

Private Net Benefits from Afforesting Marginal Cropland and Shrubland with Cork Oaks in Spain

Paola Ovando, Pablo Campos, José L. Oviedo, and Gregorio Montero

Abstract: We estimate the private net benefits from afforesting marginal shrubland and cropland with cork oaks at two Spanish cork oak sites, Aljibe and Gavarres, in different time horizon frames. The analysis integrates market and nonmarket (landowner amenity) private capital incomes, including government afforestation grants. We apply cost-benefit analysis techniques for estimating the investment present value in the periods analyzed, taking residual values of cork oak woodland into account. The results show that the profitability rate of cork oak afforestation strongly depends on government subsidies. The value of private amenities, at least in Aljibe, seems to be positively affected by the forest area's share of the total estate surface. Thus, an increase in the afforested area would enhance the private amenity annual income with respect to maintaining the original property land's treeless uses. A higher level of private amenities attached to the forest area may imply a reduction in government grants for encouraging cork oak afforestation. FOR. SCI. 56(6):567–577.

Keywords: cost–benefit analysis, private amenity, market incomes, government grants

FOREST INVESTMENT ANALYSIS IS usually based on the present value of cash flows (revenues minus operating expenditures) from timber and nontimber commodities. However, literature shows that private amenities have an important role in nonindustrial private forestland (NIPF) owner decisions (Hartman 1976, Bowes and Krutilla 1989, Newman and Wear 1993, Raunikaar and Buongiorno 2006) and that they are an important component of forestland market prices (Martin and Jefferies 1966, Samuel and Thomas 1999, Eurostat 2002, Lange 2004, Campos et al. 2009).

The joint production of timber and amenities from NIPF owners has received attention over the last few decades (for a review, see Pattanayak et al. 2002). Hartman (1976) showed that optimal harvest age could be lengthened when amenities are intrinsically bound to standing forests. However, landowner management decisions may only be affected when private land amenities are reflected in property rights over forest (Koskela and Ollikainen 1997). In this case, forest market outputs and amenities can in turn be conceived as inputs of private owner well-being (Beach et al. 2005). Thus, the integration of income derived from private amenities to estimate present values could have different empirical applications.

In recent decades, landowners in the European Union (EU) are taking a new factor into account when investing in forestry: the EU's Common Agricultural Policy (Council Regulations 2080/1992 and 1257/1999). This entails a system of community aids for afforesting agricultural land to

control agricultural production surplus. In addition, other reasons that justify this policy are the protection of the natural environment and carbon sequestration. In Spain, recent afforestation regulations include motivations such as diversification of agricultural sector income and employment, soil and water resource protection, biodiversity conservation, and forest fire incidence reduction (Boletín Oficial del Estado 2001). Afforestation subsidies intend to increase public benefits but also affect forest investment decisions at the private level.

In this study, we aimed to perform a cost-benefit analysis to evaluate the net benefits (in present value [PV] terms) that NIPF owners obtain from afforesting treeless land uses with cork oaks (*Quercus suber* L.), integrating the stream of annual incomes derived from market commodities, subsidies, and private amenities. We estimate the net benefits that landowners obtain from afforestation including taxes and subsidies on production and also the net benefits that landowners offer to society in pure market conditions. We apply this analysis to two areas in Spain: the Aljibe cork oak site when afforesting shrublands and the Gavarres cork oak site when afforesting croplands.

In a land use change context, cork oak afforestation analysis is relevant because of the high impact of the EU afforestation policy on this species. Since 1993, more than 84,000 ha have been planted with mixed and pure cork oak stands in Spain (Ovando et al. 2007). Landowners have positively responded to the afforestation programs but one

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question remains open: are current subsidy conditions encouraging this land use change within the context of an efficient private land use choice?

Recent developments in cork oak growth, silviculture, and yield models in Spain (Montero et al. 2009a, 2009b) provide biotechnical data for undertaking a cost-benefit analysis of cork oak afforestation investments. In our cost-benefit analysis, we consider finite time horizon frames that simulate the net benefits of this land use change in the medium and long terms, which requires estimating the residual values of the afforested land at the end of the periods evaluated. Because of the lack of statistical information on cork oak woodland market prices, we estimate land price functions for the complete productive cycle of an afforested cork oak stand, measuring the expected private market and amenity capital incomes.

This article is structured as follows. The second section describes the study sites, the simulated cork oak silviculture models, the data collection, the private amenity valuation, and the afforestation net benefit estimation. The third section presents the main results. The fourth section closes with discussion and conclusions.

Materials and Methods

Aljibe and Gavarres Sites

In Spain, cork oak woodland occurs both in a sparse tree-layer structure usually mixed with holm oak (called *dehesas*) and dense cork oak stands (called *monte alcornocal*). This study considers two Spanish *monte alcornocal* sites with contrasting management practices: El Aljibe Massif (Aljibe) in the Southwest (Cadiz, Andalusia), and Les Gavarres Massif (Gavarres) in the Northeast (Gerona, Catalonia). Aljibe is located in the Alcornocales Natural Park, which covers a surface of 1,677 km², with most of this area (75%) consisting of large private properties (Boletín Oficial de la Junta de Andalucía 2004a). The regional government declared Gavarres, which covers a surface area of 350 km² of which 98% is under private ownership, an area of natural interest (Botey et al. 2005). Woodland properties are particularly fragmented here and most of them do not exceed 25 ha (Consorti de Les Gavarres 2006).

The cork oak woodlands at both study sites form part of a complex mix (mosaic) of vegetation and land uses, where pure and mixed cork oak stands cover more than 50% of the Aljibe and Gavarres total surfaces (Botey et al. 2005, Campos et al. 2009). In Aljibe, mature cork oak woodland management concentrates on stripping cork. The absence of investments for facilitating natural regeneration (Campos et al. 2007), together with grazing pressure from free-range cattle and an increasing deer population, results in poor cork oak regeneration and a decline in the oak population (Pausas et al. 2009). In Gavarres, cork oak stripping is not frequent and when it is done it takes longer intervals than the ideal commercial ones (Montero et al. 2009a). Many decades of abandonment of cork oak stand management in Gavarres have led to a sharp increase in understorey, favoring devastating fires in many cases (Granyer and Meya 2002).

