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Testing Extended Accounts in Scheduled Conservation of Open Woodlands with Permanent Livestock Grazing: Dehesa de la Luz Estate Case Study, Arroyo de la Luz, Spain

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Abstract: Standard Economic Accounts for Agriculture and Forestry do not measure the ecosystem services and intermediate products embedded in the final products recorded, and omit the private non-commercial intermediate products and self-consumption of private amenities. These limitations of the standard accounts are addressed by the extended Agroforestry Accounting System, which is being tested at the publicly-owned Dehesa de la Luz agroforestry estate. The extended accounts simulate conservation forestry of holm oak and cork oak for the current as well as successive rotation cycles during which scheduled conservation of the cultural woodland landscape of the Dehesa de la Luz is carried out, improving the natural physical growth of the firewood and cork. The estimated results for 2014 reveal that private ecosystem services make up 50% of the firewood and grazing products consumed; the private environmental income accounts for 13% of the total private income; and the private environmental asset represents 53% of the total opening capital. The net value added is more than 2.3 times the amount estimated using the standard accounts. The landowner donates intermediate products of non-commercial services at a value of 85 €/ha, which are used to enhance the supply of public products.

Keywords: Agroforestry Accounting System; standard accounts; private ecosystem services consumed; private intermediate services; private environmental income and asset; private profitability rate; public products

1. Introduction

The sustainable management of the Spanish dehesa is important to rural development at the local, national, and European Union levels due to its environmental and economic value [1–4]. Open woodlands in five autonomous communities in West and Central Spain predominate over an area of 6,151,318 ha (Table 1 and Figure 1) [5]. Open holm oak woodland accounts for 73% of Spanish open woodland in the five main dehesa regions. In the absence of statistics from the government regarding public dehesas, we estimated the extent of publicly-owned Mediterranean open woodlands where the fraction of tree cover is between 5% and 75%. These public open woodland formations occupy 738,615 ha and represent 12% of the estimated total area of open woodland formations in the Spanish dehesa area (Table 1). Most of these open woodlands do not form part of dehesa estates [6]. This agroforestry system is defined as an anthropogenic land use system based mainly on extensive livestock grazing in the Mediterranean woodlands, shrublands, and grasslands, where more than 20% of the area of the estate is occupied by broadleaved species with a canopy

cover fraction of between 5% and 60% [7] (p. 7). Spanish dehesa agroforestry estates cover a total area of 3,606,154 ha and the open woodlands within them account for 2,203,002 ha (Table 2 and Figure S9) [7,8]. The natural conditions and medieval process of land appropriation have led to the concentration of most of the dehesa areas within large dehesa estates. For example, the 4575 dehesa estates of 200 hectares or more represent 64% of the total dehesa area, with an average estate size of 502 ha. The remaining 107,812 dehesa estates with less than 200 ha have an average estate size of 12 ha (Table 2).

Table 1. Open woodland area in the five autonomous communities in West and Central Spain (ha).

Tree Species	Andalucía	Castilla-La Mancha	Castilla y León	Extremadura	Madrid	Total
Holm oak	1,302,901	1,019,286	676,305	1,353,119	119,848	4,471,460
Cork	207,101	21,724	6753	138,334	190	374,102
Other oaks	27,158	156,562	662,997	91,069	20,033	957,819
Others [(1)]	118,637	105,871	103,116	7593	12,721	347,937
Open woodlands [(2)]	1,655,796	1,303,443	1,449,171	1,590,115	152,792	6,151,318

Notes: [(1)] Others includes Spanish juniper, wild olive, narrow-leaved ash, and carob tree. [(2)] Open woodlands are between $CCF_{trees} \geq 5\%$ and $CCF_{trees} \leq 75\%$, where CCF (canopy cover fraction) is the stand area covered by the tree canopies. Includes the stand ages of polewood and old growth only. Source: Own elaboration based on Reference [5].

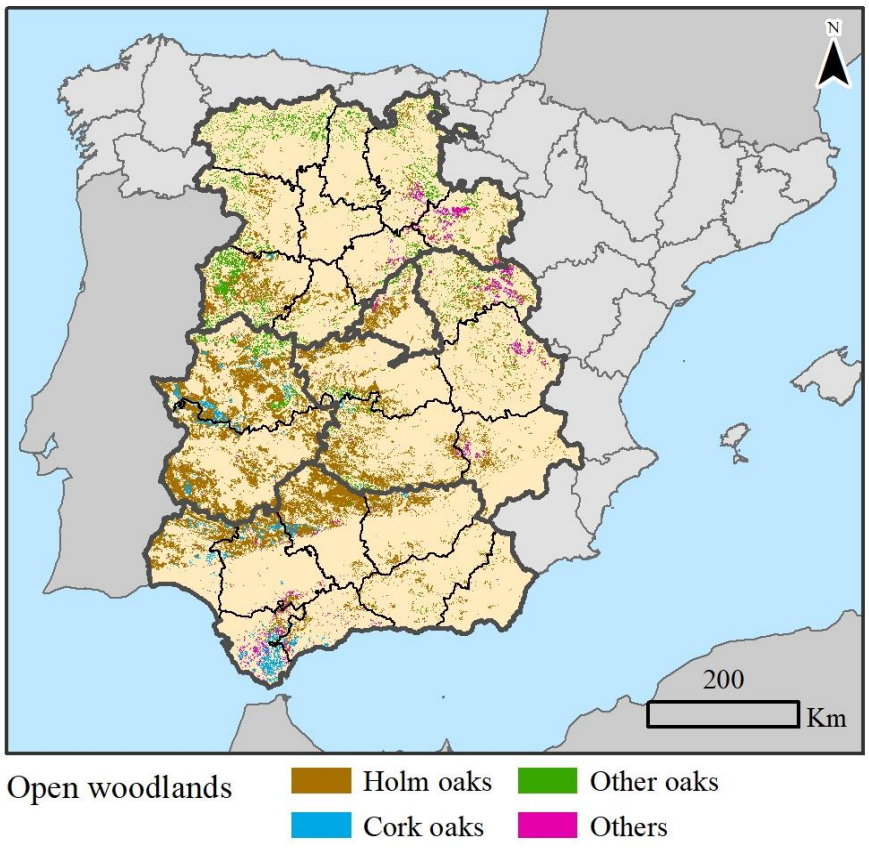

Figure 1. Map of open woodlands in the five autonomous communities in West and Central Spain by tree species. Source: Own elaboration based on Reference [5].

In the Iberian Peninsula, stakeholders have warned of the economic and environmental consequences of the decline of Spanish dehesas [6,7,9–11]. This concern is also present in the Portuguese montados, where woodlands cover 1,066,000 ha (holm oak: 329,000 ha and cork oak: 737,000 ha), mainly in the Alentejo region [12,13].

Table 2. Numbered classification of dehesa estates according to surface area in the five Spanish autonomous communities in West and Central Spain.

Dehesa Estates Size Class (ha)	Dehesa Estates Number		Area of Dehesa States			
			Open Woodland		Total	
	Nº	%	ha	%	ha	%
0 < ha ≤ 10	87,395	78	102,611	5	152,867	4
10 < ha ≤ 50	12,015	11	183,203	8	287,939	8
50 < ha ≤ 100	4612	4	209,429	10	330,672	9
100 < ha ≤ 150	2322	2	177,758	8	285,042	8
150 < ha ≤ 200	1468	1	161,912	7	253,716	7
200 < ha ≤ 300	1698	2	265,382	12	416,935	12
300 < ha ≤ 500	1521	1	373,223	17	582,026	16
500 < ha ≤ 1.000	979	1	394,791	18	658,528	18
ha > 1.000	377	0	334,693	15	638,429	18
Total	112,387	100	2,203,002	100	3,606,154	100
0 < ha ≤ 10	87,395	78	102,611	5	152,867	4
10 ≤ ha ≤ 200	20,417	18	732,302	33	1,157,369	32
ha > 200	4575	4	1,368,089	62	2,295,918	64

Source: Modified from Reference [7] (Table 23, p. 46).

The deficiency or complete lack of natural regeneration has been identified as the key problem in current dehesa open woodland management. Current grazing levels reveal that, in general, both landowners and governments overlook the question of compatibility with woodland regeneration and that today, after several centuries of inadequate grazing management, the dehesas are suffering an ongoing process of increasing natural death rates due to diseases and ageing of the trees. The regeneration of trees in Spanish dehesas is either null or scarce in 46–70% of plots and normal or abundant in 28–45% according to data from the Third National Forest Inventory for five autonomous communities with dehesas [5,7,8]. The data which reflect this general lack of regeneration are accentuated if the analysis is restricted to the tree species which most frequently form part of the livestock farming estates (holm oak, cork oak, and Pyrenean oak), with a lack of woody seedlings in 82%, 96%, and 65% of each species, respectively, in the inventoried plots [10].

The Economic Accounts for Agriculture and Forestry (EAA/EAF) is the government statistical office regulation for accounting the final products and net value added from the agriculture and forestry sector market [14]. The omission of economic statistics for dehesas from standard national EAA/EAF (hereinafter standard accounts) prevents us from determining the contribution of these agroforestry estates to the provincial and regional economies of the autonomous regions in which they are most widespread (Tables 1 and 2, Figures 1 and S9). The EAA/EAF estimates the aggregated sales of products classified as agricultural and forestry products produced in the territory at the regional or national scale without distinction between types of enterprise. Thus, agroforestry estates are not a separate part of the agricultural and forestry product statistics. For example, in the case of livestock production, no distinction is made between whether it is produced in a grazing system or in an industrial feedlot. The only economic information available on dehesas is that which has been published in scientific articles relating to a small number of large dehesas in the Spanish communities of Andalucia and Extremadura. Data from the scarce scientific publications regarding testing of the Agroforestry Accounting System (AAS) (hereinafter extended accounts) in a group of large private dehesas coincide with those from studies conducted using the same extended accounts in Mediterranean ranches in California [15,16] (see supplementary materials (SM) 1–6).

We follow the reference [17] and define products (or outputs) as goods (tangible products) and services (intangible products) produced in the accounting period in the estate for current or future consumption by people. The products measured in the Dehesa de la Luz case study are: cork and firewood natural growths, firewood harvest, acorns, grass, stored water flow, intermediate and final private services, manufactured gross capital formation of plantation and dry-stone wall, livestock products, private amenity, recreation, landscape, livestock biodiversity, and carbon. We measure the

environmental assets and/or manufactured capitals of the abovementioned products and the environmental asset of hunting.

The objective of the management at Dehesa de la Luz, undertaken by the public owner and scheduled in this study, is to reach the highest potential consumption of the goods and services produced, subject to the condition that the net worth (see SM 2) of environmental assets are not diminished at the closing of the accounting period. Achieving this objective requires the continued future presence of private forestry activities, animals, and services simultaneously, both in space and/or sequentially over time. In this study, our purpose is to examine the assumed hypothesis of economic rationale of the public landowner and the leasehold family livestock owners with regard to the supply of private manufactured intermediate products of services (hereinafter intermediate services). The framwork of our case study are as follows: the owners receive a normal manufactured net operating margin (operating benefit) from their manufactured capital investments in forestry conservation, livestock, and infrastructures, with which they produce intermediate services (ISS) to be used up as own intermediate consumption of services (SSo) for public and private activities. These services contribute to the economic activities of Dehesa de la Luz as inputs to the final products of public recreation, landscape (including human-made historical-cultural legacy), and threatened livestock biodiversity activities as well as private amenity activities. Thus, we hypothesize that the intermediate services which we attribute to private activities explain the investment rationale of the public landowner, as well as the employment and investment by leasehold family livestock owners who decide to continue with their private activities despite incurring net manufactured monetary operating margins at basic prices (after including subsidies and taxes linked to the production process) below the normal margins of the market for alternative investment options (see SM 4).

The objectives of this study are to test the monetary extended accounts for the year 2014 of the individual private activities analyzed and for Dehesa de la Luz as a whole, the ecosystem services, the intermediate services, the environmental income, the environmental assets, the total private income and its factorial distribution, and the total private profitability rates [18,19]. With regard to previous applications of the extended accounts, the novelty of the present study is that it attempts to illustrate, through the real case study of Dehesa de la Luz, the estimation of intermediate service values hidden and omitted by the standard accounts, and to assign them to the activities which produce them as well as to the public and private activities which consume them as own intermediate consumption (inputs).

2. Materials and Methods

The case study of Dehesa de la Luz is presented in this section, which deals with the modeling of physical growth functions for tree volume, firewood, cork, and acorns (Section 2.1) and the specific valuation criteria applied for each of the private products estimated in 2014 (Section 2.2). The previously published development of extended accounts is not presented in the main text of this study [4,16,19–21], although we summarize the key accounting concepts in the supplementary materials (see SM 1–4, 8–9).

Primary data have been collected through field work at Dehesa de la Luz by following ad hoc protocols in forestry, livestock, and infrastructure products and costs. Reference is made to appropriate published data where such data have been used.

2.1. Dehesa de la Luz Public Ownership Case Study

The town council of Arroyo de la Luz (Cáceres province, Spain) (Figures 2 and 3), as public owner of Dehesa de la Luz, aims to establish conservation-orientated management of forest resources and threatened autochthonous livestock breeds based on scientific information as well as to improve the offer of public products in Dehesa de la Luz. Determining the total private income and total private capital of the individual activities at Dehesa de la Luz allows us to estimate their economic profitability rates and, where appropriate, justify the compensation received from the government in reciprocity for the contribution to the intermediate services which are re-employed as

input in the supply of public products at Dehesa de la Luz. The public landowner mitigates the manufactured (man-made) investment risk and favors the supply of public products, leasing livestock grazing for most of the cattle rearing activity (with the exception of pure breeds in danger of extinction), as well as pruning firewood from holm oaks by self-employed family labor. Small game hunting, with no investment by either the landowner or hunters, is practiced by members of the local hunting society [19,22].

In this Dehesa case study, we use 'number of trees' (and omit tree biomass) because the holm oak and cork oak are not commercial wood species and acorn and periodical cork harvests are the main products, with the silviculture undertaken being similar to that of fruit tree management (cork is a periodically harvested product from the same cork oak trees). In addition, we want to highlight the quantity of plantation trees vs natural regeneration. The inventories performed in 2014 over a total area of 978 ha of Dehesa de la Luz reveal that 93% of the area is occupied by holm oaks (*Quercus ilex* L.), with a small number of cork oaks (*Quercus suber* L.) dispersed among the former (Table 3).

