no manufactured costs (Obst et al., 2019; Table 6, p. 33

[11] The valuation at market environmental price of forest water from the HOW in the refined SNA *does* modify the net value added measured by the standard SNA for irrigated land, since the ecosystem service of forest water is embedded in the agricultural products from this irrigated land.

investment ($NOSi_{rSNA}$). The latter is separated into manufactured ($NOSmi_{rSNA}$) and environmental net operating surplus ($NOSei_{rSNA}$). The $NOSei_{rSNA}$ is estimated according to the natural growth (NG_{rSNA}) –net of expected destructions- less the consumption of environmental fixed capital ($CFCe_{rSNA}$), the latter is represented in this study by the carbon emissions (Campos et al., 2019b):

$$NOS_{rSNA} = NOSm_{rSNA} + NOSe_{rSNA} \quad \text{(eq. 18)}$$

$$NOS_{rSNA} = NOSo_{rSNA} + NOSi_{rSNA} \quad \text{(eq. 19)}$$

$$NOSi_{rSNA} = NOSmi_{rSNA} + NOSei_{rSNA} \quad \text{(eq. 20)}$$

$$NOSei_{rSNA} = NG_{rSNA} - CFCe_{rSNA} \quad \text{(eq. 21)}$$

The $NOMm_{rSNA}$ coincide with the ordinary manufactured net operating margin ($NOMmo_{rSNA}$) because own manufactured gross capital formation (GCFm) is valued at production cost. Hence, $NOSmi_{rSNA}$ has a value of zero. In addition, we assume a $NOMmo_{rSNA}$ zero value for government activities, except for mushroom activity.

In this study of HOW, the rSNA omits the natural growth in the total product consumption and the environmental work in progress used in the intermediate consumption cost of the corresponding economic activity.

The total product consumption (TPc_{rSNA}) in the rSNA extends the final product consumption of the SNA to explicitly include the intermediate product (IP_{rSNA})[12].We classify the total product consumption (TPc_{rSNA})[13] into the IP_{rSNA} and final product consumption (FPc_{rSNA}). In the TPc_{rSNA} of the rSNA, double counting occurs due to the incorporation of the final product consumption (FPc_{rSNA}) embedded in the IP_{rSNA}, except for grazing ($IRMcg_{rSNA}$), which is embedded in the final products consumption of livestock farming and hunting species in the case of HOW, these having been omitted in this study. The adjusted total product ($TPcad_{rSNA}$) is estimated by subtracting from the TPc_{rSNA} the IP_{rSNA} used as own intermediate consumption of services (SSo_{rSNA}) for the HOW activities valued in this study. We avoid double counting of the TPc_{rSNA} by adding the $IRMcg_{rSNA}$ to the FPc_{rSNA}:

[12] We assume that the IP is a SNA product as it is liable to be considered a final product which is intra-consumed by HOW farm activities, although animal and agriculture activities were not valued in this case study but their grazing intermediate raw materials consumption from COW was included in the IP. In practice, the SNA does not estimate intra-consumption.

[13] We do not need to measure the manufactured gross capital formation (GCFm) in order to estimate the ecosystem services for the period. However, it is necessary to consider it in the estimation of future resource rents which, when discounted, give the values of the individual assets at the closing of the period.

$TPc_{rSNA} = IP_{rSNA} + FPc_{rSNA}$ (eq. 22)

$TPcad_{rSNA} = TPc_{rSNA} - IP_{rSNA} + IRMcg_{rSNA}$ (eq. 23)

$TPoad_{rSNA} = FPc_{rSNA} + IRMcg_{rSNA}$ (eq. 24)

The ordinary commercial intermediate consumption ($ICco_{rSNA}$)[14] in the rSNA extends the ordinary bought intermediate consumption of the SNA ($ICcob_{rSNA}$) to include ordinary own commercial intermediate consumption of services ($SScoo_{rSNA}$). The latter exclude the intermediate products of grazing ($IRMcg_{rSNA}$) as these are consumed by animal activities in the HOW, which are omitted in this study. Consequently, as there are no ordinary own intermediate consumptions of other HOW activities among the activities valued, the value of the SScoo is lower to that of the IP_{rSNA}:

$ICco_{rSNA} = ICcob_{rSNA} + SScoo_{rSNA}$ (eq. 25)

$SScoo_{rSNA} = IP_{rSNA} - IRMcg_{rSNA}$ (eq. 26)

The ordinary gross value added ($GVAo_{rSNA}$) in the rSNA is not representative of the operating income as it incorporates the cost of ordinary manufactured fixed capital consumption ($CFCmo_{rSNA}$). To estimate the latter requires the application of subjective criteria on the obsolescence and degradation of the physical stocks of constructions, equipment and other intangible manufactured capital (forest planning, wild animals and gathering of public biological products). Three sources of subjectivity exist when valuing the replacement cost of manufactured fixed capital consumed such as, on the one hand, homogeneity in the productivity of new capital goods replacing the previous ones and, on the other, the implicit inclusion of manufactured capital gains in the measurement of net value added (NVA) (McElroy, 1976). The latter still does not correspond to the operating income as it includes the intermediate consumption of woody environmental work in progress used (WPeu) which exist in the inventories of standing stocks at the opening of the period. The consequence of omitting the intermediate consumption of WPeu is the overvaluation of the NVA. That is, the ordinary net operating surplus ($NOSo_{rSNA}$) is not pure capital operating income due to overvaluation as a result of the quantity of WPeu. The ordinary labour cost component

[14] Flows of government compensation affecting the HOW activities valued have not been recorded.

(LCo_{rSNA}) of the rSNA corresponds to the paid labour in the HOW activities considered, as there is no self-employed labour in this case:

$GVAo_{rSNA} = TPc_{rSNA} - ICco_{rSNA}$ (eq. 27)

$NVAo_{rSNA} = GVAo_{rSNA} - CFCmo_{rSNA}$ (eq. 28)

$NVAo_{rSNA} = LCo_{rSNA} + NOSo_{rSNA}$ (eq. 29)

Only by estimating and assigning the IP_{rSNA} and their associated own commercial intermediate consumption ($ICco_{rSNA}$) to the individual activities which produce and utilize them can we estimate the ordinary net operating surpluses ($NOSo_{rSNA}$) and ecosystem services (ES) of the individual activities valued. We classify the $NOSo_{rSNA}$ into WPeu, ordinary manufactured net operating margin ($NOMmo_{rSNA}$) and ordinary environmental net operating margin ($NOMeo_{rSNA}$):

$NOSo_{rSNA} = WPeu + NOMmo_{rSNA} + NOMeo_{rSNA}$ (eq. 30)

Thus, we demonstrate that the ES, valued according to the "resource rent" of the total product consumption (TPc_{rSNA}), are not consistent with the definition of the environmental operating income for the ecosystems when the WPeu are included.

It is necessary to estimate the changes in the environmental assets of the del rSNA (CEA), which added to the ES give the environmental income (EI) (eq. 9 and eq. 10). At the same time, the environmental income represents the value of the contributions of environmental assets to the current and future periods of rSNA commercial total product consumptions valued in the HOW.

2.3.3. Refined SEEA-Experimental Ecosystem Accounting

It is assumed that the Obst et al. (2019: Table 6, p 33) ecosystem accounting measures a total product[15] which excludes the final product of gross capital formation (GCF), therefore we use the term 'total product consumption' (TPc) in the rSEEA-EEA.

The rSEEA-EEA and sAAS coincide in their estimates of the values of farmer activities but differ in their ecosystem sercices estimates of public `products consumption of the sAASgovernment and the rSEEA-EEA ecosystem institutional

[15] Product and output are equivalent terms in this study.

sectors. We focus on this sub-section when describing the differences and similarities in the valuation of the public products consumption estimated by the rSEEA-EA and sAAS.

To achieve consistency in the concept of social total income (TI) from the public product of the ecosystem institutional sector under the SEEA-EEA it is necessary to only register those with production functions which do not utilize manufactured costs (Obst et al., 2019: Table 6, p. 33). This is the case of water and carbon for the HOW activities considered. Our definition of public goods and services is wider than the conventional definition (Koop, & Smith, 1993)[16]. We agree on defining the public goods and services according to their economic ownership not embraced by the market in the case of activities which we attribute to farmers. We assume government economic ownership of all the ordinary final goods and services, which the public consumers benefit from for free. In the HOW, the public activities of fires services, mushroom picking, free access recreation, landscape conservation and threatened wild biodiversity preservation incur costs paid for by the public farmers (voluntary opportunity costs of the private activities) and the government. The exclusion of the manufactured costs of these five final public products consumption ($FPc_{G, rSEEA}$) in the rSEEA-EEA underlies the discrepancies between the rSEEA-EEA and sAAS frameworks in the valuation of the HOW ecosystem services. In other words, the rSEEA-EEA extend the conventional definition of public activities which we assume are omitted in Obst et al. (2019: 33), given that, as these authors assign them by convention to the ecosystem institutional sector, they cannot contain the manufactured costs, and the latter are incorporated in sAAS government institutional sector.

In the rSEEA, the non-SNA intermediate consumption incorporates the ecosystem services associated with the environmental work in progress used (WPeu) and the own intermediate consumption of the amenity originating from the opportunity costs incurred by the farmers in the HOW activities of hunting and livestock which are not valued in this study.

The ordinary net operating margin ($NOMo_{rSEEA}$) is a pure operating capital income, since we have included the WPeu in the non-SNA intermediate consumption. As in the sAAS, we separate $NOMo_{rSEEA}$ into manufactured $NOMmo_{rSEEA}$ and

[16] "Public services are characterized by non-rivalry and non-excludability. Nonrivalry implies that the use/consumption of a service by one individual does not reduce the availability of it to another individual, for example, climate regulation. […]. Nonexcludability implies that it is impossible to exclude anyone from the use/consumption of the service. Climate is also an example of nonexcludability" (Mãler et al., 2018: 9502).

environmental $NOMeo_{rSEEA}$. By SEEA-EEA convention, ecosystem activities as a $NOMmo_{rSEEA}$ with zero value.

The degradation/enhancement of environmental assets is not incorporated in the total product consumption in the rSEEA-EEA because the only consumption of environmental fixed capital (degradation) measured in the HOW is that of carbon. Given the absence of a period physical production function link between the fixation and emission of carbon, there is no reason to assume that the carbon final product consumption (fixation) contains the CFCe (emission) embedded. In other words, the only consumption of environmental fixed capital (CFCe) explicitly registered in the capital account is that of carbon activity in the environmental gross fixed capital formation final product.

Our proposal in the rSEEA-EEA as an alternative to the net value added and net operating surplus adjustments proposed by Obst et al. (2019: Table 6, p. 33) is the adjustment of the environmental assets incorporated in the estimation of environmental asset gains. Thus, the adjustments for depletion and degradation/enhancement are integrated in the estimation of the change in the environmental asset (CEA) and/or in the change in environmental net worth adjusted (CNWead) according to WPeu .

Aggregating the ES and the CNWead measured in the rSEEA-EEA gives the individual values of the HOW ecosystem environmental incomes. However, as mentioned above, the ES values of the total product consumption for public activities with no market price are not consistent with the social total income theory and therefore with theory of environmental income.

2.3.4. Integration of the refined SNA and refined SEEA-EEA into the simplified AAS in holm oak open woodland applications

Beyond the refined System of National Accounts (rSNA) ordinary net operating surplus ($NOSo_{bp,rSNA}$) at basic prices (the $NOSo_{bp,rSNA}$ is classified into environmental work in progress used (WPeu) and ordinary net operating margin ($NOMo_{bp,rSNA}$) at basic prices), the simplified Agroforestry Accounting System (sAAS) ordinary net operating margin ($NOMo_{sp,sAAS}$) at social prices is extended to include the following: i) subtraction of the WPeu and SSncoc/a/d; ii) addition of the landscape ordinary own non-commercial intermediate consumption of services ($SSncodla_{sAAS}$) to avoid double counting; iii) addition of the difference from the price of the private amenity derived from farmer willingness-to-pay ($\Delta FPaaep;_{sAAS}$) to the values of the final products

consumed, valued using the refined standard accounts at cost price of the private amenity service (Oviedo et al., 2017); (iv) addition of the difference between revealed marginal (water) and stated consumer willingness-to-pay ($\Delta PGSep_{,sAAS}$) to the cost price of the consumption of public goods and services without market prices (a part of the economic forest water, recreational services, landscape conservation service and threatened wild biodiversity preservation service) ; and (v) addition of the ordinary final product of carbon fixation (FPca) omitted by the SNA:

$$NOMo_{sp,sAAS} = NOSo_{Sbp,rSNA} - WPeu - SSncoc/a/d + SSncodla_{sAAS} + \Delta FPaa_{ep,sAAS} + \Delta PGS_{ep,sAAS} + FPca_{ep,sAAS} \quad \text{(eq. 31)}$$

$$NOMo_{sp,sAAS} = NOMo_{Sbp,rSNA} - WPeu - SSncoc/a/d + SSncodla_{sAAS} + \Delta FPaa_{ep;sAAS} + \Delta PGS_{ep,sAAS} + FPca_{ep,sAAS} \quad \text{(eq. 32)}$$

The integration of rSEEA-EEA (rSEEA for short) ordinary net value added at social prices ($NVAo_{sp,rSEEA}$) into the sAAS ordinary net value added at social prices ($NVAo_{sp,sAAS}$) is not consistent because we assume that the rSEEA omits the fire service activity (IPfs) and the ecosystem institutional sector activity ordinary manufactured total cost (TCmo), the ordinary labour cost being implicitly included in the $NVAo_{sp,rSEEA}$:

$$NVAo_{sp,sAAS} = NVAo_{sp,rSEEA} + IPfs - ICmo_{G,sAAS} - CFCmo_{G,sAAS} \quad \text{(eq. 33)}$$

where $ICmo_{G,rSEEA}$ is government ordinary manufactured intermediate consumption and $CFCmo_{G,rSEEA}$ is government ordinary manufactured consumption of fixed capital.

3. Ecosystem accounting frameworks results

We compare the HOW results of the refined SNA, refined SEEA (Obst et al., 2019: Table 6, p. 33) and simplified AAS. The results presented in these tables were estimated from AAS production and balance accounts data applied to the HOW in Andalusia in Campos et al. (in progress). These accounting frameworks applications exclude controlled animal activities (game species and livestock) and marginal agriculture which takes place in the HOW. It should be noted that these omissions do not affect the results for aggregate environmental income of the HOW at social price.

This is due to the marginality of the crops land in the HOW, and to not taking into consideration the existence of environmental income from animal activities.

