



Does private income support sustainable agroforestry in Spanish dehesa?

Pablo Campos^{a,*}, Paola Ovando^a, Gregorio Montero^b

^aConsejo Superior de Investigaciones Científicas (CSIC), Instituto de Políticas y Bienes Públicos, Calle Albasanz 26-28, Office 3E3, E-28037 Madrid, Spain

^bInstituto de Investigación y Tecnología Agraria y Agroalimentaria (INIA), Centro de Investigación Forestal, Crta. La Coruña km 7.5, 28040 Madrid, Spain

Received 1 August 2006; received in revised form 5 November 2007; accepted 7 November 2007

Abstract

Oak woodland dehesa suffers from the aging of trees without a natural regeneration of young oaks coming in to replace them. Recent European Union (EU) policy reforms for rural development focus on supporting multifunctional agriculture that complies with the EU's environmental goals, such as mitigating biodiversity losses and climate change. Such reforms could result in government support for natural woodland regeneration practices in European agroforestry systems, which are recognized for providing valuable environmental services. Managing dehesa cork oak and holm oak woodlands to stimulate the growth of new oaks could be an efficient option for maintaining, and even increasing, the dehesa's current carbon stock and biodiversity. Here we develop and apply a new agroforestry accounting system based on the concept of Hicksian income to a dehesa in the Monfragüe area of western Spain, using primary microeconomic data from a large case study. Private total income and profitability rates are measured for individual goods and services, and for the entire dehesa in a steady state. Our application extends the EU system of accounts for agriculture and forestry by including private amenity consumption by landowners and the gain or loss in human-made and natural capital. We compare an actual typical unsustainable woodland management scenario with an ideal sustainable management scenario in which there is a continuous regeneration and recruitment of holm and cork oaks as predicted by silvicultural models. The results show that, given current land use policy incentives, allowing a slow depletion of oak trees is more profitable for a dehesa private landowner than maintaining the dehesa's trees. As a result many dehesa environmental services are gradually lost. This market failure requires new land use policies that induce private land owners to invest in the renewal of aging oak woodlands. To evaluate the impacts of this new policy, we show how private landowner income is affected when changes are made to achieve sustainable management of dehesa oaks. More research is needed in order to understand how the dehesa's landowner market income and private amenities trade-off can affect the owner's land use preferences and decisions.

© 2007 Elsevier Ltd. All rights reserved.

Keywords: Monte; Oak silviculture; Amenities; Total income; Environmental services; Rural development policy

Introduction

Dehesa is an agro-silvopastoral system that dominates the landscape of the southwestern Iberian Peninsula, covering nearly 3.1 million hectares of woodland in Spain (Díaz et al., 1997). In Portugal, dehesa systems are called "montados", which cover 1.2 million hectares of woodland (Mendes, 2005). The dehesa's landscape is mostly dominated by Mediterranean evergreen holm oak (*Quercus ilex*

spp. *ballota* (Desf) Samp.) and cork oak (*Quercus suber* L.) woodland and, to a lesser extent, by deciduous oaks woodlands, pastureland, annual cropland and scrubland (Díaz et al., 1997; Joffre et al., 1999). The dehesa's ownership is characterized by large private estates (the so-called "latifundios") and multifunctional production of commercial and non-commercial (environmental) goods and services. The dehesa is commonly used for extensive livestock rearing, with the animals feeding on leaves, acorns and grass; cereal fodder is also grown in long rotations; and cork, firewood, charcoal, game, honey, and diverse other goods are also produced (Campos et al.,

*Corresponding author. Tel.: +34 618070846; fax: +34 915625567.

E-mail address: pcampos@ieg.csic.es (P. Campos).

2001). In addition to these traditional commercial uses, the *dehesa* provides much-acknowledged environmental benefits that are of growing interest to the public and policymakers, including wildlife habitat, private amenities, public recreation opportunities, carbon storage, and so on (Marañón, 1985; Díaz et al., 1997; Campos and Caparrós, 2006).

However, the *dehesa* is not sustainable under current management. Recent European Union (EU) reforms for rural development seek to support multifunctional agriculture that produces environmental benefits, and improved policies may support sustainable *dehesa* management. This study examines how private landowners might sustainably manage *dehesa* oaks, and sheds light on what might be affecting the policy initiatives for the *dehesa*. A case study approach, applying an agroforestry accounting system (AAS) that includes private amenity consumption by landowners, is used to compare private landowner income in both the sustainable and unsustainable management scenarios.

Most *dehesa* estates have unique features, but there are two common trends in the southwestern Spanish *dehesas*. First, the *dehesa* faces a gradual decay of the tree canopy as the oaks age, because tree recruitment is insufficient to offset natural or management-induced tree mortality. Changes in traditional grazing practices towards higher livestock densities throughout the year, increased mechanization of agriculture, and abandonment of tree regeneration practices have all reduced tree recruitment (Díaz et al., 1997; Pulido et al., 2001; Pulido and Díaz, 2003; Plieninger, 2007). Second, for at least two decades, *dehesa* land prices have increased faster than consumer prices¹ (MAPA, 2003). *Dehesas* have low commercial profitability rates (e.g. Campos and Riera, 1996; Campos et al., 2001), so their relative real land price rises ought to be related to the appreciation in landowners' consumption of the estates' private amenities (Campos and Mariscal, 2003, 2004; Torell et al., 2005; Campos et al., 2006; Raunikaar and Buongiorno, 2006).

The attrition of *dehesa* oak populations was not fully documented until recently (Pulido et al., 2001), which may partly explain the lack of explicit policy measures to address oak loss in current legislation (Plieninger, 2007). The EU's forestry measures in the Common Agriculture Policy (CAP) in 1992, and 1999 reforms, were not designed to mitigate the failure of oak regeneration in operating *dehesas* but to remove marginal croplands from production. In the 1993–2000 period, 197,600 ha of holm oaks and 83,435 ha of cork oaks were planted on marginal croplands in Spanish *dehesa* areas,² as part of the EU's afforestation

measures (Ovando et al., 2007). A large part (68%) of the new oak plantations in the *dehesa* was established in prior grasslands and *dehesa* woodlands with just a few trees. In fact, Spanish application of the EU's afforestation rules forbids grazing or any other agricultural use for a 20-year period after oak plantations are established (BOE, 2001). The Spanish programs include limited funds for improvements in native oak woodlands, including regeneration treatments, but landowners judged the amount insufficient to compensate for effectively managing induced natural regeneration in cork and holm oak *dehesa* woodlands (Campos et al., 2003; Martín et al., 2001). While the CAP has fostered oak plantations as a means of retiring marginal croplands, the EU provided subsidies for unrestricted livestock raising in the *dehesa*, which encouraged intensified production and a greater stocking rate, exacerbating *dehesa* overgrazing (Plieninger, 2006).

The EU's current efforts at policy reform for rural development seek to incentivize agroforestry land uses that mitigate biodiversity loss and climate change (European Commission, 2005). This new rural development initiative offers the change of potential government support for regeneration practices in European agroforestry systems, because effective management for natural regeneration of cork oak and holm oak *dehesas* could be an efficient option for maintaining and even increasing the *dehesa*'s current carbon stock and biodiversity. Consequently, we argue that a major research need is a systematic and scientifically sound analysis of how landowner private incomes are affected when changes are made to achieve sustainable management of *dehesa* oaks.

The relevance for European land use policy of applying an accounting system that considers diverse agroforestry uses is widely recognized. However, the current European Economic Accounts for Agriculture and Forestry (EAA/EAF) and the Farm Accountancy Data Network (FADN) still ignore this in practice for estimating the total income from the nation's agriculture and forestry, and from individual farms (European Communities, 1988; Eurostat, 1996, 2000; European Commission, 2006). The private agroforestry income is recognized in the European System of Accounts (ESA) regulation and is applied to the National Agroforestry System via the EAA/EAF. Notwithstanding, the EAA/EAF does not incorporate the measurement of private amenities, intermediate outputs, gross natural growth (GNG) and land revaluation. As a consequence the official statistics on private agriculture and forestry incomes are incomplete.