Sixty percent of the trees originate from natural regeneration and the remaining 40% are young trees from recent plantations. Fifty three percent of the latter trees are cork oaks planted in 1993 and the other 47% are holm oaks planted in 1993 and 2014 (Figure 4). Seven percent of the non-wooded area includes parts which are occupied by paths, roads, water courses, and pools as well as infrastructures currently used for livestock management.

Over more than 50 years, the holm oaks and cork oaks from natural regeneration in Dehesa de la Luz have diminished by 17% (see SM 5). The diameter distribution of the adult trees reveals marked ageing of the woodland. This situation led the public owner, having recently regained ownership of the trees, to initiate the recovery of the holm and cork oaks, impoverished by excessive pruning carried out by the local private owners of the trees over more than a century (a local private societal enterprise ("Sociedad Forestal") bought the holm oaks and the cork oaks in the 1880s and managed them up until the 1990s, when the regional government of Extremadura bought the trees and donated them to de municipality of Arroyo de la Luz, which previously had the ownership of grass and agricultural uses) (Figure 4). This involved the mixed plantation of holm oaks and cork oaks in 1993 and the plantation (densification) of holm oaks in 2014 (Figure 5).

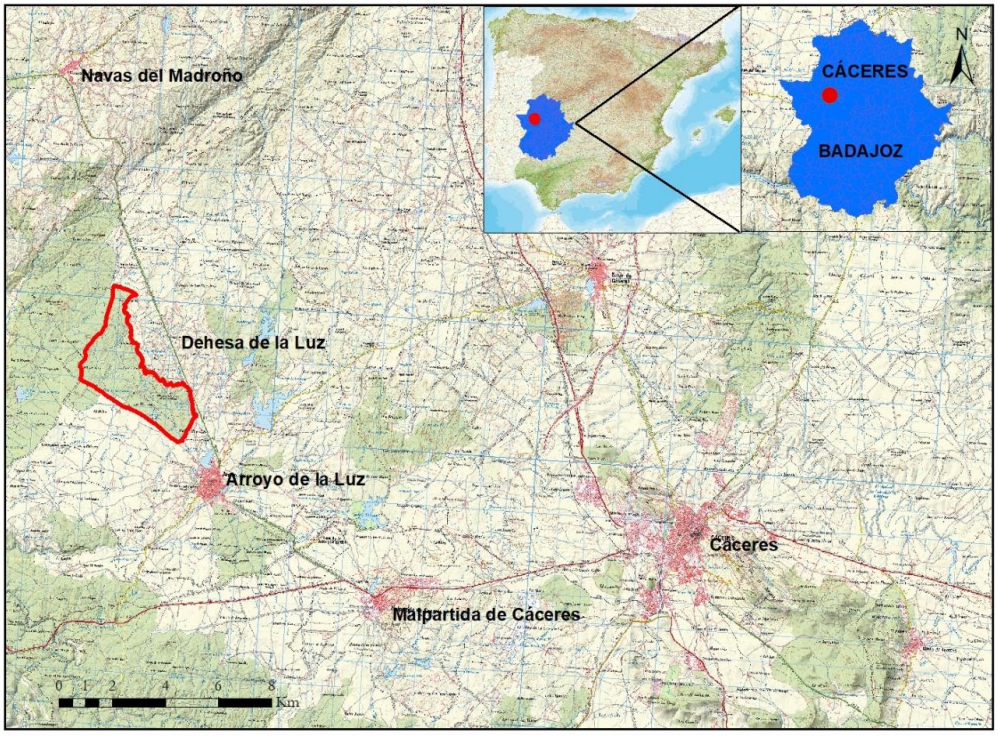

Figure 2. Location map of Dehesa de la Luz estate.

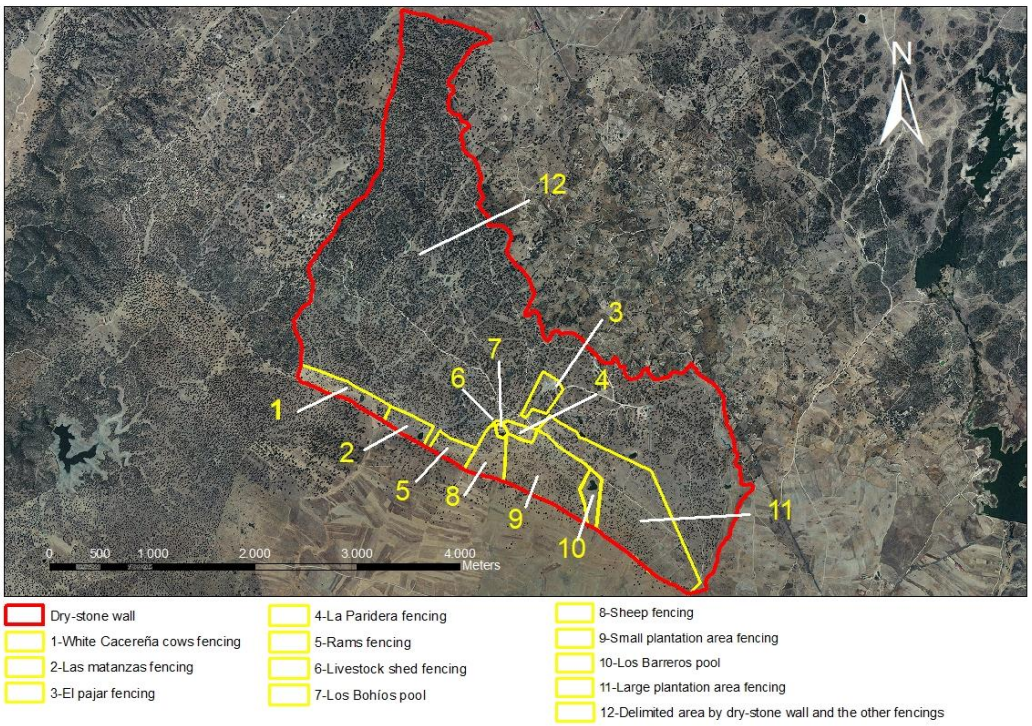

Figure 3. Orthophoto of Dehesa de la Luz.

Table 3. Open woodlands and other land use areas in Dehesa de la Luz estate (2014).

Class	N [1]	Canopy Cover Fraction (%)	Area [2]	
			(ha)	(%)
1. Wooded area	47,968	19	909	93
1.1 Natural regeneration	29,007	17	756	77
Holm oaks	28,248	17	756	77
Cork oaks	759	0		
1.2 Plantation	18,961	27	153	16
Holm oaks	8895	21		
Cork oaks	10,066	6	153	16
2. Non-wooded area			69	7
Pools			11	1
Other			58	6
3. Total			978	100

Notes: [1] Number of trees; [2] Area assigned to the main species (that which has the greatest number of trees).

The distribution of the trees by diameter class allows us to verify that the holm oaks from natural regeneration, of more than 25 cm, make up more than a third of the total. If all the holm oaks are considered, including those which were planted, 68% have a diameter at breast height (Db) of more than 25 cm (Table 4).

Thus, according to this diameter distribution, most of the holm oaks present in Dehesa de la Luz are more than 60 years old and the natural regeneration is insufficient to replace the existing woodland. In the case of cork oaks, 86% of those originating from natural regeneration have a diameter of more than 25 cm, the opposite being the case for the total population, since 95% have a diameter of less than 25 cm due to the quantity of cork oaks distributed throughout the estate and the density of the plantation carried out in 1993 (Table 4).

Table 4. Density per species, origin, and diameter class in Dehesa de a Luz (2014).

Diameter Class (cm)	Holm Oaks (Trees)			Cork Oaks (Trees)			Total (Trees)
	Natural Regeneration	Plantation	Total	Natural Regeneration [1]	Plantation	Total	
5–25	5959	5758	11,717	82	10,018	10,100	21,817
30–50	8563		8563	224	48	272	8835
55–75	9309		9309	199		199	9508
80–100	6011		6011	66		66	6077
105–125	1437		1437	12		12	1449
130–150	106		106	3		3	109
155–175				1		1	1
Total	31,385	5758	37,143	587	10,066	10,653	47,796

Notes: [1] Does not include 172 trees without branches, those which on which the diameter is impossible to measure, and the lesser non-inventoriable trees.

Figure 4. Holm oak pruning in Dehesa de la Luz. Photograph: Daniel González.

Figure 5. Old holm oaks and young holm densification in Dehesa de la Luz estate. Photograph: Daniel González.

In the inventory conducted at the opening of the 2014 accounting period, there was a greater presence of bovine livestock belonging to family livestock owners, making up 77% of the census (Table S6). Bovine rearing involves producing calves for sale after weaning at an age of between five and seven months. They graze during the whole year in the leased enclosures, and there are jointly owned Limousin studs for mating with the cows. The bovine belonging to family livestock owners are a cross with foreign breeds: Charolaise, Friesian, and Limousin [22], although there are also some pure Retinta cows.

The landowner has autochthonous livestock species, including black Merina sheep, white Cacereña cows, and Cordobes donkeys, although there are also pure breed foreign species such as Rambouillet Merina sheep and Hispano-bretón mares (Figures 6, 7 and S7). Of all the livestock belonging to the public landowner, the Rambouillet Merina sheep are the most numerous, comprising 70% of their livestock. Regarding the type of livestock on the estate, bovine make up the largest percentage (79%) of the total, followed by ovine (18%) (Table S6).

Figure 6. Endangered Cacereña White cow rearing in Dehesa de la Luz. Photograph: Daniel González.

Figure 7. Endangered Black Merina Sheep. Photograph: Fernando Pulido.

Recreational hunting for small game is leased by the public landowner to the local hunting society. However, in practice, no resource rent is paid for hunting, as the hunters deem the resource to have a reduced market value due to the scarcity of game species captured. Although the hunting product value may be modest, it has been incorporated by discounting its expected resource rent from the estimated market price of the land.

At Dehesa de la Luz there are legacy-cultural values such as the presence of archaeological sites dating from pre-Roman times and the medieval era, as well as contemporary cultural-historical constructions such as Roman-Visigothic tombs (Figures S10 and S11), the 18-km dry-stone wall which encloses the whole estate occupied by the Dehesa de la Luz (Figure 8), and a stone shepherds' hut (Figure S8). The Ermita de la Virgen de la Luz sanctuary is also a noteworthy construction situated within the estate, although the public economic services associated with it have not been addressed in our valuation on this occasion (Figure S12).

Figure 8. Historical cultural legacy dry-stone walling. Photograph: Daniel Gónzalez.

2.2. Modeling Natural Growth of Trees and Extracted Products

2.2.1. Forest Stand Inventories

The models for holm oak and cork oak production functions are estimated for the full cycle of the woodland on the basis of the existing adult trees in 2014 from natural regeneration, young trees planted in 1993, and the densification in 2014.

Modeling the production functions starts with an inventory of 34 plots, a stem count of the scarce number of adult cork oaks dispersed among the holm oaks and in 20 reforested plots in the area occupied by the 1993 plantation.

The site is divided into six forest stands, allowing a detailed analysis based on the physical and geographic characteristics of the woodland (see SM 5). Using this management division, mortality between the years 1956 and 2010 was analyzed through orthophotos and geographical information system (GIS) software, which allowed us to determine the existence of trees in each year and the potential occurrence of regeneration (see SM 5). This field data provides the basis for modeling the future conservation forestry schedule. Based on the estimated tree volume growth, firewood pruning and cork stripping rotations, and the mortality and commercial cycles of the trees, it is possible to schedule the conservation forestry for the expected future growth and extracted products

at Dehesa de la Luz. The schedule is designed in accordance with the estimated area, location, and year of intervention as well as the type of activity or treatment to be applied (see SM 5). Natural growth and extractions are estimated by physical functions fitted to the environmental characteristics and woodland management of the Dehesa de la Luz case study [19] (see SM 5).

2.2.2. Holm Oak: Tree Volume, Firewood Natural Growth, and Acorn Yield Functions

Calculating the full production cycle of the holm oak involves using the functions for estimated age (Ae) and volume (V) to calculate physical natural growth (ng), based on the measurements carried out in the inventories, the age functions developed by Reference [23], and the official databases of the National Forest Inventory (NFI). This cycle is assumed to correspond to the point at which the power function of the growth based on estimated volume tends towards asymptotic curve, estimating the point of tangency between the linear (ng_{linear}) and power (ng_{power}) functions in order to select the forestry cycles for assisted holm oak landscape regeneration (see SM 5):

$$ng = 29.5437 \cdot (Db)^{0.8156} \cdot \left(\frac{1}{Ae + 72.9785}\right) \quad (1)$$

$$ng_{linear} = -0.0002 \cdot V + 1.930 \quad (2)$$

$$ng_{power} = 2.905 \cdot V^{-0.084} \quad (3)$$

where Db is the breast height diameter in cm, Ae is the estimated age in years, and V is the volume in dm^3.

The models for annual holm oak firewood product ($P_{firewood}$) are estimated in kg, based on the measurement of a pilot pruning of 30 holm oaks representative of the diameter classes recorded in the estate inventory. This model serves to calculate firewood growth according to the models developed to estimate the total volume of holm oak based on the measurements taken and the functions used in the second National Forest Inventory (NFI) in the province of Caceres [24]. Based on this estimate, it is possible to determine the time period necessary to replace extracted firewood between two consecutive pruning operations without exceeding the accumulated growth since the previous pruning. This period is the minimum rotation between two consecutive pruning operations (see SM 5). Only holm oak firewood is considered, as pruning is not performed on cork oaks.

$$P_{firewood} = 0.6661 \cdot Db^{1.3314} \quad (4)$$

The function for acorn production from adult holm oaks originating from natural regeneration ($P_{acornnr}$) is estimated in kg by modeling the count of cupules on the floor at the end of the 'montanera' (Iberian pig fattening period) in the months of December and January, over three consecutive seasons (2013–2104 to 2015–2016). To estimate the acorn production function for young, planted holm oaks, the acorn yield model developed by Reference [25] is applied.

$$P_{acornnr} \equiv F(Cca, Da, Wa) \quad (5)$$

where Cca is the tree canopy cover area, Da is the average density of acorns per square meter, and Wa is the average weight of the acorns.

2.2.3. Cork Oak: Tree Volume, Cork Natural Growth, and Acorn Yield Functions

Given the average age of cork oaks and the scarce number of inventoried adult trees, it is not possible to obtain an acceptable production cycle using the algorithms applied to the holm oak; hence, a maximum cycle for cork stripping of 150 years is used [26].