However, the effect of excluding the above mentioned HOW activities is that the aggregate incomes of farmers and government activities at social prices do not coincide with the aggregate values at market prices obtained when all the HOW activities are considered. One reason for this result is that the commercial intermediate raw material product of grazing (IRMcg) is not registered among the own intermediate consumptions of raw materials in the activities valued, but rather in the controlled animal activities (game species and livestock). Another reason for the discrepancy in HOW activities valued between the intermediate production of services (ISS) and own intermediate consumption of services (SSo) is the inclusion in the latter of the own non-commercial intermediate consumption of services (SSnco) in the form of compensations (SSncoc), amenities (SSncoa) and donations (SSncod) originating from the omitted HOW animal activities which incur voluntary opportunity costs.

We have incorporated the government institutional sector in the rSNA, specifying the values of the ecosystem services and environmental incomes. In the rSEEA we have replaced the ecosystem institutional sector[17] with the government institutional sector.

Although Obst et al. (2019) present the SEEA results for the allocation/use of ordinary income accounts and capital account, we do not show and discuss these results here as our purpose is limited to the production accounts which estimate the ecosystem services and the capital balance account which estimates the change in the environmental assets and the change in adjusted environmental net worth, which allow us to estimate the environmental income.

In the presentation of the results we focus describing those of the sAAS and then compare them with those of the rSNA and rSEEA approaches. The sequence of the results follows the order stated below:

1. Tables 1 and S1 show the opening environmental assets and manufactured fixed capital indicators by aggregate commercial and non-commercial activities for refined SNA, refined SEEA, and simplified AAS in holm oak open woodlands in Andalusia.

[17] In the case of public activities which do not incur manufactured costs, the rSEEA-EEA and sAAS estimates of ecosystem services coincide. In the HOW, this circumstance occurs for water and carbon.

2. Tables 2 and S2-S3 show the sAAS, rSNA and rSEEA-EEA stylized sequence of production, income generation and balances accounts, which we have applied to the Andalusian HOW with the ultimate objective of estimating the environmental income. The results show the ecosystem services and incomes from the individual and aggregate activities in the holm oak open woodlands (HOW) per institutional sector and ecosystem accounting framework.
3. We describe the individual and aggregate results per sAAS institutional sector in Table 2 and Fig. 1, the rSNA in Table S2 and Fig. S1 and the rSEEA in Table S3 and Fig. S2.
4. The results for the indicators of ecosystem services and aggregate incomes for the holm oak woodlands per institutional sector and accounting method are shown in Table 3 and Fig. 2.
5. Fig. 3 shows the results for ecosystem services of each individual activity and accounting method (sAAS and rSEEA).
6. The results for the indicators of incomes and ecosystem services by aggregate commercial and non-commercial activities for refined SNA, refined SEEA and simplified AAS are shown in Tables 4 an S4
7. Environmental income and ecosystem service indexes by individual activity, institutional sector and accounting framework in holm oak open woodlands are presented in in Table 5.

3.1. Opening environmental assets and manufactured fixed capital

The holm oak is a wild fruiting tree species, the fruit of which does not generate work in progress and its natural growth in terms of firewood tends towards zero value. The work in progress environmental assets of the cork oak and other woody product trees which grow alongside the Andalusian HOW are of little value given their scarce presence (Table 1). The Andalusian HOW are found in large farms, which favours lower manufactured territorial investment per hectare, although there may be greater investment associated with individual constructions of non-industrial owner family dwellings. In the case of opening capital (Co) in the rAAS for example, as this is the broadest of the ecosystem accounting frameworks considered, the environmental assets (EAo) account for 94.2% of the Co, and the environmental assets of work in progress share 0.4% of the EAo (Table 1).

Table 1. Opening environmental assets and manufactured fixed capital indicators by aggregate commercial and non-commercial activities for refined SNA, refined SEEA, and simplified AAS in holm oak open woodlands in Andalusia, Sapin (2010: thousands of euros)

Class	Commercial activities			Non-commercial activities				Woodlands
	Woody products	Non-woody products	Total	Amenity	Landscape	Others	Total	
1. Opening environmental asset (EAo)								
rSNA	365,075	1,480,457	1,845,532	4,959,072		2,899,318	7,858,390	9,703,922
rSEEA	365,075	1,480,457	1,845,532	4,959,072	1,487,154	4,923,343	11,369,569	13,215,101
sAAS	365,075	1,480,457	1,845,532	4,959,072	1,487,154	4,923,343	11,369,569	13,215,101
1.1 Work in progress (WP)								
rSNA	57,311		57,311					57,311
rSEEA	57,311		57,311					57,311
sAAS	57,311		57,311					57,311
1.2 Environmental fixed asset of land (EFAl)								
rSNA	129,831	1,434,997	1,564,828	4,959,072		2,899,318	7,858,390	9,423,218
rSEEA	129,831	1,434,997	1,564,828	4,959,072	1,487,154	4,923,343	11,369,569	12,934,397
sAAS	129,831	1,434,997	1,564,828	4,959,072	1,487,154	4,923,343	11,369,569	12,934,397
1.3 Environmental fixed asset of biological resources (EFAbr)								
rSNA	177,933	45,460	223,393					223,393
rSEEA	177,933	45,460	223,393					223,393
sAAS	177,933	45,460	223,393					223,393
2. Manufactured fixed capital (FCm)								
rSNA	2,516	743,802	746,318		3,864	64,081	67,945	814,264
rSEEA	2,516	680,961	683,478					683,478
sAAS	2,516	743,802	746,318		3,864	64,081	67,945	814,264
3. Opening capital (Co)								
rSNA	367,591	2,224,259	2,591,850	4,959,072	3,864	2,963,399	7,926,336	10,518,186
rSEEA	367,591	2,161,418	2,529,009	4,959,072	1,487,154	4,923,343	11,369,569	13,898,578
sAAS	367,591	2,224,259	2,591,850	4,959,072	1,491,018	4,987,424	11,437,514	14,029,364

Source: Own elaboration after Campos et al. (in progress). Andalusian holm oak woodlands surface: 1,408,170 hectares.

The classification of the amenity activity among the non-commercial activities is debatable as the value of its environmental asset is embedded in the market price of the land. In any case, we have opted to include in the commercial activities only those which present observable market transactions of their consumed products consumed. Among the HOW commercial activities we have included are all the farmer activities except the amenity, and the fire services of the government/ecosystem. The quasi-private/public nature of the HOW is clear, as the environmental assets are shared in similar proportions. Among the most important individual non-commercial assets are the amenity and landscape (Table 1).

The values of the commercial environmental assets are the same in the accounting frameworks applied for the commercial activities and the amenity but differ in the non-commercial activities apart from amenity, water and mushrooms. However, the environmental assets of the rSNA activities incorporate an aggregate value which represents 73.4% of the respective sAAS activities (Table 1). In the rSNA, the absence of environmental assets of public products without market price and the omission of carbon explain the undervaluation of the environmental assets of the 12 activities with possible environmental income.

3.2. Simplified Agroforestry Accounting System ecosystem services and incomes

In these applications to Andalusian HOW of the sAAS and rSEEA-EEA at social prices[18] the valuation at social price only operates on the cost side of the own non-commercial intermediate consumption of services (SSnco). The latter stem from the use (intra-consumption) of the non-commercial intermediate products of amenity and donation (ISSnca/d) attributed to the hunting and livestock activities omitted in this study. In other words, the total product of the farmer activities does not incorporate the non-SNA intermediate products originating from the voluntary opportunity costs of the farmer activities omitted.

In this application of the sAAS at social prices to the Andalusian HOW, the ecosystem services account for 61.7%, 69.0% and 64.9% respectively of the farmer, government and total adjusted ordinary total products (TPoad) of double counting of

[18] The rSNA does not incorporate own non-commercial intermediate consumption of services originating from the opportunity cost of the HOW activities considered.

intermediate products[19] in the HOW (Table 2). Table 2 shows that the ordinary final products of mushrooms, recreational services, landscape conservation services and threatened wild biodiversity preservation exceed those of their respective ecosystem services. Only in the cases of the public products of carbon and economic water from forests do the values of the products coincide with those of their respective ecosystem services, and this is due to the absence of government and public farmers spending on their respective forest management (Table 2).

It can be observed from Table 2 that, of the HOW institutional sectors, the government contributes 49.6% to net value added, 47.1% to ecosystem services and 67.0% to environmental income (Table 2).

Due to the exclusion of HOW animals (hunting and livestock) and agricultural activities, the aggregate income values for farmers and government at social prices do not coincide with the aggregate values at market prices which are obtained when all the HOW activities are considered. One reason for this is that the commercial intermediate raw material product of grazing (IRMcg) is not recorded among the own intermediate consumption of raw materials (RMco) in the activities valued, but rather, in the abovementioned controlled animal activities. Another reason for the discrepancy between the intermediate production (IP) of the HOW and the own intermediate consumption (SSnco) is the inclusion in the latter of own services compensations (SSncoc), amenities (SSncoa) and donations (SSncod) associated with animal activities omitted from this study of the HOW.

Due to the nature of the holm oak as a fruiting-bearing species, the silvicultural model applied involves promoting open canopy cover (under 75%) through early thinning and periodical pruning in order to favour the production of grass and browse grazed by livestock, game specie and other wild fauna. Thus, ecosystem service of grazing contributes 96.6% of farmers' provisioning of ecosystem services (Table 2).

The main individual ecosystem service of the HOW is the private amenity auto-consumption. Private non-industrial farmers pay for own intermediate consumption of the amenity (SSoa), which represents 40.2% of the ordinary final product of the amenity (FPoaa).

The SSoa increases due to the use of farmer residential dwelling services and voluntary manufactured opportunity costs incurred as a result of the economic activities

[19] The intermediate product of grazing is the only one which is not re-employed in the ordinary final products of the economic activities valued in this study of the HOW. The values for farmer, government and total adjusted ordinary total products of the HOW are 533,912€, 424,887€ and 958,798€ respectively.

of other farmers and omitted in this HOW such as hunting and livestock activities. The amenity cultural ecosystem service accounts for 59.8% of the FPoaa and 87.5% of farmer total ecosystem services (Table 2).

In Table 2 it can be observed that, although the mix of holm oak woodlands with conifer species and cork oak account for 23% of the total area of HOW, woody products (timber, cork and firewood) only contribute marginally to the adjusted ordinary total product ($TPoad_{HOW}$) and ecosystem services (ES_{HOW}) of the HOW, accounting for 0.7% and 0.4% respectively.

The government landscape ordinary final product (FPola) and water supply (FPowa) are the largest individual public products, both products together making up 58.2% of government ecosystem services (Table 2). While water activity does not incur manufactured cost, the manufactured total cost of landscape activity accounts for 71.2% of FPola and landscape ecosystem services make up 28.6% of FPola (Table 2).

Recreation, mushroom gathering, carbon and threatened wild biodiversity ecosystem services account for 28.8% of the government ordinary final product. Ecosystem services of farmer and government activities contribute 67.8% and 69.0% to their respective ordinary final products.

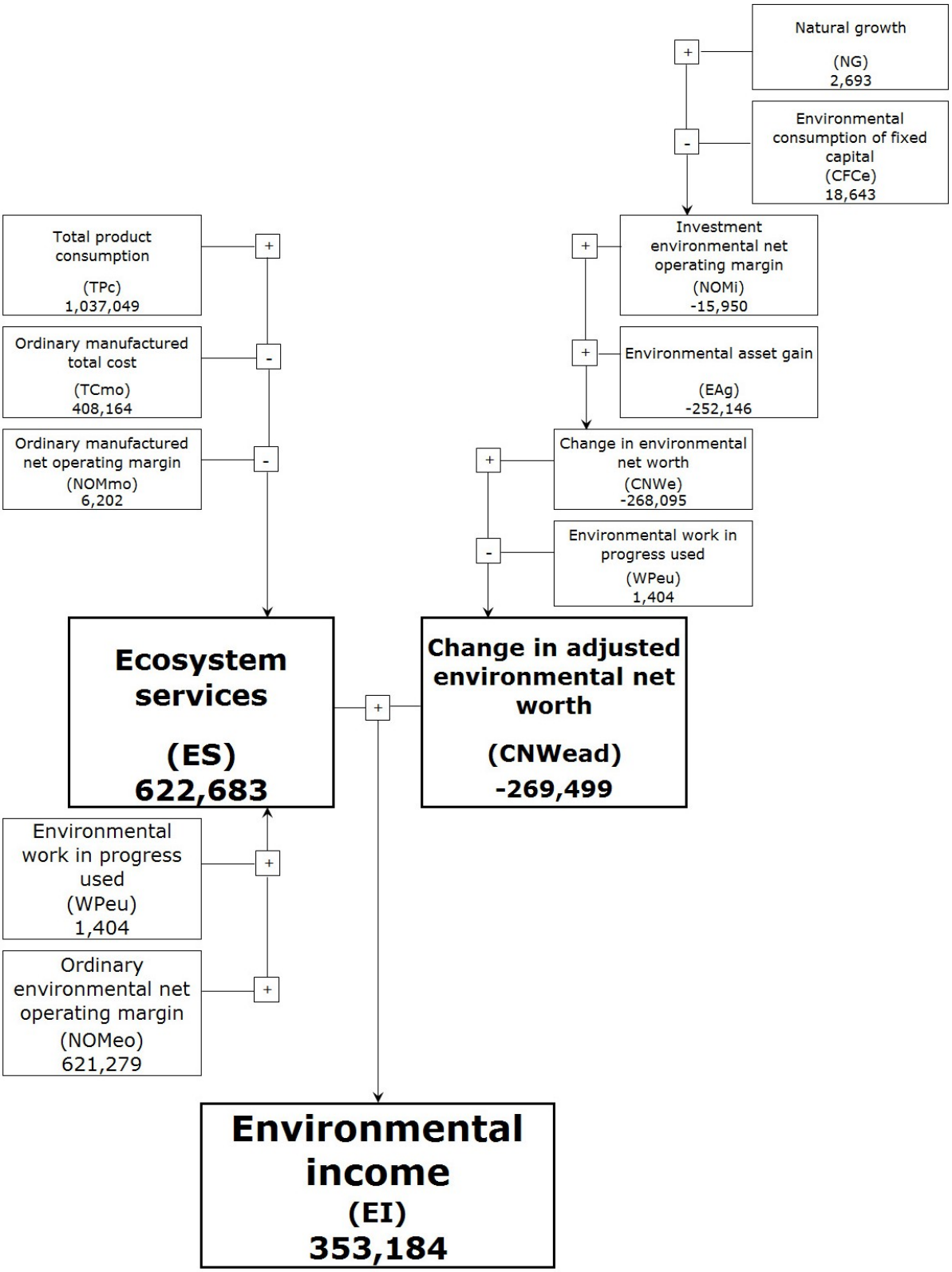
Environmental income is the key threshold indicator for the sustainable ecosystem service maximum economic value. A negative change in the adjusted environmental net worth of a product for a period (CNWead), as is the case for amenity, indicates overconsumption and usually the decline of the environmental asset[20]. Figure 1 shows a HOW total ecosystem service which is 1.8 times the total environmental income. This overconsumption of ecosystem services in the period is due to the negative changes in the environmental net worth of amenity and carbon for the period (Table 2 and Figure 1). When the amenity and carbon activities are excluded, then the ecosystem services of other HOW activities make up 93.4% of the environmental income. In other words, there is under consumption of the ecosystem services of the latter activities (Table 2).

