

Cost–Benefit Analysis of Cork Oak Woodland Afforestation and Facilitated Natural Regeneration in Spain

PAOLA OVANDO, PABLO CAMPOS, JOSÉ L. OVIEDO,
AND GREGORIO MONTERO

Cork oak woodlands in Spain occur mostly in large private estates in the west-southwest (80 percent) and in the northeast (Girona province, 13 percent), and the remaining 7 percent are spread in isolated patches in the central and eastern (Castellón province) parts of the country (see Figure 1.1). The occasional cropping of cereals, which was formerly practiced in many cork oak woodlands, has nearly disappeared over the last three decades (Moreno et al. 2007).

Two trends have emerged with regard to livestock. In the west-southwest, stocking rates and grazing pressure have increased, exacerbating the traditional lack of natural regeneration by cork oaks (Pulido et al. 2001; Chapter 10). In sharp contrast, in the northeast there is widespread abandonment of livestock, which leads to a rapid buildup of excess biomass in the cork oak woodland understory. Thus, cork oak woodlands in the northeast now contribute significantly to carbon sequestration in the short to medium term, except for the fact that they are increasingly decimated by fires. As a result, government expenditures for fighting and preventing wildfires maintain the woodlands as a carbon sink. This leads to an equity problem because ultimately it is affluent people in the cities who are the main beneficiaries of both types of public expenditure.

For some, the lack of natural regeneration of oaks in the cork oak woodlands of the west-southwest of Spain and the biomass problems of the northeast are both undesirable to the public. And in the medium to long term, both trends appear to be unsustainable from a competitive commercial cork productivity perspective. Both unsustainable management regimes appear to generate competitive private profit rates through rising real estate prices, private amenity values, cork harvesting, rental fees for hunting of wild game,

livestock grazing, and various government subsidies (Campos et al. 2008c). Nevertheless, the long period of cash losses before the time of first commercial cork stripping in cork oak stands resulting from afforestation or facilitated natural regeneration makes the expansion and renewal of cork oak woodlands economically unattractive to private landowners. If benefits and costs at current market prices are considered alone—that is, in the absence of government or international subsidies—in the short and medium term, those investments generate cash losses (Campos et al. 2007b). Nevertheless, as mentioned in Chapter 14, southern European governments and concerned interest groups state that the predicted decline of cork oak woodland public and private benefits should be offset by increasing public expenditures on cork oak afforestation and natural regeneration (ID 1997; CMA 1999; WWF 2004).

In this chapter we present an extended cost–benefit analysis for evaluating possible capital income changes, from both private and social capital perspectives in the case that either afforestation or facilitated natural regeneration is undertaken as an alternative to the two trends cited earlier. The two land management scenarios presented are commercially oriented. We assume a non-industrial woodland private owner with a mixed low-risk investor–consumer reasoning process. This implies that private landowner demands commercial returns while enjoying the private amenities derived from the woodland, shrubland, and cropland environmental services.

This cost–benefit analysis was applied in three Spanish cork oak woodland sites with different management schemes: the Aljibe massif in the southwest (Andalusia), the Monfragüe plain in the west (Extremadura), and the Gavarres massif in the northeast (Catalonia). The Aljibe site is located inside the Los Alcornocales Natural Park (see Site Profile 17.1), the Monfragüe site is part of the buffer zone of Monfragüe National Park, and the Gavarres site is a protected natural area.

Cork Oak Woodland, Shrubland, Pasture, and Cropland Management Scenarios

We simulated six idealized sustainable silviculture models for investment scenarios in pure cork oak stands: three of afforestation of bare lands and three of commercially oriented, facilitated natural regeneration. The latter entail different kinds of costly interventions, especially at the earliest stages of the cycle (e.g., for removing competing vegetation and preventing the entry of livestock and other herbivores).

We compared these six scenarios with six corresponding noninvestment scenarios, where *noninvestment* refers exclusively to the lack of cork oak forestry treatments. Those alternative scenarios were three bare lands and three aging cork oak woodlands with no treatments to encourage natural regeneration. These twelve forecast models are well adapted to the current technical and economic conditions of the three study sites. Indeed, the idealized silviculture models are based on actual data for cork oak growth and cork yields at Monfragüe, Aljibe, and Gavarres sites.