The estimate of the cork production function considers the inventories conducted stem by stem and the areas with planted trees. The model used to estimate cork yield (Pc) is taken from Reference [27]. The results obtained using this model are contrasted with the data from the last cork stripping in 2010 (these extractions being performed the same year for all the cork oaks dispersed throughout the estate), obtaining similar yield results. It is assumed that cork growth is linear during the period between stripping, with the debarking rotation (td) applied in Dehesa de la Luz being 10 years.

The cork oak acorn yield function uses a different model for the plantation cork oaks and the natural regeneration adult cork oaks. In the case of the young cork oaks, the fitted model for cork oak acorn yield published by Reference [28] is used. To calculate acorn yield in adult cork oaks, a coefficient is estimated which relates the mean yield obtained in young holm oaks and cork oaks.

2.2.4. Carbon Uptake

The carbon stored through the sink effect of the woodland is calculated using models developed by References [29,30], based on volume and growth measurements performed in the inventories (see SM 5). These models allow aboveground, large root, and fine root carbon to be measured both in holm oaks and cork oaks.

2.3. Private Activity Economic Valuation Criteria

The economic valuation uses the extended accounts. The novelties incorporated are described below, referring to conceptual aspects divulged in publications [4,16,19–22] as well as to supplementary material concerning the methodological details and some of the extended accounts application methods employed at Dehesa de la Luz.

Concepts and equations for products and costs are described in supplementary materials sections 1. The reader should consult the tables and supplementary materials for detailed explanations on accounting variables. Measuring the total private economic value of an agroforestry estate in a consistent manner using social income theory may be an impossible task [18,21]. We conducted exhaustive data collection at the estate itself to value the multiple private economic values currently consumed. Some public services have been estimated according to their public landowner production cost. The latter price is the EAA/EAF valuation criterion for non-market goods.

2.3.1. Forestry Activities

Private forestry activities in this study are classified into manufactured (human-made) conservation forestry activity (CF), cork, firewood, and grazing (grass and acorns) activities. The CF products include intermediate services and the final product of gross formation of fixed manufactured capital (GFCF) from tree plantations, the replacement of failed plantations, and densification (Figure 4). The cork and firewood products only incur ordinary costs of raw materials, services, and work in progress used in the course of extractions, and their products are natural growth, cork stripping, and holm oak firewood. Manufactured CF also enhances the natural growth of cork and firewood as well as acorn yield, increasing the value of these environmental assets.

The natural growths of cork and firewood over the period are final products classified as gross production-in-progress formation in the supply side of the production account and are registered as entries to the production-in-progress environmental assets of the capital account for the same period. The current inventories of holm oaks and cork oaks are fixed environmental assets of biological resources, valued according to the discounted expected future resource rents of cork and firewood from harvesting rotations beyond the current one. Future trees (not yet existent) which will replace those of current cycles also generate fixed cork and firewood environmental assets classified as land. The sum of the three types of environmental assets of natural growths of cork and firewood comprises the total value of their environmental assets. These valuation approaches avoid double accounting when measuring total environmental incomes and assets of cork and firewood (see SM 6 and [21]).

Grazing only incurs the ordinary cost of ploughing (Figure S6) (see the development of estimates for full production cycles of holm oak and cork oak in SM 6).

2.3.2. Water Storage Activity

The main function provided by the pools, wells, and springs is that of supplying water as an intermediate raw material product (hereinafter intermediate water) for livestock drinking troughs, although a secondary use for some pools in certain months is the rearing of tench (Figure 9). The value of the intermediate water is the ordinary cost of production (maintenance cost and ordinary consumption of fixed capital), plus the normal return from immobilized manufactured fixed capital (pools). Water pools are valued at their market replacement production cost, corrected by a factor which takes into account the state of conservation of each individual pool. The physical intermediate water and consumption were not measured.

Figure 9. Pool made with compacted soil. Photograph: Daniel González.

2.3.3. Livestock Activity

Regarding field data collection for livestock, little difficulty is involved in the physical inventory at the start of the accounting period, entries, withdrawals, and valuation of commercial products. Self-employed family labor is valued by the residual method (see SM 8) [4,16,22,31,32] if there is a positive net operating margin for livestock. If the latter is negative, that is, a monetary loss for the family livestock activity, we assume that there is a positive trade-off against a self-consumed intermediate service (ISSnca) by family livestock owners (see SM 8). This ISSnca is considered an input of own intermediate consumption of service (SSo) of the family livestock private amenity [16]. In this case study, we did not measured the total product of amenity activity, but rather their SSo. Thus, the potential environmental income for livestock is not measured.

2.3.4. Intermediate Services of Infrastructure Activities

Service activities include fencing and other infrastructures, footpaths for the public visitors, and the dry-stone perimeter wall, given its public service function as a cultural landscape with historical constructions.

The same valuation criteria as those used for the water services are followed for the livestock infrastructure services. The main function of the fencing, access gates, livestock infrastructures, and main gates is that of livestock management. Sanitation management and livestock foodstuff storage require the use of infrastructures (sheds, tanks, stables and portable troughs). The fencing and the dry-stone perimeter wall produce commercial and non-commercial intermediate services which are consumed by the livestock activity and the public landscape activity, respectively. Infrastructure service activity in 2014 also saw the final product of the dry-stone perimeter wall improvements (manufactured gross fixed capital formation) valued at restoration cost.

The roads, paths, and bridges for the free public access are mainly used for public recreational activity in Dehesa de la Luz. Hence, their construction is suitable for vehicle and pedestrian access. There is a public right of way for access to the Ermita de la Luz sanctuary.

The dry-stone perimeter wall serves the same purpose as the fencing as well as providing a public service given its cultural-historical interest (Figure 8). The concept of cultural-historical value of a fixed-capital manufactured asset refers precisely to its condition as an ancient man-made construction and as such it is assumed that citizens wish to contribute to its maintenance costs in return for using the services provided by its existence in its current state of conservation. This cultural-historical asset has survived to the present day in a partially complete state as regards the historic construction, with broken parts of the wall having been replaced with stone and construction materials. The cost incurred includes maintenance work, investment in restoration, and consumption of fixed capital of post-2004 restoration works at replacement cost. The value per cubic meter of stone wall is assumed to be the market value of its restoration. The market price of construction weighted by a correction factor that takes into account the current state of conservation is used. The capital value of the dry-stone wall is divided among the livestock activity, considering the equivalent linear meters of wire fencing, and the remaining capital value is attributed to the cultural-historical service provided by the dry-stone perimeter wall. The value of the intermediate service is estimated using the same criteria as those for the livestock and public recreational infrastructure, although the capital in this case is estimated according to the cost of the quasi-restoration of stone work weighted by a correction coefficient of 0.6.

2.3.5. Private Amenity Activity

The family livestock owners' private amenity product is valued in accordance with their production cost, thus obtaining a null net operating margin. However, the value of the environmental asset of the private amenity embedded in the market price of the land is estimated based on available published information [4,16,33].

2.4. Public Activity Valuation Criteria

We measured the imputed market value of the product, cost, and change of net worth associated with greenhouse effect carbon (environmental asset revaluation in this case). Other public activities are final services and these are not valued at simulated market price, but at public landowner production cost. Firstly, we registered the conservation forestry, livestock, dry-stone wall, and roads that produce intermediate services to be used as inputs (own intermediate consumption) by free access public recreation, option value of landscape services, and existence value of the threatened livestock biodiversity service. Secondly, we registered the respective public activities as inputs of own intermediate consumption of services (SSo). Finally, as standard accounts criterion apply, we assumed the value of public services to be equal to their SSo production cost.

Public profitability denotes the ratio between the benefits (capital income) and the immobilized capital (average annual capital invested in the economic activity) of public activities. To estimate public benefit, we needed to measure the public products at simulated market prices [4,21]. To determine this latter value, we needed to employ several non-market valuation techniques based on consumer preferences.

2.4.1. Public Recreation, Landscape, and Threatened Livestock Biodiversity Activities

In this case study of Dehesa de la Luz, we omitted the valuation of public services produced by the simulated market price criterion which consumers are willing to accept to finance the private costs of the landowners and the livestock owners, as well as the direct costs to the government for the management of public activities. Due to the omission of the public willingness-to-pay criterion, it is not possible to determine the true product values of the public activities considered in Dehesa de la Luz. The valuation of the free access for public recreation (Figure 10), landscape, and threatened

livestock biodiversity is conducted using the valuation criterion of private 'own' services costs incurred by the public landowner, family livestock owners, and family foresters.

Figure 10. Main free access entrance gate at Dehesa de la Luz. Photograph: Daniel Gónzalez.

2.4.2. Carbon Activity

The only exception to the valuation of public services at production cost is that of carbon, which is valued at simulated market price. The carbon service involves estimating the fixation and environmental consumption service of 2014 carbon dioxide emissions from the firewood consumption and their revaluation in future cycles of the woodland, which is consistent with the standard economic-environmental accounting criteria (SEEA-CF) and the extended accounts valuation criterion [4,32,34].

We estimated the environmental income from carbon stored in the trees by the variation in capital values between the opening and closing of the 2014 accounting period. This variation in net carbon assets is equivalent to the sum of the carbon environmental net operating margin and the environmental gains. The margin is calculated as the difference, over the period, between the values for carbon fixation from natural growth of firewood and cork, and the equivalent emissions, estimated from the firewood extracted in pruning operations and natural mortality in the woodland in 2014. The environmental asset gain is estimated by the revaluation of the carbon environmental asset, adjusted by the deduction of the expected fixation value at the opening of the period. The total environmental asset of carbon is recorded as fixed capital land (FClce). This environmental asset has two components: first, the carbon fixed by trees in the current production cycle, and second, the carbon that is expected to be fixed or emitted in successive production cycles. These production cycles were simulated according to silvicultural models.

2.5. Private Ecosystem Services

Ecosystem services are classified in this study according to the International Classification of Ecosystem Services (CICES) [35] and defined as 'the contributions of ecosystems to benefits (products: goods and services) used in economic and other human activity' [17] (p. 19, para. 2.23). Ecosystem services can be intermediate or final, depending on the classification of products in which they are embedded. The SEEA-EEA technical guidelines clarify the latter criterion: 'There is common misunderstanding of the role of classifications with regard to the distinction between final and intermediate ecosystem services. Put simply, it is not the case that ecosystem services must be neatly

classified between those that contribute directly to economic and social beneficiaries and those that support the ongoing functioning of ecosystems. For example, when water is extracted from a lake it would be considered final if the beneficiary was a household but intermediate if consumed by wild deer' [36] (p. 53, para. 5.33).

The private ecosystem services refer to the embedded contributions as natural production factor inputs to the values of the total products consumed from the landowner's private forestry activities at Dehesa de la Luz in 2014. The absence of cork stripping explains the null value for ecosystem services of cork consumed (the natural growth of cork and firewood are not consumed in 2014, as their contribution is taken into account in the accounting period in which they are extracted (consumed) (for methodological details see [19].

2.6. Intermediate Products of Services

If the operating benefits of manufactured investments in conservation forestry, livestock, and infrastructures for public services (recreation and cultural legacy) according to standard accounts are lower than the normal in an alternative investment, then business-as-usual investment theory states that the aforementioned activities are not competitive investments. Our hypothesis provides a solution for this unexplained occurrence which does not fit into currently accepted investment theory. We assume that the land and livestock owners obtain non-commercial intermediate services, which entail that the owners receive competitive operating benefits (manufactured net operating margin at basic prices). Our extended accounts measure the hidden donated and self-consumed intermediate services that are omitted in the standard accounts measurements of intermediate services.

In this research, our extended agroforestry accounts incorporate the intermediate products of services (intermediate services) in a manner which is consistent with the SEEA-CF [34] and SEEA-EEA [17] methodologies; although, in the latter, an ongoing approach to establish a standard for institutional sectors of the ecosystem accounts has not been agreed on. Our extended Agroforestry Accounting System (extended accounts) adopts a novel development to the SEEA-EEA model B accounts [17] (p. 134, Section 6.3.2 and p. 144, Annex A6), [21] (p. 28, SM. Eq. (3.1)), [4] (p. 50). In this model B, the ecosystem is considered as a factor of the production function of the individual products and the ecosystem is not an additional institutional sector, as treated in model A of the accounts [37] (p. 13), [17] (p. 17, para. 2.13).

Agroforestry ecosystems potentially produce environmental intermediate products of raw materials and services (although we term the latter 'intermediate services' for simplicity) with the absence of human labor and manufactured capital inputs in their production function, and more generally, they supply multiple manufactured intermediate products. The latter necessarily incorporate the values of human labor and manufactured capital contributions which, along with the contribution from the natural environment, can potentially provide embedded values of ecosystem services estimated by the residual valuation method. We underline the fact that the estimated intermediate services for conservation forestry, livestock, and infrastructures activities are manufactured (human-made) intermediate services.

Intermediate products are goods and services produced on the agroforestry estate that are used during the same period in which they are generated as own intermediate consumptions (inputs) by the same activity that produces them (intra-consumption) or by other activities (inter-consumption) on the same estate for the generation of the final products of the period. The classification and valuation of the intermediate products and the individual intermediate consumptions coincide by definition and, where all the products of the estate on which they are produced and consumed are considered, their entire aggregate value also coincides.

Intermediate products are valued at the prices of formal markets or, in the absence of formal transactions, simulated markets. It is assumed in the imputed prices of the individual donated and self-consumed intermediate products that they correspond to the normal opportunity cost of the immobilized manufactured investment in the production of the individual intermediate product.

Opportunity cost is defined by the total ordinary cost plus a normal manufactured net operating margin (see SM 4 for details of its calculation).

The assumed hypothesis of a continuing investment by the landowner in the activities of conservation forestry, livestock, and infrastructures with recreation and legacy services must reflect the achievement of a normal profit (manufactured net operating margin). Establishing sufficient evidence of obtaining a persistent profit margin in the medium term from manufactured margin at producer prices below the norm for the mentioned activities is justified by the omission in the standard accounts of the non-commercial intermediate services for the individual private activities previously mentioned.

The intermediate services are classified into commercial and non-commercial categories. The latter are noted as 'compensated' by the government (these are conventional operating and capital subsidies), donated by the public landowner, and the self-consumption of private amenities by the leasehold family livestock owners (these are used as input in the supply of self-consumed private amenity products). The public landowner aims to encourage the intermediate services to promote the supply of public products, accepting a lower private monetary manufactured net operating margin against a benefit in the form of non-commercial intermediate services for donations. The family livestock owners accept a lower private monetary manufactured net operating margin against a benefit in the form of non-commercial intermediate services for private amenity self-consumption. The family livestock owner benefit from his investment in livestock rearing is characterized by the acceptance of lower or zero compensation from self-employed family labor and, occasionally, a negative private monetary manufactured net operating margin from manufactured investment (excluding the land).