[20] While the change in the value of the environmental asset (CEA) is a real measurement, this may not be the case for CNWead. The latter incorporates the instrumental adjustment of the environmental asset (EAad) in the estimation of the environmental asset gain (EAg). The EAad, by correcting the over-valuation of the ordinary environmental net operating margin (NOMeo) justifies the potential simultaneous existence of positive CEA and negative CNWead values, as is the case for carbon in this study (Table 2 and Figure 1).

Table 2. Stylized sequence of accounts of simplified AAS in holm oak open woodlands in Andalusia, Spain (2010: thousands of euros).

Class	Farmer									Government								Wood-lands
	Timber	Cork	Fire-wood	Nuts	Gra-zing	Conserv. forestry	Resi-dential	Amenity	Total	Fire services	Recrea-tion	Mush-rooms	Carbon	Land-scape	Bio-diversity	Water	Total	
Production and generation of income accounts																		
1. Total product consumption (TPc_{sAAS})	452	964	2,126	79	47,697	3,935	20,634	482,595	558,480	53,682	43,653	25,291	58,851	155,110	15,710	126,271	478,568	1,037,049
1.1 Intermediate products (IP_{sAAS})					47,697	3,935	20,634		72,265	53,682							53,682	125,947
1.1.1 Intermediate product SNA (IP_{rSNA})					47,697	3,935	20,634		72,265	53,682							53,682	125,947
1.1.2 Intermediate product non-SNA ($IP_{non\text{-}rSNA}$)																		
1.2 Final product consumption (FPc_{sAAS})	452	964	2,126	79				482,595	486,215		43,653	25,291	58,851	155,110	15,710	126,271	424,887	911,102
1.2.1 Final product consumption SNA (FPc_{rSNA})	452	964	2,126	79				20,634	24,254		11,443	25,291		107,527	7,347	107,331	258,939	283,192
1.2.2 Final produc consumption non SNA ($Fpc_{non\text{-}rSNA}$)								461,961	461,961		32,211		58,851	47,583	8,363	18,941	165,948	627,909
2. Ordinary total intermediate consumption (ICo_{sAAS})	892	831	620	177	775	1,347	1,094	194,206	199,942	16,005	4,193	60		104,438	2,092		126,789	326,730
2.1 Manuf. intermediate consumption bought SNA ($ICmob_{rSNA}$)	603	34	302	177	775	1,347	1,094		4,332	16,005	1,985	60		2,404	2,084		22,538	26,870
2.2 Own intermediate consumption ($ICmoo_{sAAS}$)								194,206	194,206		2,208			102,035	8		104,251	298,457
2.2.1 Own intermediate consumption SNA ($ICmoo_{rSNA}$)								20,634	20,634		2,208			99,069	8		101,284	121,918
2.2.2 Own intermediate consumption non SNA ($ICmoo_{non\text{-}rSNA}$)								173,573	173,573					2,966			2,966	176,539
2.3 Environmental work in progress used (WPeu)	289	797	319						1,404									1,404
3. Ordinary gross value added ($GVAo_{sAAS}$)	-440	134	1,505	-98	46,922	2,588	19,539	288,388	358,538	37,676	39,460	25,231	58,851	50,672	13,618	126,271	351,780	710,318
4. Ordinary consumption of fixed capital ($CFCo_{sAAS}$)	63		7	28	1,488	133	7,921		9,639	3,894	2,226	36		1,035	879		8,070	17,709
4.1 Manufactured consumption of fixed capital SNA ($CFCmo_{rSNA}$)	63		7	28	1,488	133	7,921		9,639	3,894	2,226	36		1,035	879		8,070	17,709
4.2 Ecosystem degradation non-SNA ($CFCeo_{non\text{-}rSNA}$)																		
5. Ordinary net value added ($NVAo_{sAAS}$)	-503	134	1,499	-126	45,434	2,454	11,619	288,388	348,899	33,783	37,234	25,195	58,851	49,636	12,740	126,271	343,710	692,609
5.1 Labor cost (LCo_{sAAS})	3,527	146	432	1,211	4,747	2,428	4,414		16,906	33,716	5,024	87		5,020	4,377		48,223	65,128
5.1.1 Compensation of employees SNA ($LCoe_{rSNA}$)	3,527	146	432	1,211	4,747	2,428	4,414		16,906	33,716	5,024	87		5,020	4,377		48,223	65,128
5.1.2 Imputed compensation of self-employed non-SNA ($LCose_{sAAS}$)																		
5.2 Net operating margin ($NOMo_{sAAS}$)	-4,031	-12	1,067	-1,337	40,687	26	7,204	288,388	331,994	67	32,211	25,108	58,851	44,617	8,363	126,271	295,487	627,481
5.2.1 Manufactured net operating margin ($NOMmo_{sAAS}$)	-4,031	-12	1,067	-1,337	863	26	7,204		3,781	67	1,815	53		227	258		2,421	6,202
5.2.2 Environmental net operating margin ($NOMeo_{sAAS}$)					39,824			288,388	328,213		30,395	25,055	58,851	44,389	8,105	126,271	293,067	621,279
6. Ecosystem services (ES_{sAAS})	289	797	319		39,824			288,388	329,616		30,395	25,055	58,851	44,389	8,105	126,271	293,067	622,683
Changes in balance accounts																		
7. Changes in environmental asset (CEA_{sAAS})	748	3,098	12,729	14	2,766			-232,447	-213,093				2,445				2,445	-210,648
8. Changes in adjusted environmental net worth ($CNWead_{sAAS}$)	748	3,098	12,729	14	2,766			-232,447	-213,093				-56,406				-56,406	-269,499
9. Environmental income (EI_{sAAS})	1,036	3,895	13,047	14	42,590			55,942	116,523		30,395	25,055	2,445	44,389	8,105	126,271	236,661	353,184

Source: Own elaboration after Campos et al. (in progress). Andalusian Holm oak woodlands surface: 1,408,170 hectares.



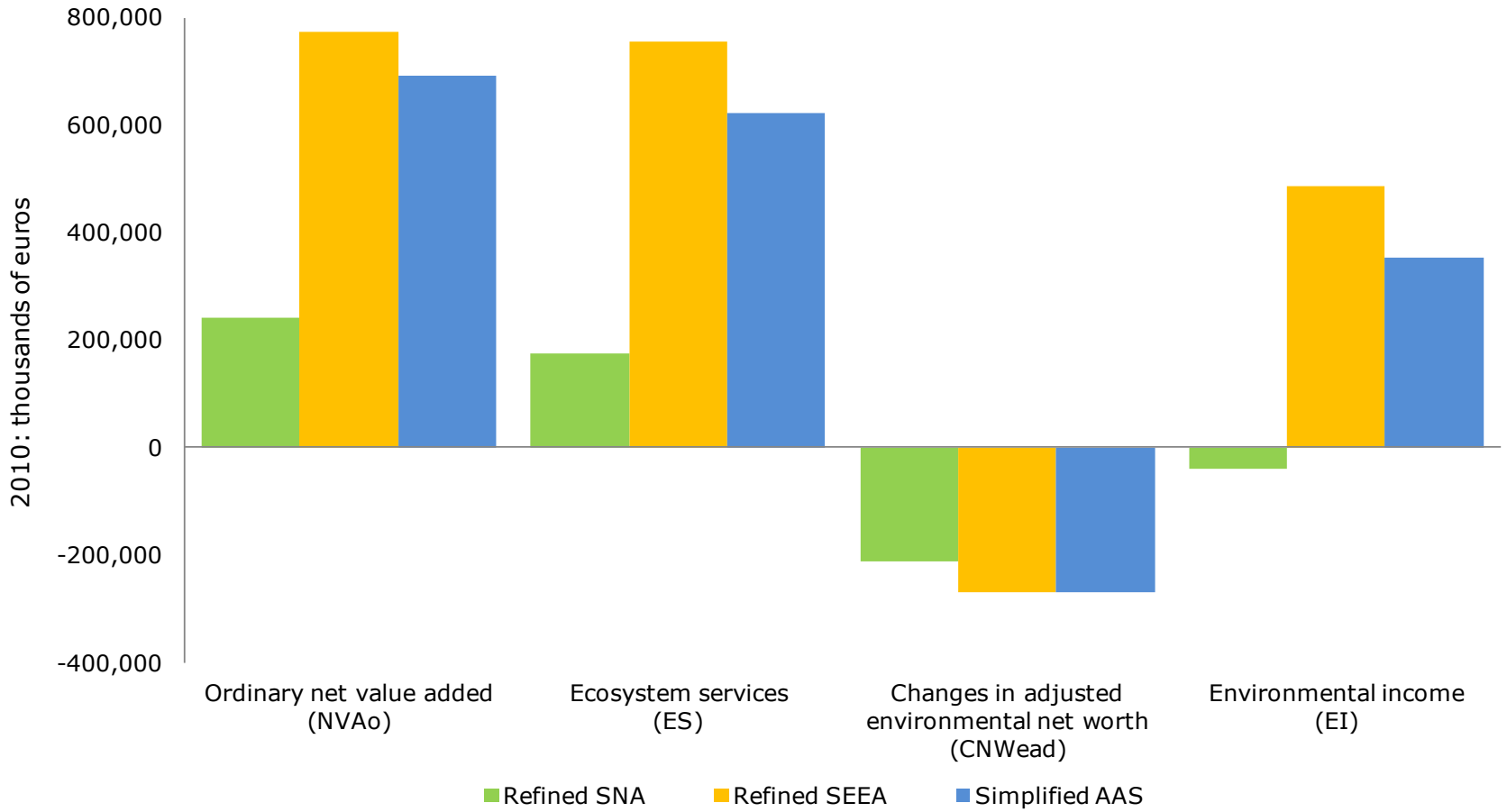
Source: Own elaboration after Campos et al. (in progress). Andalusian holm oak woodlands surface: 1,408,170 hectares.

Figure 1. Total environmental income of simplified AAS in holm oak open woodlands in Andalusia, Spain (2010: thousands euros).

Table 3. Ecosystem accounting: stylized refined SNA and SEEA-EEA versus simplified AAS sequence of accounts in holm oak open woodlands in Andalusia, Spain (2010: thousands of euros).

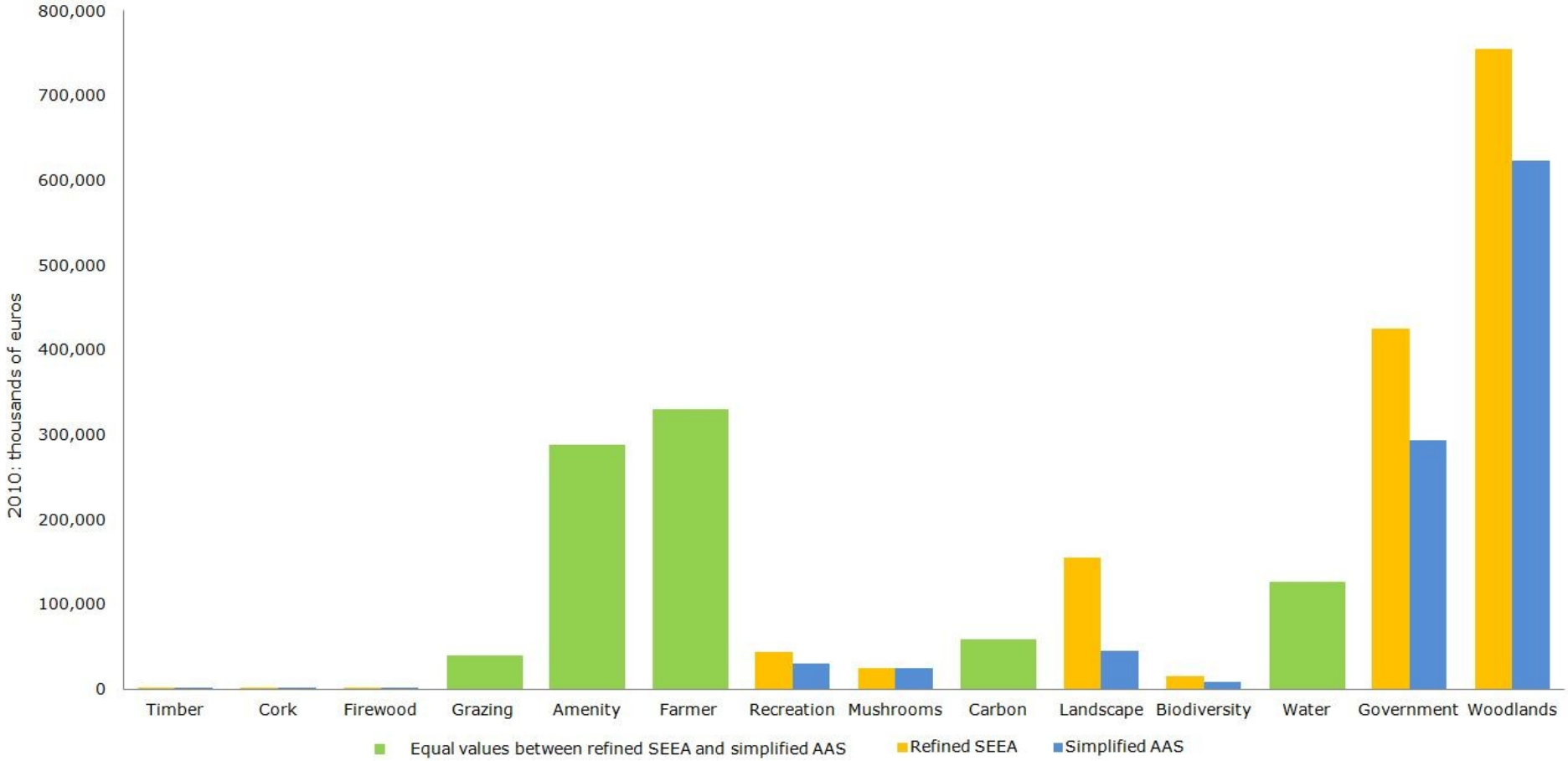
Class	Refined SNA			Refined SEEA			Simplified AAS		
	Farmer	Government	Woodlands	Farmer	Ecosystems	Woodlands	Farmer	Government	Woodlands
Production and generation of income accounts									
1. Total product consumption (TPc)	96,519	312,620	409,139	558,480	424,887	983,367	558,480	478,568	1,037,049
1.1 Intermediate products (IP)	72,265	53,682	125,947	72,265		72,265	72,265	53,682	125,947
1.1.1 Intermediate product SNA (IP_{rSNA})	72,265	53,682	125,947	72,265		72,265	72,265	53,682	125,947
1.1.2 Intermediate product non-SNA ($IP_{non\text{-}rSNA}$)									
1.2 Final product consumption (FPc)	24,254	258,939	283,192	486,215	424,887	911,102	486,215	424,887	911,102
1.2.1 Final product consumption SNA (FPc_{rSNA})	24,254	258,939	283,192	24,254	132,621	156,875	24,254	258,939	283,192
1.2.2 Final product consumption non SNA ($Fpc_{non\text{-}rSNA}$)				461,961	292,265	754,226	461,961	165,948	627,909
2. Ordinary total intermediate consumption (ICo)	24,965	123,822	148,788	199,942		199,942	199,942	126,789	326,730
2.1 Ordinary intermediate consumption SNA (ICo_{rSNA})	24,965	123,822	148,788	24,965		24,965	24,965	123,822	148,788
2.2 Ordinary intermediate consumption non-SNA ($ICo_{non\text{-}rSNA}$)				174,976		174,976	174,976	2,966	177,943
3. Ordinary gross value added (GVAo)	71,554	188,798	260,352	358,538	424,887	783,425	358,538	351,780	710,318
4. Ordinary consumption of fixed capital (CFCo)	9,639	8,070	17,709	9,639		9,639	9,639	8,070	17,709
4.1 Manufactured consumption of fixed capital SNA ($CFCmo_{rSNA}$)	9,639	8,070	17,709	9,639		9,639	9,639	8,070	17,709
4.2 Ecosystem degradation non-SNA ($CFCeo_{non\text{-}rSNA}$)									
5. Ordinary net value added (NVAo)	61,915	180,728	242,643	348,899	424,887	773,786	348,899	343,710	692,609
5.1 Labor cost (LCo)	16,906	48,223	65,128	16,906		16,906	16,906	48,223	65,128
5.1.1 Compensation of employees SNA ($LCoe_{rSNA}$)	16,906	48,223	65,128	16,906		16,906	16,906	48,223	65,128
5.1.2 Imputed compensation of self-employed non-SNA ($LCose_{non\text{-}rSNA}$)									
5.2 Net operating surplus/ margin (NOS/NOMo)	45,009	132,506	177,515	331,994	424,887	756,880	331,994	295,487	627,481
6. Ecosystem services (ES)	41,228	132,385	173,613	329,616	424,887	754,503	329,616	293,067	622,683
Changes in balance accounts									
7. Changes in environmental asset (CEA)	-213,093		-213,093	-213,093	2,445	-210,648	-213,093	2,445	-210,648
8. Changes in adjusted environmental net worth (CNWead)	-213,093		-213,093	-213,093	-56,406	-269,499	-213,093	-56,406	-269,499
9. Environmental income (EI)	-171,865	132,385	-39,480	116,523	368,480	485,004	116,523	236,661	353,184