The EAA/EAF shortcomings have led us to seek a more comprehensive approach that overcomes such accounting failures. In this study, total private incomes from agroforestry activities are calculated based on the methodological foundations of the proposal for a new AAS, developed by Campos et al. (2001), Caparrós et al. (2003), and Campos and Caparrós (2006). The adapted accounting system is applied to the "Haza de la Concepción" estate

¹Between 1990 and 2002, the average annual change in consumer prices was 1.2% points lower than the corresponding change in the Extremadura region's non-irrigated pastureland price index. The former difference increases to 4% points if a larger period (1983–2002) is considered.

²Plantation tree densities commonly range from 350 to 500 seedlings per hectare, apparently more typical of forests than of agro-sylvo-pastoral systems; but these plantations after applying selective thinning treatments will become open woodlands.

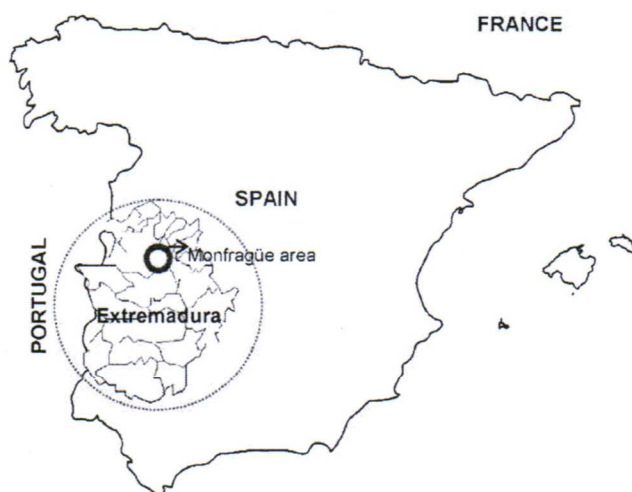


Fig. 1. The Monfragüe area in Extremadura (Spain).

(hereinafter, “Haza”), a cattle producing dehesa in the Monfragüe area (Fig. 1).

In our accounting system, permanent oak regeneration is added back to the AAS to yield an ideal sustainable silvicultural management scenario in Haza. We compare the actual unsustainable Haza management scenario with an ideal sustainable woodland management scenario using steady-state data based on Campos et al. (2003) and Martín et al. (2001). This is of special interest in the dehesa where livestock production is the dominant source of income since the sustainable woodland management scenario calls for a temporary grazing exclusion.

A major objective of this study is to show how applying the AAS at the estate scale will result in a substantial improvement in the measurement of single and aggregated joint market and amenity private incomes. A second objective of this Haza economic analysis is to show the income (commercial benefits) changes to a private dehesa owner when moving from the actual unsustainable, to an ideal sustainable, oaks management. The results might shape land use policy regulations and economic incentives that support the conservation of oak dehesa woodlands, and their public and private incomes, through agroforestry management of private lands.

Study area: Monfragüe area and Haza de la Concepción estate

Haza is publicly owned by the Cáceres Provincial Council but run as a private enterprise and legally registered with the name of “Sociedad Agropecuaria Provincial” (SAP), which makes this firm, in practice, the “owner” of the property. It is located in the Malpartida de Plasencia municipality in the Monfragüe area (Extremadura region, Western Spain—Fig. 1) and it is part of the buffer zone (195,502 ha) of Monfragüe National Park (BOE, 2007). The climate of this area is typically Mediterranean. Annual rainfall averages 700 mm (concentrated between November and April), while the mean temperature is 17 °C, with 8 °C as the extreme low mean temperature in January and high of 26 °C in July (Buyolo et al., 1998).

Haza has 676 ha of “useful agricultural land” (UAL),³ 81% of which is *monte* (woodland and dry pastureland), including mixed holm and cork oak woodland. This mixed woodland accounts for 65% of UAL, with an average density of 35 trees per hectare: 27 holm oaks and eight cork oaks per hectare. Dry pastureland (treeless un-irrigated grassland and land sown temporarily to cereals) comprises 16% of UAL. Permanent cropland accounts for 19% of UAL, with some cropland used for irrigated crops. Cropland includes harvested permanent sown meadows and annual crops for supplementary cattle fodder. These croplands are also grazed.

The most significant commercial use in Haza is as a site for the rearing of pure cattle breeds, both foreign and autochthonous: Charolais, Avileña, and Blanca Cacerense. Haza’s interest in rearing pure cattle breeds, especially the Blanca Cacerense (a native endangered breed) confirms this owner’s willingness to accept a lower commercial profitability rate to raise those cattle breeds (Rodríguez et al., 2004). The pure-bred cattle herd specialization and a bigger-than-usual area of irrigated land make Haza a somewhat untypical dehesa in the Monfragüe area. Nonetheless, these divergences from the prevailing model of private dehesa estate affect neither the accounting method developed in this study, the discussion about the private landowner’s economic rationality, nor the land use policy and trends in the dehesa area. Under the sustainable management scenario, Haza’s results provide an insight into the private dehesa owner’s opportunity cost for keeping both the oaks and the autochthonous livestock breeds (Avileña and Blanca Cacerense), given current public policies and economic incentives.

Methods

Accounting steady-state economic indicators

The private economic indicators for an average year in Haza are measured based on the following assumptions: (i) external human-made capital can be bought as needed year by year, and is calculated at 2002 prices, thus annual gross fixed capital investment in consumable fixed capital equals its annual consumption at its replacement cost; (ii) current livestock management and agriculture techniques do not change significantly; and (iii) current land market price rises are attributable to landowners’ consumption of private amenities. To estimate the land revaluation, we apply the average real variation rate in the Extremadura region’s non-irrigated pastureland price index for the 1990–2002 period (+1.2%).

³Haza’s useful agricultural land comprises both permanent cropland and monte (Díaz et al., 1997).

There is consensus among national accounting experts that “production-based measures usually rely on Hicksian income, which is the standard definition of net domestic or national product used in the national income accounts of virtually all nations today” (Nordhaus and Kokkelenberg, 1999, p. 35). By applying this total sustainable income concept to a dehesa, we developed the AAS approach to organize the market (commercial) and non-market (environmental) monetary flows generated in a 1-year period with the aim of measuring the Hicksian income. This later income guarantees that, although fully consumed in the period observed, at the end, wealth of the ecosystem would remain unchanged (for details, see Caparrós et al., 2003, p. 179).

To measure total sustainable agroforestry income, the AAS approach organizes all economic inputs and outputs into production and capital balance accounts.⁴ The private production account records the values of total output (TO) and total cost (TC), with net operating margin (NOM = TO – TC) as the owner’s residual value benefit,⁵ before operating subsidies net of taxes on products (OST). TO includes intermediate output (IO) and the final output (FO) generated in the accounting period (year). FO includes sales (FO_S), FO of own-produced (internal) woodland investment and cropland improvements or infrastructure (FO_{OI}), work-in-progress (FO_{WP})—since they are stocks of FOs of GNG, and crops and animal production in progress—, and miscellaneous other final outputs (FO_O), which includes landowners’ consumption of amenities and other final goods and services that do not fit in any of the previous FO categories.

TC includes all the costs incurred by the landowner to generate the NOM. The TC is divided into intermediate consumption (IC), employee labor costs (LCs), and fixed capital consumption (FCC). The IC includes raw materials (RM)—both own-produced (ORM) and external (ERM) ones—plus external services (ESS) and the work-in-progress used (WP_u) during the accounting period.