In Aljibe, afforestation is one alternative to counteract cork oak natural regeneration problems. In this site, we

assume that cork oaks are planted on shrublands, which are mainly used for grazing and have practically no trees. The Gavarres cork oak woodlands face different problems mainly derived from abandonment. In this site cork oak afforestation may be seen as an alternative to marginal agriculture land uses. Thus, we assume that in Gavarres cork oaks are planted on arable lands used for growing dry land crops of cereals or pulses. Both the Aljibe and Gavarres shrublands and croplands are the main treeless land use categories (Burriel et al. 2001, Boletín Oficial de la Junta de Andalucía 2004a).

Cork Oak Yields and Silviculture Models

We simulate two exogenous silviculture models for the complete life cycle of the cork oak afforestation scenario. We assume specific growth and yield models for the Gavarres (Montero et al. 2009a) and for the Aljibe (Montero et al. 2009b) sites. These models consist of a series of forestry treatments to be accomplished throughout the entire productive cycle of a planted cork oak hectare. Grazing exclusion [1] (only in Aljibe, where the current grazing pressure of red deer and cattle hinders seedling growth), formation pruning, selective thinning, shrub clearing, and sanitary felling are the main treatments prescribed for cork oak stand management (Table 1).

Cork is stripped periodically with frequencies ranging from 9 to 12 years. This builds up a management model that encourages cyclical cork yield. After the first cork stripping, successive stripping frequencies are determined exogenously, subject to wood and cork thickness growth models for each site (Montero et al. 2009a, 2009b) and to specific stripping regulations. Spanish regulations limit the first stripping of cork oaks with a breast height circumference of at least 60 cm (e.g., Boletín Oficial de la Junta de Andalucía 2004b). The wood and cork growth rate is faster for the Aljibe site, which determines that the minimum circumference is reached when the trees are 27 years old. Gavarres cork oak trees need 43 years to achieve this minimum circumference. In the first stripping, only virgin (rough) cork is obtained, which is a cork with less commercial interest than second and successive strippings (reproduction cork). The stripping frequency of reproduction cork corresponds to the time needed to attain a specific thickness for natural stoppers. Thus, reproduction cork stripping takes place every 9 years in Aljibe and every 12 years in Gavarres, yielding mainly reproduction cork and a small share of virgin cork because of an increase in the stripping height (Table 2). On the other hand, selective thinning and sanitary felling produce firewood and winter cork (the cork layer that is adhered firmly to the inner bark of firewood), which are sold as individual by-products from forestry treatments [2].

Cork oak outputs are arranged by making a distinction between two cork oak production phases: the afforestation cycle and the nonregeneration cycle (cork oak aging). We make use of physical and economic data of both phases for estimating cork oak woodland prices functions, as we detail below. The afforestation cycle considers cork oak yields from the year the cork oak stand is planted (T_0) to the year

Table 1. Cork oak silviculture treatments and cork stripping unitary costs in Aljibe and Gavarres

Class	Unit	Cork oaks age (years)		Cost	
		Aljibe	Gavarres	Aljibe	Gavarres
		(yr)		(2002 € unit ⁻¹)	
Afforestation	ha	0	0	2,420	1,862
Fence installation	ha	0	—	3,552	—
Shrub clearing	ha	Each 9 yr ¹	Each 12 yr ¹	1,166	758
Formation pruning					
First	ha	8	12	339	309
Second	ha	14	20	528	363
Third	ha	27	30	607	486
Fourth	ha	36	—	754	—
Selective thinning					
First	ha	14	20	228	325
Second	ha	27	43	819	1,315
Third	ha	45	67	2,107	1,309
Fourth	ha	63	79	907	639
Fifth	ha	81	91	899	967
Sixth	ha	—	103	—	708
Seventh	ha	—	115	—	758
Eighth	ha	—	127	—	709
Cork stripping ⁴	t	Each 9 yr ²	Each 12 yr ²	263	346
Sanitary felling	ha	Each 9 yr ³	Each 12 yr ³	211	366
Firebreaks and roads maintenance costs ⁵	ha	Each yr	Each yr	12	9

¹ Shrub cleaning is carried out to facilitate the cork harvesting process but also to favor cork oak growth in the earlier stages of the afforestation cycle.

² Cork stripping occurs every 9 or 12 years after the first cork stripping (oaks are 27 years old in Aljibe and 43 years old in Gavarres).

³ Sanitary felling consists of cutting down dead or sick trees. This operation can be carried out before cork stripping and concurring with shrub clearing. In Gavarres this operation includes sanitary treatments.

⁴ t refers to a metric ton.

⁵ In treeless shrubland there is an extra cost every 9 years (€19.5 ha⁻¹) to open strips that facilitate big game shooting.

Table 2. Cork and firewood yield from ideal Aljibe and Gavarres cork oak silviculture

Class ¹	Total cork and firewood yield							
	Aljibe				Gavarres			
	Summer harvested cork		Winter harvested cork	Firewood	Summer harvested cork		Winter harvested cork	Firewood
	Virgin	Reproduction			Virgin	Reproduction		
..... (kg ha ⁻¹ yr ⁻¹)								
Afforestation cycle (a) (1 – T _n)								
Selective thinning			69.5	489.1			60.3	414.4
First cork stripping	11.2	0.0			7.0			
Cork stripping	19.6	346.0			20.1	196.6		
Sanitary felling			47.9	246.8			3.1	20.7
Total (a)	30.8	346.0	117.4	735.9	27.1	196.6	63.3	435.1
No regeneration phase (nr) (T _{n+1} – T _{n+m})								
Cork stripping		247.7			4.4	367.5		
Sanitary felling			146.0	681.0			97.0	529.5
Total (b)		247.7	146.0	681.0	4.4	367.5	97.0	529.5
Total (a + b)	30.8	593.7	263.5	1,416.9	31.5	564.1	160.3	964.6

¹ T_n defines the afforestation cycle length, which corresponds to the time elapsed between the year cork oaks are planted to the year that regeneration treatments are prescribed. T_{n+m} (cork oak productive life cycle) is defined by the year at which the cork extraction activity ceases because of cork yield declining. T_n equals 143 years in Aljibe and 151 years in Gavarres, whereas T_{n+m} is 207 years in Aljibe and 223 years in Gavarres.

in which the regeneration treatments of the stand should start (T_n). However, our model assumes that no regeneration phase takes place but instead a second phase of nonregeneration. This phase takes into account the cork oak yields when no forestry treatments for facilitating natural regeneration are performed, and it continues from year T_n to the year in which the nonregenerated stand stops producing cork oak yields (T_{n+m}) because of a decline in cork productivity resulting from the cork oak aging process (Table 2).

