EXTENDED COST-BENEFIT ANALYSIS OF HOLM OAK *DEHESA* MULTIPLE USE AND CEREAL-GRASS ROTATIONS

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SUMMARY

The historical formation of holm oak *(Quercus ilex L.) dehesa* woodlands has often resulted in either rapid deforestation episodes by means of clear cuts or slower depletion of oak woodlands due to tree natural mortality and the absence of tree natural regeneration. Consequently, holm oak woodlands have been progressively converted into rough pasturelands, cereal croplands and scrublands. Whilst this tendency of holm oak exhaustion was not socially questioned, scientists and conservationists defending oak woodland conservation providing long run economic and environmental arguments were regarded as romantics ignoring the necessity for social progress and development. Today, these romantics are perceived as nature conservation pioneers and many of their arguments and concepts have been included in science and politics. This paper shows that cereal cropping and permanent grassland uses are more profitable to Extremadura's landowners than holm oak artificial plantations and monitored holm oak natural regeneration. Increasing social demand for recreational and conservation services have been taken into account by Spanish and European public authorities. Along last decade, the European Union and the Spanish government have financed oak reforestation over extensive-use croplands of West and Southwest Spain, resulting in an unprecedented net increase in holm oak woodlands. The presented extended cost-benefit analysis shows that even after incorporating estimated income derived from public and private consumption of environmental services, uses associated to treeless cropland, pastureland and scrubland are still preferred to traditional extensive multiple use associated to *dehesa* holm oak woodlands.

KEY WORDS: Extended cost-benefit analysis
Holm oak reforestation and natural regeneration
Cereal-grass rotations
Dehesa woodlands
Commercial and environmental incomes
Public subsidies

INTRODUCTION

Why *dehesa* owners have preferred pulling out of holm oak in favour to cropland and pastureland conversion?, why during the 1970s first half public administration subsidised these land use changes?, why current *dehesa* owners let holm oak woodlands disappear instead of carrying out monitored natural regeneration programs in which grazing is temporally prevented?, and why European and Spanish public administration have carried out holm oak reforestation programs along 1990s second half?

The aim of this paper is to provide some answers to these four questions from the economic perspective. Present discounted values (PDV) and internal rates of returns (IRT) associated in one hand to cereal cropping and ageing holm oak woodlands and in the other to artificial plantations and monitored natural tree regeneration of holm oaks are calculated and respectively compared.

Annual income (see Table 1) associated to cereal rotations correspond to steady state values calculated at 1998 market prices as described in Campos *et al.* (2001).

Holm oak reforestation and natural regeneration economic analysis have required previous prescription of a *normative* silviculture and associated physical production (Montero *et al.*, 2000). Holm oak growth and crown projection ratios were measured and estimated from field data. Acorn production function was calculated using available data in Vázquez *et al.* (1999).

Three finite time horizons are considered and thus holm oak woodland price functions must be determined. Woodland prices are supposed to depend on stand age (see Figure 1). Land prices associated to treeless land are supposed constant and equal to 1998 market prices.

Private and social holm oak woodland management is analysed. For this purpose, private landowners and society are supposed to maximise private capital income at factor costs (PCIfc) and social capital income at market prices (SCImp) respectively.

Private *dehesa* landowners often have positive values of annual environmental service self-consumption, partially motivated by their right to prevent access to visitors. In other words, landowners who declare to have positive levels of environmental service self-consumption, in the form of recreational and habitat conservation services, are willing to *give up* some of their capital income before they feel obliged to sell their *dehesa* estates. The market for land must then record landowners preferences and hence, selling prices will include the capital value [1] of controlled environmental services.

Income associated to uncontrolled consumption of environmental services, i.e. those services consumed by free access visitors along *dehesa* pathways, is estimated by means of determining visitors' willingness to pay. For this purpose, a market scenario in which visitors' monetary contribution is crucial for conservation and maintenance of the natural area is simulated.

Additionally, acorns are supposed to be partially consumed by wild fauna. Associated economic opportunity cost is thus calculated.

Society is believed to pursue maximum possible levels of commercial benefits at market prices as well as environmental ones from *dehesa* management. Society's interest

[1] Capital value is computed as the infinite horizon present discounted value of an economic flow associated to a given land use (see Campos *et al.*, 2001: Chapter 4; Martín, 2001).