The private net value added (NVA_{mp} or NVA_{fc})⁶ is calculated as the sum of NOM or net operating surplus (NOS = NOM + OST) and LC:

$$NVA_{mp} = NOM + LC,$$

$$NVA_{fc} = NOS + LC.$$

The capital balance account records the values of stocks (initial and final) and changes (entries and withdrawals) in work-in-progress and in durable goods (fixed capital) used in the accounting period to generate the total sustainable private income (TI) of the agroforestry system. Capital revaluation (Cr) is the residual value of the capital balance

account. The capital revaluation (Cr) is estimated based on final capital assets (Cf) and capital asset withdrawal (Cw) values minus initial capital assets (Ci) and entries of capital asset (Ce) values in the accounting period: $Cr = Cf + Cw - Ci - Ce$ (Caparrós et al., 2003, p. 180).⁷

Capital gains at market prices (CG_{mp}) include the changes in capital values in the accounting period, which must be aggregated to the net value added for a full estimate of TI. CG_{mp} are calculated as the sum of capital revaluations of fixed capital and work-in-progress (Cr), net of capital destructions (Cd) and FCC⁸:

$$CG_{mp} = Cr - Cd + FCC.$$

Government subsidies for capital goods net of taxes (CST) should be added to CG_{mp} for estimating private capital gains at factor cost (CG_{fc}):

$$CG_{fc} = Cr - Cd + FCC + CST.$$

The agroforestry owner’s total capital income (CI_{mp} or CI_{fc}) arises from aggregating operating benefits (NOM or NOS) and capital gains (CG_{mp} or CG_{fc}):

$$CI_{mp} = NOM + CG_{mp},$$

$$CI_{fc} = NOS + CG_{fc}.$$

The total sustainable private agroforestry income (TI_{mp} or TI_{fc}) is measured by adding capital gains to net values added (NVA_{mp} or NVA_{fc}):

$$TI_{mp} = NVA_{mp} + CG_{mp},$$

$$TI_{fc} = NVA_{fc} + CG_{fc}.$$

Immobilized capital (IMC) for the accounting period is intended to provide a standardized value of the average private investment allocated (including bare land and trees) during that period for obtaining the private capital income of the agroforestry system (Campos et al., 2001):

$$IMC = WP_{i,nu} + FC_i + 0.5(FC_{ei}) + 0.5(TO - IO - FCC),$$

where WP_{i,nu} is the initial work-in-progress not used in the accounting period, FC_i the initial fixed capital and FC_{ei} the external gross fixed investment (the rest of the abbreviations have already been defined).

The operating (*p*_o) and total (*p*) profitability rates are obtained as the quotients of operating income (NOM or NOS) and total capital income (CI_{mp} or CI_{fc}) and total IMC:

$$p_{o,mp} = NOM/IMC \quad \text{and} \quad p_{o,fc} = NOS/IMC,$$

$$p_{mp} = CI_{mp}/IMC \quad \text{and} \quad p_{fc} = CI_{fc}/IMC.$$

⁴The accounting concepts follow the Eurostat (1996, 2000), Campos et al. (2001, 2007), and Caparrós et al. (2003) terminology and definitions.

⁵Given that, in Haza, all the labor force is made up of employees, the NOM is the owner’s operating benefit.

⁶The AAS provides the private *market price* (mp) and *factor cost* (fc) subscripts; the mp subscripts simulate pure market conditions and the fc subscripts consider government subsidies net of taxes on products (ST).

⁷In steady-state assumptions, the forestry’s work-in-progress revaluation (WP_{r,t}) equals the values of the forestry work-in-progress used (WP_{u,t}) minus the forestry gross natural growth (GNG_t): WP_{r,t} = WP_{u,t} and –GNG_t (Caparrós et al., 2003, p. 191).

⁸Fixed capital consumption is added in order to correct its double counting, since FCC is included in TC for estimating the NOM and implicitly subtracted for estimating the fixed capital revaluation (FC_r).

Private amenities

The dehesa's private amenities are non-market services (private uses of property environment) that the dehesa's landowner might consume, with the owner able to exclude others. These environmental uses include active consumption (private recreational services, the ability to house and entertain friends, the country way of life, legacy values, option values, etc.) and a number of passive uses (existence values). Future income streams of private amenities are capitalized into land market prices since owners/buyers have that in mind, and are willing to pay for these private uses when they maintain a property or decide to buy a piece of land.⁹ Indeed, private amenities have been recognized by scientific literature as a land market price factor (Torell et al., 2001, p. 55; Lange, 2004, p. 79; Campos and Martínez, 2004, p. 80) and could be admitted as an ESA component although they have never been measured as such by government statistical services. The Eurostat Forest Task Force on Environmental Accounts, for example, recognizes the "private recreational uses, including those related with the existence of wild biota, game, etc." as a market land price factor (Eurostat, 2002, p. 75).

In this study, the private amenity value comes from a contingent valuation survey applied to a sample of 19 dehesa owners in the Monfragüe area (Campos and Mariscal, 2003, p. 93). Private amenities reflect the maximum commercial losses that Monfragüe owners are willing to accept (WTA) compared with the private environmental uses provided by their dehesas. In this study, it is assumed that the private amenity value is distributed across the entire area of dehesa land without singling out any individual use. The contingent valuation survey was conducted in 2000; results were updated to 2002 prices.¹⁰ We assume that the value of the amenities consumed by the landowner moves with any temporary shift in the dehesa's land price. We aim to simulate private management, paying attention to oak and cattle conservation. From these perspectives, Haza's management is controlled by the same market competition (based on commercial and environmental benefits and costs) as that of private dehesa owners. Therefore, we include private amenity self-consumption as an annual output enjoyed by Haza's owner. Hence, Haza's landowner total private benefit (capital income) is equivalent to that of the private dehesa owner.

Land price is composed of market benefits and private amenities

Under current woodland management, land value is assessed using the Monfragüe area's dehesa market prices¹¹

⁹The term "environmental services" is used here in a broad sense, but note that the "private landowners have the potential to realize financial benefit passively in the form of capitalized asset" (Samuel and Thomas, 1999, p. 204).

¹⁰The Extremadura region's non-irrigated pastureland price index changes were used (MAPA, 2003).

¹¹Those prices are based on interviews with a group of estate agents in the Monfragüe area.

(excluding buildings and infrastructure), separating woodland, pastureland and cropland uses. In the case of Haza's actual woodland scenario prices, those land prices reflect expected future benefits (the owner's capital income) from mature cork and holm oak trees depletion, that is, without ongoing investment in regeneration. The ideal sustainable cork and holm oak woodland scenario would have a different land market value than the actual scenario. The age structure and denseness of a regenerating grove of cork and holm trees are quite different from the current ones, while cropland uses and values are simulated, and would remain constant. There are not, therefore, market prices for holm and cork oak woodland in an ideal steady-state scenario; the land price is estimated by capitalizing the private capital income expected in an ideal management scenario.

Income from forestry-related activities also differs between the actual and ideal scenarios. Steady-state forestry income is capitalized using a positive real discount rate of 1%.¹² By contrast, cork stripping, grazing and hunting rents are capitalized using a real discount rate of 3%, which is assumed to be the return on capital that dehesa owners will demand from those commercial uses. In this study, the amenity self-consumption value was estimated on average for the mosaic of land uses based on a sample of the Monfragüe area's dehesas, so the land price due to this environmental service does not depend on land use change trend (Campos and Mariscal, 2003).

We assume that the breakdown of Haza's total land price is the same as the environmental and commercial income in a sample of 21 estates surveyed in the Spanish Central Mountain range's private agro-silvopastoral system, where 57% of the land price comes from commercial benefits, and 43% is tied to the owner's amenity self-consumption (Campos and Martínez, 2004, p. 80).

Measuring average annual indicators for actual woodland management

To compare the actual (unsustainable) and the simulated ideal (sustainable) woodland management scenarios, the private economic indicators use the same estimated valuation criteria, and all prices (except for land) remain constant at 2002 market or stated prices. Primary micro-economic data from the Haza case study are used. Haza's results in physical terms do not reflect any particular year, but better than five years of data go into estimating average livestock and cropland yields. Labor, machinery work, and RM used in different products come from 3 years of day-to-day data collection at Haza, occasionally but sometimes significant expenses are therefore included, but averaged over several years.

Multi-period productions such as cork are annualized, recognizing their year-on-year variation (Rodríguez et al.,

¹²In a mixed cork oak woodland estate in the *Los Alcornocales* Natural Park (Cadiz), it is estimated that the total profitability rate of silvicultural uses is 0.72% (Campos et al., 2005, p. 106).

2004). Cork and holm oak forestry and maintenance tasks are kept separate from regularly occurring Monfragüe area extractive activities. Forestry practices include annual average costs and outputs derived from pruning and sanitary felling of holm and cork oaks in Haza between 1992 and 2002. Firewood sales and self-consumption are valued at farm gate prices and recorded as forestry FOs.

The herd census is simulated so as to be in a stable situation: total cattle numbers per class and type are unchanged at the beginning and end of the accounting period. The herd balance reflects average cattle productivity, mortality, slaughtering and other practices during 10 years (Rodríguez et al., 2004).