Source: Own elaboration after Campos et al. (in progress). Andalusian Holm oak woodlands surface: 1,408,170 hectares.



Source: Own elaboration after Campos et al. (in progress). Andalusian holm oak woodlands surface: 1,408,170 hectares.

Figure 2. Selected environmental-economic ecosystem indicators measured using refined SNA and SEEA-EEA versus simplified AAS in holm oak open woodlands in Andalusia, Spain (2010: thousands of euros).



Source: Own elaboration after Campos et al. (in progress). Andalusian holm oak woodlands surface: 1,408,170 hectares.

Figure 3. Ecosystem accounting: individual ecosystem services measured by refined SEEA-EEA and simplified AAS in holm oak open woodlands in Andalusia, Spain (2010: thousands of euros).

3.3. Comparison of ecosystem accounting frameworks

When comparing the results of the rSNA, rSEEA-EEA and sAAS with regard to the HOW, the farmers and the government we focus on the aggregate values of the ordinary net value added (NVAo) at basic (rSNA) and social prices (rSEEA-EEA and sAAS), ecosystem service (ES), change in environmental asset (CEA), change in adjusted environmental net worth (CNWead) in accordance with WPeu and environmental income (EI) (Table 3 and Figs. 2-3)[21].

If we assume that sAAS provides unbiased ecosystem accounting values, then the rSNA estimates undervalue the three variables (NVAo, ES, EI) with positive values shows in Table 3 and in Fig.1. The rSNA also undervalue the negative results of the CNWead (Tables 3-S2, Fig. S1).

As the rSEEA omits the public farmer opportunity cost and the government cost it is expected that the estimates will overvalue government NVAo, ES and EI (Tables 3-S3, Fig. S2).

However, the rSEEA and sAAS provide the same estimate of CNWead. It should be emphasized that the HOW activities affected by our refinements of the SNA and SEEA are amenity and landscape.

Table 3 and Figs. 2-3 show the aggregate results of the HOW institutional sectors in the ecosystem accounting frameworks compared. Although the comparisons of the aggregate results lack conceptual consistency, they highlight the limitations of the rSNA and sSEEA-EEA for measuring the transaction values of the NVAo, ES, CNWead and EI of the 15 HOW economic activities valued in this study.

The results for the indexes compared of the ecosystem service and income indicators in the rSNA and rSEEA methodologies with respect to the base sAAS methodology show similar commercial values, except for ordinary net value added (NVAo) in the rSEEA, due to the omission of the fire service activity (Tables 4-S4). The non-commercial indixes in Tables 4 and S4 reveal notable undervaluation by the rSNA and overvaluation by the rSEEA, in the former due to the omission of carbon activity and the valuation of final public products without market price at production cost. The bias towards overvaluation in the rSEEA is due to the omission of the costs of the ecosystem institutional sector activities.

[21] The results shown in Table 3 are taken from Tables 1, S2-S3, and these tables were drawn up from the results of Campos et al. (in progress).

The indixes of the individual activities of sustainability in Table 5 show values of more than one, except for the amenity and carbon activities. The interpretation of the meaning of unsustainability of the amenity in the period lacks biophysical significance and is due exclusively to the interannual volatility of the variation in land prices, which do not change the long term tendency to real positive variations of around 3% (Ovando et al., 2016). In the case of carbon activity the overconsumption is due to the convention of attributing emission to negative environmental capital formation (fixed environmental capital consumption), since the environmental income is slightly positive (Tables 2,5).

Table 4. Income and ecosystem service index indicator comparisons by aggregate commercial and non-commercial activities for refined SNA, refined SEEA and simplified AAS in holm oak open woodlands in Andalusia, Spain (Indixes rSNA/sAAS and rSEEA/sAAS: 2010).

Class	Commercial activities			Non-commercial activities				Wood-lands
	Woody products	Non-woody products	Total	Amenity	Land-scape	Others	Total	
1. Ordinary net valued added (NVAo)								
rSNA/sAAS	2.24	1.00	1.01	0.00	0.10	0.55	0.25	0.35
rSEEA/sAAS	1.00	0.64	0.64	1.00	3.12	1.04	1.19	1.12
2. Ordinary net operating surplus (NOSo)/margin (NOMo)								
rSNA/sAAS	0.53	1.00	1.03	0.00	0.00	0.53	0.23	0.28
rSEEA/sAAS	1.00	1.00	1.00	1.00	3.48	1.08	1.22	1.21
3. Ecosystem services (ES)								
rSNA/sAAS	1.00	1.00	1.00	0.00	0.00	0.53	0.23	0.28
rSEEA/sAAS	1.00	1.00	1.00	1.00	3.49	1.08	1.23	1.21
4. Changes in environmental asset (CEA)								
rSNA/sAAS	1.00	1.00	1.00	1.00		0.00	1.01	1.01
rSEEA/sAAS	1.00	1.00	1.00	1.00		1.00	1.00	1.00
5. Changes in environmental net worth adjusted (CNWead)								
rSNA/sAAS	1.00	1.00	1.00	1.00		0.00	0.80	0.79
rSEEA/sAAS	1.00	1.00	1.00	1.00		1.00	1.00	1.00
6. Environmental income (EI)								
rSNA/sAAS	1.00	1.00	1.00	-4.16	0.00	0.69	-0.34	-0.11
rSEEA/sAAS	1.00	1.00	1.00	1.00	3.49	1.11	1.45	1.37

Source: Own elaboration after Campos et al. (in progress). Andalusian holm oak woodlands surface: 1,408,170 hectares.

Table 5. Environmental income and ecosystem services indexes by individual activities, institutional sectors and accounting frameworks in holm oak open woodlands in Andalusia, Spain (Index EI/ES: 2010).

Class	Refined SNA	Refined SEEA	Simplified AAS
1. Farmer	-4.17	0.35	0.35
1.1 Timber	3.59	3.59	3.59
1.2 Cork	4.89	4.89	4.89
1.3 Firewood	40.96	40.96	40.96
1.4 Nuts			
1.5 Grazing	1.07	1.07	1.07
1.6 Conservation forestry[a]			
1.7 Residential[a]			
1.8 Amenity		0.19	0.19
2. Government[b]/Ecosystems[c]	1.00	0.87	0.81
2.1 Fire services[a]			
2.2 Recreation		1.00	1.00
2.3 Mushrooms	1.00	1.00	1.00
2.4 Carbon		0.04	0.04
2.5 Landscape		1.00	1.00
2.6 Biodiversity		1.00	1.00
2.7 Water	1.00	1.00	1.00
Holm oak open woodlands	-0.23	0.64	0.57

[a] is non-applicable.
[b] for refined SNA and simplified AAS.
[c] for refined SEEA.
SEEIj = EIj/ESj ≥ 1, then j total product consumption (TPcj) is sustainable.

The comparisons of the results of the ecosystem accounting frameworks applications reveal that it is conceptually and effectively possible to make visible the extensions to the rSNA, rSEEA-EEA and sAAS in a manner consistent with the transaction value of the SNA valuation criterion, maintaining the valuations of the products with market price at observed market prices, at production cost for ordinary final products with no market price in the rSNA and at simulated transaction prices in this case for the rSEEA-EEA and sAAS. With respect to the sequence of simplified accounts of Obst et al.(2019: Table 6, p. 33), the extensions to the ecosystem accounting frameworks compared in this study affect the reclassifications and incorporations of new variables and government institutional sector in the rSNA (Tables 2-3, S2-S3).

4. Ecosystem accounting frameworks discussion

4.1. Brief review of literature on ecosystem services and environmental incomes from selected economic activities

We remind the reader that in this study the ecosystem service is estimated by the natural resource rent: "the resource rent can be interpreted as the extra income one obtains from having the right to utilize a natural resource" (Alfsen and Greaker, 2006: p. 10). We have defined the environmental income in previous publications as the total contribution of nature to the total income of an economic activity in the period (Campos et al., 2017, 2019a, 2019b, Ovando et al., 2016). With regard to the measurement of these two ecosystem variables, here we limit this aspect to the presentation of comparisons of the ecosystem service valuations and the changes in environmental assets by a small sample of authors, which illustrate the similarities and differences in the valuations of woody products (Campos et al., 2019a, 2019b; Vallecillo et al., 2019a), carbon (Campos et al., 2019a; Narita et al., 2018; Vallecillo et al., 2019a), free access recreational services (Campos et al., 2019a; Caparrós et al., 2017; Remme et al., 2015; Vallecillo et al., 2019b) and the environmental income (Angelsen et al., 2014; Cambell and Luckert, 2002; Cavendish, 2002; La Notte et al., 2019a, 2019b; Narita et al., 2018).

4.1.1. Woody products

The convention applied in this study, of estimating ecosystem services as the residual economic values embedded in the products generated in the period and consumed by people, excludes the accumulated final natural growth in the stocks of environmental assets at the closing of the period. Thus, it follows from this convention that it is not consistent to substitute the physical consumption of woody products for their natural growth in the period in order to estimate the ecosystem services of the woody products. Other authors prefer to estimate the ES of woody products from the net natural physical growth in the period of the woody products in progress. These authors explain that this is "in order to avoid misleading overlapping and double counting between the ecosystem service and economic activities already captured by the economic accounts" (Vallecillo et al., 2019b: p. 9).

The risk of double counting of ecosystem services of woody products is non-existent due to the exclusion of natural growth in the measurement of the former in the

revised ecosystem accounting framework applications compared in the HOW of Andalusia. In our study, the economic concept of ecosystem service refers exclusively to the standard resource rent of a product consumed directly or indirectly by people, whether represented by the WPeu or the NOMeo embedded in the value of the first possible transaction (e.g. stumpage transaction price) at the farm gate.

As regards registering the harvest and the natural growth of the woody product, there is a time difference between the period in which the natural growth takes place and the later period in which the product is harvested. Double accounting of WPwu and the NG (adjusted according to forecast future destruction) of woody products in the period allows for the measurement of the economic contribution given by nature in the form of environmental net operating margin investment (NOMei) to the net operating margin (NOM) of natural base woody products in the period. We register the accumulated final product in the form of woody natural growth (NG)-net forecast future destructions- in the supply side of the production account for the period. At the same time, the NG is registered as an entry in the balance account of the stock of woody environmental asset work in progress. The harvested environmental woody work in progress (WPeu) for the period must be registered as an output of stock of the environmental asset work in progress (EAwu) and at the same time as an intermediate consumption of environmental raw material (WPeu) according to its environmental price (unit resource rent) in the opening inventory and as a final product consumed (FPc) at market price (producer) at the farm gate. The value of the NG represents the environmental operating income from the investment (NOMei) in the woody product in the period, and coincides with the total environmental operating income (environmental net operating margin-NOMe), since the WPeu is a cost and not an ordinary environmental operating income[22].

