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Chapter 20

The Way Forward

V. Ramon Vallejo, James Aronson, Juli G. Pausas, João S. Pereira, and Christelle Fontaine

Cork oak trees and woodlands have been managed and cherished by generations of people of many different Mediterranean cultures and in many different ways. Their resilience in a sometimes hostile environment, their economic importance, and their nonmonetary, or nonmarket, aesthetic and cultural values make these cultural woodland systems an outstanding example of the kind of mutually beneficial relationship that is possible between people and the rest of nature. Today, the fate of the cork oak tree and of the ecosystems and landscapes where it thrives depend in large part on pragmatic issues of land use and economic tradeoffs. But the way people think and feel about the tree and the landscapes is important too. Here as everywhere, ethics, cultural values, and identity play a big role in the way people act, along with short-term economic considerations.

Before the twentieth century, there was no single-purpose silviculture for cork oak, but rather multipurpose, multiuse management was carried out under conditions of local self-sufficiency. There was an embeddedness that now seems lost and far away to most of us in our urbanized societies. This cultural and socioecological integration made cork oak woodlands less vulnerable to fluctuating market values. Changes in the demand for cork or other specific products, discussed at various points in this book, are now leading to rapid changes in management and land value. Yet those multiple uses, adapted over time in a wide range of regional and local contexts, explain why we still see such a large variety of cork oak woodland systems and landscapes today. That multiplicity of socioecological contexts and long-nurtured management systems can provide clues, strategies, and tools for future management scenarios in a rapidly and radically changing world. In this final chapter we

review what has gone wrong and then discuss the way forward to meet the challenges of the future, creatively and adaptively.

Cork Oak Decline

Once established, cork oaks are naturally resilient and readily withstand the vagaries of the Mediterranean climate and a host of potential catastrophes. However, over the last century this has changed. Resilience has declined, thanks to human imprudence. In the late nineteenth and early twentieth centuries, excessive tannin extraction after bark stripping caused large-scale mortality and was probably one of the main causes of the long-term decline of cork oak woodlands described in several previous chapters (cf. Montoya 1988). But the declining well-being of cork oak trees endangers whole ecosystems and, indeed, whole landscapes we may well call heritage landscapes because they are derived from ancestral agro-silvopastoral systems. Also at risk are the biodiversity itself and the goods and services these heritage ecosystems provide to people. Given the added influence of present climate change and the likely scenario of gradual drying in Mediterranean basin, the risks and hazards seem to be getting worse.

Although cork may provide some fire protection (see Chapter 1), the occurrence of wildfires after bark stripping is a particularly serious threat for cork oak tree survival (Pausas 1997). In the parts of southern Europe where active management and exploitation of cork are disappearing, along with agricultural abandonment and rural exodus, secondary ecological succession is taking place. This means colonization and spreading of shrubs and the generation of an excessively high fuel load of very flammable vegetation. Moreover, for the last forty years throughout the western Mediterranean, the rainless periods of summer have gradually become longer, extending into the spring and combining with hot weather (Paredes et al. 2006), greatly increasing wildfire hazard (Pereira and Santos 2003; Pausas 2004). In North Africa, for the time being, wildfires are limited because of high land use intensity. However, overuse and overgrazing are getting worse, leading to the blockage of natural regeneration of cork oak and other trees (see Chapters 3 and 10) and galloping desertification.

A prominent result of the recent decline, north and south of the Mediterranean, is that a growing number of cork oak trees and groves are orphaned in increasingly fragmented and dysfunctional landscapes, characterized by agricultural abandonment in some areas and overly intensive use in others. Too much exploitation and too little both spell potential disaster for cultural cork oak woodlands. So what can be done to counter these worrisome trends, in

Europe and North Africa, in the larger context described by the Millennium Ecosystem Assessment (MA 2005a, 2005b)?

Europe

From 1988 to 2006, the European Union made an ambitious effort to monitor tree crown conditions throughout Europe, under the direction of the Federal Research Centre for Forestry and Forest Products (UN/ECE and EC report on Forest Condition in Europe; Lorenz et al. 2000, 2007). In southern Europe, approximately 100 plots and 1,500 cork oak individuals were included in the study. For the whole dataset, cork oak defoliation dramatically increased since 1990 and remains high to the present day. In comparisons with similar tree species (e.g., cork oak and holm oak) growing under the same climatic conditions in southern Europe, the trends of worsening defoliation in conditions are almost parallel (Lorenz et al. 2000, 2007). This suggests the dominant role of water stress as a major cause of defoliation, possibly followed by diseases (see Chapter 9).