Modeling ideal oak woodland management

The results of ideal holm and cork oak silvicultural models at a physical steady-state are used to estimate outputs and costs under a permanent natural regeneration scheme for oaks (Montero et al., 2000, 2003). Steady state implies indefinitely maintaining a balanced (stable) tree age structure and tree density per hectare for mixed holm and cork oak woodland. In economic terms, steady state assumes constant annual prices, except for land revaluation, and assumes that the operating subsidies and taxes on products (OST) remain unchanged. Steady state becomes an ideal construction in which the holm and cork oak woodland endures forever. Management-induced natural oak regeneration cycles for holm and cork oak woodland last for 250 and 144 years, respectively, according to norms of the ideal sustainable silvicultural model (Montero et al., 2000, 2003). We assume that Haza's current mosaic of land uses remains the same. Thus, the ideal model's mixed cork and holm oak woodland covers over 65% of the Haza UAL, just as it does in the actual scenario. In the model, this is allocated to 15% of pure cork oak and 50% of pure holm oak woodland and tree density figures are set to an age distribution required to sustain Haza's current woodland area. Other land uses and yields are assumed to remain constant, including cattle herd size.

The ideal silvicultural model for natural tree regeneration affects grazing resources (GR) because of a 20-year grazing exclusion period that allows natural regeneration, after the start of regeneration practices. The exclusion period prevents cattle—in the case of Haza—from browsing on immature oaks. The quantity of forage units (FU)¹³ consumed by cattle in the oak woodlands must be reduced in the ideal scenario, and it is assumed that in Haza this will be offset by supplementary feeding to maintain the current cattle herd size. Average costs of the various ways (except grazing) in which cattle are fed at Haza (Rodríguez et al.,

2004, p. 89) are used for estimating forestry and livestock outputs and costs that are related to the production and consumption of GR.

Results

Comparison of physical indicators under the actual and ideal scenarios

This subsection shows a selected set of physical indicators that reflect the actual quantities of resources consumed during the accounting period, their origin—internal (own-produced) or external—and other indicators related to annual production and cattle feeding costs. Actual unsustainable management is compared with ideal sustainable management at Haza (Table 1).

Livestock feeding

Extensive livestock systems in today's Spanish dehesa maintain a livestock stocking rate influenced at any one time by public subsidies, a shortage of labor, and presumably the landowner's increasing amenity interest in livestock (Campos, 2005). Today, over 30% of the total energy requirements (ERs) for livestock husbandry in the dehesa comes from supplementary livestock feed (e.g. Campos et al., 2001, p. 52). Livestock stocking rates are become decoupled from the dehesa's natural forage production and are not indicators of dehesa grazing resource consumption. Instead, the residual estimate for forage units extracted by livestock grazing, after other supplementary feed (non-grazing) has been subtracted from total ERs, is a more accurate measurement for indicating grazing intensity. A notable feature at Haza is a large amount of supplementary feed required, some 726 forage units per hectare of UAL (FU ha^{-1}), which represents 54% of total annual cattle ER. Crops, mainly irrigated ones, contribute a considerable amount, and are used for both grazing and as supplementary feed, so that self-produced crops (IO) meet 37% of total cattle ER. The GR of the monte meet 42% of total livestock ER within an average extraction of 557 FU ha^{-1} (Table 1). Together, the internal feed from grazing and harvested crops grown at Haza total a volume of 1061 FU ha^{-1} , or some 79% of the total annual ER of cattle (1339 FU ha^{-1}).

An ideal oak woodland management scenario would forcibly reduce woodland grazing access through temporary grazing exclusion periods. It is estimated that monte GR would in that case meet just 34% of total cattle ER (460 FU ha^{-1}), a decrease of 97 FU ha^{-1} . Supplementary fodder would rise to almost two-thirds of ER (Table 1). In the Haza actual management scenario, the average forage unit consumed by grazing and for supplementary feeding costs 0.25 € FU^{-1} . Haza's own feeding resources cost an average of 0.22 € FU^{-1} , while external (bought) feeding resources cost 0.30 € FU^{-1} . Forage units consumed by grazing represent the lower-cost means of delivering cattle ER (0.14 € FU^{-1}) (Rodríguez et al., 2004, p. 89). Changes

¹³A forage unit (FU) represents the energy contained in a kilogram of barley, with 14.1% humidity, that is 2723 kilocalories of metabolic energy (INRA, 1978).

Table 1

Comparison of the physical and economic indicators between actual and ideal oak woodland scenarios at Haza (data per hectare and year)

Class	Units ^a	Actual scenario (A)			Ideal scenario (B)			Differences (B–A)		
		Own resources	External resources	Total	Own resources	External resources	Total	Own resources	External resources	Total
Livestock fodder	FU ha ⁻¹	1061	278	1339	964	375	1339	–97	97	0
Monte grazing	FU ha ⁻¹	557		557	460		460	–97		–97
Cropland grazing	FU ha ⁻¹	56		56	56		56	0		0
Supplementary feed	FU ha ⁻¹	448	278	726	448	375	823	0	97	97
Unitary feeding costs	€ UF ⁻¹	0.22	0.30	0.25	0.24	0.31	0.26	0.02	0.01	0.01
Average trees densities	Trees QS ⁻¹	35.0		35.0	160.4		160.4	125.4		125.4
Cork oak	Trees QS ⁻¹	8.1		8.1	163.6		163.6	155.5		155.5
Holm oak	Trees QS ⁻¹	26.9		26.9	159.4		159.4	132.5		132.5
Cork extraction	kg ha ⁻¹	19.3		19.3	55.3		55.3	36.0		36.0
Cork oak firewood extraction	kg ha ⁻¹	17.4		17.4	253.9		253.9	236.5		236.5
Holm oak firewood extraction	kg ha ⁻¹	124.2		124.2	269.3		269.3	145.1		145.1
Employment	H ha ⁻¹	26.5	0.6	27.1	27.2	2.5	29.7	0.7	1.9	2.6
Machinery works	H ha ⁻¹	5.6	0.2	5.8	5.6	1.3	6.9	0.0	1.1	1.1
Fossil fuel ^b	l ha ⁻¹		13.8	13.8		18.1	18.1		4.4	4.4

Source: Rodríguez et al. (2004) and Montero et al. (2000, 2003).

^aFU, forage units; H, hours; QS, oak woodland hectare; ha: useful agricultural land (UAL) hectare.^bGas oil, petrol and engine oil.

in the present contributions to grazing and supplementary feeding would slightly raise the average forage unit cost to 0.26 €FU⁻¹. Both the own-produced and external feeding resource costs would increase (Table 1).

Cork and firewood

The mixed cork and holm woodland density under ideal steady-state management includes all tree ages. Ideal silvicultures of pure cork oak and holm oak woodland under this scenario would result in average densities of 164 cork oaks and 159 holm oaks per hectare, for oaks aged over 30 years. These ideal steady-state holm and cork oak densities give an open woodland canopy cover of less than 65% for cork oak and 56% for holm oak. Considering that 65% of Haza's UAL is covered by oaks and assuming the current cork and holm oak distribution, the latter figure would entail an average tree density of 160 oaks per mixed holm and cork oak woodland hectare (QS), with an average tree canopy cover of 60% under Haza's ideal simulated steady-state management. Under Haza's actual management, the average annualized cork yield¹⁴ is

19.3 kg ha⁻¹ of UAL (fresh cork weight). Under Haza's ideal cork oak woodland management in a steady state, the yield would be 55.3 kg ha⁻¹ of UAL or almost three times Haza's current cork stripping (Table 1).

Under Haza's actual management—considering the last two sanitary fellings and maintenance prunings and their timing—annualized firewood extraction is 17.4 kg ha⁻¹ from cork oak and 124 kg ha⁻¹ from holm oak. In a steady state, Haza's ideal silvicultural thinning, pruning, regeneration and final felling could produce 254 kg of cork oak and 269 kg of holm oak firewood per hectare of UAL (Table 1).