Market and Amenity Data

All data for forest commodities, subsidies and private amenities are presented at 2002 local market and imputed prices (Table 3) [3]. Private landowners profit at both study sites from selling cork and by-products (firewood and winter cork) derived from forestry treatments and from leasing out the land for grazing (only in Aljibe) and hunting.

Data on market output prices, forestry, and cork stripping costs are taken from the market as direct exchange values.

Table 3. Commercial and environmental outputs unitary prices and values

Class	Unit	Price/value		Afforestation cycle value ¹	
		Aljibe	Gavarres	Aljibe	Gavarres
		... (2002 € unit ⁻¹) ...		.. (2002 € ha ⁻¹ and year ⁻¹) ..	
Summer harvested cork	kg	1.10	1.16	412.9	259.2
Virgin cork	kg	0.24	0.30	7.4	8.1
Reproduction cork	kg	1.17	1.28	405.5	251.1
Winter harvested cork	kg	0.10	0.15	11.7	9.5
Firewood without bark ²	t	30	40	22.1	17.4
Grazing rent (from year 20 – T_n) ³	ha and yr	20	—	17.5	—
Hunting rent (game) ³	ha and yr	45	9	39.4	9
Dry cropland rent	ha and yr	—	80	—	80
Private amenities	ha and yr	213	225	213	225
Government grants					
Afforestation grants	ha	2,314	2,331	17.1	15.3
Maintenance premium (5 yr)	ha and yr	288	288	10.0	9.5
Income cover loss premium (20 yr)	ha and yr	60	114	15.8	15.0
Grants for pruning	ha	192	168	5.3	2.2
Grants for first thinning	ha	577	326	4.0	2.1
Grants for second thinning	ha	—	210	—	1.4
Grants for fences	ha	2,469	—	17.1	—
Grants for manual shrub clearing	ha	894	673	86.9	53.1
Grants for sanitary treatments	ha	—	245	—	13.3

¹ The values of commercial and environmental output refer to the afforestation cycle of length T_n (see Table 2). Each per hectare and year output value (x) is estimated using the equation, $\sum_{t=0}^{T_n} x(t) \cdot (1/T_n)$.

² t refers to a metric ton.

³ Grazing exclusion, which excludes both domestic livestock and wild animal browsing owing to fence installation in this site, is prescribed for a 20-year period in Aljibe.

They were obtained from in-depth interviews with local agents: landowners and forestry companies working in both study sites (Tables 1 and 3). This enables simulation of the outputs and costs that would be obtained in the event of a cork oak stand being established and managed as outlined in the exogenous silvicultural models throughout the cork oak stand life cycle. The market value attributed to hunting revenue is the annual monetary amount that landowners would obtain from leasing their properties out for big game in Aljibe and small game in Gavarres local markets. Grazing resource revenue in Aljibe is the local market price for leasing 1 ha of cork oak woodland and 1 ha of shrubland.

For treeless land uses we consider that the only source of private market revenue that landowners obtain in Aljibe comes from leasing 1 ha of shrubland for grazing and big game purposes. In Gavarres, we assume that the landowner would receive revenues from leasing dry land out to other farmers for cereal or pulse crops, as well as from leasing land to a local hunting association for small game.

Total private costs included in the analysis are predominantly related to the management of cork oak stands (forestry treatments and cork stripping). On the other hand, it is assumed that there are no management costs associated with private amenities. Total costs include intermediate consumption of raw materials and services and the labor costs of employees. We assume that forestry treatments are performed by external companies using their own machinery. Thus, there are no general costs or machinery or equipment asset depreciation costs affecting the cork oak woodland silviculture costs. The only general costs come from private expenses for maintaining firebreaks and access roads and are equally distributed among the land uses of the studied sites (Table 1).

Landowners also receive grants defined by Spanish Regulation 6/2001 (Boletín Oficial del Estado 2001) to cover plantation costs, a 5-year maintenance cost premium for native broadleaf species, and a 20-year income loss cover premium depending on previous land use. For the income loss cover premium, we consider the minimum grants to marginal shrublands in Aljibe and herbaceous croplands in Gavarres. Our analysis also includes other grants defined by the regional governments for shrub clearing, thinning, first pruning, and maintenance works for firebreaks and roads (Table 3).

For ensuring the persistence of afforested stands once subsidies come to an end, the Spanish regulation states that holders of afforestation grants for slow-growing species have the obligation of registering the afforested tract as forestland (Boletín Oficial del Estado 2001). This registers the afforested land under the rules of the Spanish Forest Law, which heavily restricts forestland use change on both privately- and publicly-owned land (Boletín Oficial del Estado 2003). Even in the event of a forest fire, these restrictions apply, and forestland status cannot be changed.

Finally, landowners benefit from private amenities such as recreational uses, lifestyle, heritage values, and enjoyment of nature in general (Smith and Martin 1972, Campos et al. 2009). Because market prices do not exist for the annual consumption of private amenities, environmental valuation techniques are required to estimate their annual income value (Campos et al. 2009).