Forest cover is generally increasing throughout Europe (FAO 2006a). In the case of cork oak stands, there are conflicting trends. Whereas afforestation of agricultural lands led to a gross increase in area in some regions, there have been losses due to decline, forest fires, or land use changes. For example, in Portugal the national forest inventories detected a gross increase in cork oak area of 5 percent in 1995, as compared to the area three decades earlier, but there was a 10 percent loss between 1995 and 2005 as a result of forest fires in 2003 (Tomé et al. 2007). However, over the next few decades part of these burned forests may well recover and then be classified once again as cork oak woodland in the national forest inventory. At the same time, tree density is decreasing in cork oak woodlands; for example, stands with less than forty trees per hectare increased from 10 percent of the cork oak area in 1995 to 30 percent in 2005 (M. Tomé, personal communication, 2007). In Machuqueira do Grou, Portugal (see Site Profile 4.1), the recorded rate of mortality indicates that stand density decreased by 17 percent over the last ten years (N. A. Ribeiro, personal communication, 2007). In Spain, forest inventories indicate a slight but significant increase in the area of cork oak stands, just as in Portugal, but there was also an increase in both basal area and number of trees, indicating denser forests.

The area covered by cork oak is probably expanding slightly in places where new plantings are being undertaken (e.g., in Andalucía and Portugal) and where agriculture has been abandoned and rainfall and soil fertility are sufficiently high to allow natural regeneration (Pons and Pausas 2006;

Chapter 10). In fact, in moderately grazed stands recruitment occurs in most years (Pons and Pausas 2006; Pausas et al. 2006). However, long-lasting recolonization is highly dependent on land use in the expanding fringes of cork oak populations.

North Africa

The current surface area occupied by cork oak in Algeria, Morocco, and Tunisia is probably less than 30 percent of its potential area (Charco 1999) because of overgrazing and poor management (see Chapters 14 and 17; cf. FAO 2001). Increasing drought and persistent overexploitation both promote decline. The result varies in relation to the technological and socioeconomic conditions and availability of resources, but in general overexploitation of resources is much stronger in northwestern Africa than in southern Europe. This is part and parcel of a much broader set of problems affecting North Africa and, indeed, much of the developing world. It consists of a spiral of environmental degradations and desertification intimately related to overpopulation, poverty, and poor distribution of goods and services. In the absence of sustainable land use systems and adequate government aid, ongoing forest clearance and outright desertification are proceeding at a rate of about 2 percent a year (Marchand 1990; López-Bermúdez and García-Gómez 2006), which is just about the same rate at which agricultural lands are being abandoned in southern Europe.

In other words, the western Mediterranean and, indeed, the region as a whole (Blondel and Aronson 1999) represent a very coherent microcosm of world problems with the north–south contrast referred to already, plus the growing population and pollution problems north and south and the menace of major climate change and aridization, as we saw in previous chapters. That being said, how can we go forward? What practical things can be done? In the remainder of this chapter, we will explore the possibilities.

Cork Oak Woodland Products

Cork oak woodlands produce two high-quality, high-cost products for world markets: natural cork and black pig ham. As pointed out in Chapters 5 and 16, increasing dependency on the wine bottle stopper market is worrisome because this sales outlet is facing stiff competition from alternative materials. This constitutes a real threat for the survival of cork oak woodlands because they may lose their economic viability if the bottle stopper market for cork

slumps drastically. But, as complements to the consistently high commercial value of high-quality cork products, new marketing and distribution campaigns highlighting the advantages of cork and various forest certification instruments (see Chapter 17) can help maintain the value of cork production and hence the maintenance of healthy cork oak woodlands. Indeed, natural cork stoppers have lower environmental impacts in terms of carbon dioxide emissions and pollution (i.e., stoppers thrown away) than aluminum and plastic closures for wine. In fact, cork stripping does not kill the trees, and the amount of cork harvested is almost negligible compared with ecosystem carbon flux (e.g., the mass of cork harvested is only 2–5 percent of the net primary productivity of the trees during the cork production period, 9 to 12 years). As a consequence, cork harvest barely affects ecosystem carbon balance, and ecosystem carbon sequestration should be credited as an asset in cork production.

Meanwhile, other products are gaining ground. In particular, the recent opening of overseas markets for high-quality cured ham, derived from the ancestral race of rustic black pigs raised in Spanish *dehesas* and Portuguese *montados*, brings higher value to acorn crops produced in these agroforestry systems. The rapidly growing demand for this cured ham may easily surpass current levels of production, opening the way for the expansion of black pig husbandry in *dehesas* and *montados* and generating interest in expanding the surface areas of this system.

If the economics of the exploitation of a given *dehesa* or *montado* system are positive, in terms of cork stripping and associated grazing or hunting rents, the problem is to find technical and administrative solutions for sustainable management to ensure regeneration. However, if the cost–benefit ratios are disadvantageous under current market conditions, new public policy and legislation will be needed to conserve or restore cork oak woodlands in the public interest (see Chapters 15 and 17). This is true in northern Africa and in southern Europe.