The NG is not the only income from the woody environmental asset in the period, another component of its environmental income (EI) is the environmental asset gain (EAg). The EI expresses the total contribution of nature in the period to the current consumption and to indefinite future consumptions of woody products forecast to be harvested. However, in the ecosystem accounting methodologies applied we are interested in presenting the EI with an identity equivalent to the original, which explicitly expresses its dependence on the ES component (WPeu) and the change in the

[22] The fact that the WPeu are implicitly defined in the SNA as operating resource rent is explained by the fact that, at the same time, the measurement of NG is omitted. However, a bias towards over/under estimation may occur if physical growth is lower/higher than the woody product harvested, all else being equal.

woody environmental asset in the period. Thus, the EI as the sum of the ES and changes in the environmental assets (CEA) simply expresses the over/under-consumption of woody total products in the period, depending on whether ES is, respectively, higher/lower than EI.

4.1.2. Carbon

Our valuation of the ecosystem service of carbon at market price as regards carbon fixation by HOW shrubs and trees coincides with that of other authors: "we considered CO2 uptake from the atmosphere to the ecosystem as a proxy for the assessment of the ecosystem service (Vallecillo et al. (2019a: p.44). We differ from Vallecillo et al. (2019a) in that we incorporate the environmental income (EI) from carbon for the period measured according to the change in opening and closing environmental assets (CEA). The CEA integrates the fixation (ES) and the emission (CFCe) of carbon. Thus, the measurement of the EI can also be presented as the fixation of carbon (ES) plus the change in environmental net worth adjusted (CNWead) according to the current fixation (ES). We take issue with other authors who do not acknowledge the flow of carbon fixation as an ecosystem service but, with an apparent lack of logic, propose that CEA should be acknowledged: "In the estimations, we consider that carbon retention does not concern flow benefits but changes the stock value of the forest, as carbon dioxide sequestration due to a current increase in the forest stock does not bring immediate benefits for humans at present, but does affect the intertemporal welfare in the form of mitigated damage by climate change in the future, i.e., increased levels of future consumption" (Narita et al., 2018. p. 194). We accept that the effects of fixation (ES) on the consumption of products occur in the same period in which they take place and that they persist over time, whereas the effects of the emissions (CFCe) do not affect the products consumed in the current period but DO have an enduring effect on products consumed in the future.

4.1.3. Free access recreation service

We estimate the recreational visits declared by visitors with movements beyond the peri-urban natural spaces of the Andalusian region through a contingent valuation survey of Spanish households (Campos et al., 2019a). We estimate the price of the transaction using the simulated exchange value method based on an on-site contingent valuation survey of the visitors to the natural areas of Andalusia (Oviedo et al., 2016).

The value of the final product consumed (FPc) of recreational services by free access visitors to the Andalusian HOW is estimated by multiplying the estimated exchange value of the visit by the median willingness to pay (DAP_M) half the total number of visits. The ecosystem service (ES) of the recreational visits is estimated by the PFc less the total ordinary manufactured cost (TCmo) and the ordinary manufactured net operating margin (NOMmo) (Campos et al., 2019a; Caparrós et al., 2017). In other words, the recreational visit final product consumed is not usually the value of the ecosystem service, as evidenced in the HOW, where the ES accounts for 69.6% of the FPc of the recreational services.

Our estimates of the value of the HOW recreational services differ from those of other authors according to the type of visits and the type of exchange value of the visit. Vallecillo et al. (2019a) simulate all the ordinary (habitual) visits by local inhabitants to the natural areas around them, including peri-urban natural areas, based on a distance function (Vallecillo et al., 2019b: p. 200). The price of the visit is assumed to be the usual cost to the visitors derived from applying the zonal travel cost method (Vallecillo et al., 2019b: p. 200a). The authors assume that the estimated consumer surplus in this case is a "proxy" value of the simulated transaction price of the visits: "For zonal TCM [travel cost method], consumers' purchasing habits are estimated based on the number of trips that they make at different travel costs. […] the travel cost was the most suitable proxy to estimate the exchange value of visits generated at different distances, even when assessing walking/biking trips. As time travelling or cycling to recreation sites cannot be valued with exchange price, the travel expenses by car represent replacement costs which proxy the value of recreation in line with SEEA guidelines" (Vallecillo, 2019a: p. 2001).

Our estimations also differ from those of Remme et al. (2015). According to these authors, visitors are those who move in a radius of 15 kilometres from a place where they spend at least one night in tourist accommodation in the region of Limburg-Holanda in an area near to or within the natural area visited. The ecosystem service of the recreational visit is estimated according to the difference in price of the tourist accommodation with respect to other accommodation not influenced by the environmental services of the natural area: "Average resource rent per tourist was calculated separately for the three regions based on differences in average expenditure and the number of tourists visiting the area. Resource rent was spatially allocated to

natural areas based on the number of tourists visiting natural areas within a 15 km radius around each accommodation" (Remme et al., 2015. 120).

4.1.4. Environmental incomes

As far as we know, the use of the term 'environmental income' with the implication of sustainability as we use it, was first defined by Cavendish (2002): "where resource change is very dramatic (e.g. the decline in sandalwood […]), then some adjustments [in resource rent] are necessary to derive a figure for sustainable [total and environmental] income" (Cavendish, 2002: pp. 49-50). Narita et al. (2018) implicitly acknowledge the EI when estimating the environmental assets, considering that they depend on the environmental margin and capital gains: "p [environmental asset price] embodies the marginal service flows (dividends) and capital gains of the evaluated stock, adjusted by time discounting and future stock growth" (Narita et al., 2018. p. 190). La Notte et al. (2019a, 2019b) also implicitly accept the concept of environmental income when they assume indefinite future scheduling of of sustainable management of environmental assets, which integrates the consumption and posible improvements in the estimation of the environmental price of the assets: "If a sustainability threshold can be established, it becomes possible to calculate what we can call "potential flow" (or sustainable flow). If the actual flow of the service (the use) is equal or below the potential flow, then the capacity to provide the same (or enhanced) amount of ecosystem service is guaranteed" (La Notte et al., 2019b: p. 160).

The ecosystem service and environmental income income values of a product consumed are similar if the change in environmental asset is small, and if the above defined conditions of sustainability are fulfilled, they also coincide with the sustainable environmental income value.

Among the pioneering applications of the concept environmental income (EI), we should highlight the studies of family-scale subsistence economy incomes of shepherds and "salvage" product collectors in free access silvopastoral landscapes in Africa, Asia and Latin America (Angelsen et al., 2014; Cambell and Luckert, 2002). Although these pioneering applications of environmental income do not usually adjust the resource rent (ecosystem services) according to the changes in the environmental assets (CEA) for the period, often because they assume these changes to be minimal, they implicitly acknowledge in these cases, a situation of indefinite continuity of stable state and/or improvement in the physical amount of renewable natural resources:

"where changes in the resource stocks studied are known to be small - as was the case in the year comprising the Shindi study – then the effort required to adjust household accounts for changes in resource stocks is probably excessive" (Cavendish, 2002: p. 49).

4.2 Ecosystem accounting framework comparison beyond SNA and draft SEEA

We focus the discussion on the conceptual structures of the three ecosystem accounting frameworks applied to the measurement of HOW ecosystem environmental incomes. The most significant conceptual changes that we have incorporated in the stylized sequence of accounts of Obst et al. (2019: Table 6, p. 33) are discussed below (see Tables 2-3, S2-S3).

The rSNA final product consumption ecosystem services ($FPc_{non\text{-}SNA}$) are not accounted for as they are embedded in the SNA intermediate and final products consumption. Given their condition as ongoing environmental work in progress used (WPeu) at the opening of the period, it would be inconsistent to consider the WPeu as an period intermediate product. We include as rSNA the government SNA final product consumption (FPc_{SNA}) of public products without market prices consumed (recreation, landscape and biodiversity) at production costs and the final public products consumption with market prices (mushrooms and water) at market value.

The non-SNA final products consumption ($FPc_{non\text{-}SNA}$) of the rSEEA and sAAS components are non-SNA ordinary intermediate consumption ($ICo_{non\text{-}SNA}$) and ecosystem services ($ES_{non\text{-}SNA}$) not accounted for in the rSNA and market value of public products of mushrooms and water.

The rSEEA-EEA includes the ecosystem as an institutional sector (Obst et al. (2019: Table 6, p. 33), and it does not include, by previous convention, public farmer voluntary opportunity costs and government manufactured costs. We include as rSEEA-EEA government SNA ordinary final product (FPo_{SNA}), the production costs of public products consumed without market prices (recreation, landscape and biodiversity) and the market value of public products with market prices (mushrooms and water).

Our sAAS incorporates the institutional sector of government as a collective owner of the public economic activities. We consider the ordinary total product (TPo_{rAAS}) of (i) fire services measured at production cost, (ii) mushrooms, water and carbon at market prices, and (iii) recreation, landscape and biodiversity at the marginal price of consumer willingness to pay. We then separate the TPo_{rAAS} into SNA ordinary

final product (FPo_{SNA}) and non-SNA ordinary final product ($FPo_{non\text{-}SNA}$) (see Tables 2-3, S2-S3).

The ESs in the rSEEA-EEA is larger than that of the sAAS because the former omits the total ordinary costs of the public farmers and government incurred in the management and regulation of ordinary total public products. The rSEEA-EEA public ecosystem service ($ES_{rSEEA\text{-}EA}$) estimates are considered overvaluations, except for water and carbon because these products do not have ordinary manufactured costs.

There has been no degradation of the future physical productivities of HOW economic activities when long-term horizon scheduled sustainable biological modelling (Campos et al., in progress) is used, and when estimating the changes in environmental assets at environmental price (unit resource rent) discounted at the closing of the period, a greater environmental asset value is obtained for each individual activity than at the opening of the period, except in the case of the private amenity environmental asset. This change in the latter is due to the depreciation in the market price of land in 2010.

The rSNA ordinary net operating surplus (NOSo) overvalues the pure operating capital income (net operating margin) in comparison with the rSEEA-EEA and sAAS frameworks. This is due to the inclusion in the rSNA of the environmental work in progress used (WPeu) in NOSo, which, as it is an input from the opening inventory of cork (work in progress produced years previously), is not considered in the SNA as intermediate consumption of the economic activities in the period. In contrast to the rSNA criterion, the rSEEA-EEA and sAAS exclude WPeu from the NOSo, that is, under these two ecosystem accounting frameworks we assume that NOSo coincides with the ordinary net operating margin (NOMo).

Timber, cork, firewood and acorns do not include the consumption of manufactured fixed capital in the form of plantations when they were compensated by government. Since they are produced for the purposes of public landscape conservation services, we register them under an activity designated as ‘conservation forestry’ (see details in Campos et al, 2019a). The use of manufactured fixed capital equipment is imputed in the intermediate consumption service paid by the farmer to contracted corporate services.

Changes in environmental assets (CEA) correspond to the environmental assets at the closing of the period (EAc) less those at the opening of the period (EAo). Changes in adjusted environmental net worth (CNWead) according to WPeu usually coincide with the CEA. In this HOW study, CNWead and CEA differ only with respect

to carbon activity. This is due to our assumption that carbon emission is a consumption of the fixed environmental asset (CFCe). That is, carbon emission is not embedded in carbon ordinary final product (carbon fixation).

This HOW study shows that the individual product environmental income for the period may correspond with its sustainable economic ecosystem services. We establish this hypothesis through the following future steady state assumptions: (i) the changes in environmental assets will be zero in future indefinite periods for recreation, mushrooms, water, landscape and threatened wild biodiversity; (ii) based on current inventories, the biological cycles of the tree plantations for timber (conifer trees), cork (cork oak) and firewood (holm oak) and their assumed future natural regeneration point to a positive change in adjusted environmental net worth in accordance with WPeu ($CNWead > 0$). In simpler terms, given that the environmental income from timber, cork and firewood exceed their respective ecosystem services, it is consistent to conceptualize the EI as a maximum sustainable ecosystem service value of these woody products, which we can consume in the period without reducing the value of their environmental asset at the closing, and (ii) it is reasonable that the ecosystem services and the environmental income from market woody products have the same values whichever the ecosystem account framework applied. This is not the case with the ecosystem services of private amenity and public non-market ordinary final products, due to the fact that their ES and EIs have been omitted completely in the rSNA and the ecosystem institutional sector of the rSEEA-EEA does not include the manufactured cost of ordinary final public goods and services.

In summary, with regard to the updating of the mainstream concept of ecosystem services (ES) and environmental assets from forest/woodland landscapes, there is general agreement that standard SNA economic activities should be refined to incorporate non-market total products and incomes, economic rent (resource rent) as the true value of the ES for the period and, all else being equal, their future discounted flows reveal the values of the environmental assets for the period. Although there are no mainstream academic discrepancies as regards the concept of environmental income, the absence of standard, complete sequences of ecosystem accounts means that in practice, different terms continue to be used such as environmental income, ecosystem income or sustainable potential flow (Atkinson and Obst, 2017; Edens et al., 2013; Krutilla, 1967; Stone, 1984; La Notte et al., 2019a, 2019b).

4.3. Corporation versus regional scale holm oak open woodland applications: convergences and divergences

The AAS methodologies are the same whichever the scale of the applications. Our AAS applications give the same results for ecosystem services and environmental assets, and logically, the results vary due to differences in the areas valued. The macro scale of the Andalusian HOW does not include results for hunting activities, livestock and agriculture (this activity being only nominal). In contrast, the micro scale results for a sample of holm oak open Woodland farms *do* incorporate these activities omitted in the regional scale application to the Andalusian HOW.

¿Why are animal activities important in the case of the estimates of ecosystem service values at regional scale if the ES incorporated in the final animal products consumed have been measured according to the environmental activities of hunting (as a substitute environmental value of hunting activity grazed fodder not paid for by the livestock farming) and grazing paid for by livestock farming? The answer is that the animal activities are relevant because at both scales our AAS at social price incorporate the government compensations and the opportunity costs incurred by the owners in the management of the hunting, livestock and agricultural activities. The compensations and opportunity costs are double counted; on the one hand, as intermediate products of the hunting, livestock and agriculture activities, and on the other, as own intermediate consumption of the private amenity and public landscape conservation activities, thereby affecting the ecosystem service estimates of these latter two activities both at corporation (HOD) and regional (HOW) scales.

In short, in the applications of our sAAS to the HOW at regional scale in Andalusia, the intermediate product does not coincide with the own intermediate consumption due to the omission of hunting, livestock and agriculture activity. In other words, our regional application does not present the total income and total capital, but it does present the total values of the ecosystem services, the environmental income and the environmental assets. We present Andalusia scale maps of the ecosystem services and environmental income at producer prices.

As the farm scale applications (HOD) include all the economic activities observed in the spatial unit, they present the measurements for total income and total capital. In this case the micro application shows the complete reality of the production and balance accounts at farm scale, which is the mínimum relevant economic unit to

estimate the opportunity costs incurred by the owners of the land and livestock. In this case the intermediate product and the own intermediate consumption values coincide.