Table 1

Annual income associated to annual cereal croplands, pasturelands, steady state holm oak woodlands, and cereal-grass rotations. Values are expressed in pesetas per hectare and correspond to 1998 market conditions.

Economic variable	Annual cereal cropping	Steady state cereal-grass rotations	Pasturelands	Steady state holm oak woodlands
Labour costs	10,964	3,655	0	4,149
Private commercial income				
Private commercial capital income at market prices (PCCImp)	8,154	5,918	6,951	4,495
Private commercial capital income at factor costs (PCCIfc)	23,000	10,867	6,951	10,319
Private total commercial income at market prices (PTCImp)	19,118	9,573	6,951	8,644
Private total commercial income at factor costs (PTCIfc)	33,964	14,522	6,951	14,468
Private income				
Private capital income at market prices (PCImp)	14,304	12,068	13,101	10,645
Private capital income at factor costs (PCIfc)	29,150	17,017	13,101	16,469
Private total income at market prices (PTImp)	25,268	15,723	13,101	14,794
Private total income at factor costs (PTIfc)	40,114	20,672	13,101	20,618
Social income				
Social capital income (SCI)	15,604	13,368	14,401	13,815
Commercial capital income (CCI)	6,654	4,418	5,451	2,995
Environmental capital income (ECI)	8,950	8,950	8,950	10,820
Social total income (STI)	26,568	17,023	14,401	17,964
Total commercial income (TCI)	17,618	8,073	5,451	7,144

on holm oak woodland conservation is uncertain since no monitored [2] tree natural regeneration scheme has taken place over ageing woodlands.

The extended cost benefit analysis carried out in this paper includes (i) commercial income, (ii) income associated to environmental service consumption by landowners (self-consumption) and free access visitors, and (iii) income associated to wild fauna acorn consumption. Precisely, the inclusion of these last two income sources gives the extended feature to this cost benefit analysis.

METHODOLOGY

Time horizons

Finite time horizon analysis requires consideration of land residual values. Throughout the analysis, land value enters capital income functions negatively at the beginning of the period ($t = 0$), and positively and correspondingly discounted at the end of the time horizon ($t = T$). A continuous function for the price of holm oak woodland depending on stand age has been estimated as follows. The infinite horizon present discounted value of private capital income at market prices (PCImp) associated to an artificial plantation of holm oak with no tree natural regeneration at the end of the silvicultural cycle and transition to treeless cropland is calculated for different discount rates and all tree ages. By comparing obtained capital values with available market prices for adult holm oak woodlands and cereal croplands, the implicit discount rate is obtained [3]. The continuous function for holm oak woodland prices is consequently estimated by fitting a polynomial function to the capital value function evaluated at the resulting implicit discount rate [4] (see Figure 1).

Three different time horizons are considered:

(i) *20 years time horizon.* After 20 years to plantation subsidies for income compensation are not longer given to landowners engaged into reforestation or natural regeneration [5] schemes. Additionally, grazing is not longer restricted.

(ii) *52/54 years time horizon.* Acorn production of holm oak plantations or natural regeneration stands attains representative levels at the age of 52 and 54 respectively.

(iii) *141/143 years time horizon.* At this age, tree density is quite low and consequently acorn production decreases. Conversely, surface grazing resources become more important.

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[2] See Montero *et al.* (2000) for full details on holm oak natural regeneration silvicultural cycles.

[3] The implicit discount rate minimises the distance between prices calculated as capital values and observed market prices.

[4] Implicit discount rates are in this case between 2.5 and 3.5 %.

[5] Although monitored natural regeneration has not actually taken place along European Union (EU) reforestation programs, authors have simulated natural regeneration scenarios as described in Montero *et al.* (2000). Subsidies are supposed to be similar to the ones actually offered for artificial plantations, apart from maintenance subsidies perceived along first five years to plantation, which are assumed to be zero in the case of tree natural regeneration.