3. Results

3.1. Physical Assets and Yields of Forestry

3.1.1. Open Woodlands Condition and Expected Future Improvement Trends

Table 5 presents the scheduling for full cycles of conservation forestry for the proposed cultural landscape valued as the final environmental asset, indicating future interventions and the rotation period applied (see SM 5). Regarding this future horizon, if the proposed future plantations and interventions continue as scheduled (Table 5), the product, growth, and other parameters representative of the forest species present in the estate will increase.

The estimated average age of the adult holm oaks and cork oaks at Dehesa de la Luz in 2014 was 165 (±4.2) and 109 (±3.6) years, respectively. In 2014, the density of the naturally regenerated holm oaks and cork oaks was more than double that of the planted trees, reaching a similar density by 2100 (Table 6). The canopy cover (CCF) of the estate circa 2014 was 19%, increasing to 31% by 2100 with the planned conservation forestry schedule. The conservation forestry cycles estimated for holm oak and cork oak are 225 and 150 years, respectively. For the pruning of holm oak firewood, a rotation period of 41 years has been established, which is compatible with the growth of the holm oaks, and which will be reduced to 27 years once the currently existing aged trees have gone. In the case of cork stripping, the current rotation period of 10 years is maintained.

Table 5. Schedule of the future assisted regeneration of holm oaks and cork oaks at Dehesa de la Luz.

Forest Stand	Plot (ha)	Production Pruning		Densification		Formative Pruning		Replacing Failed Plants		Debarking		Regeneration Felling		Grazing Delimitation	
		Next (year)	Period [(1)] (years)	Next (year)	Period (years)	Next (year)	Period (years)	Next (year)	Period (years)	Next (year)	Period (years)	Next (year)	Period (years)	Next (year)	Period (years)
1	21	2029	41	2120	110	2121	110	2015	110	2020	10				
1	18.8	2028	41	2120	110	2121	110	2015	110	2020	10				
1	24.7	2027	41	2120	110	2121	110	2015	110	2020	10				
1	26	2026	41	2120	110	2121	110	2015	110	2020	10				
2	23.5	2025	41	2014	35	2015	35	2019	35	2020	10				
2	21.1	2030	41	2014	35	2015	35	2019	35	2020	10				
2	21.3	2031	41	2014	35	2015	35	2019	35	2020	10				
2	23.2	2045	41	2022	35	2023	35	2027	35	2020	10				
2	22.1	2046	41	2022	35	2023	35	2027	35	2020	10				
3	24.8	2039	41	2018	205	2019	205	2023	205	2020	10				
4	28.8	2040	41	2026	210	2027	210	2031	210	2020	10				
4	23.7	2041	41	2026	210	2027	210	2031	210	2020	10				
4	22.8	2042	41	2026	210	2027	210	2031	210	2020	10				
4	22.2	2043	41	2030	210	2031	210	2035	210	2020	10				
4	16.4	2047	41	2022	210	2023	210	2027	210	2020	10				
4	19.2	2048	41	2022	210	2023	210	2027	210	2020	10				
4	19.1	2049	41	2030	210	2031	210	2035	210	2020	10				
4	21.2	2050	41	2030	210	2031	210	2035	210	2020	10				
4	21.8	2051	41	2030	210	2031	210	2035	210	2020	10				
4	27.6	2052	41	2034	210	2035	210	2039	210	2020	10				
4	20.8	2055	41	2034	210	2035	210	2039	210	2020	10				
4	20.5	2056	41	2034	210	2035	210	2039	210	2020	10				
4	23.8	2020	41	2034	210	2035	210	2039	210	2020	10				
5	20	2023	41	2026	225	2027	225	2031	225	2020	10				
5	20.4	2024	41	2038	225	2039	225	2043	225	2020	10				
5	22.9	2044	41	2038	225	2039	225	2043	225	2020	10				
5	19.2	2053	41	2038	225	2039	225	2043	225	2020	10				
5	21.8	2054	41	2038	225	2039	225	2043	225	2020	10				
5	27.2	2016	41	2042	225	2043	225	2047	225	2020	10				
5	17.7	2017	41	2042	225	2043	225	2047	225	2020	10				
5	16.5	2018	41	2042	225	2043	225	2047	225	2020	10				
5	24.3	2019	41	2042	225	2043	225	2047	225	2020	10				
5	26.1	2021	41	2046	225	2047	225	2051	225	2020	10				
5	26.1	2022	41	2046	225	2047	225	2051	225	2020	10				
R	24.6	2032	41			2159	150			2023	10	2144	150	2144–2164	130
R	23	2033	41			2159	150			2023	10	2144	150	2144–2164	130
R	21.8	2034	41			2159	150			2023	10	2144	150	2144–2164	130
R	12.5	2035	41			2159	150			2023	10	2144	150	2144–2164	130
R	7.7	2035	41			2159	150			2023	10	2144	150	2144–2164	130
R	16.9	2036	41			2159	150			2023	10	2144	150	2144–2164	130

R	21	2037	41	2159	150	2023	10	2144	150	2144–2164	130
R	25.2	2038	41	2159	150	2023	10	2144	150	2144–2164	130

Notes: [1] The pruning period is 41 years until all the trees from natural regeneration have been replaced by planted trees, when the pruning period becomes 27 years. Soil tilling is carried out over the area where pruning was performed the previous year.

Table 6. Projection of the future condition and supply of the main products of holm oaks and cork oaks at Dehesa de la Luz.

Class	Average Age (years)			Density (Trees)			Acorn Production (t)			Cork Growth (t)			Firewood Growth (m^3)			Canopy Cover Fraction (%)		
	Year 2014	Year 2050	Year 2100	Year 2014	Year 2050	Year 2100	Year 2014	Year 2050	Year 2100	Year 2014	Year 2050	Year 2100	Year 2014	Year 2050	Year 2100	Year 2014	Year 2050	Year 2100
1. Natural regeneration	163	200	250	32,144	29,681	27,054	147.4	154.0	156.2	1.9	2.7	3.0	63.0	52.1	36.3	17	19	19
Holm oak	165	201	251	31,385	29,202	26,646	146.2	152.7	154.9				63.0	52.1	36.3	17	18	18
Cork oak	109	145	195	759	479	408	1.2	1.3	1.3	1.9	2.7	3.0				0	0	1
2. Plantation	19	40	81	15,824	26,475	26,384	9.3	56.5	195.5	4.4	10.4	23.1	2.4	19.5	46.3	2	5	12
Holm oak	15	30	69	5758	17,244	18,198	4.2	35.8	158.1				2.4	19.5	46.3	1	3	7
Cork oak	21	57	107	10,066	9231	8186	5.1	20.6	37.4	4.4	10.4	23.1				1	3	5
3. Total	117	124	166	47,968	56,156	53,438	156.6	210.5	351.7	6.3	13.1	26.1	65.4	71.6	82.6	19	24	31

3.1.2. Physical Natural Growth and Extractions of Firewood, Cork, Acorn, and Grass

The pruning of holm oaks in 2014 took place over an area of 19 ha. The annual growth of firewood accounts for 45% of the firewood extracted, which is due, in the first place, to the fact that extractions carried out in 2014 were larger than the accumulated growth since the last pruning. This was firstly because the holm oak firewood was extracted beyond the maximum cycle established in this study, and secondly due to dead holm oak firewood being extracted (estimated at 37% of the amount of green firewood extracted and making up 23% of the total in 2014). Table 7 shows the values for the growth and extraction of firewood, valued at stumpage price per ton.

The grazing price of acorn and grass (including browse) was estimated to be 0.035 €/forage unit (FU) at Dehesa de la Luz in 2014 [19,22]. Grass and acorn make up 87% and 13%, respectively, of the total grazing value (Table 7). The acorn yield per tree, obtained using the cupules count model, is below that expected for holm oaks of that diameter due to the ageing of adult trees and the excessive pruning that has taken place in the past.

Grazing (including acorn, grass and browse) are the main forestry activity raw material at Dehesa de la Luz. The value of cork growth at Dehesa de la Luz is 6% that of grazing.

Table 7. Annual products of wood, cork, acorns, and grass at Dehesa de la Luz (2014).

Class	Unit (u)	Yield (u/100 Trees)	Quantity (u)	Price (€/u)	Value (€)
Firewood extraction	t	19.4	147.0	3.7	538.0
Annual firewood growth	t	0.2	65.7	2.1	139.8
Annual cork growth	kg	58.4	6325.7	0.3	2198.8
Grazing consumption	100 FU *		8234.9	3.5	28,723.6
Grass and browse	*100 FU*		*7131.5*	*3.5*	*24,875.0*
Acorn	*100 FU*	*2.4*	*1103.4*	*3.5*	*3848.6*

* FU: Physical forge unit represents a kilogram of barley with humidity of 14.1% which provides a content of 2.723 kcal/kg DM (dry matter) of metabolisable energy.

3.1.3. Carbon Uptake

The value of carbon fixation by holm oaks is almost four times that of cork oaks, while the carbon emissions from holm oaks are more than 10 times greater due to the quantity of firewood extracted in 2014. Due to the quantity of carbon emissions from the holm oaks, the net fixation value is negative, whereas in the case of the cork oaks it remains positive (Table S9).

3.1.4. Livestock Grazing

The 2014 accounting period total metabolic energy requirements of the landowner's and family's livestock that feed on the Dehesa de la Luz estate is estimated to be 1013.7 FU/ha. Eighty three percent of these energy requirements are provided by grazing, while the remaining 17% comes from the provision of supplementary foodstuff. In the case of family livestock owners, the accounting period total physical energy requirements of the livestock are estimated at 794 FU/ha.

Eighty two percent of these family's livestock energy requirements are met by grazing and the remaining 18% corresponds to supplementary foodstuff. For the landowner's livestock, the requirements are estimated at 219.4 FU/ha, with 88% of that coming from grazing and 12% supplementary foodstuff (Table 8).

Regarding the different livestock, bovine consume 796 FU/ha, of which 81% is grazed and the other 19% is supplemented. Equine consumption is estimated at 39 FU/ha, of which 94% corresponds to grazing and 6% to supplementary foodstuff (Table 8).

The total price of the feed consumed is estimated at 0.074 €/FU, that of the family livestock owners being double that of the landowner (Table 9) [19,22]. There is no marked difference in the prices of supplementary foodstuff (Table 9).

Table 8. Livestock grazing and supplementary foodstuff consumption in Dehesa de la Luz (2014: FU/ha).

Class	Forage Units (FU)				
	Grazing			Supplements	Total
	Grass and Browse	Acorn	Total		
1. Family livestock owners	561.8	86.9	648.7	145.5	794.3
1.1 Bovine	547.7	84.7	632.5	143.8	776.2
1.2 Equine	14.1	2.2	16.3	1.8	18.1
2. Landowner	167.6	25.9	193.5	25.9	219.4
2.1 Ovine	140.9	21.8	162.6	15.7	178.3
Rambouillet Merina	129.0	20.0	148.9	14.3	163.3
Black Merina	11.9	1.8	13.7	1.3	15.0
2.2 Bovine	8.8	1.4	10.2	9.6	19.8
2.3 Equine	17.9	2.8	20.7	0.6	21.3
Total	729.4	112.8	842.2	171.5	1013.7

Table 9. Price of grazing and supplementary foodstuff by owner and livestock type at Dehesa de la Luz (2014: €/100 FU).

Class	Grazing	Supplements	Total
1. Family livestock owners	4.2	27.2	8.4
1.1 Bovine	4.0	27.2	8.3
1.2 Equine	12.1	29.5	13.8
2. Landowner	1.1	22.4	3.6
2.1 Ovine	0.7	26.4	3.0
Rambouillet Merina	0.7	26.4	3.0
Black Merina	0.7	26.4	3.0
2.2 Bovine	0.0	15.7	7.6
2.3 Equine	4.5	25.0	5.1
Total	3.5	26.5	7.4

3.2. Selected Physical Capital and Product Indicators per Livestock Type

The number of calves born to each reproductive female is higher for the landowner than for the family livestock owners. In contrast, the number of equine births is greater among the family livestock owners than for the landowner. The fertility rate of the two ovine breeds differs moderately, the figure being 0.7 for the Rambouillet Merina and 0.8 in the case of the Black Merina sheep (Table S7)

The sale of calves per reproductive female is greater in the case of the landowner than for the family livestock owners. The ratio of calf sales to births is 78% in the case of the landowner and 71% for the family livestock owners. Concerning ovine livestock, the ratio of sales to births is 43% for the Rambouillet Merina and 38% for the black Merina. The equine livestock belonging to the landowner had a sales-to-births ratio of 33%, while in the case of the family livestock owners, no sales of foals were made during the accounting period.

Table S7 shows the average prices used per livestock type and owner for the different livestock product valuations. In the case of calf sales, it can be seen that the landowner's price is higher than that of the family livestock owners.

3.3. Selected Economic Indicators of Private Activities at Dehesa de la Luz

Table 10 presents the main accounting identities used in the estimation of income, total capital, and private yield rates in the case study of Dehesa de la Luz [4,16,18,20,32].

Table 10. Intermediate services, ecosystem services, immobilized capital, incomes, and profitability rates for selected identities of the extended accounts.

Class	Identities
Intermediate services (ISS)	ISS = ISSc + ISSnc
Ecosystem services consumed (ES)	ES = TPc − ICmo − LCo − CFCo − NOMmo
Net value added (NVA)	NVA = TP − IC − CFC
Net operating margin (NOM)	NOM = TP − TC
Labor cost (LC)	LC = LCe + LCse
Opening capital (Co)	Co = WPo + FCo
Capital revaluation (Cr)	Cr = Cc + Cw − Co − Ce
Capital gains (CG)	CG = Cr − Cd + Cad
Capital income (CI)	CI= NOM + CG
Total income (TI)	TI = NVA + CG
Environmental income (EI)	EI = TI − LC − CIm
Resource rent (RR)	RR = ENOM + WPeu − NGe
Immobilized capital (IMC)	IMC = Co + WC
Operating profitability (o)	o =NOM/IMC
Capital gain profitability (g)	g = CG/IMC
Current profitability (r)	r = CI/IMC

Abbreviations: ISSc: commercial intermediate services. ISSnc: non-commercial intermediate services. TPc: total product consumption. ICmo: ordinary manufactured intermediate consumption. LCo: ordinary labor cost. CFCo: ordinary consumption of fixed capital. NOMmo: ordinary manufactured net operating margin. TP: total product. IC: intermediate consumption. CFC: consumption of fixed captial. TC: Total cost. LCe: labor cost employees. LCse: labor cost self-employed. WPo: opening work in progress. FCo: opening fixed capital. Cc: closing capital. Cw: capital withdrawals. Ce: capital entries. Cd: capital destructions. Cad: capital adjustments. CIM: manufactured capital income. NOMe: environmental net operating margin. WPeu: environmental work in progress used. NGe: environmental natural growth. WC: working capital.