Private amenity values are obtained from the results of a contingent valuation (CV) survey applied to a sample of Aljibe and Gavarres woodland owners (Campos et al. 2009). The amenity income is estimated as the maximum amount of money that woodland owners are willing to give

up (to pay) before selling their property to move to an alternative investment (for a detailed discussion of this CV design and its advantages with respect to other environmental valuation techniques, see Campos et al. 2009). This willingness-to-pay (WTP) question was referred to the entire mosaic of land uses (forest and treeless lands) for the property of each landowner surveyed. Thus, this income value does not differentiate between the different land uses of the areas studied.

We use the mean WTP as the monetary value for the amenity income of the Aljibe and Gavarres landowners because it represents the maximum WTP that a landowner would pay on average in a hypothetical market for this amenity consumption. We accept that in this hypothetical market each property is a quasi-unique asset and the maximum WTP from each potential consumer (landowner) could be collected (Campos and Caparrós 2009). Otherwise, a single price would be set in the market (for a detailed discussion, see Campos and Caparrós (2009)).

The assumption of a common market value for each different land use in the property (and consequently in the area studied) places an important limitation on our analysis. Cork oak afforestation implies a change in the mosaic of land uses in favor of forestland, and this could have an impact on the private amenity values. Because the CV surveys used for estimating amenity values did not perform a cross-temporal analysis, we cannot estimate how WTP varies if the land uses of the property change. However, we can perform a cross-sectional analysis of the WTP values and the land uses of the properties from the landowner sample to estimate the marginal variation in the WTP value derived from a variation of the forestland in the properties. To this end, for both case studies we performed linear and semilog regressions using the WTP as the dependent variable and the hectares of land covered by trees in the property (TREE) and its quadratic term (TREE²) as explanatory variables.

Net Benefits from Cork Oak Afforestation

Net benefits of afforestation are calculated considering the present values of the private capital incomes that a landowner obtains from afforesting cropland or shrubland with cork oak or alternatively from these treeless land uses. Private capital incomes are estimated as the difference between the value of total outputs (TO) and total costs (TC) for each year t in the period considered. Market revenues from cork and firewood and from grazing, game, and dry land rents (CO) and the imputed value of private amenities (PA) are the components of TO in calculation of capital income at market prices (CI_{MP}). Capital income at factor cost (CI_{FC}) also includes operating subsidies net of taxes on production (OST):

$$CI_{MP}(t) = CO(t) + PA(t) - TC(t), \quad (1)$$

$$CI_{FC}(t) = CO(t) + PA(t) + OST(t) - TC(t). \quad (2)$$

From the perspective of society, national income does not include taxes or subsidies on production. This criterion is followed by the standard system of national accounts

(SNA 2008) when the net value added is estimated as the balancing item of the production account at market prices. Thus, capital income at market prices shows the operating surplus that a landowner receives in pure market conditions. However, when taxes and subsidies on production are included, the SNA 2008 balancing item of the generating income account becomes the net operating surplus at factor cost obtained by the landowner (European Communities et al. 2009, Table 2.13, p. 31). Therefore, we estimate the net benefits of cork oak afforestation at market prices and factor costs to show the economic benefits for society and landowner, respectively, at both case study sites.

The present value of capital income flows and net benefits from the cork oak afforestation is evaluated for three time horizon frames (T): the first when the cork oaks are 20 years old, which is the end of the government premium to cover income losses; the second when the cork oaks are 67 years old, given that at this age at least three cork harvests have been performed at both sites; and the third when the cork oaks are 143 years old, which in both cases is close to the end of the afforestation productive cycle.

Annual incomes (y_a) from cork oak afforestation are estimated according to Equations 1 and 2 for each year (t) of the time horizon frames considered, except for the initial ($t = 0$) and final ($t = T$) years. In the initial year, the land capital value (P_j) starts with a negative sign in the capital income equation. In the final year, it enters with a positive sign and discounted (Campos et al. 2003). Thus, the present value of the annual income flows from cork oak afforestation (V_a), at each of the time horizon frames we analyze (T), is determined in accordance with the expression,

$$V_a = (y_a(0) - P_j) + \sum_{t=1}^{T-1} \delta^t y_a(t) + \delta^T (y_a(T) + f(T)), \quad (3)$$

$$T \in \{20, 67, 143\}.$$

where δ is the discount function of type $1/(1 + r)$, r is the annual discount rate, P_j is the market price of land use j on which the cork oak plantation is established, and $f(T)$ is the cork oak woodland expected value according to the estimated land price function at the end of each of the time horizons evaluated.

In contrast, the present value (V_j) of the annual income flows (y_j) [4] derived from the treeless land uses (alternative to cork oak afforestation), at each one of the time horizon frames we analyze (T), is estimated as

$$V_j = (y_j(0) - P_j) + \sum_{t=1}^{T-1} \delta^t y_j(t) + \delta^T (y_j(T) + P_j), \quad (4)$$

$$T \in \{20, 67, 143\}.$$

The undiscounted land value (P_j) at the end of the time horizon frame analyzed matches up with the land price at the initial period, because Equation 4 indicates the present value associated with a scenario in which there is no land use change. In analyzing net benefits of land use change, what counts for comparison purposes are the differences between the present values of capital incomes from cork oak

afforestation and the alternative scenario of continuing with treeless land uses (either shrubland or cropland): $V_a - V_j$.

Cork Oak Woodland Price Functions Estimation

To estimate the land value that a hectare of cork oak woodland would generate according to the age of the trees, we consider capital incomes derived from market revenues and from private amenities. To this end we estimate a continuous function $[f(t)]$ for the cork oak woodland price for each site that relates the expected value [5] of an even-aged cork oak woodland (z , measured in 2002 € per hectare) to the age of the cork oaks (t , measured in years). We assume that after the afforestation cycle, the cork oak would enter an aging process and eventually disappear [6] because Campos et al. (2007) and Ovando et al. (2009) show that there is no evidence that the natural regeneration of aging cork oak woodlands would be facilitated under current market prices and government economic incentives. Thus, the range of annual capital incomes (CI_{MP}) we use to estimate cork oak woodland functions corresponds to cork oak woodland starting from afforestation with no natural regeneration and then returning to the original shrubland (Aljibe) and dry land (Gavarres) uses at the end of its life cycle.