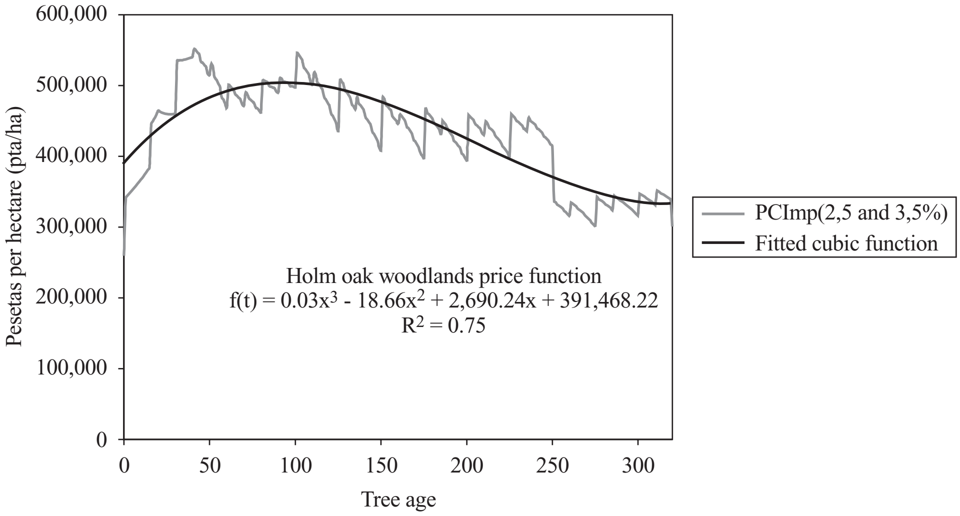

Fig. 1.–Holm oak woodland price function estimation. Prices are expressed as a function of tree age. Prices are given in 1998 pesetas per hectare (pta/ha)

Costs and revenues

Commercial and environmental revenues

Revenues are valued at 1998 market prices and do not include subsidies net of taxes on products. When market transactions do not take place, as in the case of private and social consumption of environmental services, market scenarios are appropriately simulated.

Acorns. Holm oak acorn production is estimated for all different tree age classes taking into account *vecería* effects. 60 % of total acorn production is supposed to be consumed by pigs in *montanera* (feed units (FU) are paid twice as much when acorns are used by pigs rather than alternative livestock species). The remaining 40 % is assumed to be consumed by wild fauna.

Pasture. Pasture production over holm oak woodlands is supposed to depend on crown projection ratio. Cereal cropping has also some pasture production due to rotational management.

Firewood. Silvicultural treatments such as cuts, thinnings, and regeneration cuts produce firewood.

Cereal income. Private and social capital income at market prices and factor costs are estimated. *Dehesa* owner is supposed to rent this type of land use.

Game income. Little game is assumed to take place over holm oak *dehesa* estates. These services are also hired out to a local hunting society.

Income from controlled environmental services. A contingent valuation survey carried out in Monfragüe Shire shows that *dehesa* owners are willing to trade off lower income returns for environmental service self-consumption assurance. A conservative value is accepted as a market *proxy* for the value of environmental service consumption, in particular, half the median of the obtained distribution for visitors' willingness to pay. As a result, environmental service self-consumption in the form of recreation and habitat conservation is estimated (Mariscal and Campos, 2000).

Income from uncontrolled environmental services. Free access visitors' willingness to pay is also estimated by means of a contingent valuation survey carried out in Monfragüe. In this case, the median was taken as the market *proxy* for entrance fees. Consumption of environmental services includes recreation and habitat conservation services (Campos, 1998).

Subsidies net of taxes on products. Subsidies for cereal cropping are taken from National Agricultural Accounts (MAPA, 1999). In the case of holm oak reforestation, subsidies correspond to those actually given in Extremadura through application of ECC Council Regulation 2080/92 (Comisión Europea, 1992; Consejería de Agricultura y Comercio y Dirección General de Estructuras Agrarias de la Junta de Extremadura, pers. comm., 1999 and 2001). Taxes correspond to 1998 agricultural general tax regime. Public administration expenditure on fire protection, service provision to visitors, and guarding, are included and accounted as implicit subsidies.

Commercial costs

National accounts criteria (Eurostat, 1996) and its pilot application to forests (Eurostat, 2000) are used for costs estimation. Environmental costs have not been measured in this study.

Intermediate consumption. Public administration direct expenditure is assumed to have positive effects over described commercial revenues and hence must be included as intermediate consumption. Public administration investments are nonetheless excluded. Hired services for silvicultural treatment works constitute the only additional entry to intermediate consumption, as other activities are directly hired out by landowners and hence, imply no intermediate costs to landowners. Associated labour costs are obviously excluded from intermediate consumption calculation. Intermediate consumption is measured at market prices and hence, do not include subsidies net of taxes on products.