The six investment scenarios include a series of cork oak forestry treatments to be completed over the entire productive cycle of afforestation or of a facilitated natural regeneration. The main prescribed treatments are twenty years of grazing exclusion only in Aljibe and Monfragüe, because there is no livestock grazing in the Gavarres site. In addition, at all three sites, treatments include structural tree pruning, selective thinning, shrub clearing, and regeneration felling, which consists of cutting a large percentage of aging cork oak trees in such a way that on-site seeding under the tree canopy is encouraged without completely forgoing cork extraction. This is made possible by leaving the most productive trees standing until the final clear-cut of remaining mature trees takes place (for details see Campos et al. 2007b). According to the silviculture models analyzed, cork stripping takes place every nine years in Aljibe and Monfragüe and every twelve years in Gavarres after the first cork oak stripping, which takes place when trees are twenty-six years old in Monfragüe, twenty-eight years in Aljibe, and forty-four years in Gavarres. In all three cases, the first stripping takes place when the trees reach a circumference of 60 centimeters at breast height.

To simulate afforestation investment scenarios, we assumed that the current vegetation cover, where new plantations are being carried out, is unproductive shrubland in Aljibe, pastureland in Monfragüe, and marginal cropland in Gavarres. The ideal silvicultural models start with afforestation using cork oaks, followed by the application of the aforementioned forestry treatments. In the three investment scenarios based on facilitated natural regeneration, we assumed that the current vegetation is aging cork oak woodland at all three study sites, where trees are 144 years old in Aljibe and Monfragüe and 151 years old in Gavarres. In this case, our silvicultural models start with regeneration felling treatment on the senescent woodland, followed by the application of pruning, thinning, and shrub clearing as needed.

For the three facilitated natural regeneration scenarios, the corresponding nonrenewal scenarios were the aforementioned aging cork oak woodlands. In this case, however, the regeneration treatment is not applied at the time that

regeneration felling should, in theory, be carried out. Under these noninvestment scenarios, the cork oak will disappear in the future, as we assume that livestock grazing in Aljibe and Monfragüe and marginal crops in Gavarres are the private owners' main commercial interests. It is expected that in Aljibe and Monfragüe, cork stripping will cease after a few decades, as a direct consequence of declining tree numbers and cork productivity, resulting eventually in the complete disappearance of cork oak and a return to shrubland and pastureland uses, respectively. In the case of Gavarres, however, we assumed that the noninvestment scenario would reduce commercial cork productivity, with a subsequent abandonment of commercial cork-oriented treatments and a return to cropland use after the unproductive cork oak stand is cleared.

Present Discounted Values of Capital Income from Cork Oak Investment and Noninvestment Scenarios

In our forecast models, landowners obtain private capital income from the sale of cork, firewood, cropland rents, grazing, and hunting rents, as well as government net subsidies and private amenities (i.e., nonmarket, self-consumption services internalized in woodland market prices). The landowners, visitors, and society as a whole all benefit from the social capital income derived from private capital *income at market prices* (without consideration of net subsidies) and from the public environmental capital income (i.e., public environmental benefits minus government expenditures). For the latter income, we incorporated three public environmental incomes: the recreation services provided for visitors, natural habitat conservation (joint option and existence values) services for visitors (only at Aljibe and Monfragüe), and cork oak woodland carbon sequestration services at all three sites. Furthermore, we assumed that government subsidies and taxes would influence current private capital income gain and loss, respectively, but not modify the current social capital income of cork oak woodlands.

We further assumed constant prices corresponding to real (sales, net subsidies, and costs) or estimated (private amenity and public environmental benefits) market prices in 2002. Even so, we analyzed the sensitivity of results to variations on 2002 cork prices ranging from ± 25 percent to ± 50 percent. In order to aggregate both commercial and environmental benefits in a homogeneous manner, we used simulated *exchange prices* for private amenity, recreation, habitat conservation, and carbon sequestration services (Campos et al. 2008c).

Private and Public Benefit Exchange Values

Except for private amenity value, woodland private benefits were drawn as direct market exchange values (i.e., price time quantity) (Table 15.1). The values attributed to hunting rent reflect the amount that landowners would be paid for leasing their estates for developing big (Aljibe and Monfragüe) or small game (Gavarres), net of costs and taxes. The grazing rent reflects the market prices for leasing 1 hectare of cork oak woodland, shrubland, or pastureland, for supplying edible food for livestock grazing (Campos et al. 2007b).

The commercial benefits that landowners obtain from bare lands before cork oak afforestation in Aljibe and Monfragüe derive from grazing and hunting. In Gavarres, landowners obtain revenues from leasing land for cropping and from renting hunting rights (Table 15.1).