3.3.1. Net Value Added

Estimating the private net value added for both the public landowner and the leasehold family livestock owners at Dehesa de la Luz is extremely complex and somewhat controversial in the academic sphere as well as in national accounting offices (Table 11). Although no landowner private amenity product is consumed, the service activity is that which contributes most to the total net value added (NVA) at Dehesa de la Luz, as is the case at large private dehesas [4,32]. This is due to the allocation of the intermediate product of infrastructure services at a value of 3% of the immobilized capital (Tables 11 and S10). In 2014, there was large own investment in the restoration of the dry-stone wall.

The next most important contributors to the NVA after services are the forestry activity (Tables 11 and S2) and livestock (Tables 11 and S8). As for water activity, this relates to the intermediate product of services and the amortization of livestock drinking water infrastructures (Table 11). The labor income is concentrated in livestock rearing (31 €/ha), firewood (13 €/ha), and conservation forestry (12 €/ha)

The incomes from employee labor and self-employed family labor account for similar quantities (Table 11).

Table 11. Owners and government production account for Dehesa de la Luz (2014: €/ha).

Class	Forestry	Water	Livestock	Services	Amenity	Owners	Recreation	Landscape	Carbon	Biodiversity	Public	Total
	1	**2**	**3**	**4**	**5**	**6 = Σ 1 a 5**	**7**	**8**	**9**	**10**	**11 = Σ 7 a 10**	**12 = 6 + 11**
1. Total product (TP)	128	19	300	185	18	650	15	119	3	5	142	792
1.1 Intermediate product (IP)	56	19	57	99		230						230
Intermediate raw materials (IRM)	34	19				53						53
Intermediate services (ISS)	22		57	99		178						178
Commercial (ISSc)	22			20		42						42
Non-commercial (ISSnc)	1		57	79		136						136
Compensated (ISSncc)			34			34						34
Donated (ISSncd)	1		5	79		85						85
Amenity (ISSnca)			18			18						18
1.2 Final product (FP)	72		244	86	18	420	15	119	3	5	142	562
Sales (FPs)	17		74			91						91
Gross fixed capital formation (GFCF)	52		28	86		167						167
Gross work in progress formation (GWCPF)	2		142			144						144
Autoconsumption (FPa)					18	18						18
Public goods and services (PGS)							15	119	3	5	142	142
2. Total cost (TC)	101	4	292	107	18	521	15	119	2	5	142	663
2.1. Intermediate consumption (IC)	69		260	86	18	433	15	119	2	5	142	575
Raw materials (RM)	35		100			135						135
Bought (RMb)	31		52			83						83
Own (RMo)	4		48			53						53
Services (SS)	33		30	86	18	167	15	119	2	5	142	309
Bought (SSb)	33		10	86		129						129
Own (SSo)	0		20		18	38	15	119		5	140	178
Environmental (SSe)									2		2	2
Work in progress used (WPu)	1		131			131						131
2.2 Labor cost (LC)	25		31			57						57
Employees (LCe)	12		18			30						30
Self-employed (LCse)	13		14			27						27
2.3 Consumption of fixed capital (CFC)	7	4		20		32						32
3. Net operating margin (NOM)	27	15	8	79		129			0		0	129
4. Gross valued added (GVA)	59	19	40	99		217			0		0	217
5. Net valued added (NVA)	52	15	40	79		185			0		0	185

3.3.2. Intermediate Services

The intermediate services are estimated at 178 €/ha for the total area of Dehesa de la Luz in 2014. These intermediate services are produced by conservation forestry, livestock, and infrastructure service activities in the following proportions: 12%, 32%, and 56%, respectively (Table 12).

The non-commercial intermediate services (ISSnc) contribute 136 €/ha. Non-commercial intermediate services compensated (ISSIncc) by the government to the owners of the land and livestock make up 34 €/ha. The intermediate services donated (ISSncd) by the public owner to recreational visitors and society as a whole (public landscape conservation services and conservation of biological and cultural diversities) add up to 85 €/ha (Tables 11 and 12). The cultural diversity service attributed to the dry-stone wall contributes 75% of the ISSncd. The family livestock owners consume amenity intermediate services (ISSnca) to a value of 18 €/ha. The ISSc values of the conservation forestry are below the aggregate values of their intermediate raw material products of grazing and firewood (Table 11). The ISSnc of livestock rearing are higher than the ISSc of conservation forestry. The ISSnc of the infrastructure services exceed the combined value of the conservation forestry and the livestock rearing.

Table 12. Intermediate product of services by activity for Dehesa de la Luz (2014: €/ha).

Class	Commercial	Non-Commercial				Total
		Compensated	Donated	Amenity	Total	
Conservation forestry	22		1		1	22
Livestock		34	5	18	57	57
Family livestock owners		14		18	32	32
Bovine		14		17	32	32
Equine				0	0	0
Landowner		19	5		25	25
Ovine		16	1		17	17
Rambouillet Merina		14			14	14
Black Merina		1	1		3	3
Bovine		2	4		6	6
Equine		2			2	2
Infrastructures services	20		79		79	99
Fencing	11		64		64	75
Other infrastructures	9					9
Paths			15		15	15
Private	42	34	85	18	136	178

3.3.3. Ecosystem Services

Grazing makes up 98% of the total ecosystem services consumed, and the remaining 2% corresponds to firewood (Table 13). If the ecosystem services of grazing and firewood are compared with the net environmental operating margin, it can be appreciated that the latter coincides with the service of grazing, and is inferior to the firewood service due to the fact that extraction exceeds growth [19].

Table 13. Landowner ecosystem services consumed at Dehesa de la Luz (2014: €/ha).

Class	Total Product Consumption	Ordinary Manufactured Intermediate Consumption	Ordinary Labor Cost	Ordinary Consumption of Fixed Capital	Ordinary Manufactured Net Operating Margin	Ecosystem Services	
	TPc	ICmo	LCo	CFCo	NOMmo	ES	%
Provisioning	200	274	44	4	−147	25	100.0
Cork		0				0	0.0
Firewood	21	8	13		0	1	2.2
Grazing	29	5			0	24	97.8
Water	19	0		4	15	0	0.0
Livestock	131	260	31		−162	na	na
Regulating	22	55	12	7	−52	0	0.0
Conservation forestry	22	55	12	7	−52	na	na
Cultural	117	104		20	−8	0	0.0
Amenity	18	18				0	0.0
Infrastructure services	99	86		20	−8	na	na
Total	339	433	57	32	−207	25	100.0

na: Not applicable.

3.3.4. Total Capital

The environmental asset of the dehesas generally makes up more than 80% of the total capital [32]. Given the scarce crop land and the fact that livestock management activities only take place up to the offspring weaning stage, the need for investment in machinery is limited. As for livestock rearing infrastructures (such as pools and wire fenced enclosures) and the residential dwellings for families of individual owners as well as the managers of the institutional owners (public and private), investment is mainly undertaken by large dehesa owners [32,38].

According to our hypothesis of non-commercial intermediate products, the dry-stone wall provides a non-commercial intermediate cultural-historical service. It is donated by the landowner to promote the final public products consumed by open access recreational visitors and society as a whole through its preservation. The valuation of the dry-stone wall in accordance with the cost of restoration is 1721 €/ha (Tables 14 and S11). The priority condition of providing a cultural-historical public service underlies its substantial contribution to the private capital of the estate, only surpassed by the environmental asset contribution of the private amenity service (2518 €/ha) (Table 14). Paradoxically, this environmental asset does not present the consumption of its private amenity service due to the fact that the owner is an institution.

The past trend towards the depreciation of the raw materials environmental asset, namely, grazing, firewood and acorns, the latter due to the decline in acorn yield resulting from the ageing of holm oaks at Dehesa de la Luz, explains the fact that in 2014, they only accounted for 35% (1396 €/ha) of the total environmental asset (4007 €/ha) (Table 14). The investment in infrastructures (3148 €/ha) and livestock (444 €/ha) accounted for 47% (3592 €/ha) of the total opening capital value (7599 €/ha) invested in Dehesa de la Luz in 2014 (Table 14). The remaining 53% corresponds to the contribution of the environmental asset.

Table 14. Private capital balance account of Dehesa de la Luz (2014: €/ha).

Class	1. Opening Capital	2. Capital Entries				3. Capital Withdrawals						4. Revaluation	5. Closing Capital
		2.1 Bought	2.2 Own	2.3 Other	2.4 Total	3.1 Used	3.2 Sales	3.3. Destructions	3.4 Reclassifications	3.5 Other	3.6 Total		
	(Co)	(Ceb)	(Ceo)	(Ceot)	(Ce)	(Cwu)	(Cws)	(Cwd)	(Cwrc)	(Cwo)	(Cw)	(Cr)	(Cc)
1. Capital (C = WP + FC)	7599		311		311	131	2	1	2	0	137	−38	7735
2. Work in progress (WP)	161		144		144	131			2		133	1	172
2.1 Cork (WPc)	23		2		2				2		2	1	24
2.2 Firewood (WPf)	7		0		0	1			0		1	0	6
2.3 Non-breeding livestock (WPnb)	131		142		142	131					131		142
3. Fixed capital (FC)	7438		167		167		2	1		0	3	−39	7563
3.1 Land (FCl)	3275											−19	3255
Commercial (FClc)	756											1	757
Cork (FClco)	22											1	23
Firewood (FClf)	1											0	1
Grass and browse (FClg)	622												622
Acorn (FCla)	18											1	19
Hunting (FClh)	93												93
Environmental (FCe)	2518											−20	2498
Amenity (FCea)	2518											−20	2498
3.2 Biological resources (FCbr)	1016		28		28		2	1		0	3	25	1065
Cork (FCbrc)	528											16	544
Firewood (FCbrf)	6									0	0	0	6
Acorn (FCbra)	168											1	169
Breeding and draught livestock (FCbrb)	313		28		28		2	1			3	8	346
3.3 Plantations (FCp)	76		52		52							−14	114
3.4 Infraestructure (FCco)	2578		86		86							−26	2639
3.5 Pools (FCp)	494											−5	489

3.3.5. Capital Income

Private activities at Dehesa de la Luz, before taking into account the non-commercial intermediate services (ISSnc), generate negative capital income at the producer's price (CIpp) of −18 €/ha in 2014. After including the SSIncc, we estimate a basic price capital income (RCpb) of 16 €/ha. If we add to the latter the SSIncd and SSInca, we obtain a social private price capital income of 118 €/ha (Table S12).

The environmental income (EI) accounts for 19% of the total social capital income of Dehesa de la Luz, and the remaining 81% corresponds to the total manufactured capital income (CIm). Concerning forestry activity, the measurement of capital income at the producer's price, basic price, and social price reveals positive values of 35, 35, and 36 €/ha, respectively (Table S12). Livestock activity generates capital income for the three types estimated at −42, −8, and 15 €/ha, respectively (Table S12). The infrastructure services contribute to the different capital income with −5, −5, and 73 €/ha respectively. The environmental income from the forestry activity is 43 €/ha, which is more than its total capital income as the manufactured capital income is negative. The contribution of the private amenity services to the environmental income is negative, with a value of −20 €/ha due to the negative variation in the price of the land in 2014.

The total manufactured capital income, imputed as normal in its net operating margin component (except for the family livestock owners and loggers which are residually measured at basic prices), mainly comes from the infrastructure services, contributing 73 €/ha. The forestry and water service activities contribute −7 and 14 €/ha, respectively, to the manufactured capital income (Table S12).

3.3.6. Total Income

The net value added is the operating income which, determines the value of the long-term horizon total income, although the capital balance account revaluation/depreciation in the accounting period must be estimated in order to add them to the net value added, thus obtaining the true total income for short- and medium-term horizons. In the absence of extraordinary destructions, the variation in the price of the land is one of the main causes of the revaluation/depreciation of the environmental asset. In 2014, a total capital depreciation of −38 €/ha occurred (Table S13). The capital gains (in fact losses in 2014), which are estimated based on adjusted depreciation for accounting purposes to avoid double accounting and destructions due to livestock mortality, are subtracted, giving a negative capital gain of −11 €/ha. Quantities close to the NVA and total income are obtained with this limited loss of capital for 2014 (Table S14).

In 2014, a comparison of the AAS and EAA/EAF methodologies revealed marked differences if we consider that the estimated amount of NVA is 2.3 times greater with the AAS than with the EAA/EAF measurement (Table S14).

3.3.7. Profitability

Our definitions of the current and real profitability differ in that the first substitutes the variation in the current price of the land in that accounting period for the real average rate of variation (net rate of inflation) in the price of grazing land in Spain over the period of 1994–2014 [16,32]. The results for the current and real operating profitability rates coincide due to the effect of the variation in prices of the land and manufactured capital. These price variations only affect the rate of capital income (Table 15).

The operating and total current private profitability rates at social prices are positive, while the current capital gain is negative. The total real profitability of 2.3%, the real capital gain of which is positive for all the activities as a whole, reflects an overall rate in which the individual products display markedly different results (Table 10).

Table 15. Private profitability rates for Dehesa de la Luz (2014: %).