Labor and machinery employment

The annual employment supply of 27.1 h per UAL hectare (Table 1) is considered particularly high in comparison to similar private dehesa estates in Monfragüe. Cattle management (especially feeding) at Haza creates a considerable labor demand, accounting for 60% of total annual employment (Rodríguez et al., 2004). Many land tasks, chiefly crop growing and cattle feeding, require the use of different machines, with an average annual requirement of 5.8 machine hours and 13.8 l of fossil fuel per hectare and year (Table 1). Almost all machinery work requirements are supplied by Haza's own equipment. Haza

¹⁴This average yield has been measured taking into account two stripping periods (1986 and 1997). We recognize that cork stripping will decline under actual management scenario.

ideal scenario would raise the requirements for labor (+10%), machinery work (+19%) and fossil fuels (+32%), especially for carrying out the ideal oak woodland silvicultural treatments (Table 1). Cattle labor demand would also increase since supplementary feeding requires more labor and machine hours than grazing alone (Rodríguez et al., 2004, p. 89).

Comparison of private economic indicators under the actual and ideal scenarios

This subsection shows the private production accounts for the actual management scenario. This table breaks down the data for forestry, cork stripping, forestland GR, hunting rent, cattle, hay, maize silage and GR from meadows, annual crops, other commercial goods and services (dwelling services and infrastructure construction), and private amenities (Table 2). Table 3 refers to the simulated ideal management scenario and presents only those items whose results differ from the actual scenario, and tracks the size of those differences with respect to the actual scenario.

Comparison of operating benefits under Haza's actual and ideal scenarios

Forestry activity, besides firewood sales, includes the value of silvicultural treatments and natural cork growth as part of the forestry FO. This activity totals a NOM before net subsidies of 22.4 € ha⁻¹. In Haza, cork stripping generates a NOM of 13.7 € ha⁻¹ (Table 2).

GR rent, as an IO, accounts for 87.1 € ha⁻¹, with a NOM of 23.9 € ha⁻¹. For GR accounting, the FOs of work-in-progress (FO_{wp}) include annual forage cropping on rangeland, and the owner's internal investment (FO_{oi}) includes pasture improvements and other grazing investment. Forage

crops growing in monte could not be separated from woodland and pastureland owing to the difficulties of separating intermediate GR outputs (Table 2).

Cattle husbandry is the main management activity at Haza, with a TO of 647.1 € ha⁻¹, contributing 55% of Haza TO. A large part of Haza resources including labor, machinery and annual intermediate external expenditures are devoted to cattle production, which accounts for 64% of Haza's TC and 45% of its LC. Cattle NOM indicates the results under pure market price conditions, generating a negative value of -112.1 € ha⁻¹ (Table 2). However, current government subsidies for cattle husbandry at Haza add 167.0 € ha⁻¹, generating a positive NOS after net subsidies of 54.9 € ha⁻¹.

Crops grown at Haza generate negative NOM figures of -22.2 € ha⁻¹ for meadows and -37.2 € ha⁻¹ for annual crops (Table 2). Crop-growing for cattle reflects the desire of managers to control fodder quality. The negative NOM generated by hay growing, the grazing of meadows and annual crop-growing is not mitigated by government operating subsidies, so the NOS is negative (Rodríguez et al., 2004). When cattle husbandry and crop-growing are put together, the NOS is positive once again.

The amenity self-consumption figure is an agroforestry joint benefit of market outputs; since we have not considered the production cost of such amenities, the amenity output matches the owner's environmental benefit. The amenity self-consumption value estimated in the Monfragüe area's dehesa amounts to an average of 100.2 € ha⁻¹, which represents roughly 8.4% of Haza's TO (Table 2).

In Haza, the FO is 940.1 € ha⁻¹ and the IO is 245.9 € ha⁻¹. Since IOs are accounted for in the output and cost sides (in order to estimate the net value added for a single good or service), TO is a double accounting figure

Table 2

Private production account at Haza under the actual oak woodland management scenario (2002 € ha⁻¹)^a

Class	Forestry	Cork stripping	Grazing resources	Hunting rent	Cattle	Meadows	Annual crops	Other CGS ^b	Private amenities	Total
1. Total output (TO)	34.9	41.4	92.5	7.1	647.1	51.4	173.0	38.4	100.2	1186.0
1.1 Intermediate output (IO)	2.1		87.1		39.6	35.1	82.0			245.9
1.2 Final output (FO)	32.9	41.4	5.4	7.1	607.5	16.3	91.0	38.4	100.2	940.1
1.2.1 Gross internal investment (FO _{oi})	7.7		2.1		60.1	7.1	0.0	28.5		105.5
1.2.2 Final sales (FO _s)	6.0	41.4			200.4	9.2	55.5	0.0		312.5
1.2.3 Final stock (FO _{wp})	18.2		3.3		347.0		35.5	0.0		404.0
1.2.4 Other final output (FO _o)	0.9			7.1				9.9	100.2	118.1
2. Total cost (TC)	12.6	27.7	68.6		759.2	73.6	210.2	28.3		1180.1
2.1 Intermediate consumption (IC)	9.9	24.0	46.0		627.2	22.0	110.4	17.7		856.8
2.1.1 Raw materials (RM)	0.7		42.1		273.4	15.3	63.4	9.6		404.5
2.1.1.1 Own raw materials (ORM)			34.1		194.6	3.4	2.2	0.0		234.3
2.1.1.2 External raw materials (ERM)	0.7		8.0		78.8	11.9	61.2	9.6		170.6
2.1.2 External services (ESS)	2.3	0.5	0.6		6.8	6.7	11.5	8.1		36.8
2.1.3 Work-in-progress used (WPu)	6.9	22.8	3.3		347.0	0.0	35.5	0.0		416.2
2.2 Employees labor costs (LC)	2.7	3.7	11.9		106.6	28.2	71.5	9.6		234.2
2.3 Fixed capital consumption (FCC)			10.7		25.4	23.4	28.3	1.0		88.8
3. Net operating margin (NOM)	22.4	13.7	23.9	7.1	-112.1	-22.2	-37.2	10.1	100.2	5.9

^aHectares of useful agricultural land (UAL).

^bCGS: commercial goods and services.

Table 3

Private production accounts at Haza under the ideal and actual oak woodland management scenarios (2002 € ha⁻¹)

Class	Ideal scenario (B)						Differences (B–A) ^b				
	Forestry	Cork stripping	Grazing resources	Cattle	Rest of activities ^a	Total	Forestry	Cork stripping	Grazing resources	Cattle	Total
1. Total output (TO)	147.9	105.8	83.3	647.1	370.1	1354.1	113.0	64.4	–9.2		168.1
1.1 Intermediate output (IO)	6.7		77.9	39.6	117.1	241.3	4.7		–9.2		–4.6
1.2 Final output (FO)	141.2	105.8	5.4	607.5	253.0	1112.8	108.3	64.4			172.7
1.2.1 Gross internal investment (FO _{oi})	62.4		2.1	60.1	35.6	160.2	54.7				54.7
1.2.2 Final sales (FO _s)	28.9	105.8	0.0	200.4	64.7	399.7	22.9	64.4			87.2
1.2.3 Final stock (FO _{wp})	49.0		3.3	347.0	35.5	434.8	30.8				30.8
1.2.4 Other final output (FO _o)	0.9				117.2	118.1	0.0				0.0
2. Total cost (TC)	150.4	72.0	68.6	782.1	312.1	1385.2	137.9	44.4		22.9	205.1
2.1 Intermediate consumption (IC)	47.5	60.9	46.0	640.3	150.1	944.8	37.6	36.9		13.1	87.6
2.1.1 Raw materials (RM)	3.8		42.1	285.5	88.3	419.7	3.1			12.1	15.2
2.1.1.1 Own raw materials (ORM)			34.1	185.4	5.6	225.0	0.0			–9.2	–9.3
2.1.1.2 External raw materials (ERM)	3.8		8.0	100.1	82.7	194.7	3.1			21.3	24.5
2.1.2 External services (ESS)	13.9	1.4	0.6	7.8	26.3	50.1	11.6	0.9		1.0	13.6
2.1.3 Work-in-progress used (WPU)	29.8	59.5	3.3	347.0	35.5	475.1	22.9	36.0			58.9
2.2 Employees labor costs (LC)	40.6	11.1	11.9	116.1	109.3	289.0	37.9	7.4		9.5	54.8
2.3 Fixed capital consumption (FCC)	62.4		10.7	25.6	52.7	151.4	62.4			0.2	62.6
3. Net operating margin (NOM)	–2.5	33.7	14.7	–135.0	58.0	–31.1	–24.9	20.0	–9.2	–22.9	–37.0

^aRest of activities: include hunting rent, meadows, annual crops, other commercial goods and services (CGS) and private amenities.^bUpper-case 'A' indexes actual scenario results.

for the amount of the IO, that is, the latter is implicitly included in the total FO. Under Haza's actual management, the operating benefit before net subsidies (at market prices) amounts to 5.9 € ha⁻¹ (Table 2).