The expected value of a cork oak woodland of age t , in transition to a j treeless land use ($V_{a,nr \rightarrow j}$), is defined by the expressions

$$V_{a,nr} = \sum_{i=t}^{T_{n+m}} \delta^{i-t} y_{a,nr}, \quad \forall t \in \{1, \dots, T_{n+m}\}, \quad (5)$$

$$V_{a,nr \rightarrow j} = V_{a,nr(t)} + \delta^{T_{n+m}+1-t} \left(\frac{1}{1-\delta} \right) y_j, \quad \forall t \in \{1, \dots, T_{n+m}\},$$

where $y_{a,nr}$ is the annual capital income (CI_{MP}) at market prices of cork oak woodland at year t , considering that after T_{n+m} years the cork extraction activity would come to an end [7] and the stream of private capital income is replaced by the stream of capital incomes ($CI_{MP,j}$) accrued from a treeless j land use (y_j). Note that land expected value is estimated without considering net operating subsidies, as we assume that current government subsidies do not affect the land market prices because they are transitory and have little influence (Campos and Martínez 2004).

We estimate a series of cork oak woodland expected land values for cork oak ages ranging from year 1 to year T_{n+m} ,

using as discounting rates the profitability rates of the treeless land uses before afforestation. These values are used to estimate cork oak woodland price functions $[f(t)]$.

Discount Rates Estimation

For private investments, returns should profit above the opportunity cost of capital (Row et al. 1981). For afforestations, this opportunity cost of capital could be represented by the profitability rates (rates of return on capital) of alternative land uses.

In this study, we use the profitability rates from shrubland and cropland uses before cork oak afforestation, based on 2002 market conditions, to discount the future stream of capital income from these land uses and from cork oak afforestation. These discount rates connect the present value (in an infinite time horizon frame) of private capital income at market prices from a land use j (displaced by the cork oak plantation) to its market price (Table 4).

We represent a standard shrubland in Aljibe and a dry land crop field in Gavarres. These land uses, with a land market price P_j , generate commercial and environmental outputs to the landowner. We assume that the annual capital income at market prices from the land use j ($CI_{MP,j}$) obtained by the NIPF landowner is stationary and that the capital investment allocated in 1 year to generate this capital income reflects the present value of the expected future stream of commercial and amenity capital incomes for this j land use. Hence, the profitability rate (r_j) from land uses before cork oak afforestation comes from the equation

$$r_j = \frac{CI_{MP,j}}{P_j}. \quad (6)$$

Because of the lack of statistical information on land market prices for specific land uses at the sites studied, we estimate the shrubland (Aljibe) and dry land (Gavarres) market prices based on the prices stated by a sample of landowners for those land uses in 2002 (we used CV experimental data from Campos et al. 2009) [8].

Results

Private Amenity Values

The CV survey of Campos et al. (2009) showed a mean WTP of €213 ha⁻¹ for the Aljibe landowners ($N = 40$) and €225 ha⁻¹ for the Gavarres landowners ($N = 30$) [9]. These estimates represent the monetary value of the amenity consumption of the average woodland owner for

Table 4. Shrub and cropland uses annual capital incomes, land prices, and estimated profitability rates (2002 € per hectare)

Class	Annual capital income				Land price: (P_j) ¹ (f)	Profitability rates ²	
	CO-TC (a)	PA (b)	CI_{MP} (c = a + b)	OST (d)		r_c (g = a/f · 100)	r (h = c/f · 100)
						(%).....	
Aljibe	51	213	264	11	275	0.8	4.1
Gavarres	80	225	305	4	309	1.6	6.0

¹ Average land prices considering the prices stated by a sample of 49 landowners in Aljibe and 17 landowners in Gavarres.

² The profitability rate denoted by r is estimated considering the private capital incomes derived from market goods and services and private amenities, whereas r_c is estimated considering only commercial capital incomes.

an accounting period (in this case, year 2002) and for the mix (mosaic) of land uses of the average property of the sample. These values are integrated in the cost-benefit analysis as the annual private amenities obtained from 1 ha of the property during the life cycle of the cork oak afforestation, assuming that they are common to all land uses of the property and that they remain constant over time.

If we assume that the amenity values of forestland differ from those of treeless land, then we have to use the regressions in Table 5. These regressions place the WTP as a function of the forestland in the property. We found significant effects for the Aljibe case but not for the Gavarres site. The absence of this effect in Gavarres could be caused by the fact that the properties in this sample have an important proportion of their surface covered by trees (92% on average) and that additional units of forestland do not provide higher amenity values to them. Therefore, the analysis considering forestland effects on amenity values will focus exclusively on the Aljibe site.

In Table 5 [10], the intercept represents the WTP value common to all land uses. The parameter for TREE and TREE² represents the marginal change in the WTP value caused by an increase in 1 ha of the forestland in the property and its squared term, respectively. For the linear model (WTP-lin), an increase of 1 ha of forestland in the average property in the sample (a piece of land of 827 ha) implies an increase of €0.144 ha⁻¹ in the WTP. For a 25-ha afforestation size project the increase is €3.49 ha⁻¹ and for a 50-ha afforestation size project the increase is €6.74 ha⁻¹. For the semilog model (WTP-slog), these increases in WTP are €0.182 ha⁻¹, €4.45 ha⁻¹, and €8.69 ha⁻¹, respectively.

Cork Oak Woodland Prices Functions and Discounting Rates

Figure 1 shows the cork oak woodland price functions $[f(t)]$ estimated for Aljibe and Gavarres. In Gavarres, a quadratic function (without intercept) is the one that better represents the evolution in cork oak woodland value as a function of the age of the oaks. In Aljibe, a cubic function

better illustrates this relation. In both cases, the functions display proper adjustments (adjusted $R^2 > 0.95$).

The profitability rates for the land uses before afforestation are 4.1% in Aljibe (shrubland) and 6.0% in Gavarres (dry land farming). In Aljibe we round this number up to 4.0%. These rates will be used for discounting the stream of expected capital income.

