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Ecosystem accounting for measuring total income in private and public agroforestry farms

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ABSTRACT

We develop an ecosystem accounting system to estimate individual products' biophysical and total income indicators. The ecosystem products are grouped into private and public activities and measured consistently with the principle of exchange value of the standard national accounts. Private products comprise timber, cork, firewood, conservation forestry, grazing, livestock, hunting, crops and private amenity, while the public ones comprise mushrooms, carbon, water, public recreation, landscape and threatened biodiversity services. Our accounting approach revises and extends the standard agricultural and forestry sector income accounts by incorporating intermediate products, natural growth, private amenity, carbon sequestration and capital gain. Furthermore, our approach extends the standard government sector income accounts by including the economic value of the consumption of public final products delivered by ecosystems on the basis of simulating prices for non-market products. We apply the agroforestry accounting system to a group of 39 agroforestry farm case studies in Andalusia, Spain. We provide results for two agroforestry farm groups: publicly owned coniferous forest and privately owned native hardwood forest (*dehesa*). Total income attained, on average, €140 per hectare in coniferous forests and €352 per hectare in *dehesas*. Cork natural growth and private amenity are the main products explaining private income in *dehesa* farms. Forestry activity products, particularly timber natural growth and the intermediate products of conservation forestry, are the main sources of private income in the coniferous forests. Public incomes from non-market products are the main contributors of total income in *dehesas* and forests.

1. Introduction

Ecosystem services and products play a key role in supporting decision making on land management (Bateman et al., 2013; de Groot et al., 2010, Millenium Ecosystems Assessment, 2005). However, ecosystem conservation strategies are undermined by the lack of statistical data on environmental and total incomes in the standard System of National Accounts (SNA) (Boyd and Banzhaf, 2007; Brouwer et al., 2013; European Commission, EC et al., 2009). This situation is especially relevant in agroforestry farms, where the gap between the net value added reflected in the SNA figures for forestry and agriculture and more comprehensive agroforestry ecosystem accounts can be noteworthy (Campos, 2015; Campos and Caparrós, 2006; Ovando et al., 2016).

The debate in scientific and policy arenas on which ecosystem services and products should be consistently integrated into national income accounts has prompted new approaches to extend the standard SNA (Boyd and Banzhaf, 2007; Campos, 2015; Edens and Hein, 2013; Remme et al., 2015). United Nations (UN) et al. (2014a) ongoing System of Environmental and Economic Accounting-Experimental Ecosystem Accounting (SEEA-EEA) guidelines discuss the recommendations for valuing ecosystem services, in line with the valuation principles of the SNA, and call for testing experimental extensions in order to include the value of ecosystem services embedded in the market value of products, and of those ecosystem services omitted and/or undervalued in the standard SNA (Obst et al., 2016).

Over the last decade, scholars have developed some empirical experience with biophysical ecosystem services accounting (e.g.: Maes et al., 2012; Schröter et al., 2015), but only a few studies apply monetary ecosystem accounting aligned with SNA valuation principles and total income measurement (Caparrós et al., 2003; Campos and Caparrós, 2006; Goio et al., 2008; Hultkrantz, 1992; Ovando et al., 2016). Despite the interest attracted by the SEEA-EEA, at present there are no international standard approaches to develop ecosystem service accounts (Edens and Hein, 2013), and the scope of the experimental extensions to the SNA for measuring total income accounts is still under discussion (Campos, 2015; Obst, 2015; Obst et al., 2016; United Nations et al., 2014a).

This research aims to develop the Agroforestry Accounting System (AAS) to estimate a set of individual spatially-explicit biophysical and

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economic indicators that characterize the production processes of private and public ecosystem services and products at the farm-scale for a group of 39 agroforestry large farms. Private products comprise timber, cork, firewood, conservation forestry, grazing, livestock, hunting, crops, private amenities and other private products. Public products include mushrooms, carbon, water, public recreation, landscape, threatened biodiversity and other public products.[2] The biophysical and economic indicators associated with those private and public products provide useful insights to guide specific land use planning and ecosystem conservation policies for public and private farms.

The AAS represents an accounting approach for an ecosystem's total income estimation that is consistent with the SNA and SEEA–EEA exchange valuation principle (Campos, 2015; Campos and Caparrós, 2006; Caparrós et al., 2003; European Commission et al., 2009; United Nations, et al., 2014a,b). In contrast to the SNA production cost approach, and following the SEEA–EEA recommendations, the AAS uses the Simulated Exchange Value (SEV) method for estimating the economic value of final products consumption where no alternative markets exist. SEV estimations take into account the demand for a non-market final product, which is measured using non-market valuation techniques, as well as the supply function to obtain the market equilibrium price assuming a specific market structure (Caparrós et al., 2003, 2015). AAS methodology could be applied to individual products for any ecosystem concept and scale, although it has been, at the moment, only applied at the micro scale to agroforestry farms in Mediterranean climate regions (e.g. Campos and Caparrós, 2006; Campos et al., 2008; Oviedo et al., 2013) and at the macro scale to the forest ecosystems of Andalusia region in Spain (Caparrós et al., 2016).