Labour costs. They include all labour costs directly generated in cereal croplands, holm oak reforestations and natural regeneration stands.

Fixed capital consumption. The unique considered fixed capital consumption corresponds to fencing costs, due to 20 year grazing restriction over artificial plantations and natural regeneration stands. Residual value associated to fencing is assumed to be zero in all analysed time periods.

Determination of time discount rate

An implicit discount rate is obtained by comparing capital values of PCImp associated to cereal croplands and ageing holm oak woodlands with corresponding observed market prices. In this case, under 1998 market conditions and prescribed holm oak selviculture, the discount rate that makes capital values closer to observed market prices corresponds to 2.5 %. This discount rate is assumed equal to all land uses within *dehesa* estates.

Annual capital income variables

Private capital income at market prices

Private total revenue (TR) includes all mentioned revenues except uncontrolled environmental service consumption (ESCu) and wild fauna acorn consumption (WFAC). Private total costs (TC) include all described costs except public administration intermediate costs (PAIC). Private capital gains (PCG) are not annually [6] considered when calculating private capital income at market prices (PCImp) and hence, PCImp value is equivalent to private net operating income (PNOI):

$$\text{PCImp} = \text{PNOI} = \text{TR} - \left(\text{ESCu} + \text{WFAC}\right) - \left(\text{TC} - \text{PAIC}\right)$$

Private capital income at factor costs

Private capital income at factor costs (PCIfc) is assumed to be the variable taken into account by landowners when making decisions.

In this case, PCIfc is equal to private net operating surplus (PNOS) and it is simply the value of PCImp plus subsidies net of taxes on products (SNT):

$$\text{PCIfc} = \text{PNOS} = \text{PCImp} + \text{SNT} = \text{PNOM} + \text{SNT}$$

Social capital income

Social capital income (SCI) is estimated at real and imputed market prices, without subsidies net of taxes on products. As social capital gains (SCG) have not been introduced, SCI is equivalent to net operating margin (NOM). This last variable is calculated by adding to PNOM, uncontrolled environmental service consumption (ESCu) and wild fauna acorn consumption (WFAC). Precisely, the sum of ESCu and WFAC constitutes uncontrolled environmental net operating margin (ENOMu):

$$\text{SCI} = \text{NOM} = \text{PNOM} + \text{ESCu} + \text{WFAC} = \text{PNOS} + \text{ENOMu}$$

Present discounted values

The aim of this section is to provide the mathematical expressions for finite horizon present discounted value calculation. Values have to be calculated for all the proposed time horizons and land uses. For more detailed analysis on finite and infinite horizon present discounted values refer to Campos *et al.* (2001): Chapter 4.

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[6] Alternatively, capital gains are considered by land residual value function, calculated as the difference between the present discounted value of land price at time T and the value of land at time t = 0, i.e. ^{T} f (T) – f (0).

Cereal cropland rotations, pasturelands and scrublands

Steady state annual income variables associated to treeless land uses are denoted by $_i$, where i denotes land use: annual cereal cropping (i = 1), cereal-grass rotations (i = 2), pasturelands (i = 3), and scrublands (i = 4). Present discounted values for each time horizon and land use are calculated as follows:

$$\begin{array}{l} V_{i(finite)} \quad (\ _i - p_i^{land}) \quad \overset{T-1}{\underset{t=1}{}} \ ^t \ _i \quad ^T (\ _i - p_i^{land}) \\ V_{i(finite)} \quad (\ _i - p_i^{land}) \quad \frac{- \ ^T}{1-} \quad _i \quad ^T (\ _i - p_i^{land}) \end{array} \qquad T = 20;52;141; \qquad i \qquad [1]$$

Where p_i^{land} represents market price for land with use i, and is discount function (1 / (1 + r)), r is annual discount rate.