The two scales of the applications described present certain new aspects. In the case of the regional application to the HOW incorporating opportunity costs, the innovation with respect to Campos et al. (2019a) is that in the latter the results are presented at producer prices, whereas in the new application at regional scale to the HOW of Andalusia the results include non-commercial intermediate services stemming from government use compensations and opportunity costs incurred by the public and private owners of the land and livestock.

The application at HOD farm scale is preceded in part by Campos et al. (2017) and in its entirety by Campos et al. (2019b). The first of these two publications applies the AAS accounts to commercial activities and does not estimate the value of the ecosystem services of the public goods and services, except for carbon. The application of the AAS to a reduced sample of open cork oak *dehesas* (COD) in Andalusia incorporates the valuations of the ecosystem services and the environmental income and social prices.

According to (UNSD,2019: p16) "the same accounting principles used for macro-scale accounting can be applied at the business level. Thus, there is potential for SEEA EEA to play a role in both corporate and national scale natural capital accounting" (UNSD, 2019: p.16). The relevance of these micro applications at farm scale is that, among other aspects, to avoid overvaluation bias of the ES estimates at market prices in the SEEA-EEA applications (which we have noted but not avoided in the publication Campos et al. (2019a: p.234) and which affects the results whichever territorial scale is used), the ES estimates must be presented at social prices. Therefore, the macro scale applications require estimations of the own non-commercial intermediate consumption stemming from government compensations and opportunity costs incurred voluntarily by the owners of the land and livestock, and it is necessary that these costs be previously measured for each activity at individual farm scale.

5. Conclusions

This application of ecosystem accounting frameworks for the holm oak open woodland ecosystem in Andalusia, integrated in the slightly refined System of National Accounts, serves to reinforce the recommendation of many academics to broaden the

standard net value added based on observed transactions and simulated exchange value to include additional ordinary final products.. Inaddition, to measure current period ecosystem service consumption, the economic activities must be valued beyond basic prices to include the farmers´ voluntary opportunity costs incurred by theirs economic activities and their counterpart of own non-commercial intermediate econsumpotion of services (SSnco), favouring the supply of private amenity auto-consumption by the farmers and free consumption of public final goods and services.

One of the most notable findings of this study is that the environmental income of a product in a period corresponds with its maximum sustainable economic ecosystem service. Furthermore, given a scheduled future sustainable bio-physical threshold, the environmental income is also the indicator that provides the long term horizon for sustainable bio-physical ecosystem management.

We conclude that to measure ecosystem services and environmental income consistently with total social income, the institutional sector of government must be included in the institutional sectors of the ecosystem accounting to avoid measurement bias as that associated with the rSNA and rSEEA-EEA frameworks.

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Appendix: Supplementary material

Ecosystem Accounting:
Application to Holm Oak Open Woodlands in Andalusia-Spain

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This appendix includes:

Supplementary text for

Ecosystem Accounting:
Application to Holm Oak Open Woodlands in Andalusia-Spain

List of contents:

S1. Refined System of National Accounts

S1.1. Institutional sectors of the HOW in the refined SNA

The rSNA assumes that the government is an institutional sector of the HOW which is independent of the private and public landowners which we include in the farmer institutional sector. The inclusion of the government in the rSNA is an important difference in relation to the SNA. The latter places the government HOW activities outside the HOW activities.

S1.2. Production and generation of income accounts

S1.2.1. Ordinary total product

S1.2.1.1. Intermediate product

Our refined SNA (rSNA) presents the intermediate production as a visible SNA product whereas the standard SNA omits it as a product. Having defined the intermediate production for all the HOW area, the intermediate production of raw materials for the grazing activity (IRMcg) is registered as own commercial intermediate consumption of hunting and livestock activities (RMcohu/li) in the HOW. In this case, the hunting and livestock activities in the HOW which consume the grazing have not been valued here.

The *conservation silviculture* activity incorporates the commercial intermediate service (ISScccf) at production cost. The ISScccf, if it where the case, includes the annualized compensations (consumption of historic fixed capital) for the plantations compensated by the government. The *residentia*l activity generates a commercial intermediate services (ISScre) valued at market leasehold price. The fire *services* activity generates a commercial intermediate service (ISScfs) valued at production cost.

In our study of the HOW there is no double counting of the IRMcg and SSncodla. In contrast, the intermediate products of the *conservation* silviculture, residential services and fire services valued in the refined SNA do generate double counting in the total product (output) consumed by an amount of 78,250 thousand euros. In other words, the adjusted ordinary total product is 330,889 thousand euros (Table S2).

S1.2.1.2. Ordinary final product

Our aim of estimating the values of the ecosytem services obliges us to estimate the final product consumed, excluding the own-account manufactured gross capital formation (GCF). The GCF, however, will form part of the future ordinary final product calculation via the consumption of ordinary manufactured fixed capital.

Our refined SNA incorporates the government activities of mushroom gathering by free-access visitors and economic water stored in reservoirs, of which the final public products consumed are valued according to the market price at the farm gate or at the reservoir (in both cases coinciding with the resource rent). The government activities of free-access recreation, landscape conservation and threatened wild biodiversity preservation are valued according to the final public products consumed at production cost.

The weighting of the contribution of ecosystem services is referred to the adjusted final product consumed (without double accounting of the intermediate production).

The omission of the government activities of the HOW in the standard SNA leads to an undervaluation of 76.4% of the total product consumed in the period, since the standard SNA only include the farmers institutional sector among the HOW activities (Table S2).

S1.2.2. Ordinary total intermediate consumption

Ordinary total intermediate consumption includes the manufactured commercial intermediate services bought which are produced outside the HOW (ICmob) along with the intermediate consumption of ordinary manufactured own services, both commercial (SSmco) and non-commercial (SSmoo) produced in the HOW by activities which *are* valued and controlled animal activities, the valuation of which has been omitted in this study.

In this case the refined SNA maintains the same criterion as the standard SNA in that it does not incorporate the extractions (WPeu) of timber, cork and firewood present in the inventories of the opening of the period in the intermediate consumption. These extractions of environmental work in progress woody products (WPeu) when valued by the unit resource rent (environmental price) correspond to the value of the ecosystem services.

As regards private amenity activity, that originating from the residential service (ISScre) is registered as own commercial intermediate consumption. In the case of landscape activity, conservation silviculture (ISSccf) and fire services (ISScfs) are registered as own commercial intermediate consumption of services. Also registered here are the compensated own non-commercial intermediate consumptions (SSncoc) stemming from the compensated non-commercial intermediate services of the animal activities (ISSncchu/li). The latter are due to the compensations which the farmers receive from the government for animal activities, the aim of which is the conservation of the HOW cultural landscape.

The government activities account for 83.2% of the HOW intermediate consumptions estimated by the refined SNA. The comparisons of individual activities reveal that it is the private amenity and landscape activities which account for 82.1% of the HOW intermediate consumptions according to the refined SNA (Table S2).

S1.2.3. Ordinary gross value added

It should be borne in mind that the ordinary gross value added in the refined SNA differs from the total gross value added in that it does not include the gross value added of the own-account production of the goods which comprise the gross capital formation of the period.

The results show that the government accounts for 72.5% of the HOW gross value added consumed (Table S2).

S1.2.4. Ordinary net value added

The refined SNA does not incorporate the consumption of manufactured fixed capital corresponding to the HOW activity own-account gross capital formation output for the period in the ordinary net value added estimate. Similarly, the consumption of environmental fixed capital of the environmental assets valued are not incorporated in the refined SNA.

As might be expected given the silvopastoral character of the HOW, the grazing activity is that which makes the greatest contribution to the NVA of the farmers, accounting for 73.4%. However, the government activities account for 2.9 times more NVA than the farmers activities. Among the government activities, the economic water from reservoirs consumed makes up 59.4% of the NVA of the government activities (Table S2).

S1.2.4.1. Ordinary compensation of employees

In our application of the refined SNA to the 14 HOW activities valued, the use of unpaid self-employed labour was not observed in the generation of the total products consumed of the HOW activities valued in the period. The absence of mixed income in this case simplifies the calculation of the net operating surplus. We highlight the fact that the demand for employment in the HOW government activities valued is 2.9 times the amount corresponding to the farmers. The residential services and fire services activities account for 58.5% of the cost of the demand for labour associated with the generation of the final products consumed (Table S2).

S1.2.4.2. Ordinary net operating surplus

The relatively low value of the WPeu in the HOW takes the NOSo closer to the ordinary net operating margin (NOMo). The NOMo is composed of the ordinary manufactured net operating margin (NOMmo) and the ordinary environmental net operating margin (NOMeo). When the ecosystem services (ES) are recorded as the sum of the WPeu and the NOMeo, the NOSo represents the sum of the ES and the NOMmo.

The contribution of the NOMmo to the NOSo is marginal, the contribution of the ES being 97.8% of the NOSo. The ES of grazing and water account for 82.9% of the NOSo (Table S2).

S1.2.5. Ecosystem services

The refined SNA allows us to estimate the ecosystem services without the need to extend the concepts of economic activity, except in the case of mushrooms and economic water in reservoirs. As regards the free-access gathering of mushrooms by recreational mushroom pickers we recognize the existence of the time employed by recreational visitors without opportunity cost (zero cost) and as there are no government ordinary manufactured costs the final product consumed and the ecosystem services of mushrooms coincide, valued at market price. With regard to the water, its condition as an economic activity requires us to recognize that natural precipitation is a zero cost input of the production function of HOW surface water in reservoirs. This latter assumption extends the standard SNA concept of economic activity to include those with only physical input at zero price contributing to the activity period ordinary final product.

The ES account for 52.5% of the adjusted ordinary total product (net of double counts). The work in progress used (WPeu) products of timber, cork and firewood make up 3.4% of the total value of the farmers ES. The ordinary environmental net operating margin (NOMeo) of grazing accounts for the remaining 96.6% of farmers ES. If we omit the estimations of the mushroom and water activities, the results and the consistency of the ecosystem accounts are notably affected. Mushrooms and water account for 76.3% of the ecosystem services in the 14 activities valued by the refined SNA (Table S2). The farmers ES make up the remaining 23.7% of the HOW ES. The sum of the ES of grazing, mushrooms and water accounts for 99.2% of the HOW ES estimated by the refined SNA. These contributions relative to the total HOW ecosystem services will change significantly in comparison to the estimates in our versions of the rSEEA-EEA and sAAS models applied.

S1.3. Ordinary capital account and changes in balance account

S1.3.1. Ordinary capital account

The ordinary capital account shows the net saving, the consumption of manufactured fixed capital (CFCmo) and as balancing item of both flows, the net loan/net credit. We do not discuss this account here as the net saving does not affect the environmental income estimation and the CFCmo has been dealt with in the ordinary production account.

S1.3.2. Changes in balance account

S1.3.2.1. Variations in manufactured fixed capital

The estimation of the ES residual value is dependent on the production factors of manufactured capital and labour having been previously remunerated. The ordinary production and generation of income accounts show the ordinary manufactured labour costs and ordinary fixed capital consumption which allow the ES to be estimated. The consumption of ordinary manufactured fixed capital (CFCmo) is derived from the opening manufactured fixed capital (FCmo). The manufactured fixed capital at the closing of the period (FCmc) shows the final value derived from the inputs and outputs of capital in the period. In 2010, the drop in prices of buildings and other infrastructures

caused a negative variation in the manufactured fixed capital. Residential dwellings account for 98.7% of the decrease in manufactured fixed capital. (Table S1).

S1.3.2.2. Changes in environmental assets

We present the results for the change in environmental assets (CEA) as the difference between the environmental assets at the closing (EAc) and opening (EAo) of the period (Table S2).

The change in the environmental assets includes the environmental work in progress (WPe) as well as the environmental fixed assets (EFA). The environmental assets of mushrooms and water show no change as the same quantities and prices are assumed indefinitely in the future. The farmers' environmental assets of timber, cork, firewood, industrial fruits and grazing show positive changes. These results are exclusively due to the increase in biological productivity of the inventoried trees, to which scheduled silvicultural treatment is applied over the whole cycle of their useful life. However, in 2010 the negative change in the amenity environmental asset led to a negative result for the aggregate change in the HOW environmental assets.

The changes in the individual environmental assets of the HOW coincide with the changes in adjusted environmental net worth according to the WPeu (CNWead), except carbon.

S1.3.2.3. Changes in adjusted environmental net worth according to WPeu

The estimation of the ordinary net value added at basic price in the revised SNA resolves the estimation of ecosystem services for the current period. We need to estimate what the maximum value of the ecosystem service of each individual product would need to be in order to maintain unchanged the value of its environmental asset at the closing of the period. The variable which resolves this question is the environmental income (EI). The EI estimation requires the ES to be adjusted according to the change in environmental net worth (CNWead), in turn adjusted according to the WPeu. The CNWead is obtained from the environmental assets at the closing and opening of the period along with the outputs and inputs of the capital balance account in the period. To find this variable it is necessary to estimate the NG, the consumption of environmental fixed capital (ecosystem degradation), the revaluation of environmental assets (EAr) and the adjustment in the environmental assets (EAad), which together with the latter give the environmental asset gain (EAg).

All the variables requiring the CNWead to be calculated come from the environmental asset balance account. We present the results for the change in individual CNWead.

The changes in the values of the environmental assets are positive for all products except for the amenity activity. It is assumed that mushrooms and water have zero CNWead as the environmental price and future flows of ecosystem services do not change. The value of the CNWead falls in the case of the farmers due to the drop in land prices in the period. The silvicultural production function models for timber, cork, firewood, industrial fruits and acorns show positive CNWead values (Table S2).

S1.4. Environmental income

It is reasonable to assert that the departments for statistics of the different nations should prioritize the measurement of environmental income from the environmental assets with market prices. In the case of the HOW we have incorporated eight of these assets. However, the weight of the *amenity* environmental asset is determinant in the total value of the environmental income of the HOW for the period. We have included this environmental asset, omitted in the standard SNA, given the observable nature of the market price of the land.

Fig. S1 shows the sequence of identities which, having calculated the rSNA ecosystem services (ES) and changes in adjusted environmental net worth (CNWead) according to the WPeu, allow the estimation of the total environmental income (EI) from the aggregate HOW activities valued.

The refined SNA presents a negative aggregate result. This result means that the ecosystem service for the period excedds the máximum sustainable consumption which is represented by the environmental income. The remaining seven assets present environmental incomes which coincide in their values with those of the ecosystem services in the case of mushrooms and water, and exceed the values of the latter in the case of timber, cork, firewood and grazing.