Class	Current Profitability			Real Profitability		
	Operating	Capital Gain	Total	Operating	Capital Gain	Total
1. Forestry	1.8	0.6	2.4	1.8	0.6	2.4
1.1 Cork	0.4	2.6	3.0	0.4	2.6	3.0
1.2 Firewood	1.2	0.4	1.6	1.2	0.4	1.6
Silviculture	1.2	0.4	1.7	1.2	0.4	1.7
Pruning	0.0	0.0	0.0	0.0	0.0	0.0
1.3 Grazing	3.0	0.2	3.2	3.0	0.2	3.2
Grass and browse	3.3	0.0	3.3	3.3	0.0	3.3
Acorn	2.1	0.8	2.9	2.1	0.8	2.9
1.4 Conservation forestry	0.0	−6.4	−6.4	0.0	−6.4	−6.4
2.Water	3.0	−0.2	2.8	3.0	−0.2	2.8
3. Livestock	1.8	1.4	3.3	1.8	1.4	3.3
3.1 Family livestock owners	1.1	2.1	3.1	1.1	2.1	3.1
Bovine	1.1	2.1	3.2	1.1	2.1	3.2
Equine	0.1	−0.6	−0.6	0.1	−0.6	−0.6
3.2 Landowner	5.7	−1.7	4.0	5.7	−1.7	4.0
Ovine	5.0	−2.1	2.9	5.0	−2.1	2.9
Rambouillet Merina	2.2	−1.7	0.6	2.2	−1.7	0.6
Black Merina	22.4	−4.8	17.6	22.4	−4.8	17.6
Bovine	16.9	0.1	17.0	16.9	0.1	17.0
Equine	−2.9	−2.0	−5.0	−2.9	−2.0	−5.0
4. Infrastructures services	3.0	−0.2	2.8	3.0	−0.2	2.8
Fencing	3.0	−0.2	2.8	3.0	−0.2	2.8
Other infrastructures	3.0	2.5	5.5	3.0	2.5	5.5
Paths	3.0	−1.0	2.0	3.0	−1.0	2.0
5. Amenity	0.0	−0.8	−0.8	0.0	1.4	1.4
Total	1.7	−0.1	1.5	1.7	0.6	2.3

3.4. Public Activities

3.4.1. Carbon Environmental Income and Asset Values at Simulated Market Price

There is no bought intermediate consumption of services (SSb) in the case of carbon activity. However, the environmental intermediate consumption of the service of carbon emissions from the firewood extracted (SSe) is registered. The price of the carbon natural growth and emission is valued at European trade prices for greenhouse effect carbon [39]. This European industrial market price for greenhouse effect carbon, applied to the annual growth of the holm oaks and cork oaks, works out at a market value of around 3 and 2 €/ha, respectively, in 2014, resulting in an almost null environmental net operating margin (Table 11 and Table S9).

The balance capital account for carbon shows a significant gross revaluation of 16 €/ha, caused by the discounted future growth of recent plantations, since the current adult trees present a negative net discounted value (Table S9). The environmental income and total income of carbon activity coincide at 14 €/ha in 2014 and represent a third of the estimated private environmental income at Dehesa de la Luz (Table S13).

3.4.2. Public Recreation, Landscape, and Threatened Livestock Biodiversity Products

Since information was not available on the public consumers' willingness-to-pay for the final products of public recreation, landscape, and threatened biodiversity activities consumed in 2014, in accordance with the EAA/EAF standard criterion, the value of the final products was estimated by the private own (self) manufactured intermediate consumption of services (SSo). Therefore, their net value added was estimated as null (Table 11). The private intermediate self-consumption of services by the private activities accounts for 21% of the private SSo, and the other 79% of private SSo corresponds to public activities. The landscape activity accounts for 85% of the private intermediate consumption of the public activities (Table 16). In other words, the final product of public activities is concentrated in the landscape activity at Dehesa de la Luz (Table 11). This result is mainly due to

the landowner donated private non-commercial intermediate services (ISSncd) associated with the provision of the dry-stone wall public service (Table 12).

Table 16. Intermediate consumption of services at Dehesa de la Luz (2014: €/ha).

Class	Commercial	Non-Commercial				Total
		Compensated	Donated	Amenity	Total	
Private	20			18	18	38
Conservation forestry	0					0
Livestock	20					20
Family livestock owners	13					13
Bovine	13					13
Equine	0					0
Landowner	7					7
Ovine	6					6
Rambouillet Merina	*6*					*6*
Black Merina	*1*					*1*
Bovine	0					0
Equine	0					0
Amenity				18	18	18
Public	22	34	85		118	140
Recreation			15		15	15
Landscape	22	34	64		98	119
Biodiversity			5		5	5
Total	42	34	85	18	136	178

4. Discussion

4.1. Lack of Landowner Concern over Conservation Forestry Investment

The current state of the regeneration of dehesas is mainly the result of poor livestock grazing management, which has hampered the regeneration of trees. However, sustained grazing can be compatible not only with natural regeneration but also with plantations, as long as the individual trees in plantations are protected against controlled animal browsing. To achieve successful natural regeneration and plantation of trees in plots, it is necessary to establish appropriate areas of forest in the process of regeneration and to schedule the rotation of regeneration plots in dehesa open woodlands, based on the biological lifecycles of the trees.

The lack of investment in conservation forestry by a group of large private dehesa estates in Andalusia is worthy of mention [32]. It is unusual for owners to make investments for the benefit of future generations without receiving compensation from the government, given that competitive profitability results are mainly generated by amenities, and these are not affected in the short or medium term by the current rate of decline in raw material extractions of firewood, cork, acorns, and grass from dehesa woodlands. In this regard, the historical variations in the price of the land should also be taken into account. The private owner prefers to invest in land and livestock, which contribute in the short/medium term to avoiding negative monetary profitability along with medium to high private amenity or public profitability [4,16,32,38]. The manufactured investment in plantations today will only provide monetary capital income decades from now, which may be the main reason for the lack of woodland renewal. The high level of uncertainty with regard to the realization of future profits also underlies the uncertainty regarding the change of net worth in the present for these future yields (see SM 2). However, the landowner who, at some point in the future, harvests the products of these historical plantations will be the beneficiary of greater monetary operating margins since the historical costs of the conservation forestry will have been amortized.

Spanish dehesa woodland landscape conservation was mainly undertaken in the 1980s and 90s as a result of government compensation, co-financed by the European Union under the regulations of the programme for setting aside agricultural land of the Common Agricultural Policy (CAP) [40]. This is the case of Dehesa de la Luz, where a programme of plantation and tree densification was

applied in holm oak and cork oak woodlands in 1993 and 2014, respectively. In this particular case, the landowner was totally compensated by the Extremadura government in return for commercial intermediate services associated with the conservation forestry activity carried out since 1993.

Environmental groups sometimes question the compensations (subsidies) provided under the Common Agricultural Policy (CAP) for livestock grazing which is not subject to the use of appropriate practices for the regeneration of the dehesa open woodland. The fact is that animal grazing (both livestock and game species) is essential to the existence of dehesa open woodland. Although public payments for livestock farming are not subject to auditing of compatibility with the natural regeneration of the trees, it is generally accepted that livestock provide the grazing with which the owner potentially constructs or destroys the dehesa open woodlands, in the latter case through inadequate management.

4.2. From Spanish Dehesa Private Low Commercial Operating to High Total Profitability Rates

Sufficient cash flow is important for large private family owners when their household livelihoods depend to a large degree on the monetary income from the dehesas. For large private owners of dehesas, dependence on government compensation is limited [16,41]. As for small and medium sized landowners, who were outside the scope of this research, we would imagine that for many of them, obtaining a positive net cash flow is a requirement for dehesa management. In these cases, it is the residual remuneration from self-employed family labor and income from the land and livestock that guide the landowners. The small leasehold livestock owners of Dehesa de la Luz, however, accept moderate or even null compensation for self-employed family labor and investment in livestock in return for self-consumption of amenities.

The operating profitability rate and the current gain rate should be important in the medium and long term and, to a lesser extent, in the short term due to volatility in the annual physical yield of grazing and the annual variation in the prices of land. The rationale that distinguishes investment in the dehesa from non-agrarian investment (e.g., public or industrial financial capital such as shares in a publicly traded company) is that land and livestock owners can benefit from self-consumed amenity services apart from the monetary benefit. For these reasons, private industrial landowners (capitalists) who, not being a natural person, cannot consume amenities, incur a potential loss because the market price of the dehesa land does include the private amenity discounted as a component of the price of the land [16,42]. Therefore, these private landowners tend to sell their estates to obtain greater monetary profitability from their investment in other forms of capital. In the case of public dehesas, the option of selling them is restricted by institutional and cultural settings. The loss to the public landowner of potential margin due to the absence of self-consumption of private amenities could, in this case, be counteracted by a greater supply of public products based on the provision of intermediate services of conservation forestry, threatened livestock, and historical-legacy service activities.

Published information on the private profitability of dehesas and montados is limited to the results for a group of large estates in Extremadura, Andalucía, and Alentejo. The profitability of dehesas has been estimated using extended accounts, showing moderate private commercial operating profitability both at producer's prices and basic prices. The results show −3% to 4% of the private commercial (excluding private amenities) operating profitability rates. Results from testing extended accounts reveal that the large dehesa estates obtain more highly competitive private real total profitability rates between 5% and 7% after taking into consideration the private amenities and real capital gains, mainly stemming from land revaluations that were not anticipated at the opening of the accounting period [1,4,15,16,32,43,44]. Other publications have applied standard accounts to agroforestry system estates [20,41,45–47]. Reference [41] defines a concept of 'profitability rate' which is estimated from the standard net operating surplus (which includes self-employed labor compensation) and the total capital. The standard accounts net operating surplus (NOS) could overestimate the standard capital investment profitability rate. The NOS includes the implicit remuneration of unpaid family labor (LCse). Thus, NOS is an operating income which includes the operating benefit of the investment (the extended accounts net operating margin (NOM)) plus the

remuneration of the LCse. The investment theory consistent with the theory of capital profitability only includes the NOM. Therefore, by definition, NOM is less than or equal to NOS. The latter results when LCse = 0.

The high profitability rate reported by Reference [41] for the group of large dehesas studied ("grupo 4") is still more surprising if it is borne in mind that the extended broadened extend the standard accounts measurements to include the natural growth of cork and firewood, non-commercial intermediate services, private amenities, and capital gains. These authors estimate a commercial operating profitability of 6% on the total capital (which could be approximately 4% if our estimate of the residual compensation for imputed self-employed labor is excluded from the net operating surplus). It is debatable whether this result is significantly linked to the extraction of natural resources. In the absence of measurement errors, it is likely that it is significantly influenced by production processes based on the purchase of foodstuff for semi-industrial livestock production, especially of Iberian pigs and their crossbreeds. Reference [41] applies the EAA/EAF, which, as we know, do not estimate the natural growth of cork and firewood, and which limit the valuation of the products of these raw materials to the extractions of the period. Furthermore, since natural growth of firewood is omitted in the EAA/EAF, work-in-progress products extracted are not recorded as a cost in the period according to their value at the opening of the period, thus in the standard accounts double accounting of these values is avoided. The prices of grazing leases for the agrosilvopastoral systems of large family farms in Andalusia are estimated in Reference [31]. The available references [4,6,15,16,20–32,43,44,46,47] correspond to applications by other authors of EAA/EAF and AAS in dehesa estates that report commercial profitability rates for cork, firewood, grazing, and livestock both at producer's prices and at basic prices, which are notably lower than those of Reference [41].

The private operating profitability of public dehesas tends to be lower than that of private dehesas due to the absence of the self-consumption of private amenities. When the management by public owners is oriented towards increasing the supply of intermediate services in order to promote public activities, it can result in reduced commercial operating profitability at producer's prices [47]. This is the case of Dehesa de la Luz, with a substantial public landowner donation of non-commercial intermediate services to promote the supply of public products consumed by free access public recreation and society as whole when the services come from landscape, threatened biodiversity, and dry-stone wall legacy cultural services (Tables 11, 12, and 16).

4.3. Comparison of Results of Standard versus Extended Accounts

The Economic Accounts for Agriculture and Forestry are produced by the government at the national level and include the economic activities of all the national agricultural estates. Thus, the aggregate result from all the individual estates corresponds to the total agroforestry 'estate' for the nation as a whole, since it includes all the national agricultural products. Therefore, the standard accounts is also applicable at the scale of the individual agroforestry estate, without the need for any conceptual change. The only change is instrumental and refers to the standard accounts part of the intermediate products, which is omitted, and another part, which is usually traded, is considered a final product of 'intra-consumption' when used as an input in the same estate. The extended accounts (AAS) measure all raw materials and services produced (intermediate products) and consumed (own intermediate consumption) by the estate activities in the accounting period.

We need to estimate the total product and total costs of single activities or products at the estate scale. The reason for this is that we need to estimate the benefit of a single product in order to estimate individual environmental assets and capitals. As an example, we can consider the acorn production consumed by livestock grazing on the estate. The discounted future benefit (resource rent) from the acorns gives the value of its environmental asset. The acorns are an intermediate product of forestry activity (raw material) and, during the same accounting period, are also an intermediate consumption of own raw material by livestock activity at the same estate.

In the case of Dehesa de la Luz, divergences between the standard versus extended accounts measurements of the private net value added of activities managed under the responsibility of the public landowner (either directly or delegated through leaseholds for family livestock rearing) are

due to differences in the concept of economic products and the fact that the standard accounts do not include the natural growth of cork and firewood or the work-in-progress use of firewood from pruning operations and dead holm oaks. Both accounting methodologies coincide with the value of products according to market price or, where this is not available, the production cost. Another point of coincidence is that they both estimate the amortization (consumption of fixed capital) according to the lowest replacement cost of the manufactured fixed capital replaced.

With regard to the application of the extended accounts in Dehesa de la Luz, the private service activity includes the non-commercial intermediate service of the dry-stone wall. This intermediate service of restoration is not acknowledged in the standard accounts, which only include the livestock fencing service provided by the dry-stone wall. Hence, the most economical replacement cost for this service is to substitute it with a wire fence. In our case we accept this cost of replacement of the amortization, which is attributed to own intermediate consumption of services of the livestock rearing activity, while the additional cost of restoration, over and above the cost of the wire fence, is considered a non-commercial intermediate service of the dry-stone wall donated by the landowner to maintain the cultural landscape at Dehesa de la Luz.

Apart from the deficiencies described above, another problem with the standard accounts relates to the 'timing' of the measurement of net value added for cork and firewood, since the only criterion applied is that of extraction, whereas natural growth is omitted in the valuation of the product over the accounting period. However, as this problem of the 'timing' of the net value added measurement is not an issue with the extended accounts, this methodology for net value added measurement is more consistent with economic theory.

Comparing the standard and extended accounts, the standard accounts value the net value added at the producer's price whereas the extended accounts calculate it at the social price (producer's prices plus non-commercial intermediate services). The extended accounts private net value added is more than 2.3 times the value estimated using the standard accounts.