Haza's ideal management scenario would generate quite different results than those arising from the actual scenario. Maintaining oak trees permanently requires higher internal investment than in the actual scenario. In an ideal scenario, forestry activity would generate a negative NOM of –2.5 € ha⁻¹, while cork stripping would have a NOM of 33.7 € ha⁻¹. Forestland GR total a NOM of 14.7 € ha⁻¹. But, if the areas are closed for grazing, cattle NOM would be more negative: –135 € ha⁻¹, due to an increase in supplementary feeding. In Haza, the NOM of other goods and services remains the same as in the actual scenario, so the total NOM in an ideal scenario for Haza would have a negative figure of –31.1 € ha⁻¹ (Table 3).

Silvicultural treatments under the ideal scenario for Haza would increase current LCs and external services more than 10-fold, while annual cork sales would rise less than three-fold. Therefore, taking current prices into account, the private incremental output of investing in the sustainable management of oak woodland is lower than the incremental cost stated in the case study of Haza's dehesa (Table 3).

Land values, current capital revaluation and capital gains

Under Haza's actual scenario, the land's market price is 4621 € ha⁻¹ of UAL at the beginning of the year 2002. Under Haza's ideal scenario (in which the woodland owner's commercial benefit is capitalized using a positive discounting rate), the land's estimated market price is 4816 € ha⁻¹ (Table 4).

In a steady-state situation, Haza's actual scenario totals a negative capital revaluation (Cr) of –52.0 € ha⁻¹ (Table 5). Haza's ideal sustainable scenario Cr reaches –90.1 € ha⁻¹. Differences in Cr are due to the own internal investment in silviculture treatments in the ideal scenario that are almost four times more than current levels; the latter is not offset by the revaluation of work-in-progress subject to discounting, which is more than three times higher for the ideal scenario. In Haza, the capital gains at market prices (CG_{mp}) are estimated to be 34.4 € ha⁻¹ in the actual scenario, and 59.7 € ha⁻¹ in the ideal scenario (Table 5).

Total private income

Under Haza's actual management, the net value added at market price (NVA_{pm}) accounts for 240.1 € ha⁻¹, but this total operating income at factor cost (NVA_{fc}) reaches 417.4 € ha⁻¹. Under Haza's ideal management, the NVA_{pm} totals 257.9 € ha⁻¹ and the NVA_{fc} amounts to 441.8 € ha⁻¹. Under the ideal scenario, higher labor income offsets the owner's lower operating benefit and the labor income gain is higher than the capital income loss (Table 5). Under Haza's actual and ideal management, the owner's total benefits after net subsidies (CI_{fc}) are 214.9 € ha⁻¹ and 209.7 € ha⁻¹, respectively; the latter is 2.5% lower than its corresponding actual scenario figure. In Haza's actual and ideal scenarios, the total private incomes after net subsidies (TI_{fc}) are 449.1 € ha⁻¹ and 498.7 € ha⁻¹, respectively, and 274.5 € ha⁻¹ and 317.6 € ha⁻¹ if net subsidies are excluded (Table 5).

Profitability rates

IMC totals 6906 ha⁻¹ under Haza's actual scenario and 7513 € ha⁻¹ in its ideal scenario (Table 5). This is the owner's average annual investment in the Haza operation that could be compared with the return on the same

Table 4

Land shared value between commercial and environmental owner benefits: comparison between the actual and ideal scenarios (2002 € ha⁻¹)^a

Class ^b	Surface of UAL (%)	Actual scenario (A)			Ideal scenario (B)			Differences (B–A)		
		COM	ENV	Total	COM	ENV	Total	COM	ENV	Total
Monte	81	1865	1419	3284	2060	1419	3479	195	0	195
Woodland	65	1626	1237	2864	1821	1237	3059	195	0	195
Pastureland	16	239	182	420	239	182	420	0	0	0
Cropland	19	760	578	1337	760	578	1337	0	0	0
Total UAL	100	2625	1996	4621	2820	1996	4816	195	0	195

^aTotal UAL land price weighs up for different land uses and vegetation over total Haza UAL surface.^bCOM, commercial partial land prices; ENV, environmental partial land prices.

Table 5

Comparison between private annual incomes and profitability rates at Haza (2002 € ha⁻¹)^a

Class	Actual scenario (A)		Ideal scenario (B)		Differences (B–A)	
	Market prices	Factor costs	Market prices	Factor costs	Market prices	Factor costs
1. Employees labor cost (LC)	234.2	234.2	289.0	289.0	54.8	54.8
2. Net operating margin or surplus (NOM or NOS)	5.9	183.2	–31.1	152.8	–37.0	–30.4
3. Operating subsidies net of taxed (OST)		177.3		183.9	0.0	6.6
4. Net value added (NVA)	240.1	417.4	257.9	441.8	17.8	24.4
5. Capital revaluations (Cr)	–52.0	–52.0	–90.1	–90.1	–38.2	–38.2
6. Capital destruction (Cd)	2.4	2.4	1.6	1.6	–0.8	–0.8
7. Fixed capital consumption (FCC)	88.8	88.8	151.4	151.4	62.6	62.6
8. Subsidies on capital goods net of taxes (CST)		–2.7		–2.7	0.0	0.0
9. Capital gains (CG)	34.4	31.7	59.7	57.0	25.2	25.2
10. Capital income (CI)	40.3	214.9	28.6	209.7	–11.7	–5.2
11. Total income (TI)	274.5	449.1	317.6	498.7	43.1	49.7
12. Immobilized capital (IMC)	6906.4	6906.4	7512.8	7512.8	606.3	606.3
13. Operating profitability rate (po) (%)	0.1	2.7	–0.4	2.0	–0.5	–0.6
14. Total profitability rate (p) (%)	0.6	3.1	0.4	2.8	–0.2	–0.3

^aExcept for p_o and p , which are stated in percentage terms.

amount of an alternative investment with similar risk and time horizon frameworks.

The operating (p_o) profitability rate and total (p) profitability rate received by the dehesa landowner that matter are those estimated at factor cost, which is to say, after considering subsidies net of taxes. Under Haza's actual scenario, the operating and total profitability rates at factor cost amount to 2.7% and 3.1%. Under Haza's ideal scenario, those rates are 2.0% and 2.8%, respectively (Table 5). However, since the ideal scenario's woodland price is estimated by the capitalization of the steady-state hypothetical owner's total benefit at market prices (CI_{mp}), the 2% operating profitability rate is biased due to the discount rate that we apply.

Discussion

Towards the greening of European economic accounts for agriculture and forestry

There is a significant gap between the system of national accounts regulation (e.g. ESA in the EU) and the current

application of its related Economic Accounts for Agriculture and Forestry (e.g. EAA/EAF in the EU). The EAA/EAF significantly undervalues private dehesa income and they do not include the private amenities consumed by the landowner and the capital gains on the land. EAA/EAF aim to measure the nation's agroforestry net value added (operating income) based mainly on commodities. Therefore, missing private landowner amenities is, without doubt, inconsistent with income theory, and in accordance with today's overarching ESA regulation, private amenity must be an ESA output.

Since amenity self-consumption and the changes in asset value are not included, the Eurostat EAA/EAF system takes into account less than 51% of Haza's private total income at market prices. The relevance of the AAS approach for estimating a theoretically sound figure for private total income (Hicksian income) is twofold. First, the operative AAS applied to Haza illustrates the potential benefits of improving the shortcomings of the EAA/EAF, whose omission of IOs renders the measure of any agroforestry single activity income impossible. Second, AAS allows for a homogeneous aggregation of private

operating income from market benefits and un-priced services (amenity self-consumption), and from private income derived from changes in human-made and natural asset value (capital gains). Nevertheless, an estimated flow value of private amenities shows that even recent green accounting developments fail to incorporate amenity self-consumption (Eurostat, 2002; United Nations European et al., 2003). The AAS proposes including this private amenity value but acknowledges that to measure an accurate flow value is time-consuming. However, it also highlights that further research on temperate agroforestry systems in developed countries must include private amenity income in order to account for actual land prices and private capital income, where there are no other non-agroforestry potential uses that could affect the land market price.