Cork Oak Afforestation and Alternative Land Use Comparison

Table 6 shows the present value of private capital income for the complete cork oak afforestation cycle for the three time horizons evaluated in Aljibe and in Gavarres, where we assume similar amenity values for all land uses of the property. Note that for these results the difference between the PV depends solely on market output and costs.

At market prices, the capital income PV displays negative values for all of the time horizons evaluated. Similarly, the net benefits of afforesting with cork oaks are negative at both sites. Negative net benefits tend to increase within the time length of the evaluated horizons in Aljibe. In Gavarres, net benefits remain practically the same throughout the time horizons analyzed.

At factor costs (when net operating subsidies are taken into account), planting shrubland with cork oaks in Aljibe is the preferred investment option for a landowner who demands profitability rates ranging from 2 to 6% (Table 6; Figure 2). In Gavarres, planting cork oaks on dry land is also efficient in economic terms when subsidies are taken into account for landowners who implicitly demand a profitability rate of 6%. At this site, cork oak afforestation generates lower net benefits than those accrued at the Aljibe site in all of the time horizons analyzed (Table 6). However, at higher discounting rates (>6%) the cork oak afforestation option in Gavarres tends to be better than that in Aljibe because of the effect of afforestation grants that are received throughout the first 20 years of the afforestation cycle (Figure 2).

Two key market factors that affect net benefits derived from afforestation projects are cork prices and land rents from treeless land uses before afforestation takes place. In

Table 5. Regression models for the landowners' willingness to pay (WTP) in the Aljibe and in the Gavarres sites

Parameters	Aljibe		Gavarres	
	WTP-lin	WTP-slog	WTP-lin	WTP-slog
INT (intercept)	113.410 (34.545) ¹	4.626 (0.199) ¹	402.952 (87.965)	5.525 (0.321)
TREE (hectares of the property covered by trees)	0.351 (0.101) ¹	1.984E-03 (5.854E-04) ¹	-0.952 (0.796)	-2.307E-03 (2.907E-03)
TREE ² (square of hectares of the property covered by trees)	-1.883E-04 (5.548E-05)	-1.056E-06 (3.203E-07)	6.080E-04 (6.610E-04)	1.442E-06 (2.414E-06)
N	36	36	30	30
R ²	0.2691	0.2602	0.0687	0.0329
Adjusted R ²	0.2248	0.2154	-0.0003	-0.0387
χ ² test	11.29 ¹	10.85 ¹	2.13	1.01

Data are presented as coefficients (SE).

¹ Significant at the 1% level.

lin, linear; slog, semilog.

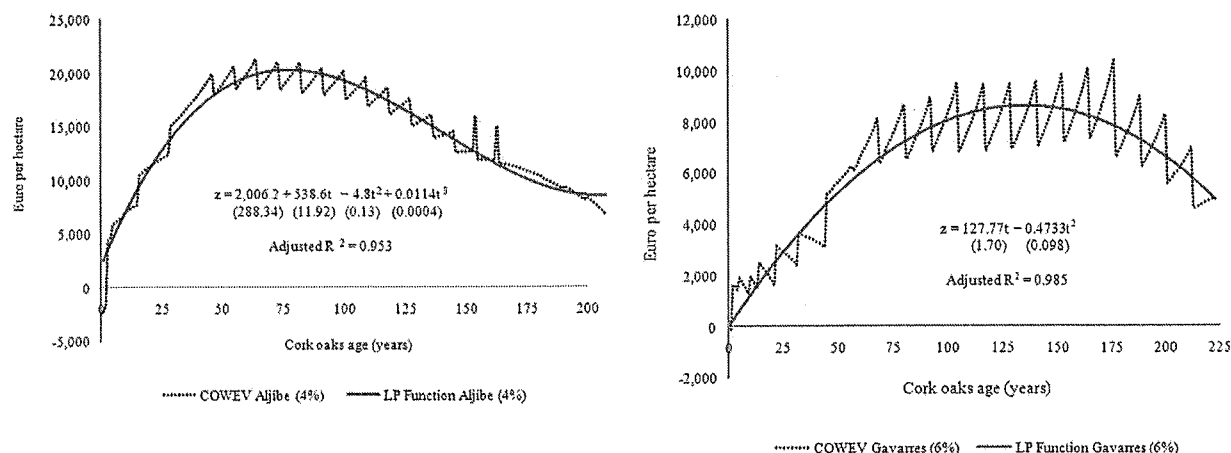


Figure 1. Cork oak woodland price functions, where z represents the land price (LP) function considering cork oak woodland expected values (COWEV) and the cork oak stand age (t). Data are reported as 2002 € per hectare. SEs are presented in parentheses. All the parameters are significant at 1% levels.

Table 6. Present values of cork oak afforestation capital incomes and net benefits

Class ¹	Aljibe			Gavarres		
	20 yr	67 yr	143 yr	20 yr	67 yr	143 yr
CI_{MP}						
Cork oak afforestation (A)	-7,234.3	-8,272.9	-8,696.8	-5,376.3	-5,224.0	-5,233.7
Treeless land (B)	367.3	440.2	453.2	273.7	260.4	259.5
Net benefit market prices (A - B)	-7,601.63	-8,713.10	-9,150.01	-5,649.94	-5,484.45	-5,493.23
CI_{FC}						
Cork oak afforestation (A)	1,691.1	1,980.9	1,733.4	731.7	1,175.0	1,188.1
Treeless land (B)	523.9	699.8	731.2	327.3	335.0	335.5
Net benefit factor costs (A - B)	1,167.2	1,281.2	1,002.3	404.4	840.0	852.6

¹ Private discount rates of 4% in Aljibe and of 6% in Gavarres. Mean willingness-to-pay values are used.