Private amenity includes owners' exclusive on-site enjoyment (current active use) plus a number of landowner option values (future active use) and passive uses (existence values) (Campos et al. 2007a; see Table 13.1). The private amenity value was measured by three *contingent valuation surveys* ap-

TABLE 15.1.
Commercial and environmental benefit prices in Aljibe, Monfragüe, and Gavarres (2002 €/unit).

Class	Aljibe	Monfragüe	Gavarres
Commercial benefits			
1. Summer stripped cork (kg) ^a	1.10	1.18	1.18
1.1 Virgin cork (kg)	0.24	0.27	0.30
1.2 Reproductive cork (kg)	1.17	1.22	1.28
2. Winter cork (kg)	0.10	0.06	0.15
3. Firewood without bark (kg)	0.03	0.02	0.04
4. Grazing rent (forage units)	0.09	0.10	
5. Hunting rent (ha)	38.10	42.10	9.00
6. Dry cropland rent (ha)			79.80
Environmental benefits			
1. Private amenity (ha)	209.30	100.20	225.40
2. Public visitor services (ha)	11.00	23.00	n.a.
2.1 Recreation (ha)	5.10	10.50	
2.2 Conservation (ha)	5.90	12.50	
3. Carbon (t C)	23.00	23.00	23.00

^aAverage summer stripped cork price is estimated considering the share of virgin and reproductive cork obtained at each site.

n.a., not available.

plied to a sample of cork oak woodland owners in Los Alcornocales Natural Park, Monfragüe district, and the Girona province. We assumed that the private amenity value was the same for all the land uses considered at each study site (Table 15.1), although we recognize that this might not be realistic. The monetary amounts that public visitors of Monfragüe and Aljibe were assumed to be willing to pay for recreational use, as an increase in the cost of the visit, and for habitat conservation as a contribution to a voluntary fund, came from two contingent valuation surveys.

In the near future, carbon emission reductions and sequestration in cork oak woodlands will have market value, and therefore owners may profit from selling carbon credits derived from cork oak afforestation and even from avoiding deforestation. However, this was not the situation when this study was carried out. Accordingly, carbon sequestration was considered here simply as a public service, and its monetary value was set to correspond to the global damage cost avoided by mitigating 1 ton of carbon for the period of 2000–2010 (Table 15.1). Like all of the numerous estimates of the *marginal cost* of damage of increasing atmospheric CO₂, this assumption is subject to great uncertainty. Thus, we estimate the sensitivity of results to carbon prices ranging from €0/t C to €100/t C.

Private and Public Cost Measurement

Private total costs considered were those of the system of national accounts: labor costs, intermediate consumption (raw materials and services), and fixed capital consumption (human-made capital depreciation). These costs partially reflect the economic effort of managing the three cork oak woodlands, given that government agencies, both national and regional, assume public expenditures that affect the provision of the accounted private and public benefits. From various government agencies we collected data on the effective government expenditures in 2002 in Aljibe and in Monfragüe (no data were available for Gavarres) for fighting wildfires and providing information and other minor services to recreational visitors, which were equally distributed over the entire area of those two sites.

Capital Income Change Present Discounted Values

The economic analysis of investment scenarios, compared with their corresponding noninvestment scenarios, was performed on the basis of private and social capital income change estimates at present discounted values. We

assumed that a nonindustrial private owner would seek to maximize her or his private capital *income at factor costs* (i.e., including government subsidies net of taxes and at present discounted value). Concurrently, from the societal perspective, we assumed the goal of obtaining the greater social capital income at market prices and present discounted value.

We assumed that the sustainable ideal silvicultural management of either afforestation or a facilitated natural regeneration would lead to a permanent commercial cork oak woodland stand. Thus, the afforestation and facilitated natural regeneration productive cycles are followed by an infinite sequence of identical natural regeneration rotations (cycles) at a fixed time interval, over which period the owner repeatedly incurs cork oak natural regeneration treatment costs.

We applied cost–benefit analysis tools to estimate the present discounted values of the all future streams of private and social capital incomes surrounding the analyzed land use management scenarios (Campos et al. 2007b). The stream of private benefits and costs was discounted using the estimated real profitability rates that landowners get from bare land uses before afforestation at each study site. This represents the private opportunity cost of capital for land investment at the study sites. The estimated annual private profitability rates were 4 percent in Aljibe, 5.5 percent in Monfragüe, and 6 percent in Gavarres. The public (environmental) capital income was discounted assuming an imputed 2.5 percent annual social *discount rate*, although a sensitivity analysis to social discount rates ranging from 1 percent to 7 percent was also provided.