S2. Refined SEEA-Experimental Ecosystem Accounting

S2.1. HOW institutional sectors in the SEEA-EEA

In this section our aim is to present a description of the valuations considered by the rSEEA-EEA based on the modified stylized sequence of accounts of Obst et al. (2019: Table 6, p. 33).

We consider that the refined System of Environmental Economic Accounting-Experimental Ecosystem Accounting (rSEEA-EEA), which is a modified extended version of that by Obst et al. (2019: Table 6, p. 33), is less complete and consistent for the purposes of restoration and improvement of HOW environmental assets than the simplified Agroforestry Accounting System (sAAS), as revealed by the comparisons conducted.

Although this SEEA-EEA model is consistent for estimating the ecosystem services of public products without manufactured costs, it would not be in the case of the products which contain them.

The singularity of the institutional sectors resides in the fact that they reflect the aggregation of economic units under the responsibility of people. However, Obst et al. (2019) concede autonomy to the public ecosystem institutional sector by defining them as an institutional sector with ordinary total product production factors which are exclusively formed by physical natural resources input at zero cost. In this circumstance, the ecosystem institutional sector of the SEEA-EEA would give inconsistent valuations of the ecosystem services of ordinary final public products with production functions which incur government and private costs for the public farmers.

S2.2. Production and generation of income accounts

The rSEEA-EEA includes carbon activity alongside those already considered in the rSNA. This activity only registers the carbon fixation in the ordinary production account. The emission of carbon has no physical productive link with the fixation of carbon in the period. This means that carbon emission must be considered a consumption of environmental fixed asset (CFCeca) derived from the right of the farmers to cut down the woody vegetation and therefore it is registered in the government environmental capital formation account for carbon.

S2.2.1. Ordinary total product

The novelty in the rSEEA-EEA valuations is the substitution of the production cost of the final products by the price derived from the farmers' marginal willingness to pay for the self-consumption of amenities and by the simulated exchange value derived from the public consumers' willingness to pay for free-access recreational services, landscape conservation and the preservation of threatened wild biodiversity (Table S3).

S2.2.1.1. Intermediate product

The intermediate products of the rSEEA-EEA and the rSNA are the same. The intermediate products are all the farmers activities, since, as we have mentioned previously, the ecosystems by definition do not incur manufactured costs. Ecosystem environmental costs have not been recorded. (Table S3).

S2.2.1.2. Ordinary final product

The ordinary final products of the rSEEA-EEA and the rSNA differ in that the former includes the ecosystem services omitted in the rSNA and the new carbon activity.

The total value of the amenity is separated into the non-SNA ordinary final product (manufactured total cost and margin) and the non-SNA ecosystem service. The omission of the government cost explains the fact that the products without market price, that is, recreation, landscape and biodiversity, have the same value as their non-SNA ecosystem services. The final product of water is separated into SNA and non-SNA. The latter value represents the ecosystem service of water consumed by the industrial, services and household sectors. SNA water corresponds to ecosystem services of crop irrigation (Table S3).

S2.2.2. Ordinary total intermediate consumption

The rSEEA-EEA also differs from the rSNA in that it considers two new non-SNA intermediate consumptions. It incorporates the commercial intermediate consumptions of extractions (WPeu) of timber, cork and firewood present in the inventories at the opening of the period. The amenity activity registers own non-commercial intermediate consumption of amenity (SSncoa) as non-SNA. These SSncoa are derived from the voluntary opportunity cost accepted by the private farmers for their management of hunting and livestock activities (Table S3).

S2.2.3. Ordinary gross value added

The incorporation of the non-SNA values from the intermediate consumption of the WPeu and SSncoa, the ecosystem services and the omission of government costs by the ecosystem institutional sector are the causes underlying the changes in the gross value added (GVA) of the rSEEA-EEA with respect to the rSNA (Table S2).

S2.2.4. Ordinary net value added

The ordinary net value added (NVAo) in the rSEEA-EEA does not include the consumption of environmental fixed asset (ecosystem degradation) for the environmental assets (ecosystem assets) valued. The increase in the NVAo with respect to the rSNA is due to the same causes as the GVAo (Table S3).

S2.2.4.1. Ordinary compensation of employees

The omission of government costs by the ecosystem institutional sector is the reason for the absence of salaried employee costs (Table S3).

S2.2.4.2. Ordinary net operating surplus

The fact that the rSEA-EEA incorporates the WPeu in the intermediate consumption means that the ordinary net operating surplus (NOSo) corresponds with the ordinary net operating margin (NOMo) (Table S2).

S2.2.5. Ecosystem services

The ecosystem services (ES) of the rSEEA-EEA are extended with respect to the rSNA due to the changes in the valuations of the final products consumed at market prices of the amenity, recreational, landscape and threatened wild biodiversity services, along with the incorporation of the carbon activity.

We do not describe here the ES valuations of the activities without market price of the ecosystem institutional sector given the bias towards overvaluation caused by not taking into account the government costs associated with the offer. In this situation, the ES of the recreational, landscape and biodiversity servies are in fact the values of the products, not of their ES (Table S3).

S2.3. Ordinary capital account and changes in balance account

S2.3.1. Ordinary capital account

The ordinary capital account shows the flows of net savings, consumption of manufactured fixed capital and degradation of the ecosystem measured by the consumption of the environmental fixed asset (CFCe) associated with the products consumed in the period. The CFCe corresponds to the forest carbon emissions (Table S3).

S2.3.2. Changes in balance account

S2.3.2.1. Variations in manufactured fixed capital

The variations in the manufactured fixed capital of the farmers are the same in the rSEEA-EEA and the rSNA. The ecosystem institutional sector, by definition, does not employ manufactured fixed capital (Table S3).

S2.3.2.2. Changes in environmental assets

In the rSEEA-EEA, the products without market price of amenity, recreation, landscape and biodiversity are added to the environmental assets already included in the rSNA, along with the environmental asset of the 'new' activity of greenhouse effect carbon.

As stated previously in this document, all the rSNA changes in the environmental asset (CEA) coincide with the changes in the adjusted environmental net worth according to WPeu (CNWead). With the exception of carbon, all the other CEA in the rSEEA-EEA coincide with their respective CNWead (Table S3).

S2.3.2.3. Changes in adjusted environmental net worth according to WPeu

All the variables required to calculate the CNWead come from the environmental asset balance and the individual CNWead. The changes in the values of the environmental assets are positive for all products except for the amenity activity. (Table S3).

S2.4. Environmental income

Fig. S2 shows the sequence of accounting identities which, having previously calculated the rSEEA-EEA ecosystem services (ES) and changes in adjusted environmental net worth (CNWead) according to WPeu, allow the total environmental income (EI) from the aggregate activities of the HOW activities valued to be estimated.

The rSEEA-EEA result for environmental income is lower than that of the ES. The bias towards overvaluation of the environmental income of the ecosystem institutional sector detracts from the description of the results. In the main text these results for the environmental income (EI) are commented on with respect to those of the sAAS, highlighting the greater consistency of the latter ecosystem accounting framework with the theory of ecosystem service sustainability.

References

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Supplementary tables for

Ecosystem Accounting:

Application to Holm Oak Open Woodlands in Andalusia-Spain

Table S1. Index indicators of opening environmental assets and manufactured fixed capital by aggregate commercial and non-commercial activities for refined SNA, refined SEEA, and simplified AAS in holm oak open woodlands in Andalusia, Spain (2010)

Class	Commercial activities			Non-commercial activities				Wood-lands
	Woody products	Non-woody products	Total	Amenity	Land-scape	Others	Total	
1. Opening environmental asset (EAo)								
rSNA/sAAS	1.00	1.00	1.00	1.00	0.00	0.59	0.69	0.73
rSEEA/sAAS	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.1 Work in progress (WP)								
rSNA/sAAS	1.00		1.00					1.00
rSEEA/sAAS	1.00		1.00					1.00
1.2 Environmental fixed asset land (EFAl)								
rSNA/sAAS	1.00	1.00	1.00	1.00	0.00	0.59	0.69	0.73
rSEEA/sAAS	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.3 Environmental fixed asset biological resources (EFAbr)								
rSNA/sAAS	1.00	1.00	1.00					1.00
rSEEA/sAAS	1.00	1.00	1.00					1.00
2. Manufactured capital (FCm)								
rSNA/sAAS	1.00	1.00	1.00		1.00	1.00	1.00	1.00
rSEEA/sAAS	1.00	0.92	0.92		0.00	0.00	0.00	0.84
3. Opening capital (Co)								
rSNA/sAAS	1.00	1.00	1.00	1.00	0.00	0.59	0.69	0.75
rSEEA/sAAS	1.00	0.97	0.98	1.00	1.00	0.99	0.99	0.99

Source: Own elaboration after Campos et al. (in progress). Andalusian holm oak woodlands surface: 1,408,170 hectares.

Table S2. Stylized sequence of accounts of refined SNA in holm oak open woodlands in Andalusia, Spain (2010: thousands of euros).

Class	Farmer									Government								Wood-lands
	Timber	Cork	Fire-wood	Nuts	Gra-zing	Conserv. forestry	Resi-dential	Amenity	Total	Fire services	Recrea-tion	Mush-rooms	Carbon	Land-scape	Bio-diversity	Water	Total	
Production and generation of income accounts																		
1. Total product consumption (TPc_{rSNA})	452	964	2,126	79	47,697	3,935	20,634	20,634	96,519	53,682	11,443	25,291		107,527	7,347	107,331	312,620	409,139
1.1 Intermediate products (IP_{rSNA})					47,697	3,935	20,634		72,265	53,682							53,682	125,947
1.1.1 Intermediate product SNA (IP_{rSNA})					47,697	3,935	20,634		72,265	53,682							53,682	125,947
1.1.2 Intermediate product non-SNA ($IP_{non\text{-}rSNA}$)																		
1.2 Final product consumption (FPc_{rSNA})	452	964	2,126	79				20,634	24,254		11,443	25,291		107,527	7,347	107,331	258,939	283,192
1.2.1 Final product consumption SNA (FPc_{rSNA})	452	964	2,126	79				20,634	24,254		11,443	25,291		107,527	7,347	107,331	258,939	283,192
1.2.2 Final product consumption non SNA ($Fpc_{non\text{-}rSNA}$)																		
2. Ordinary total intermediate consumption (ICo_{rSNA})	603	34	302	177	775	1,347	1,094	20,634	24,965	16,005	4,193	60		101,472	2,092		123,822	148,788
2.1Manufactured intermediate consumption bought SNA ($ICmob_{rSNA}$)	603	34	302	177	775	1,347	1,094		4,332	16,005	1,985	60		2,404	2,084		22,538	26,870
2.2 Own intermediate consumption ($ICmoo_{rSNA}$)								20,634	20,634		2,208			99,069	8		101,284	121,918
2.2.1 Own intermediate consumption SNA ($ICmoo_{rSNA}$)								20,634	20,634		2,208			99,069	8		101,284	121,918
2.2.2 Own intermediate consumption non SNA ($ICmoo_{non\text{-}rSNA}$)																		
3. Ordinary gross value added ($GVAo_{rSNA}$)	-151	930	1,824	-98	46,922	2,588	19,539		71,554	37,676	7,250	25,231		6,055	5,255	107,331	188,798	260,352
4. Ordinary consumption of fixed capital ($CFCo_{rSNA}$)	63		7	28	1,488	133	7,921		9,639	3,894	2,226	36		1,035	879		8,070	17,709
4.1 Manufactured consumption of fixed capital SNA ($CFCmo_{rSNA}$)	63		7	28	1,488	133	7,921		9,639	3,894	2,226	36		1,035	879		8,070	17,709
4.2 Ecosystem degradation non-SNA ($CFCeo_{non\text{-}rSNA}$)																		
5. Ordinary net value added ($NVAo_{rSNA}$)	-215	930	1,817	-126	45,434	2,454	11,619		61,915	33,783	5,024	25,195		5,020	4,377	107,331	180,728	242,643
5.1 Labor cost (LCo_{rSNA})	3,527	146	432	1,211	4,747	2,428	4,414		16,906	33,716	5,024	87		5,020	4,377		48,223	65,128
5.1.1 Compensation of employees SNA ($LCoe_{rSNA}$)	3,527	146	432	1,211	4,747	2,428	4,414		16,906	33,716	5,024	87		5,020	4,377		48,223	65,128
5.1.2 Imputed compensation of self-employed non-SNA ($LCose_{non\text{-}rSNA}$)																		
5.2 Net operating surplus ($NOSo_{rSNA}$)	-3,742	784	1,385	-1,337	40,687	26	7,204		45,009	67		25,108				107,331	132,506	177,515
5.2.1 Manufactured net operating margin ($NOMmo_{rSNA}$)	-4,031	-12	1,067	-1,337	863	26	7,204		3,781	67		53					120	3,901
5.2.2 Environmental net operating margin ($NOMeo_{rSNA}$)					39,824				39,824			25,055				107,331	132,385	172,210
5.2.3 Environmental work in progress used (WPeu)	289	797	319						1,404									1,404
6. Ecosystem services (ES_{rSNA})	289	797	319		39,824				41,228			25,055				107,331	132,385	173,613
Changes in balance accounts																		
7. Changes in environmental asset (CEA_{rSNA})	748	3,098	12,729	14	2,766			-232,447	-213,093									-213,093
8. Changes in adjusted environmental net worth ($CNWead_{rSNA}$)	748	3,098	12,729	14	2,766			-232,447	-213,093									-213,093
9. Environmental income (EI_{rSNA})	1,036	3,895	13,047	14	42,590			-232,447	-171,865			25,055				107,331	132,385	-39,480

Source: Own elaboration after Campos et al. (in progress). Andalusian Holm oak woodlands surface: 1,408,170 hectares.

Table S3. Stylized sequence of accounts of refined SEEA in holm oak open woodlands in Andalusia, Spain (2010: thousands of euros).