Ageing holm oak woodlands without tree natural regeneration

Holm oak woodlands aged 250 years and not entering the monitored natural regeneration program are evaluated along following 20, 54, and 143 years. Annual income variables are denoted as follows:

$$y_{nnr(finite)}(t) = \begin{array}{ll} t = 250 & y_{nnr(finite)}(250) = y_{nnr}(250) - f(250) \\ t = T & y_{nnr(finite)}(T) = y_{nnr}(T) + f(T) \qquad T = 270{,}304 \\ t \quad 250; T & y_{nnr(finite)}(t) = y_{nnr}(t) \end{array} \qquad [2]$$

Where f (t) is estimated continuous function for holm oak woodland prices, and represents land value when stand age is t. Present discounted values for first two time horizons are calculated by the following expressions:

$$V_{nnr(250)(finite)} = \overset{T}{\underset{t=250}{}} \ ^{t-250} y_{nnr(finite)}(t) \qquad T = 270{,}304 \qquad [3]$$

Alternatively, when time horizon is above 70 years, ageing woodlands are supposed to become treeless croplands, pasturelands or even scrublands. For transition to treeless land use i, present discounted value for last time horizon (T = 143) is given by:

$$\begin{array}{l} V_{nnr(250)(finito)} \quad \overset{320}{\underset{i=250}{}} \ ^{i-250} y_{nnr(finite)}(i) \quad \overset{142}{\underset{t=71}{}} \ ^t \ _i \quad ^{143} \ _i \quad p_i^{land}) \\ V_{nnr(250)(finito)} \quad \overset{320}{\underset{i=250}{}} \ ^{i-250} y_{nnr(finite)}(i) \quad \frac{^{71} - \ ^{142} \ 1}{1-} \quad _i \quad ^{143} \ _i \quad p_i^{land}) \end{array} \qquad [4]$$

Artificial plantation and monitored tree natural regeneration

Annual income variables associated to artificial plantations or natural regeneration stands are denoted by expressions [5] and [6] respectively:

$$y_{a(finite)}(t) = \begin{array}{ll} t = 0 & y_{a(finite)}(0) = y_a(0) - p_i^{land} \\ t = T_a & y_{a(finite)}(T_a) = y_a(T_a) + f(T_a);\ \ T_a \quad 20;52;141 \\ t \quad 0, T_a & y_{a(finite)}(t) = y_a(t) \end{array} \qquad [5]$$

$$y_{n(finite)}(t) = \begin{array}{ll} t = 0 & y_{n(finite)}(0) = y_n(0) - f(250) \\ t = T_n & y_{n(finite)}(T_n) = y_n(T_n) + f(T_n);\ \ T_n \quad 20;54;143 \\ t \quad 0, T_n & y_{n(finite)}(t) = y_n(t) \end{array} \qquad [6]$$

Associated present discounted value expressions are consequently:

$$V_{a(finite)} \quad \sum_{t=0}^{T_a} {}^{t} y_{a(finite)}(t) \quad T_n \quad 20;52;141 \qquad [7]$$

$$V_{n(finite)} \quad \sum_{t=0}^{T_n} {}^{t} y_{n(finite)}(t) \quad T_n \quad 20;54;143 \qquad [8]$$

RESULTS

Holm oak reforestation and cereal-grass rotations

The market

Present discounted values (PDVs) of PCImp are negative for all considered time horizons in the case of holm oak reforestation through artificial plantations. Conversely, corresponding values for cereal-grass rotations are positive. PDVs at market prices get larger in both cases as time horizon increases, nonetheless increases are larger in the case of cereal-grass rotations. Hence, incurred loss in PDV due to land use change to holm oak woodland increases also with time horizon (Table 2).

Internal rates of return (IRR) evolve in a different manner. Whilst in the case of holm oak artificial plantations IRR increase with time horizon (+2.36 from T = 20 to T = 141), the ones associated to cereal-grass rotations decrease with time horizon (–.14 from T = 20 to T = 141). Losses in IRR values due to land use change from cropland to holm oak woodland decrease as time horizon increases, and are improved in 2.5 points (see Table 3).