We estimated the present discounted values of capital income gains (if positive) or losses (if negative) as the difference between capital incomes present discounted values, obtained from afforestation and facilitated cork oak woodland natural regeneration investment scenarios and the capital income's present discounted values, generated by bare land uses and aging cork oak noninvestment scenarios. In the next sections we will use the term *income* to refer to the capital income's present discounted value.

The private and public agents' cork oak investment rationales described in the next sections are based on the net present capital income changes (gains or losses) measured in Aljibe, Monfragüe, and Gavarres for twelve compared scenarios.

It must be noted that livestock, crop, and game activities do not affect directly the afforestation and facilitated natural regeneration cost–benefit analysis, but these activities indirectly influence the cost–benefit analysis via the values of grazing, cropland, and hunting rents.

Cork Oak Afforestation and Facilitated Natural Regeneration under the Current Private Owner Investor–Consumer Perspective

Over the last decade, the European Union and the Spanish government have strongly encouraged cork oak afforestation on abandoned pastures, shrublands, and croplands under European Regulations 2080/92 and 1257/99 (Ovando et al. 2007). In 2002, these government aids were established to encourage investment in cork oak afforestation through a five-year plant maintenance payment and a twenty-year compensation for grazing exclusion. According to our studies, planting with cork oak a shrubland in Aljibe and a pastureland in Monfragüe became the preferred options for private investors accepting profitability rates equal to or lower than 4.0 percent and 5.5 percent, respectively. The Aljibe and Monfragüe private capital income gain at factor cost was equal to €1,006/ha and €52/ha, respectively (Table 15.2). In Gavarres, however, afforestation led to a capital income loss of €3,084/ha for a private investor who normally demands a profitability rate of 6 percent, when compared with growing annual crops on the same piece of land (Table 15.2).

TABLE 15.2.

Capital income changes from cork oak afforestation and facilitated cork oak woodland natural regeneration in Aljibe, Monfragüe, and Gavarres sites (2002 €/ha).

Class ^a	Cork oak afforestation		Facilitated cork oak natural regeneration	
	Private capital income at factor costs	Social capital income at market prices	Private capital income at factor costs	Social capital income at market prices
Aljibe				
Investment scenario (A)	7,929	–2,726	7,112	2,143
Noninvestment scenario (B)	6,923	5,811	11,861	8,005
Capital income change (A – B)	1,006	–8,537	–4,749	–5,862
Monfragüe				
Investment scenario (A)	3,218	–811	4,742	2,776
Noninvestment scenario (B)	3,166	3,636	9,529	9,407
Capital income change (A – B)	52	–4,447	–4,787	–6,631
Gavarres				
Investment scenario (A)	6,382	162	8,695	5,957
Noninvestment scenario (B)	9,466	5,383	11,076	9,724
Capital income change (A – B)	–3,084	–5,221	–2,381	–3,767

^aDiscounting rates of 4% in Aljibe, 5.5% in Monfragüe, and 6% in Gavarres were applied for discounting private benefits and costs, and public benefits and costs were discounted using a social discount rate of 2.5%.

Private capital income associated with facilitated cork oak natural regeneration (investment scenario) results in a worse private economic alternative than letting an aging cork oak woodland deplete (noninvestment scenario) (Table 15.2). Current government aids to facilitate cork oak natural regeneration management, as contrasted with afforestation, are insufficient to make this an attractive investment option for private owners (Table 15.2).

Afforestation and Facilitated Natural Regeneration under Current Societal Preferences

At all three study sites, investment scenarios for afforestation and facilitated natural regeneration generated social capital income losses (Table 15.2). These results are not very sensitive to variation in the social discount rate used for estimating the present discounted values of future public benefits and costs (Figure 15.1).