4.4. Private Incomes and Capital Sensitivity to Discount Rate Changes

The normal discount rate of 3% applied in Dehesa de la Luz to the future resource rents (see SM 3) from firewood, cork, acorn, and grass raw materials (intermediate products) gives their individual environmental asset, which are consistent with market prices for the land declared by the landowners of the Andalusian dehesa estates. Our choice of discount rate coincides with the rates applied in the net present value method used by the Spanish government for the valuation of estates, that is, applying the rate of return on 30-year public debt for the three years prior to the valuation [48,49]. The discount rates applied in the valuation of woodlands in the United Kingdom [50,51] are also similar to our rate and to those of the Spanish government. The manufactured capital invested is not affected by variations in the discount rate, but the manufactured capital income, environmental income, and environmental asset are affected [52]. In this case, the values of the intermediate infrastructure services were imputed, applying normal 3% rates of return. The natural growth of cork and firewood, both current and future, were estimated in accordance with the net present value of their discounted resource rent. From a baseline discount rate of 3%, reducing this rate by half would increase the environmental asset of Dehesa de la Luz by 72%, and increasing the discount rate by 50% would lead to a decrease in the environmental asset of −17% (Table 17).

Table 17. Private income and capital sensitivity to discount rate changes at Dehesa de la Luz.

Class	Manufactured Opening Capital (€/ha)	Manufactured Capital Income (€/ha)	Manufactured Working Capital (€/ha)	Environmental Income (€/ha)	Environmental Asset (€/ha)	Index Respect Environmental Asset (%)
Discount rate to 1.5%	3591.7	37.8	94.0	101.1	6876.7	172
Discount rate to 3.0%	3591.7	77.4	89.0	22.8	4007.3	100
Discount rate to 4.5%	3591.7	117.1	87.2	16.8	3324.3	83

4.5. Strengths and Weaknesses of Testing Extended Accounts in Dehesa de la Luz

This study shows the versatility of the Agroforestry Accounting System, applied in this case to individually quantify of the intermediate services, the total income, and factorial distribution corresponding, among other indicators, to private activities at Dehesa de la Luz. These extended accounts provide the owners with a suitable tool for decision-making with regard to conservation forestry and its relationships with other private and public economic activities at Dehesa de la Luz. The lack of social price valuation of public services in this case study makes it impossible to present a relevant comparison of commercial vs non-commercial values in this study. Nevertheless, private non-commercial intermediate services have been measured and these represent the main products consumed which are supplied by private activities at Dehesa de la Luz.

The scale of the extended accounts testing at Dehesa de la Luz provides a high degree of robustness to the quantification and valuation of the products and private costs, taking into account the observed economic rationale of the public landowner, leasehold family livestock owners, and loggers. The availability of detailed inventories of the woodland, livestock, man-hours employed, as well as the consumption of raw material and services per type of activity allows the physical yields and economic results to be assigned, thus minimizing individual product measurement bias. In this situation, the estimates of ecosystem services, intermediate services, environmental income, environmental asset, labor income, net operating margin, net value added, capital gains, change of net worth, capital income, and total private income are feasible and consistent with the theory of economic market valuation, both real and simulated. However, the fact that these results are subject to the author's choice of discount rate and its future variations creates an unknown level of uncertainty. This is inherent to all economic activity, which includes changes of net worth in estimates of net operating margin and total capital income.

The hypothesis that intermediate services donated by the public landowner are embedded in the value of the public services for which public consumers are prepared to pay is somewhat controversial, as the consumption of public products at Dehesa de la Luz, in accordance with the consumer's willingness-to-pay, has not been valued. This weakness in the extended accounts is similar to that of the standard accounts with regard to the manufactured gross fixed capital formation, which it also values according to production cost.

The weakness which we believe to be most important in the application of the extended methodology to conservation forestry is that it does not incorporate future variations in the public environmental services of carbon and water trade-off in the context of surplus demand for irrigation water in the lower Tagus river basin. Improvements regarding the densification and natural growth of young holm oaks and cork oaks, in contrast to the alternative land use option of treeless grazing, will lead to a decrease in surface water run-off beyond Dehesa de la Luz to the pool and dams. This competition between the environmental services of carbon and the surface water yield regulated in the pools of Arroyo de la Luz and collected in the reservoirs of the lower Tagus basin is a critical issue which has not been addressed in this study and will be a prioritized aspect of future research [53].

5. Concluding Remarks

5.1. Dehesa de la Luz Open Woodland Cultural Landscape Conservation

The long-term conservation of the cultural landscape of dehesa open woodland is not viable without animal grazing, although agricultural activity may be absent as currently occurs, at least to a certain degree, in dehesa systems of large estates [4,32,38]. A dehesa is shaped by livestock management and of continual investment in forestry over long natural production cycles, so that the natural landscape matures and reaches a fragile balance between the conservation and consumption of its natural resources.

5.2. Critical Ecosystem Capital and Economic Data Lag Failures

A general limitation of the concept of ecosystem services consumption and which, therefore, is present in the Dehesa de la Luz case study, is the lack of certainty of the signs of its physical and monetary variation over the same accounting period. The estimated ecosystem services and environmental net operating margin values for Dehesa de la Luz are proximate, apparently indicating that consumptions do not significantly exceed the accumulated natural growth of firewood and grass yield in the accounting period. In fact, firewood extraction was greater than natural growth in 2014. Therefore, these economic results do not necessarily mean that ecological decline is absent in Dehesa de la Luz, due to the short-sightedness of the market that omits non-catastrophic physical environmental decline, if indeed it exists, from both the short- and medium-term revaluation of the market price of the land. This limitation is inherent to the economic valuation of the natural environment in general. Environmental conservation is a preference expressed in social choice, subject to the restraint of tolerable cost to current generations in order to guarantee physical capital above the critical thresholds of irreversible loss of such capital. It could be said that the environmental asset value tells us the importance which actual people give to the future consumption of nature services, although the value of the current consumption does not provide us with unequivocal information regarding the variation in the biological condition of the environmental asset. This ecological condition may not be explicit in the economic value until critical thresholds of the ecological integrity of the cultural ecosystem are reached.

5.3. Socially Tolerable Government Cost for Improving Dehesa Public Services

The public service of the cultural landscape of Dehesa de la Luz is favored by investment in conservation forestry, and this public benefit is one of the most important factors justifying public payment to land and livestock owners. However, future commercial yields of firewood and grazing (acorns, browse, and grass) do register in the market, although these private yields are considered sub-products with no cost, since the costs of plantation and densification are assigned to the conservation forestry activity.

In this study, we show the legitimacy of potential payment to private landowners for losing monetary income when this is valued according to the value of non-commercial intermediate services consumed in the production of public services. Based on the results obtained in this study, the demands for compensation for lost monetary income by landowners can be legitimated since the cost to the landowner of promoting the production of public environmental services is identified. However, the social legitimacy of the payment of lost monetary income has not been considered in our study. To address the social legitimacy of government compensation to land and livestock owners, it is necessary to collate the variation in the compensated production of public services valued according to the willingness-to-pay of active and passive consumers with the public expenditure incurred.

The social legitimacy of public compensation for the private non-commercial intermediate services used as inputs for the renovation of dehesa landscape, autochthonous livestock breeds, and unique constructions of public interest (dry-stone wall) is not covered in this study of Dehesa de la Luz, as the valuation of public services in accordance with the consumer's willingness-to-pay and the direct cost of government administration of public activities were omitted. We assumed, however, that public consumers are at least prepared to pay the cost associated with private intermediate services ascribed as inputs to the production of public free access recreation, landscape, and livestock biodiversity activities (Table 11).

5.4. Private Amenity versus Public Services Trade-Off in Spanish Dehesas

The current, predominantly environmental service economy associated with Spanish dehesas is illustrated by the large contribution of private amenity services in large private dehesas, and to a lesser extent evidenced by the ecosystem services embedded in the firewood, cork, and grazing products consumed [4,16]. Dehesa public landowners face the challenge of counteracting the loss of

private amenity services by incorporating new public products in greater amounts than those offered by private dehesas, in which much of the public free access use is lost. Private dehesas limit or completely avoid the consumption of certain public services, particularly recreational use, since the private landowner has the right to prohibit entry to the estate. Although the public dehesa owner also has this right, public recreational use is frequently favored where there is an effective demand.

The conceptual impossibility of self-consumption of private amenity services by the public landowner, as with institutional property (private non-family, non-profit entities, and public institutions) has a significant influence on the differences in the composition of the final private product of public dehesas. This high importance of the private amenity is the main factor underlying the modest ecosystem service and net environmental margin values measured in Dehesa de la Luz, in comparison to those estimated in large private family dehesas in Andalusia [4,16,52].

At Dehesa de la Luz, the public owner promotes free access to visitors for recreational use. The public owner could charge visitors to Dehesa de la Luz, either collecting money or payment in kind for at least part of this use (in this study we did not estimated the public recreational value). In this situation, we are not able to compare whether the public property would generate a recreational net operating margin that exceeds the loss of the private amenity net operating margin. However, the public property of Dehesa de la Luz does not lose private amenity environmental gains which we assume to be represented by unpredicted future variation in the price of land at the opening of the accounting period. The environmental asset of the amenity, like that of any other capital stock, represents the current discounted value of future resource rent and not those of past accounting periods.

5.5. Spanish Dehesas Public and Private Governance Concerns

Finally, the conservation of the dehesa cultural landscape is dependent on the continuation of livestock grazing, investment in conservation forestry, and government public service activities. The challenge facing both public and private social interests in dehesa open woodland landscape regeneration is to reach an equitable and inclusive agreement on the distribution of conservation payments among consumers, government (in representation of society as a whole), and landowners for the supply of intermediate services.

Supplementary Materials: The supllementary materials are available online at www.mdpi.com/2076-3298/4/4/82/s1.

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Author Contributions: Pablo Campos is the main author and responsible for designing the contents, writing the main text and supplementary material of the article, the methods and accounting valuation criteria. Bruno Mesa is co-responsible for designing the technical methodology for modelling the full-cycle silviculture and is co-writer on parts 2.2 and 3.1 of the main text and parts SM 5 and SM 6 of the supplementary material as well as coordinator of the data processing through designing the Excel application which is used to estimate the products and valuation of the complete cycle in the silvicultural models for holm oak and cork oak. Alejandro Álvarez is responsible for data processing through the desing of Excel spreadsheets for the extraction of wood, livestock rearing and infrastructure services and is also co-writer of parts 3.1 and 3.2 of the main text and SM 8 of the supplementary material. He is co-responsible with Bruno Mesa and Pablo Campos for editing the add-on information used in this study. Francisco M. Castaño co-responsible, along with Bruno Mesa, for designing the modelling approach for the complete cycle silviculture and is responsible for the forest inventory field data collection and survey for estimating pruning and chopping of wood , and is also responsible for the design and development of the GIS cartography used. Fernando Pulido is co-responsible for the development

of the sampling protocols for the woodland inventory, the extractions of wood and qualitative modelling of the conservation forestry.

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References

1. Campos, P.; Ovando, P.; Montero, G. Does private income support sustainable agroforestry in Spanish dehesa? *Land Use Policy* **2008**, *25*, 510–522, doi:10.1016/j.landusepol.2007.11.005.
2. Díaz, M.; Campos, P.; Pulido, J.P. The Spanish dehesas: A diversity in land-use and wildlife. In *Farming and Birds in Europe*; Pain, D.J., Pienkowski, W., Eds.; Academic Press: London, UK, 1997; pp. 178–209; ISBN 9780125442800.
3. Rodríguez-Estévez, V.; Sánchez-Rodríguez, M.; Arce, C.; García, A.R.; Perea, J.M.; Gómez-Castro, A.G. Consumption of Acorns by Finishing Iberian Pigs and Their Function in the Conservation of the Dehesa Agroecosystem. In *Agroforestry for Biodiversity and Ecosystem Services—Science and Practice*; Kaonga, M.L., Ed.; InTech: Rijeka, Croatia, 2012; pp. 1–22; ISBN 9789535104933.
4. Ovando, P.; Campos, P.; Oviedo, J.L.; Caparrós, A. Ecosystem accounting for measuring total income in private and public agroforestry farms. *For. Policy Econ.* **2016**, *71*, 43–51, doi:10.1016/j.forpol.2016.06.031.
5. Dirección General de Conservación de la Naturaleza. *Mapa Forestal de España 1:50.000*; Ministerio de Medio Ambiente: Madrid, Spain, 2007.
6. Campos, P.; Carranza, J.; Miguel Coleto, J.; Diaz, M.; Diéguez, E.; Escudero, A.; Ezquerra, F.J.; Lopez, L.; Fernandez, P.; Montero, G.; et al. *Libro Verde de la Dehesa*; Universidad de Extremadura: Plasencia, Spain, 2010; pp. 1–48.
7. Ministerio de Agricultura, Pesca y Alimentación. *Diagnóstico de las Dehesas Ibéricas Mediterráneas*; Secretaría General de Agricultura y Alimentación, Dirección General de Desarrollo Rural: Madrid, Spain, 2008; Tomo 1; Unpublished.
8. Ministerio de Agricultura, Pesca y Alimentación. *Diagnóstico de las Dehesas Ibéricas Mediterráneas*; Secretaría General de Agricultura y Alimentación, Dirección General de Desarrollo Rural: Madrid, Spain, 2008; Tomo 2; Unpublished.
9. Alejano, R.; Domingo, J.M.; Fernández, M.; Alaejos, J.; Calzado, A.; Carevic, F.; Del Campo, A.; Domínguez, L.; Fernández de Villarán, R.; Flores, E.; et al. *Manual Para la Gestión Sostenible de las Dehesas Andaluzas*; Foro para la Defensa y Conservación de la Dehesa "Encinal" and Universidad de Huelva: Huelva, Spain, 2011; p. 465; ISBN 9788461540020. Available online: http://rabida.uhu.es/dspace/handle/10272/6641 (accessed on 14 September 2017).
10. Plieninger, T.; Rolo, V.; Moreno, G. Large-scale patterns of *Quercus ilex*, *Quercus suber*, and *Quercus pyrenaica* regeneration in Central-Western Spain. *Ecosystems* **2010**, *13*, 644–660, doi:10.1007/s10021-010-9345-2.
11. Senado. *Informe de la Ponencia de Estudio Sobre la Protección del Ecosistema de la Dehesa*; Boletín Oficial de las Cortes Generales: Madrid, Spain, 2010; pp. 1–27. Available online: http://www.senado.es/legis9/publicaciones/pdf/senado/bocg/I0553.PDF (accessed on 14 September 2017).
12. Instituto da Conservação da Natureza e das Florestas. *IFN6—Áreas dos Usos do Solo e das Espécies Florestais de Portugal Continental. Preliminary Results*; ICNF: Lisboa, Portugal, 2013; p. 35. Available online: http://www.icnf.pt/portal/florestas/ifn/resource/ficheiros/ifn/ifn6-res-prelimv1-1 (accessed on 14 September 2017).
13. Lauw, A.; Ferreira, A.G.; Gomes, A.A.; Moreira, A.C.; Fonseca, A.; Belo, A.; Azul, A.M.; Mira, A.; Murilhas, A.; Pinheiro, A.C.; et al. *Livro Verde dos Montados*; ICAAM: Évora, Portugal, 2013; pp. 1–61.
14. European Communities. *Manual on the Economic Accounts for Agriculture and Forestry EEA/EAF 97 (Rev. 1.1)*; EC, EUROSTAT: Luxembourg, Luxembourg, 2000. Available online: http://ec.europa.eu/eurostat/documents/3859598/5854389/KS-27-00-782-EN.PDF/e79eb663-b744-46c1-b41e-0902be421beb (accessed on 14 September 2017).
15. Oviedo, J.L.; Ovando, P.; Forero, L.; Huntsinger, L.; Álvarez, A.; Mesa, B.; Campos, P. The private economy of dehesas and ranches: Case studies. In *Mediterranean Oak Woodland Working Landscapes. Dehesas of Spain and Ranchlands of California*; Campos, P., Huntsinger, L., Oviedo, J.L., Starrs, P.F., Díaz, M., Standiford, R., Montero, G., Eds.; Springer: Dordrecht, The Netherlands, 2013; pp. 389–424; ISBN 9789400767065.