Table 2

Present discounted values for capital income associated to holm oak artificial plantations and natural regeneration stands compared to those of cereal-grass rotations and ageing holm oak stands without monitored natural regeneration. Values expressed in 1998 pesetas per hectare, 2.5 % discount rate

Class	Artificial plantation or cereal-grass rotations			Monitored natural regeneration or no natural regeneration		
Time horizon (years)	20	52	141	20	54	143
Private capital income at market prices (PCImp)						
Artificial plantation/natural regeneration (AP or NR)	–250,970	–232,305	–229,917	–334,185	–315,792	–313,156
Cereal-grass rotations/no natural regeneration (CGR or NNR)	83,387	144,202	189,186	–208,164	–194,327	–165,446
Gains (AP – CGR or NR – NNR)	–334,257	–376,507	–419,103	–116,021	–121,465	–147,710
Private capital income at factor costs (PCIfc)						
Artificial plantation/natural regeneration (AP or NR)	446,048	525,009	576,682	114,668	189,812	241,369
Cereal-grass rotations/no natural regeneration (CGR or NNR)	165,381	292,281	385,993	–124,374	–44,855	23,901
Gains (AP – CGR or NR – NNR)	280,667	232,728	190,689	239,062	234,667	217,468
Social capital income (SCI)						
Artificial plantation/natural regeneration (AP or NR)	–228,961	–175,082	–138,367	–301,719	–247,269	–219,293
Cereal-grass rotations/no natural regeneration (CGR or NNR)	104,853	183,102	240,887	–172,729	–133,995	–92,503
Gains (AP – CGR or NR – NNR)	–333,814	–358,184	–379,254	–128,990	–113,274	–126,790

Table 3

Internal rate of return (IRR) associated to holm oak artificial plantations and natural regeneration stands compared to those of cereal-grass rotations and ageing holm oak stands without monitored natural regeneration. Values are given in percentage and correspond to 1998 market and public intervention conditions

Class	Artificial plantation or cereal-grass rotations			Monitored natural regeneration or no natural regeneration		
Time horizon (years)	20	52	141	20	54	143
Private capital income at market prices (PCImp)						
Artificial plantation/natural regeneration (AP or NR)	–0.76	1.14	1.6	–1.33	0.85	1.4
Cereal-grass rotations/no natural regeneration (CGR or NNR)	4.33	4.21	4.19	–0.17	1.21	1.77
Gains (AP – CGR or NR – NNR)	–5.09	–3.07	–2.59	–1.16	–0.36	–0.37
Private capital income at factor costs (PCIfc)						
Artificial plantation/natural regeneration (AP or NR)	15.55	13.72	13.68	4.01	2.29	3.85
Cereal-grass rotations/no natural regeneration (CGR or NNR)	6.17	6.03	6.01	0.8	2.19	2.61
Gains (AP – CGR or NR – NNR)	9.38	7.69	7.67	3.21	0.1	1.24
Social capital income (SCI)						
Artificial plantation/natural regeneration (AP or NR)	–0.47	1.49	1.98	–1.06	1.24	1.79
Cereal-grass rotations/no natural regeneration (CGR or NNR)	4.81	4.69	4.66	0.29	1.61	2.08
Gains (AP – CGR or NR – NNR)	–5.28	–3.2	–2.68	–1.35	–0.37	–0.29

The landowner

Both cereal cropping and holm oak reforestations are currently subsidised by public administration since application of ECC Council Regulation 2080/92.

Present discounted values of PCIfc associated to holm oak artificial plantations are larger than those associated to cereal-grass rotations in all analysed time horizons. For longest time horizon, present discounted values are above land market prices in both cases. Gain associated to land use change from croplands to woodlands decreases with time horizon, going from a maximum of 280,667 pesetas per hectare (pta/ha) (T = 20) to a minimum of 190,689 pta/ha (T = 141) (see Table 2).

Internal rates of return of PCIfc associated to holm oak reforestation are more than double those of cereal-grass rotations. Largest gain due to land use change takes place for lowest time horizon and equals 9.38 (Table 3).

Society

Present discounted values of social capital income (SCI) are higher in cereal-grass rotations than in reforested woodlands. Losses induced by land use change from croplands to woodlands attain maximum value for T = 141 and amounts to –379,254 pta/ha (Table 2).

Conversely, loss in IRR value from land use change is minimum for T = 141 and attains –2.68 points (Table 3).

Holm oak monitored natural regeneration and no natural regeneration stands

The market

Present discounted values of PCImp associated to holm oak monitored natural regeneration and ageing holm oak stands with no natural regeneration are negative for all considered time horizons. Comparing both cases, no natural regeneration provides higher income values. Monitored natural regeneration incurs in additional losses that attain a maximum of –147,710 pta/ha when T = 143 (Table 2).