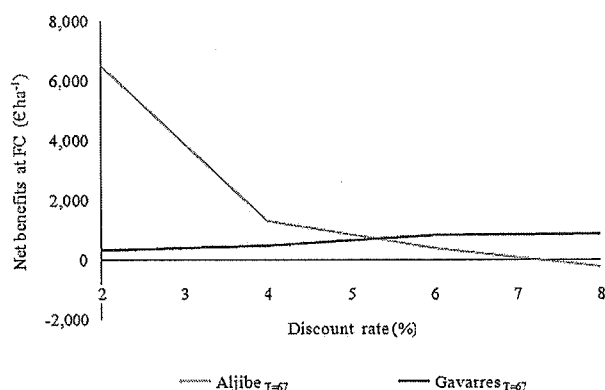


Figure 2. Sensitivity of cork oak afforestation net benefits PV to discount rates. Data are reported as 2002 € per hectare.

Aljibe, although the opportunity cost of alternative land uses is lower than that in Gavarres, planting cork oaks would become a worse investment than grazing and game if the rent from these uses were 100% higher. In Gavarres, cork oak afforestation would start off being less competitive when crop and small game rents were 61% higher (Figure 3).

The effect of Cork price variations on land use change net benefits is more significant in Aljibe than in Gavarres because of the longer time length needed in Gavarres before

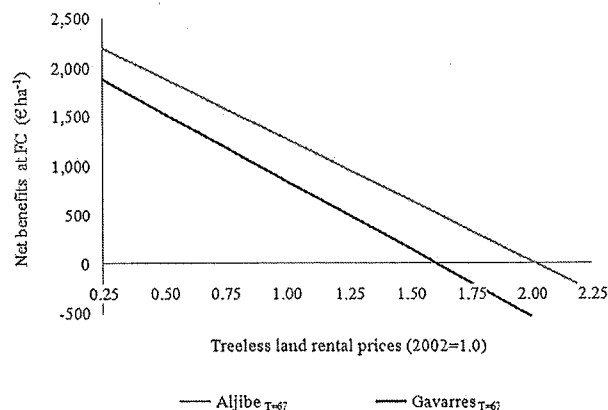


Figure 3. Sensitivity of cork oak afforestation net benefits PV to treeless land rental prices. Data are reported as 2002 € per hectare.

cork of commercial interest can be obtained (Montero et al. 2009b). In Aljibe, a decrease of 30% in cork prices would make the afforestation investment less profitable than maintaining the treeless shrubland (Figure 4).

Government grants are the major factor affecting afforestation net benefits. The effect is more pronounced when the afforestation is evaluated, considering the results of the first 20 years ($T = 20$). In Aljibe, a decrease of 15% in the

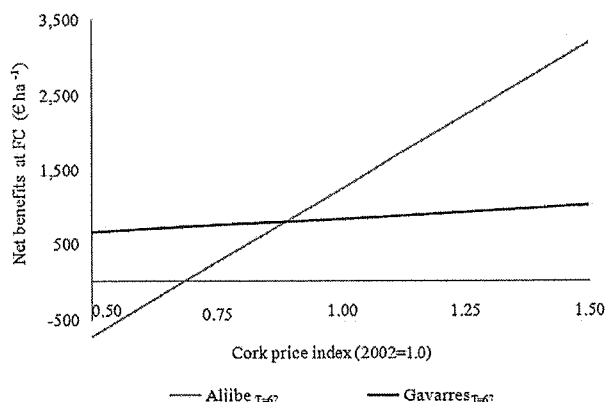


Figure 4. Sensitivity of cork oak afforestation net benefits PV to cork prices. Data are reported as 2002 € per hectare.

current European afforestation grants during the first 20 years of the plantation's life cycle would make this forestry investment less advantageous than the alternative one in this study site. In Gavarres, the level of government subsidies would have to fall to 7% to make cork oak afforestation less profitable than maintaining treeless shrubland for the 20 years time horizon analysis (Figure 5).

For taking into account variations in amenity values as a consequence of the afforestation, we use the linear regression model for Aljibe from Table 5 because of its higher goodness of fit. Using the results from this model, we simulate the effects on the amenity value of cork oak afforestations of 10, 25, and 50 ha in a single property [11] in the Aljibe site.

According to the model, the amenity value of the average NIPF landowner in the Aljibe case (a landowner who owns an 827-ha property in which 548 ha correspond to forestland) is €249 ha⁻¹. This value rises to €252 ha⁻¹ for an increase in 25 ha of the forestland in the property and to €256 ha⁻¹ for an increase in 50 ha of forest surface.

Considering these values, we estimate the PVs of cork oak afforestation net benefits per planted hectare as shown in Figure 6. The variation in the private amenity value for a

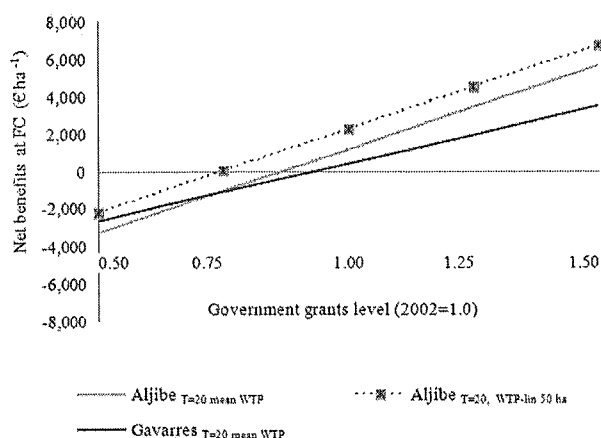


Figure 5. Sensitivity of cork oak afforestation net benefits PV to government grant levels. Data are reported as 2002 € per hectare.

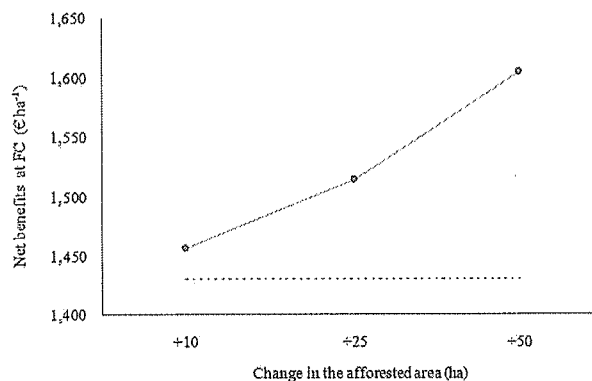


Figure 6. Sensitivity of cork oak afforestation net benefits PV to private amenity values in the change in the afforested area in Aljibe with respect to the average forest area (548 ha) in the sample of landowners surveyed by Campos et al. (2009). Data are reported as 2002 € per hectare.