Given that we assume that private amenity, current visitors' recreation, visitors' habitat conservation concerns (i.e., visitor option and existence values), and government expenditures have the same values for all land uses at each site, it follows that social capital income changes are entirely due to private commercial capital income changes at market prices (i.e., independent of government subsidies and taxes on products) and carbon emission reduction or mitigation values. Private capital income strongly depends on cork sales, but as Figure 15.2 shows, social capital income changes are sensitive only to variations in market prices for cork and carbon mitigation. In the

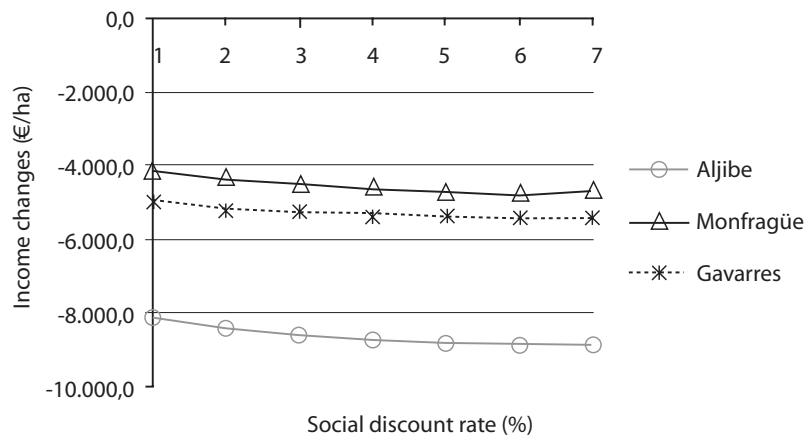


FIGURE 15.1. Sensitivity analysis of social capital income changes to social discount rates in cork oak afforestation scenarios.

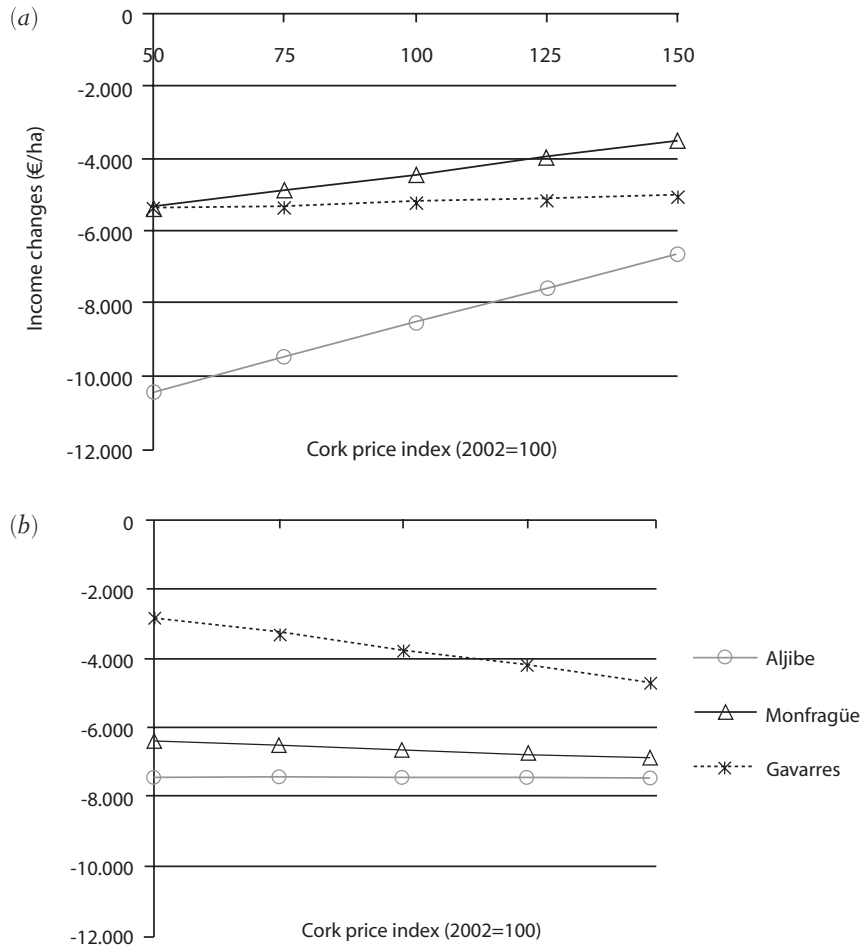


FIGURE 15.2. Sensitivity analysis of social capital income changes to cork prices in (a) cork oak afforestation and (b) facilitated cork oak natural regeneration scenarios.

afforestation scenarios, this is due to the long lag time before cork of commercial interest is obtained. Although changes in cork prices affect both natural regeneration investment and noninvestment scenarios (note that an aging cork oak stand with no regeneration treatments still produces cork for some decades; Campos et al. 2008c), investment scenarios would imply social capital losses even if cork prices increased by 50 percent.