Implications for land use policy

A lack of tree replacement is a common failure in dehesa ecosystems. In this situation, the policy dilemma is how to counter the gradual loss of oaks in the dehesa (with expected negative consequences for biodiversity and carbon stock conservation), while maintaining the private profitability of current dehesa uses. Our analysis of the steady state is set in time, and attempts to show the differences in private income between actual and ideal states enjoyed by the benefiting generations, without considering what was sacrificed or enjoyed before arriving at a steady state. Indeed, the generations that choose to invest in holm or cork oak natural regeneration and to produce a sustainable natural regeneration are unlikely to witness the oak woodland's return to steady state it will take too long. Although, the 'best' results in an ideal scenario (ignoring previous sacrifices) are used for comparison with the actual unsustainable practices, it is still more profitable for a private land owner to gradually let the oak woodlands disappear in favor of pasture and scrubland, given current market prices for cork and other oak products. Moreover, if investment in cork and holm oak woodland regeneration is carried out, it reduces future commercial income by considerably more than simply allowing a slow depletion of oak trees, as shown by Campos et al. (2003) for cork oak dehesas and Martín et al. (2001) for holm oak dehesas in the Monfragüe area.

Regeneration costs explain a private landowner's rationality in not encouraging natural regeneration of oaks. However, the market may be behaving short-sightedly here since the slow disappearance through aging of a significant number of holm oak and cork trees could drive up the future price of well-wooded dehesas at the expense of treeless pastureland or scrubland. It is very likely that the present economic values of cork, wood, GR and environmental services actually undervalue their future profitability. Uncertainty about the future provision of dehesa environmental services may require that public compensa-

tion be given to dehesa owners for investing in natural regeneration treatments in aging oak woodlands.

At present, we cannot attribute an individual amenity value to different agroforestry land uses. It could be assumed that the estimated private amenity value relies on an estate exceeding a certain minimum woodland area, above which size the dehesa produces certain un-priced services or amenities. For this reason, it seems reasonable to expect that a future decrease in dehesa oak woodland area would also reduce amenity self-consumption on the basis of the losses in the dehesa landscape and biodiversity values.

There is a positive relationship between maintaining agroforestry commercial uses and land appreciation, which suggests that landowners are aware of any deterioration of the agroforestry natural and cultural values in the dehesa, but dehesa oak conservation seems to be detached from amenity self-consumption in the short-term horizon. Previous studies show that sustainable oak regeneration in the dehesa leads to commercial losses, and this may be the key short-term reason for a lack of private investment in the further conservation of dehesa oaks (Campos et al., 2003; Martín et al., 2001). The latter might be combined with a misperception of the future scarcity of oak woodland because oak depletion is a gradual process.

The relationship between amenity self-consumption and public subsidies for natural regeneration may be the crucial issue. On the one hand, apart from providing environmental services to landowners, maintaining the dehesa's natural values indirectly provides diverse public benefits (i.e. scenic values, biodiversity, carbon storage, and flood and erosion control). In this sense, although landowners benefit from amenities self-consumption and are protective of their private ownership rights, they may acknowledge that the government has a duty to protect natural resources (Huntsinger et al., 2004). On the other hand, the presence of high levels of amenities self-consumption may reduce the cost to government of encouraging oak woodland conservation. Campos and Mariscal (2003) show that the minimum compensation levels for undertaking agroforestry practices of environmental interest in the Monfragüe area are lower for dehesa owners with a higher willingness to accept commercial losses for consumption of private amenities.

Even if pursuing natural oak regeneration is not economically profitable, given current preferences and the shortcomings of the government's land use policy, we argue that the dehesa oak woodlands should be maintained above a threshold size and perhaps developed to maintain future options for providing rare commodities (e.g. cork and a large range of livestock races) and working landscape amenities for future generations. The long-term conservation of the dehesa cork and holm oaks may depend considerably on effective compensation schemes since private landowners seem unable to accept a short-term commercial income decrease sufficient to prevent the depletion of dehesa woodlands. This work gives an insight

into the income commercial losses that private owners may incur if natural oak regeneration treatments and grazing restrictions are applied. The paradox is that, although the dehesa's short-term private income is competitive, it does not support sustainable agroforestry management of the dehesa.

The dehesa's lack of natural regeneration could be both a market and a policy failure. From the perspective of assessing the risk of the loss in public goods (the increasing risk of biodiversity and carbon losses due to aging oaks), we argue that the lack of a suitable measurement for the dehesa's total Hicksian income negatively influences current European and Spanish land use policy regulations and incentives. This lack of relevant data about landowners' economic behavior, which includes the influence of amenities on landowners' preferences, is critical for implementing the public expenditure of the European CAP's ongoing land-use policy reform. A clear example is the need to make common antagonistic policies compatible, as current policies favor more intensive agroforestry grazing and contribute to the lack of natural oak regeneration.

We highlight here that future research is needed to improve scientific knowledge of the minimum payments required and that efficient and effective compensation schemes are required to induce dehesa owners to invest in the regeneration of aging oak woodlands in operating dehesa systems. In Haza, this mitigates biodiversity losses and allows the livestock industry to preserve local breeds. The dehesa has become a luxury asset where investors simultaneously accept low commercial income (even losses) against the private consumption of amenity benefits from the land and landownership. This particular circumstance should be addressed in EU policy design to correct market failures that will result in the loss of the dehesa and its rich environmental assets and services.

Acknowledgments

This research paper was funded by the research projects Cork Oak Economics and Silviculture (National R&D Fund project number AGL2000-0936-CO2-O2) and Conservation and Restoration of European cork Oak woodlands: a unique ecosystem in the balance (European Union R&D Fund project number QLRT-2001-01594). We specially thank the managers of the Haza de la Concepción estate, Alfonso Díaz and Micaela Tovar, as well as other Haza employees for their valuable help in obtaining the data required to apply the AAS methodology. We are very grateful to Paul Starrs for many helpful discussions of this paper. We thank two anonymous reviewers for helping us to significantly improve the previous version of this study. Notwithstanding the valuable help received from the aforesaid persons and institutions, we are solely responsible for any shortcomings or errors that may remain in this study.