50-ha afforestation increases the PV of the cork oak afforestation by €168.5 ha⁻¹. However, given these results, it is expected that under pure market conditions (without subsidies) private amenities by themselves do not encourage cork oak afforestation.

Nonetheless, the relation between the WTP for private amenities and government grants for afforestation may be an important issue. The presence of higher private amenity levels attached to more afforested land may justify the reduction in government expenses for encouraging oak woodland conservation. In the case of Aljibe, when we simulate a 50-ha afforestation, we found that government grants have to fall by up to 25% before the PV of net benefits becomes a negative figure (Figure 5). This finding implies that grants can fall 10% more before an afforestation project becomes an undesirable investment for the landowner compared with the scenario that considers the same amenity value for all the mosaic of land uses.

Discussion and Conclusions

Our results show that the EU targeted afforestation program and other regional government grants for forest management provide enough economic incentives to drive NIPF owners to carry out afforestation investments in alternative land uses in the Aljibe and Gavarres sites in Spain (with 2002 prices and subsidies). These results are consistent with the observed behavior of landowners of extensive agricultural lands suitable for growing cork oaks, before and after the application of European Regulations 2080/1992 and 1257/1999 in Spain.

Nonetheless, the response of private landowners has been dissimilar in Spain. Most of the plots afforested with cork oaks are located on treeless land previously used for extensive cropping and grazing in the Western Andalusia and Extremadura regions. Our Aljibe results and the findings of Campos et al. (2003) confirm that these government grant schemes are encouraging this land use change in the Southwestern Spanish *montes* and *dehesas*, within a context of an efficient private land use choice. In contrast, in Gerona province (where Gavarres is located) scarcely 57 ha of pure

and mixed cork oak stands have been afforested under European Regulation 2080/1992 between 1993 and 2000 (Ovando et al. 2007), despite the expected positive net benefits that landowners would have obtained from these investments.

The limited success of cork oak afforestation on land previously used for agriculture at Gavarres could be linked to the level of forestry incentives but also to the incentives for agriculture, which can increase the opportunity cost of land use change. However, this limited success even holds for plots with a relatively low opportunity cost, as is the case for marginal dry land, where cork oak afforestation would generate net benefit in Gavarres [12]. Thus, the limited success of afforestation with this species could also have been influenced by the preference of landowners for maintaining the current mosaic of land uses and vegetation on their properties, especially because the current cork oak woodland surface exceeds 50% of the Gavarres massif. In addition, we should not forget that within the Gavarres context, land fragmentation can also be one of the reasons for the small number of afforestation projects observed in this site. In this context of land fragmentation, the main reasons for maintaining the rural private properties in Gavarres may be related to the self-consumption of private commodities (game) and amenities (recreational values, legacy, and others).

Using the contingent valuation experiment data of Campos et al. (2009), we have found a positive relationship between the WTP for private amenities and the forestland area in the Aljibe site. Although the increase in the amenity value derived from an increase in the forestland is not high enough to encourage cork oak afforestation in the absence of government grants, it implies that the minimum compensation level for undertaking an afforestation project in Aljibe could be lower. In the Gavarres site, we did not find this relationship to be significant, which may suggest the presence of a saturation effect associated with the proportion of forestland in the land properties.

The results of this study show that the EU afforestation programs may have encouraged the long-term conservation of cork oak woodlands, given the long life cycle of this species, in the Aljibe and Gavarres sites in Spain, providing incentives for carrying out cork oak afforestation within a context of an efficient land use change decision. Landowners have enlarged their long-term market incomes and may have increased the value attached to the private amenities of their properties.

Apart from private benefits, EU afforestation policy may have also have provided diverse public benefits to society (i.e., public scenic values, biodiversity, carbon storage, and flood and erosion control), as this was the main reason that these afforestation policies were launched (Boletín Oficial del Estado 2001). However, the social dimension of the benefits generated from these afforestations is beyond the scope of this article, and further research is needed to determine whether or not the cost of these government grants is socially justified and worth the public benefits they provide.

Endnotes

- [1] Grazing exclusion is prescribed for a 20-year period in Aljibe, this period being a mandatory condition to get income loss cover premium in the frame of the EU afforestation targeted program.
- [2] Cork oaks are always stripped in summer, whereas other forestry treatments are normally undertaken during autumn and winter.
- [3] The CV survey for valuing private amenities was conducted in Gavarres in 2002 and in Aljibe between 2002 and 2004. Aljibe data were adjusted to 2002 € using the consumer price index (Campos et al. 2009).
- [4] Estimated according to Equations 1 and 2, except for the initial ($t = 0$) and final ($t = T$) years.
- [5] Note that this land expected value is not restricted just to the stand expectation value because it includes, besides the present value of other private nontimber, market incomes and private amenities.
- [6] Afforestation grants are conceived for converting agricultural lands to forest and because these newly afforested lands should be registered as forestland, once the first afforestation cycle comes to an end this plot cannot be elected for afforestation grants again.
- [7] In Aljibe, some cork oaks remain standing until they die, whereas no further firewood extraction is presumed to take place. In Gavarres, the model considers that the remaining aged cork oaks are clearcut before the land is shifted back to agriculture.
- [8] The survey procedure is a common criterion for estimating land prices, for example, by the US Department of Agriculture (US Department of Agriculture 2007).
- [9] The WTP values expressed in € ha⁻¹ are weighted by property size. This weighted mean represents the average value for the total sampled land because each WTP value has a different weight according to the corresponding property size.
- [10] Other regressions were tested using additional explanatory variables. For example, the size of the property was introduced as an explanatory variable but was correlated with the variable TREE.
- [11] In the region of Andalusia, where Aljibe is located, 50 ha was the maximum surface area (by individual landowner) that could benefit from EU afforestation subsidies.

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