Class	Farmer									Ecosystems								Wood-lands
	Timber	Cork	Fire-wood	Nuts	Gra-zing	Conserv. forestry	Resi-dential	Amenity	Total	Fire services	Recrea-tion	Mush-rooms	Carbon	Land-scape	Bio-diversity	Water	Total	
Production and generation of income accounts																		
1. Total product consumption (TPc_{rSEEA})	452	964	2,126	79	47,697	3,935	20,634	482,595	558,480		43,653	25,291	58,851	155,110	15,710	126,271	424,887	983,367
1.1 Intermediate products (IP_{rSEEA})					47,697	3,935	20,634		72,265									72,265
1.1.1 Intermediate product SNA (IP_{rSNA})					47,697	3,935	20,634		72,265									72,265
1.1.2 Intermediate product non-SNA ($IP_{non\text{-}rSNA}$)																		
1.2 Final product consumption (FPc_{rSEEA})	452	964	2,126	79				482,595	486,215		43,653	25,291	58,851	155,110	15,710	126,271	424,887	911,102
1.2.1 Final product consumption SNA (FPc_{rSNA})	452	964	2,126	79				20,634	24,254			25,291				107,331	132,621	156,875
1.2.2 Final produc consumption non SNA ($Fpc_{non\text{-}rSNA}$)								461,961	461,961		43,653		58,851	155,110	15,710	18,941	292,265	754,226
2. Ordinary total intermediate consumption (ICo_{rSEEA})	892	831	620	177	775	1,347	1,094	194,206	199,942									199,942
2.1Manufactured intermediate consumption bought SNA ($ICmob_{rSNA}$)	603	34	302	177	775	1,347	1,094		4,332									4,332
2.2 Own intermediate consumption ($ICmoo_{rSEEA}$)								194,206	194,206									194,206
2.2.1 Own intermediate consumption SNA ($ICmoo_{rSNA}$)								20,634	20,634									20,634
2.2.2 Own intermediate consumption non SNA ($ICmoo_{non\text{-}rSNA}$)								173,573	173,573									173,573
2.3 Environmental work in progress used (WPeu)	289	797	319						1,404									1,404
3. Ordinary gross value added ($GVAo_{rSEEA}$)	-440	134	1,505	-98	46,922	2,588	19,539	288,388	358,538		43,653	25,291	58,851	155,110	15,710	126,271	424,887	783,425
4. Ordinary consumption of fixed capital ($CFCo_{rSEEA}$)	63		7	28	1,488	133	7,921		9,639									9,639
4.1 Manufactured consumption of fixed capital SNA ($CFCmo_{rSNA}$)	63		7	28	1,488	133	7,921		9,639									9,639
4.2 Ecosystem degradation non-SNA ($CFCeo_{non\text{-}rSNA}$)																		
5. Ordinary net value added ($NVAo_{rSEEA}$)	-503	134	1,499	-126	45,434	2,454	11,619	288,388	348,899		43,653	25,291	58,851	155,110	15,710	126,271	424,887	773,786
5.1 Labor cost (LCo_{rSEEA})	3,527	146	432	1,211	4,747	2,428	4,414		16,906									16,906
5.1.1 Compensation of employees SNA ($LCoe_{rSNA}$)	3,527	146	432	1,211	4,747	2,428	4,414		16,906									16,906
5.1.2 Imputed compensation of self-employed non-SNA ($LCose_{rSEEA}$)																		
5.2 Net operating margin ($NOMo_{rSEEA}$)	-4,031	-12	1,067	-1,337	40,687	26	7,204	288,388	331,994		43,653	25,291	58,851	155,110	15,710	126,271	424,887	756,880
5.2.1 Manufactured net operating margin ($NOMmo_{rSEEA}$)	-4,031	-12	1,067	-1,337	863	26	7,204		3,781									3,781
5.2.2 Environmental net operating margin ($NOMeo_{rSEEA}$)					39,824			288,388	328,213		43,653	25,291	58,851	155,110	15,710	126,271	424,887	753,099
6. Ecosystem services (ES_{rSEEA})	289	797	319		39,824			288,388	329,616		43,653	25,291	58,851	155,110	15,710	126,271	424,887	754,503
Changes in balance accounts																		
7. Changes in environmental asset (CEA_{rSEEA})	748	3,098	12,729	14	2,766			-232,447	-213,093				2,445				2,445	-210,648
8. Changes in adjusted environmental net worth ($CNWead_{rSEEA}$)	748	3,098	12,729	14	2,766			-232,447	-213,093				-56,406				-56,406	-269,499
9. Environmental income (EI_{rSEEA})	1,036	3,895	13,047	14	42,590			55,942	116,523		43,653	25,291	2,445	155,110	15,710	126,271	368,480	485,004

Source: Own elaboration after Campos et al. (in progress). Andalusian Holm oak woodlands surface: 1,408,170 hectares.

Table S4. Incomes and ecosystem service indicators by aggregate commercial and non-commercial activities for refined SNA, refined SEEA and simplified AAS in holm oak open woodlands in Andalusia, Spain (2010: thousands of euros)

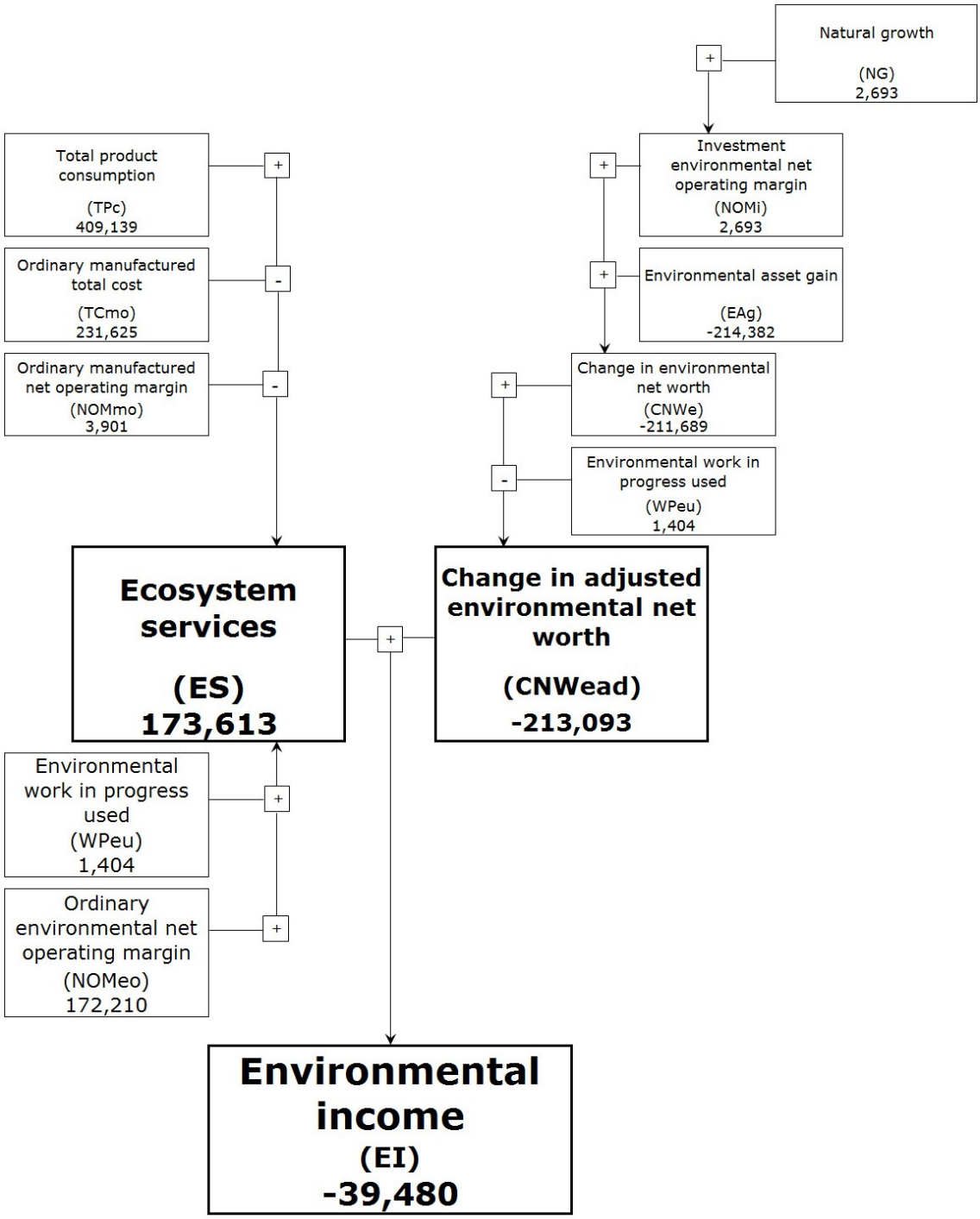
Class	Commercial activities			Non-commercial activities				Woodlands
	Woody products	Non-woody products	Total	Amenity	Landscape	Others	Total	
1. Ordinary net valued added (NVAo)								
rSNA	2,533	93,164	95,697		5,020	141,926	146,945	242,643
rSEEA	1,129	59,382	60,511	288,388	155,110	269,777	713,275	773,786
sAAS	1,129	93,164	94,294	288,388	49,636	260,291	598,316	692,609
2. Ordinary net operating surplus (NOSo)/margin (NOMo)								
rSNA	-1,572	46,648	45,076			132,439	132,439	177,515
rSEEA	-2,976	46,581	43,605	288,388	155,110	269,777	713,275	756,880
sAAS	-2,976	46,648	43,672	288,388	44,617	250,804	583,809	627,481
3. Ecosystem services (ES)								
rSNA	1,404	39,824	41,228			132,385	132,385	173,613
rSEEA	1,404	39,824	41,228	288,388	155,110	269,777	713,275	754,503
sAAS	1,404	39,824	41,228	288,388	44,389	248,677	581,455	622,683
4. Changes in environmental asset (CEA)								
rSNA	16,574	2,780	19,354	-232,447			-232,447	-213,093
rSEEA	16,574	2,780	19,354	-232,447		2,445	-230,002	-210,648
sAAS	16,574	2,780	19,354	-232,447		2,445	-230,002	-210,648
5. Changes in environmental net worth adjusted (CNWead)								
rSNA	16,574	2,780	19,354	-232,447			-232,447	-213,093
rSEEA	16,574	2,780	19,354	-232,447		-56,406	-288,853	-269,499
sAAS	16,574	2,780	19,354	-232,447		-56,406	-288,853	-269,499
6. Environmental income (EI)								
rSNA	17,978	42,604	60,582	-232,447		132,385	-100,061	-39,480
rSEEA	17,978	42,604	60,582	55,942	155,110	213,370	424,422	485,004
sAAS	17,978	42,604	60,582	55,942	44,389	192,271	292,602	353,184

Source: Own elaboration after Campos et al. (in progress). Andalusian holm oak woodlands surface: 1,408,170 hectares.

Supplementary figures for

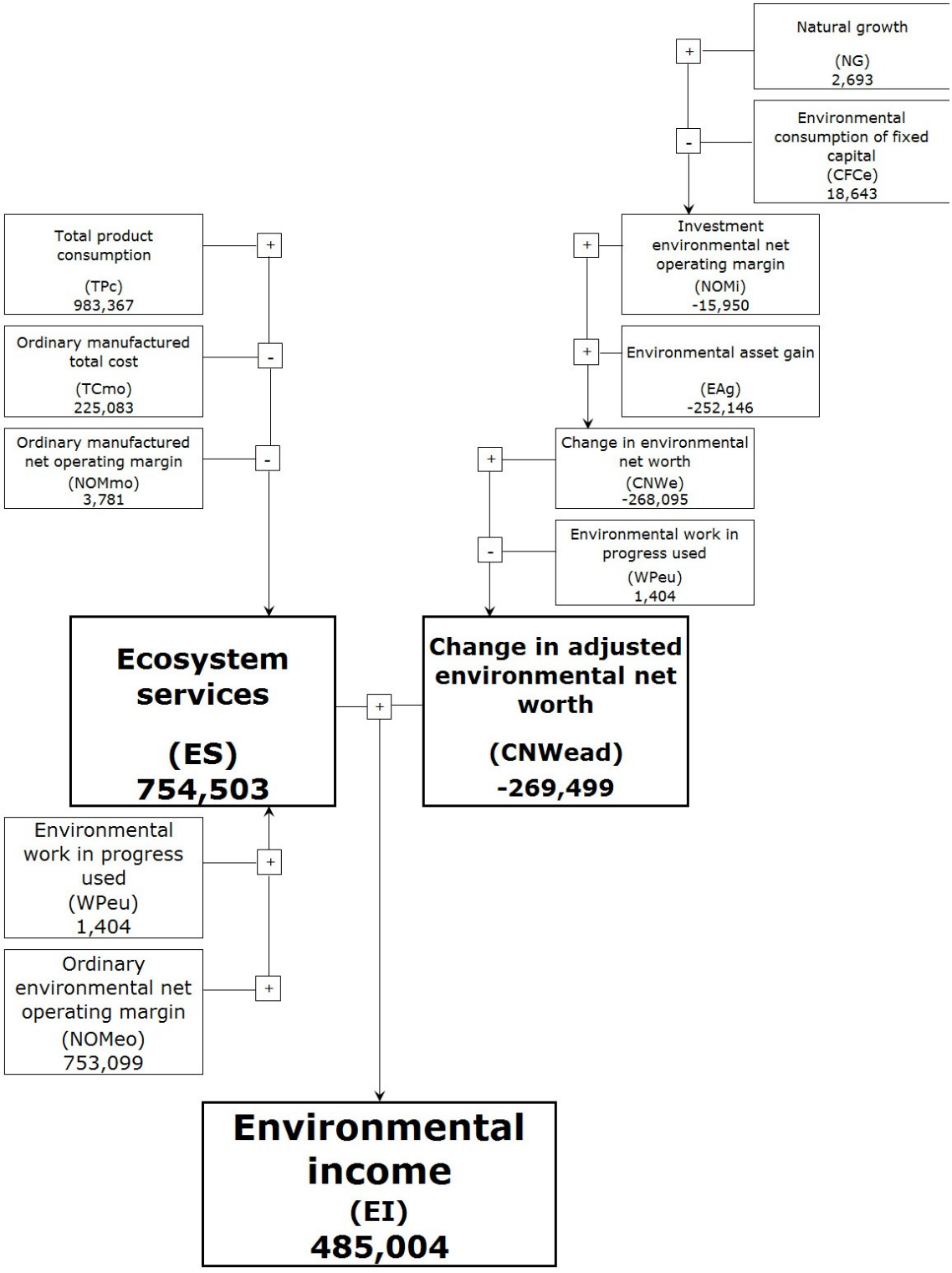
Ecosystem Accounting:

Application to Holm Oak Open Woodlands in Andalusia-Spain



Source: Own elaboration according to Campos et al. (in progress). Andalusian holm oak open woodland area: 1,408,170 hectares.

Figure S1. Total environmental income in refined SNA for holm oak open woodlands in Andalusia, Spain (2010: thousands of euros).



Source: Own elaboration according to Campos et al. (in progress). Andalusian holm oak open woodland area: 1,408,170 hectares.

Figure S2. Total environmental income in refined SEEA in holm oak open woodlands in Andalusia, Spain (2010: thousands of euros).