References

- Boletín Oficial del Estado (BOE), 2001. Real Decreto 6/2001, de 12 de enero, sobre fomento de la forestación de tierras agrícolas. BOE 12, 1621–1630.
- Boletín Oficial del Estado (BOE), 2007. Ley 1/2007, de 2 de marzo, sobre la declaración del Parque Nacional de Monfragüe. BOE 54, 9106–9116.
- Buyolo, T., Troca, A., Cabezas, J., Escudero, J.C., 1998. Ordenación de los complejos ambientales del Parque Natural de Monfragüe y su área de influencia. Universidad de Extremadura, Cáceres, 167pp.
- Campos, P., 2005. La renta ambiental en las dehesas de producción de ganado de lidia. *Revista del Instituto de Estudios Económicos* 3, 141–161.
- Campos, P., Caparrós, A., 2006. Social and private total Hicksian incomes of multiple use forests in Spain. *Ecological Economics* 57 (4), 545–557.
- Campos, P., Mariscal, P., 2003. Preferencias de los propietarios e intervención pública: el caso de las dehesas de la comarca de Monfragüe. *Investigación Agraria, Sistemas y Recursos Forestales* 12 (3), 407–422.
- Campos, P., Martínez, M., 2004. Multiple use of *Pinus sylvestris* and *Quercus pyrenaica* forests in the Spanish Central System. Sustainability of Agro-silvo-pastoral Systems. Dehesas and Montados. In: Schnabel, S., Gonçalves, A. (Eds.), *Advances in GeoEcology*, vol. 37. Catena Verlag, Reiskirchen, pp. 71–83.
- Campos, P., Riera, P., 1996. Rentabilidad social de los bosques. Análisis aplicado a las dehesas y montados ibéricos. *Recursos, Ambiente y Sociedad* 751, 47–62.
- Campos, P., Rodríguez, Y., Caparrós, A., 2001. Towards the Dehesa total income accounting: theory and operative Monfragüe study cases. *Investigación Agraria, Sistemas y Recursos Forestales Special Issue* 1, 45–69.
- Campos, P., Martín, D., Montero, G., 2003. Economías de la reforestación del alcornoque y la regeneración natural del alcornocal. In: Pulido, F.J., Campos, P., Montero, G. (Eds.), *La gestión forestal de la dehesa*. Junta de Extremadura and IPROCOR, Mérida, pp. 107–164.
- Campos, P., Oviedo, J.L., Ovando, P., 2005. La cadena de la economía del corcho en los Montes Propios de Jerez de la Frontera. *Revista Española de Estudios Agrosociales y Pesqueros* 208, 83–113.
- Campos, P., Caparrós, A., Oviedo, J.L., Huntsinger, L., Seita-Coelho, I., 2006. Contingent valuation of private amenities from the Mediterranean woodlands of Spain, Portugal and California. In: Ninth Biennial Conference of ISEE on Ecological Sustainability and Human Well-Being, New Delhim, India, 15–19 December 2006.
- Campos, P., Daly-Hassen, H., Oviedo, J.L., Ovando, P., Chebil, A., 2007. Accounting for single and aggregated forest incomes: application to public cork oak forests in Jerez (Spain) and Iteimia (Tunisia). *Ecological Economics*. doi:10.1016/j.ecolecon.2007.06.001.
- Caparrós, A., Campos, P., Montero, G., 2003. An operative framework for total Hicksian income measurement: application to a multiple use forest. *Environmental & Resource Economics* 26, 173–198.
- Díaz, M., Campos, P., Pulido, F.J., 1997. The Spanish dehesas: a diversity in land-use and wildlife. In: Pain, D.J., Pienkowski, M.W. (Eds.), *Farming and Birds in Europe. The Common Agricultural Policy and its Implications for Bird Conservation*. Academic Press, London, pp. 178–209.
- European Commission, 2005. Council regulation (EC) no. 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD). *EU Official Journal* 277, 1–38.
- European Commission, 2006. Community committee for the farm accountancy data network Farm Return Data Definitions Accounting years 2006, 2007. RI/CC 1256 rev. 4. European Communities, Brussels, 71pp.

- European Communities, 1988. Community strategy and action programme for the forestry sector. Communication of the Commission COM (88) 255 final, 74pp.
- Eurostat, 1996. European System of Accounts: ESA-95. European Communities, Luxemburg, 383pp.
- Eurostat, 2000. Manual on Economic Accounts for Agriculture and Forestry—EAA/EAF 97 (Rev.1.1). European Communities, Luxemburg, 181pp.
- Eurostat, 2002. The European framework for integrated environmental and economic accounting for forests—IEEAF. European Communities, Luxemburg, 106pp.
- Huntsinger, L., Sulak, A., Gwin, L., Plieninger, T., 2004. Oak Woodland Ranchers in California and Spain. In: Schnabel, S., Ferreira, A. (Eds.), Sustainability of Agro-Silvo-Pastoral Systems. Dehesas, Montados. Advances of GeoEcology, vol. 37. Catena Verlag, Reiskirchen, pp. 309–326.
- Institut National De La Recherche Agronomique (INRA), 1978. Principes de la nutrition et de d'alimentation des ruminants. Besoins alimentaires des animaux. Valeur nutritive des aliments. INRA, Versailles.
- Joffre, R., Rambal, S., Ratte, J.P., 1999. The dehesa system of southern Spain and Portugal as a natural ecosystem mimic. Agroforestry Systems 45, 57–79.
- Lange, G.M., 2004. Manual for environmental and economic accounts for forestry: a tool for cross-sectoral policy analysis. FAO Working Paper. FAO, Rome, 120pp.
- Marañón, T., 1985. Diversidad florística y heterogeneidad ambiental en una dehesa de Sierra Morena. Anales de Edafología y Agrobiología 54, 1183–1198.
- Martin, D., Campos, P., Montero, G., Cañellas, I., 2001. Extended cost benefit analysis of holm oak dehesa multiple use and cereal grass rotations. Investigación Agraria, Sistemas y Recursos Forestales Special Issue 1, 109–124.
- Mendes, A.M.S.C., 2005. Portugal. In: Merlo, M., Croitoru, L. (Eds.), Valuing Mediterranean Forests: Towards Total Economic Value. CAB International, Wallingford, pp. 331–352.
- Ministerio de Agricultura, Pesca y Alimentación (MAPA), 2003. Encuesta de precios de la tierra 2003 (Base 1997). Secretaría General Técnica, MAPA, Madrid, 54pp.
- Montero, G., Martin, D., Campos, P., Cañellas, I., 2000. Selvicultura y producción del encinar (*Quercus ilex* L.) en la comarca de Monfragüe. CSIC-INIA-UCM Internal Working Paper. CSIC-INIA-UCM, Madrid, 47pp.
- Montero, G., Martin, D., Cañellas, I., Campos, P., 2003. Selvicultura y producción del alcornoque. In: Pulido, F.J., Campos, P., Montero, G. (Eds.), La gestión forestal de la dehesa. Junta de Extremadura and IPROCOR, Mérida, pp. 63–106.
- Nordhaus, W., Kokkelenberg, E.C., 1999. Nature's numbers: expanding the national economic accounts to include the environment. National Academic Press, Washington, 250pp.
- Ovando, P., Campos, P., Montero, G., 2007. Forestaciones con encina y alcornoque en el área de la dehesa (1993–2000). Revista Española de Estudios Agrosociales y Pesqueros, 214, forthcoming.
- Plieninger, T., 2006. Las dehesas de la penillanura cacereña. Origen y evolución de un paisaje cultural. Universidad de Extremadura, Cáceres, 198pp.
- Plieninger, T., 2007. Compatibility of livestock grazing with stand regeneration in Mediterranean holm oak parklands. Journal for Nature Conservation 15, 1–9.
- Pulido, F.J., Díaz, M., 2003. Dinámica de la regeneración natural del arbolado de encina y alcornoque. In: Pulido, F.J., Campos, P., Montero, G. (Eds.), La gestión forestal de la dehesa. Junta de Extremadura and IPROCOR, Mérida, pp. 39–62.
- Pulido, F.J., Díaz, M., Hidalgo, S.J., 2001. Size structure and regeneration of Spanish holm oak *Quercus ilex* forests and dehesas: effects of agroforestry use on their long-term sustainability. Forest Ecology and Management 146 (1–3), 1–13.
- Raunika, R., Buongiorno, J., 2006. Willingness to pay for forest amenities: The case of non-industrial owners in the south central United States. Ecological Economics 56, 132–143.
- Rodríguez, Y., Campos, P., Ovando, P., 2004. The commercial economics of a public dehesa in the Monfragüe shire. In: Schnabel, S., Ferreira, A. (Eds.), Sustainability of Agro-silvo-pastoral Systems. Dehesas, Montados. Advances of GeoEcology, vol. 37. Catena Verlag, Reiskirchen, pp. 85–96.
- Samuel, J., Thomas, T., 1999. The valuation of unpriced forest products by private woodland owners in Wales. In: Roper, C.S., Park, A. (Eds.), The Living Forest. Non-Market Benefits of Forestry. Forestry Commission, London, pp. 203–212.
- Torell, L.A., Rimbe, N.N., Tanaka, J.A., Bailey, S.A., 2001. The lack of a profit motive for ranching: implications for policy analysis. In: Torell, L.A., Barlett, T., Larrañaga, R. (Eds.), Current Issues in Rangeland Resource Economics. Annual Meeting of the Society for Range Management, pp. 47–58.
- Torell, L.A., Rimbe, N.R., Ramírez, O.A., McCollum, D.W., 2005. Income earning potential versus consumptive amenities in determining Ranchland values. Journal of Agricultural and Resource Economics 30 (3), 537–560.
- United Nations European, Commission, International Monetary Fund, Organisation for Economic Cooperation and Development and World Bank, 2003. Handbook of National Accounting. Integrated Environmental and Economic Accounting 2003 (SEEA, 2003). Final Version, 598pp.