Carbon income could be a relevant public economic value for cork oak afforestation and natural regeneration projects only if its price reached a value several times higher than the current €20 t C avoided social damage service. Thus, the slow cork oak growth rate penalizes the short-term benefits

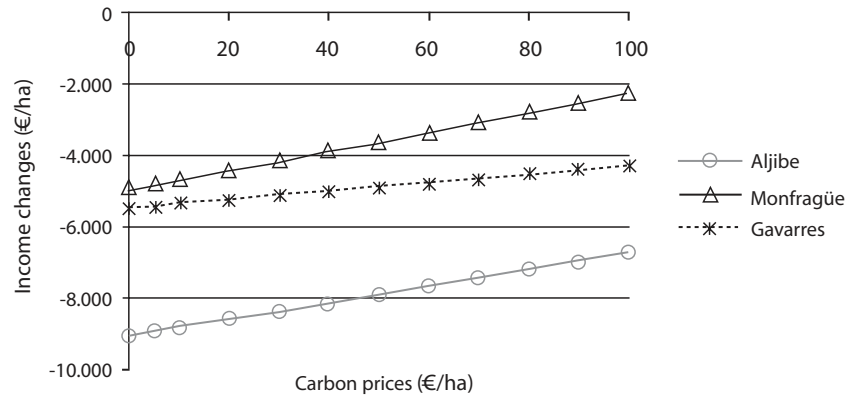


FIGURE 15.3. Sensitivity analysis of social capital income changes to carbon prices in cork oak afforestation scenarios.

accrued from sequestering carbon, even if higher carbon prices (greater than €50/t C) are assumed (Figure 15.3). However, native cork oak woodlands store carbon for longer periods and bestow higher biodiversity and scenic values compared with afforestation with fast-growing species.

Conclusions

Cork oak afforestation is an expensive alternative that, at present, requires strong government subsidies, especially because of the long time lag between planting and obtaining cork of commercial interest. Thus, both cork oak afforestation and facilitated natural regeneration alternatives are expensive and involve an opportunity cost related to grazing resource use, cropping, and cork yields (Campos et al. 2008c).

At present, government afforestation aid provides sufficient incentives to encourage private owners in Aljibe and Monfragüe to invest in cork oak afforestation. However, in Gavarres, those incentives are insufficient to provide an attractive alternative to cropland instead of cork oaks.

In contrast with afforestation aid, insufficient government aid is given for restoring aging cork oak woodlands in the three study sites. This could be a government policy failure because recent studies suggest that restoration and sanitary treatments on existing wooded Mediterranean oak stands might be preferable, in terms of biodiversity conservation and carbon release mitigation, to the artificial creation of new stands (Campos et al. 2006).

Given the limitations of current societal preferences, afforesting bare lands with cork oak and facilitating the natural regeneration of aging cork

oak woodlands both lead to social capital income losses as a result of the willingness to pay revealed in the marketplace and stated in contingent valuation surveys by visitors to the woodlands (Table 15.2). We recognize that the individuals' willingness to pay for habitat conservation might not prevail in a situation of increasing risk of irreversible biodiversity losses. From an ethical perspective, however, the precautionary principle should prevail for all policy decisions related to preserving an endangered ecosystem such as cork oak woodlands. In other words, in the presence of uncertainty regarding future biological diversity loss with the current decline of aging cork oak woodlands in the Mediterranean region, government criteria to provide incentives for cork oak conservation should not be based only on the positive or negative changes in social capital income. Instead, woodland conservation, enhanced management options, and, wherever needed, restoration should be supported by government (and the European Union) on the basis of *society-tolerable cost*.

Furthermore, in the context in which our cost–benefit analysis was carried out, it is worth noting that market values of cork oak woodlands may be the result of short-sighted agents' behavior because the slow disappearance through age of a significant number of cork oak stands might drive up the price of the surviving stands in the future, as compared with bare lands without tree cover, in the same areas. Therefore, it is possible that the current market or environmental values estimated in this study for private commercial incomes, private amenity, and public environmental income, at present discount values, undervalue the real private and social capital incomes that cork oak woodlands will offer in the future. The final chapter in this section reviews the current state of the manufactured cork industry and trade and considers prospects for the future.

Acknowledgments

This study was funded by the research project “Cork Oak Economics and Silviculture” Spanish 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 QLKS-CT-2002-01596).