When analysing IRR, maximum loss due to implementation of holm oak monitored natural regeneration instead of leaving the woodland age and disappear occurs when time horizon is shortest (T = 20), attaining a loss of –1.16. Losses decrease with time horizon down to –.37 when T = 143 (Table 3).

The landowner

Present discounted value of PCIfc is higher in all considered time horizons for holm oak monitored natural regeneration stands than for ageing ones with no natural regeneration. Gain due to monitored natural regeneration decreases with time horizon and has a maximum value when T = 20 of 239,062 pta/ha (Table 2).

In terms of IRR of PCIfc, gains due to engagement in natural regeneration programs decrease with time horizon from 3.21 when T = 20 to 1.24 when T = 143 (Table 3).

Society

The PDV of SCI is lower for monitored natural regeneration stands than for ageing ones independently of considered time horizons. For a time horizon of 20 years, PDV loss amounts to –128,990 pta/ha, whilst IRR one is of –1.35 points (Tables 2 and 3).

DISCUSSION OF RESULTS

This section evaluates relevant land use options under current market conditions and public intervention scenario. On one side, cereal-grass rotations are evaluated against holm oak artificial plantations. Additionally, the option of holm oak monitored natural regeneration is compared with actual silvicultural practice of natural regeneration absence.

Holm oak artificial plantations and cereal-grass rotations: a comparison

Current ageing holm oak woodlands are gradually and generally converted into treeless natural pasturelands due to natural regeneration absence. Additionally, pasturelands constitute most popular treeless land use along *dehesas* from West and Southwest Spain (Díaz, Campos y Pulido, 1997). Cereal-grass rotations are often aimed to maintain pasture productivity in *dehesas.* In economic terms, annual income at market prices is higher for pasturelands than for cereal-grass rotations. Nonetheless, when subsidies are introduced, annual income levels at factor cost are higher for cereal-grass rotations than for pasturelands (Table 1).

Present extended cost-benefit analysis results show that at market prices, over soils whose fertility could not admit higher land use intensity than that associated to cereal-grass rotation, management leading to pasture maintenance or improvement through cereal-grass rotations rather than holm oak artificial plantation is rational in economic terms. When analysing annual income results, steady state holm oak woodlands offer lower annual private (at market prices) and social income levels than cereal-grass rotations and pasturelands (Table 1).

At market prices, i.e. without subsidies net of taxes on products, the option of cereal-grass rotations is preferred to holm oak reforestations by both private and social agents and under all analysed time horizons. Society's preference for cereal-grass rotations rather than holm oak reforestations is consistent with historical *dehesa* social management until application of ECC Council Regulation 2080/92. This fact can be regarded as a contradiction, in one side social capital income is lower for woodland use than for cereal-grass rotations, and in the other, public administration expends large funds on holm oak reforestation. Either actual subsidies to holm oak reforestations are too high or author's estimation of social capital income is undervalued, most probably, a combination of the two explains it best.

When looking at income values at factor costs, i.e. including subsidies net of taxes on products, PDVs associated to holm oak artificial plantations are much higher than those of cereal-grass rotations. In terms of IRR, gains due to reforestation are between 7.67 and 9.38. These two facts may show slight over compensation to private landowners entering reforestation schemes. It could be that landowners would be willing to increase reforestation area accepting current income (at factor cost) levels (Table 3).

Social capital income estimation may be under valued due to the absence of income estimations associated to net carbon abatement and soil erosion reduction. Net income contribution associated to omitted environmental services is nonetheless uncertain. For instance, land use change from cereal-grass rotations or pasturelands into oak woodlands may have positive or negative externalities over water services.

Holm oak monitored natural regeneration stands and ageing holm oak woodlands: a comparison

In the absence of subsidies net of taxes on products, private managers would let holm oak woodlands age and consequently disappear. This tendency towards ageing holm oak woodlands appears to be true also for social agents. In fact, ECC Council Regulation 2080/92 does not include monitored natural regeneration programs in its reforestation subsidy schemes. Present discounted value distances associated to monitored natural regeneration stands and ageing ones are shorter than in the case of reforestations and cereal-grass rotations. Thus public expenditure on maintenance and improvement of holm oak woodlands could be lower if monitored tree natural regeneration programs were introduced in public administration subsidising schemes (Tables 2 and 3).