2. Materials and methods

2.1. Case studies

This study focuses on 39 agroforestry farms comprising 15 publicly owned coniferous forests and 24 privately owned *dehesa* farms that are distributed across Andalusia, southern Spain (Fig. 1). Andalusia is a very diverse region, with about 4.6 million hectares (54% of its territory) covered by Mediterranean forest and grasslands (Campos, 2015). These are complex ecosystems that have traditionally been managed jointly to supply timber and non-timber products. The agroforestry farm case studies illustrate well the complexity of vegetations and multiple product supply that typify Mediterranean coniferous forest and *dehesa* in Andalusia (Ovando et al., 2015; Oviedo et al., 2015).

The economic ecosystem unit is an agroforestry farm that is characterized by the type of landownership (private or public) and the vegetation cover, comprising two main dominant vegetation types: native hardwoods and coniferous forest. Coniferous and native hardwood forests cover 730,677 and 1,812,654 ha, respectively, in Andalusia (Campos, 2015). The *dehesa* category comprises farms dominated by native hardwoods (>50% of the surface), mainly by open oak and wild olive woodlands with a tree canopy cover[3] between 5% and 75% (Ovando et al., 2015). The coniferous forest category is assigned to those farms in which softwoods occupy >50% of their total surface.

Private *dehesas* have an average useful agricultural land (UAL)[4] of 674 ha (SD ± 522), with 88% of the farms larger than 200 ha and 46% larger than 500 ha. Close to 78% of the *dehesa* surface is covered by native hardwood trees, with an average canopy cover of 36%. Public forests are much larger, with an average size of 3,647 ha of UAL (SD ± 3,498), all the farms having a surface bigger than 500 ha. In this case, coniferous tree species cover 60% of the public forests area with an average canopy cover of 48%. The majority of the farms belong to hunting estate reserves, accounting for 96% of the studied *dehesa* area and 93% of the forest area. Half of the *dehesa* case studies belong to open reserves, while 46% of hunting estate reserves are fenced. In the case of public forests, only 20% of the farms belong to fenced hunting reserves, while 73% belong to open ones. The majority (62%) of the studied public forests and private *dehesas* belong to Natural Park[5] areas, while 10% of the public forests' surface is inside the Sierra Nevada National Park. Our results are not representative of agroforestry farms in Andalusia given the average farm size and the share of the agroforestry land under different protection status, although our results give relevant insights on factors that may be driving public forest and large *dehesa* managements. Those insights are relevant at the regional level when we consider that large *dehesas* account for the main share of Andalusian hardwoods, and that about 69% of conifer forests are publicly owned (Campos, 2015).

2.2. Total income accounting

Total income refers to the aggregated value of incomes derived from private and public products and the economic activities that generate these products. Private activities embrace those ecosystem products managed by landowners in both privately or publicly owned economic units (farms) that result from the exclusive right to get profit from the production process outcome and transfer its capital value to third parties. Product value and the cost of private activities are usually observed in formal markets, although this is not the case for the private amenity activity (see below). Ecosystems also provide public products that, although they are not the object of a transaction, are considered as having economic values given their scarcity and that their use usually involves a government manufactured production cost. Public activities are then ascribed to the government ecosystem management delivering final products, which are freely consumed by users. The final consumption of public products is valued using both imputed market prices and simulated exchange values applying *ad hoc* non-market valuation methods (Caparrós et al., 2016).

Naturally occurring services and products generated during the accounting period without incurring labor and manufactured costs are termed as environmental income (Campos, 2015). The net return from manufactured capital is named manufactured capital income (MCI). We measure the individual contributions of environmental (EI) and manufactured capital (MCI) assets and labor (LC) to total income (TI = EI + MCI + LC) for individual agroforestry products. The total income factor distribution for cork and firewood follows the same distribution criteria as timber according to Ovando et al. (2016), while agriculture and livestock are considered pure manufactured activities, and consequently we assume that their environmental income is null. Other environmental incomes are estimated considering the market prices from similar existing markets (e.g. mushrooms and carbon), the hedonic price for water, the residual price from observed market prices (grazing and hunting) and simulated exchange values (private amenity, public recreation, landscape and threatened biodiversity) (Campos, 2015; Ovando et al., 2015, 2016; Caparrós et al., 2016). The manufactured capital incomes are estimated as the normal return to the manufactured immobilized capital (MIC) (Ovando et al., 2015). Here, we assume a normal return (i) to this immobilized capital of 3%. We use the similar criterion applied by the Spanish Treasury to compensate the landowner for Government land expropriation (Boletín Oficial del Estado, 2015). Labor compensations are observed (registered) for employees, while the compensation for self-employed labor (independent worker) is estimated as a residual value, as detailed later.

The AAS approach provides an operational system of accounts to organize biophysical and monetary data describing different production

[2] The other public products include government expenditures for firefighting and other minor products.

[3] Canopy cover (or density) refers to the percentage of the total ground area shaded by the vertical projection of tree crowns; while forest cover, in our case, refers to any area with trees that has a minimum canopy cover of 5%.

[4] UAL refers to the aggregated forest and agricultural lands, excluding infrastructure and water bodies.

[5] The Natural Park protection figure refers to natural areas that maintain extractive uses compatible with threatened biodiversity preservation and landscape conservation.