16. Oviedo, J.L.; Huntsinger, L.; Campos, P. The Contribution of Amenities to Landowner Income: Case of Spanish and Californian Hardwood. *Rangel. Ecol. Manag.* **2017**, *70*, 518–528, doi:10.1016/j.rama.2017.02.002.
17. United Nations; European Commission; Food and Agriculture Organization of the United Nations; Organization for Economic Co-operation and Development; World Bank Group. *System of Environmental Economic Accounting 2012—Experimental Ecosystem Accounting [SEEA-EEA]*; United Nations: New York, NY, USA, 2014; p. 198; ISBN 9789211615753. Available online: http://ec.europa.eu/eurostat/documents/3859598/6925551/KS-05-14-103-EN-N.pdf (accessed on 14 September 2017).
18. Campos, P. Cuentas agroforestales: Retos de la medición de la renta total social de los montes de Andalucía. In *Economía y Selviculturas de Los Montes de Andalucía*; Campos, P., Díaz-Balteiro, L., Eds.; Memorias científicas de RECAMAN; Editorial CSIC: Madrid, Spain, 2015; Volume 1, memoria 1.1, pp. 18–152; ISBN 9788400100407.
19. Campos, P.; Mesa, B.; Castaño, F.M.; Álvarez, A.; Pulido, F.J. *Economía de la Actividad Forestal Privada del Propietario de la Dehesa de la Luz*; Working Paper 2017-03; Instituto de Políticas y Bienes Públicos (IPP) CSIC: Madrid, Spain, 2017. Available online: http://ipp.csic.es/sites/default/files/content/workpaper/2017/2017_03_ippwp_camposmesacastanoalvarezpulido.pdf (accessed on 14 September 2017).
20. Campos, P.; Daly, H.; Oviedo, J.L.; Ovando, P.; Chebil, A. Accounting for single and aggregated forest incomes: Application to public cork oak forests of Jerez in Spain and Iteimia in Tunisia. *Ecol. Econ.* **2008**, *65*, 76–86, doi:10.1016/j.ecolecon.2007.06.001.
21. Campos, P.; Caparrós, A.; Oviedo, J.L.; Ovando, P.; Álvarez-Farizo1, B.; Díaz-Balteiro, L.; Carranza, J.; Beguería, S.; Díaz, M.; Herruzo, A.C.; et al. *Bridging the Gap between National and Ecosystem Accounting*; Working Paper, 2017-04; Instituto de Políticas y Bienes Públicos (IPP) CSIC.: Madrid, Spain, 2017. Available online: http://ipp.csic.es/sites/default/files/content/workpaper/2017/2017_04_ippwp_campos_etal.pdf (accessed on 20 September 2017).
22. Campos, P.; Álvarez, A.; Mesa, B.; González, D. Economía de las vacas, ovejas y yeguas de la Dehesa de la Luz. In *La Dehesa de la Luz en la Vida de Los Arroyanos*; Campos, P., Pulido, F., Eds.; Ayuntamiento de Arroyo de la Luz. Editorial Luz y Progreso: Arroyo de la Luz, Spain, 2015; pp. 157–218; ISBN 9788460682127.
23. Plieninger, T.; Pulido, F.J.; Konold, W. Effects of land-use history on size structure of holm oak stands in Spanish dehesas: Implications for conservations and restoration. *Environ. Conserv.* **2003**, *30*, 61–70, doi:10.1017/S0376892903000055.
24. Ministerio de Agricultura, Pesca y Alimentación. *Segundo Inventario Forestal Nacional, 1986–1997: Extremadura: Provincia de Cáceres*; Instituto Nacional para la Conservación de la Naturaleza: Madrid, Spain, 1994; ISBN 8485496604.
25. Fernández-Rebollo, P.; Carbonero-Muñoz, M.D. *Control y Seguimiento de los Programas Agroambientales Para el Fomento de la Dehesa en Andalucía. Technical Report*; Consejería de Agricultura y Pesca, Junta de Andalucía: Seville, Spain, 2008; Unpublished.
26. Montero, G.; Cañellas, I. *Manual de Reforestación y Cultivo del Alcornoque*, 2nd ed.; INIA-Mundi-Prensa: Madrid, Spain, 1999; p. 103; ISBN 9788484761211.
27. Montero, G.; Torres, E.; Cañellas, I.; Ortega, C. Modelos para la estimación de la producción de corcho en alcornocales. *Investigación Agraria Sistemas y Recursos Forestales* **1996**, *5*, 97–127.
28. Montero, G.; Pasalodos-Tato, M.; López-Senespleda, E.; Ruiz-Peinado, R.; Bravo-Oviedo, A.; Madrigal, G.; Onrubia, R. Modelos de selvicultura y producción de madera, frutos y fijación de carbono de los sistemas forestales de Andalucía. In *Economía y Selviculturas de Los Montes de Andalucía*; Campos, P., Díaz-Balteiro, L., Eds.; Memorias Científicas de RECAMAN; Editorial CSIC: Madrid, Spain, 2015; Volume 1, memoria 1.2, pp. 153–396; ISBN 9788400100407.
29. Montero, G.; Ruiz-Peinado, R.; Muñoz, M. *Producción de Biomasa y Fijación de CO_2 Por Los Bosques Españoles*; Monografía INIA, Serie Forestal: Madrid, Spain, 2005; p. 270; ISBN 9788474985122.
30. Rolo, V.; Moreno, G. Interspecific competition induces asymmetrical rooting profile adjustments in shrub encroached open oak woodlands. *Trees Struct. Funct.* **2012**, *26*, 997–1006.
31. Campos, P.; Ovando, P.; Mesa, B.M.; Oviedo, J.L. Environmental income of livestock grazing on privately owned silvopastoral farms in Andalusia, Spain. *Land Degrad. Dev.* **2016**, doi:10.1002/ldr.2529.

32. Ovando, P.; Campos, P.; Mesa, B.; Álvarez, A.; Fernández, C.; Oviedo, J.L.; Caparrós, A.; Álvarez-Farizo, B. Renta y capital de estudios de caso de fincas agroforestales de Andalucía. In *Renta Total y Capital de las Fincas Agroforestales de Andalucía*; Campos, P., Ovando, P., Eds.; Memorias científicas de RECAMAN; Editorial CSIC: Madrid, Spain, 2015; Volume 4, memoria 4.2, pp. 156–445; ISBN 9788400100445.
33. Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente. *Encuesta de Precios de la Tierra*; Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente: Madrid, Spain, 2014. Available online: http://www.mapama.gob.es/es/estadistica/temas/estadisticas-agrarias/encuestadepreciosdelatierra 2014_tcm7-407561.pdf (accessed on 15 September 2017).
34. United Nations; European Union; Food and Agriculture Organization of the United Nations; International Monetary Fund; Organization for Economic Cooperation and Development; World Bank. *System of Environmental–Economic Accounting 2012—Central Framework [SEEA-CF]*; United Nations: New York, NY, USA, 2014; p. 378; ISBN 879211615630. Available online: https://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf (accessed on 14 September 2017).
35. Haines-Young, R.; Potschin, M. *CICES V4.3—Revised Report Prepared Following Consultation on CICES Version 4: Technical report to the European Environment Agency*; United Nations: New York, NY, USA, 2013. Available online: http://unstats.un.org/unsd/envaccounting/seearev/GCComments/CICES_Report.pdf (accessed on 25 October 2017).
36. United Nations Environmental Program; United Nations Statistics Division; Convention on Biological Diversity. *SEEA Experimental Ecosystem Accounting: Technical Recommendations, Consultation Draft*; United Nations: New York, NY, USA, 2015. Available online: https://unstats.un.org/unsd/envaccounting/workshops/ES_Classification_2016/SEEA%20EEA%20Tech%20Rec%20Consultation%20Draft%208.1%20Dec2015%20final.pdf (accessed on 25 October 2017).
37. Obst, C.; Hein, L.; Edens, B. National Accounting and the Valuation of Ecosystem, Assets and Their Services. *Environ. Resour. Econ.* **2016**, *64*, 1–23, doi:10.1007/s10640-015-9921-1.
38. Oviedo, J.L.; Campos, P.; Caparrós, A. Valoración de servicios ambientales privados de propietarios de fincas agroforestales de Andalucía. In *Renta Total y Capital de Las Fincas Agroforestales de Andalucía*; Campos, P., Ovando, P., Eds.; Memorias científicas de RECAMAN; Editorial CSIC: Madrid, Spain, 2015; Volume 4, memoria 4.1, pp. 8–155; ISBN 9788400100445.
39. Sistema Electrónico de Negociación de Derechos de Emisión de Dióxido de Carbono (SENDECO$_2$). Available online: http://www.sendeco2.com/es/precios-co2 (accessed on 14 September 2017).
40. Ovando, P.; Campos, P.; Montero, G. Forestaciones con encina y alcornoque en el área de la dehesa en el marco del Reglamento (CE) 2080/92 (1993–2000). *Revista Española de Estudios Agrosociales y Pesqueros* **2007**, *214*, 173–186.
41. Gaspar, P.; Mesias, F.J.; Escribano, M.; Rodriguez de Ledesma, A.; Pulido, F. Economic and management characterization of dehesa farms: Implications for their sustainability. *Agrofor. Syst.* **2007**, *71*, 151–162, doi:10.1007/s10457-007-9081-6.
42. Campos, P.; Oviedo, J.L.; Caparrós, A.; Huntsinger, L.; Coelho, I. Contingent valuation of woodland owners private amenities in Spain, Portugal and California. *Rangel. Ecol. Manag.* **2009**, *62*, 240–252, doi:10.2111/08-178R2.1.
43. Campos, P.; Riera, P. Rentabilidad social de los bosques. Análisis aplicado a las dehesas y los montados ibéricos. *Información Comercial Española* **1996**, *751*, 47–62.
44. Campos, P.; Rodríguez, Y.; Caparrós, A. Towards the Dehesa total income accounting: Theory and operative Monfragüe study cases. *Investigación Agraria: Sistemas y Recursos Forestales* Special issue: New Forestlands Economic Accounting: Theories and Applications. **2001**, *1*, 45–69.
45. Campos, P. *Evolución y Perspectivas de la Dehesa Extremeña*; Editorial de la Universidad Complutense: Madrid, Spain, 1984; p. 498.
46. Campos, P.; Sesmero, J. Análisis económico de un grupo de dehesas de Extremadura (1983–1984). In *Conservación y desarrollo de Las Dehesas Portuguesa y Española*; Campos, P., Martín, M., Eds.; Ministerio de Agricultura, Pesca y Alimentación: Madrid, Spain, 1987; pp. 487–534; ISBN 8474795338.
47. Rodríguez, Y.; Campos, P.; Ovando, P. Commercial economy in a public Dehesa in Monfragüe Shire. In *Sustainability of Agro-silvo-pastoral Systems. Dehesas & Montados*; Schnabel, S., Gonçalves, A., Eds.; Serie Advances in GeoEcology 37; Catena Verlag: Reiskirchen, Germany, 2004; pp. 85–96; ISBN 9783923381500.

48. Boletín Oficial del Estado. *Real Decreto 1492/2011, de 24 de Octubre, Por el Que se Aprueba el Reglamento de Valoraciones de la Ley de Suelo*; Boletín Oficial del Estado: Madrid, Spain, 2011; p. 26. Available online: https://www.boe.es/boe/dias/2011/11/09/pdfs/BOE-A-2011-17629.pdf (accessed on 14 September 2017).
49. Boletín Oficial del Estado. *Real Decreto Legislativo 7/2015, de 30 de Octubre, Por el Que se Aprueba el Texto Refundido de la Ley de Suelo y Rehabilitación Urbana*; Boletín Oficial del Estado: Madrid, Spain, 2015; p. 59. Available on line: https://www.boe.es/boe/dias/2015/10/31/pdfs/BOE-A-2015-11723.pdf (accessed on 14 September 2017).
50. Economics for the Environment Consultancy Ltd. (EFTEC). *Developing UK Natural Capital Accounts: Woodland Ecosystem Accounts*; Department for Environment, Food and Rural Affairs (Defra): London, UK, 2015; p. 97. Available online: http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18909 (accessed on 14 September 2017).
51. Office for National Statistics; Department for Environment, Food and Rural Affairs (Defra). *Principles of Natural Capital Accounting*; Office for National Statistics: Newport, UK, 2017; p. 52. Available online: https://www.ons.gov.uk/economy/environmentalaccounts/methodologies/principlesofnaturalcapitalaccounting (accessed on 14 September 2017).
52. Ovando, P.; Caparrós, A.; Diaz-Balteiro, L.; Pasalodos, M.; Beguería, S.; Oviedo, J.L.; Montero, G.; Campos., P. Spatial Valuation of Forests' Environmental Assets: An Application to Andalusian Silvopastoral Farms. *Land Econ.* **2017**, *93*, 85–106, doi:10.3368/le.93.1.87.
53. Beguería, S.; Campos, P.; Serrano, R.; Álvarez, A. Producción, usos, renta y capital ambientales del agua en los ecosistemas forestales de Andalucía. In *Biodiversidad, Usos del Agua Forestal y Recolección de Setas Silvestres en los Ecosistemas Forestales de Andalucía*; Campos, P., Díaz, M., Eds.; Memorias científicas de RECAMAN; Editorial CSIC: Madrid, Spain, 2015; Volume 2, memoria 2.2, pp. 102–273; ISBN 9788400100421.