Current subsidies to holm oak artificial plantations have been more than enough to offset land use change into woodlands along the 1995-1999 period. Subsidising scheme for monitored holm oak natural regenerations is designed *ad hoc.* As already mentioned, there is no application in reality of natural regeneration schemes. Hence, resulting private preferences cannot be contrasted with observed private management. Present results show that when looking at PDVs of private capital income at factor costs, natural regeneration stands provide higher levels than ageing holm oak stands (Table 2).

CONCLUSIONS

Throughout presented extended cost-benefit analysis, it is assumed that the number of hectares reforested are not enough to change current provision of environmental services in the form of recreation and habitat conservation. The only additional accounted environmental service is future wild fauna acorn consumption associated to reforestations.

Social and private agents' behaviour with respect to holm oak woodland conservation may appear myopic. Holm oak woodlands provision could decrease down in the future and hence associated environmental services. Consequently, holm oak woodlands economic value will be higher due to the scarcity factor. If social agents were discounting future environmental income at higher discount rates than the ones considered in this study, actual subsidies to holm oak reforestation would be well above appropriate levels.

Economic analysis has traditionally treated new complex issues in the simplest possible manner (Heal, 1998). Economic valuation of *dehesa* multiple use with the inclusion of environmental services has only recently started (Campos *et al.*, 2001). The use of a unique discount rate may under value natural regeneration and reforestation scenarios.

Nonetheless, the lack of both, new studies with decreasing discount rates in tree age and actual market transactions records for *dehesa* assets encourage the application of a unique implicit discount rate.

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RESUMEN

Análisis coste-beneficio ampliado del uso múltiple de una tierra como encinar adehesado y cultivo de cereal al tercio

La formación histórica del encinar adehesado ha conducido bruscamente –mediante la repentina tala de la encina– o lentamente –por su muerte natural y ausencia de regeneración– a la disminución continuada de la población de encinas en favor del cultivo agrícola, el pastizal y el matorral. Mientras esta tendencia de desaparición de las encinas no era cuestionada socialmente, la defensa de la encina con argumentos económicos y ambientales de largo plazo por parte de algunos científicos y conservacionistas era vista por la corriente mayoritaria de los técnicos de la agronomía como una posición impregnada de romanticismo que ignoraba la necesidad del progreso social. Hoy los románticos del encinar de ayer son percibidos como pioneros de la conservación de la naturaleza, y muchos de sus argumentos y conceptos han sido incorporados a los programas docentes y políticos. En este artículo se desarrolla la tesis de que en Extremadura el uso de una tierra agrícola marginal como cultivo al tercio o pastizal permanente le es más rentable al propietario que las opciones de plantar encinas y regenerar el encinar envejecido con sus propios recursos económicos. Las crecientes demandas sociales de disfrute recreativo y en defensa de la conservación del encinar se han integrado en las cuestiones ambientales incorporadas a las agendas de los gobiernos español y europeo. En la última década la Unión Europea y el Gobierno español han financiado la reforestación con arbolado de quercíneas en las tierras de cultivo extensivo de las dehesas del oeste y sudoeste español, y por primera vez en la historia de la gestión de la dehesa, se va a producir una notable expansión del encinar, en el caso de que las superficies repobladas lleguen a su madurez. El análisis coste-beneficio ampliado comparado sobre los valores presentes descontados de las rentas privada y social, originadas en las tierras no-aptas para el cultivo anual, prueban que la incorporación a las rentas comerciales del encinar adehesado de las rentas estimadas de los servicios ambientales consumidos por el publico y auto-consumidos por los propietarios no son suficientes para mantener y expandir el uso múltiple de la tierra como encinar adehesado, persistiendo la tendencia histórica de evolución del encinar adehesado hacia el cultivo extensivo desarbolado, el pastizal permanente y el matorral, esta secuencia es la que

prefieren los propietarios privados y públicos, y la que seguramente se produce cuando gestionan sus encinares en ausencia de subvenciones al mantenimiento y expansión de las encinas.

PALABRAS CLAVE: Análisis coste-benefico ampliado
Reforestación de encinas
Regeneración natural de encinas
Rotación al tercio cereal-pasto
Dehesa arbolada
Renta comercial
Renta ambiental
Subvenciones públicas

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