Apart from the two top products already mentioned, natural cork and black pig ham, other products and services are obtained from cork oak woodlands, as reviewed in various chapters of this book (e.g., Chapters 5 and 14–17). One of these that is gaining importance is recreational and tourism value, both for locals living in nearby cities and for international tourists. In Spain, in particular, the amounts of money that visitors are willing to pay for recreational use of cork oak forests and woodlands, including *dehesas*, is increasing (see Chapter 15). This may soon surpass the monetary value of conventional market products traditionally obtained. The same recreational

value could also emerge in some North African cork oak woodland regions, especially near the Mediterranean coast, as agrotourism and nature-based tourism increase.

By contrast, the recreational value of *montados* is uncertain in Portugal, as well as Italy and France, except in the eastern French Pyrenees. Because of the process described in Chapter 16, in Portugal there is still much emphasis on cork, followed by cattle (including organic farming) and, more recently, pork. Edible mushrooms (e.g., truffles) are important here and there. Hunting is important too. The future of tourism, as a direct benefit of the cork oak woodlands of France and Italy, is also unclear but should not be neglected. The Mediterranean basin is the world's number one tourist destination, and there is an increasing demand for rural tourism, agrotourism, and sustainable ecotourism, as well as "geotourism," which combines natural history and historical and cultural components. Cork oak woodlands clearly have great potential in this regard.

Management Options

Cork oak ecosystems and landscapes are in transition between traditional forms of land use and new social demands, both environmental and productive. The challenge is that any alternative management option should not reduce future options. Because the main causes of ecosystem degradation are local and driven by socioeconomic factors, management alternatives should also be local. For instance, in northeastern Spain the high value of private amenity use (see Chapter 15), together with a general process of abandonment of management practices and domestic grazing, with insufficient colonization by natural herbivores, led to an "unnatural" situation of undergrazing, with huge accumulation of fuels in the understory, increasing fire risk. The challenge here is to maintain the heritage landscape value of cork oak woodlands while keeping fire risk at a manageable level. Indeed, controlling wildfires is clearly a major issue for management of all southern European forests and woodlands.

Therefore, cork oak woodlands must be managed and restored with respect to fire risk. In the extreme case of managed *dehesa* and *montado* systems, fire risk is very low because of the horizontal and vertical discontinuity of fuels. Fuel distribution in the landscape should be designed to reduce the risk of wildfire propagation. Tree density (e.g., using structures as firebreaks and ecotones), understory fuel control, and grazing management are effective fire prevention measures for cork oak woodlands. Consideration of spatial factors in restoration projects is poorly developed to date. The challenge

is to match habitat suitability to fire prevention principles. Spatially explicit models of fire propagation, together with habitat quality spatial distribution through geographic information systems, provide tools at the project scale to advance in this direction (Pausas 2006; Duguy et al. 2007; Pons and Pausas 2008). For this, as for reducing stocking rates, appropriate environmental policies, public investments and subsidies, and financial institutions are going to be needed.

Protecting the *dehesa* or *montado* from excessive grazing, by seasonally excluding seedlings or stands from grazing until the tree canopy escapes the reach of herbivores, is a successful technique in some areas managed as natural parks. However, *dehesa* and *montado* systems today range primarily from heavily managed agro-silvopastoral systems, with high short-term economic returns, low biodiversity, and low resilience, to seminatural, high biodiversity, silvopastoral systems, with low use pressure, low economic return, and higher resilience. A middle way is needed. Multipurpose sustainable use of these woodlands should promote high-value herbivores, with low stocking rates that would favor high species richness in the herbaceous layer, and also allow spontaneous cork oak recruitment. Of course, oak tree recruitment is neither regular nor frequent even in natural or seminatural woodlands. Successful recruitment occurs only after rare periods of exceptionally favorable weather, and such periods may be critical for regeneration in cork oak woodlands.

Conservation and Restoration

There are difficulties in ascertaining the potential distribution of cork oak today and in the future. The present area has been artificially expanded and maintained for centuries but also disturbed, fragmented, and degraded by people. However, one simple and obvious response to global warming and regional aridization would be to anticipate and, indeed, encourage the expansion of cork oak woodlands to more mesic climate regions, ideally adjacent to current woodlands, so as to facilitate gene flow and other biological movements and migrations. This seems especially appropriate in the case of populations growing in the driest portions of the current distribution area of cork oak and for isolated populations, such as those found in many places in the Iberian Peninsula and North Africa (see Figure 1.1). This option is limited and will be regulated by evolving land use patterns and market conditions and, in some areas, by the lack of appropriate soils in neighboring wetter regions. As suggested in Chapter 17, ecoregional land use planning will be a key instrument for assisting cork oak migration as an adaptation measure. But policy decisions will be needed uphill of any such efforts.

Some large and overexploited cork oak woodlands, such as the Maamora, the largest existing managed cork oak woodland in the world, should also receive special international protection and attention, in a management model combining the concerns of the three international conventions that were signed at the 1992 Rio de Janeiro World Summit on Sustainable Development (the United Nations Framework Convention on Climate Change, the Convention on Biological Diversity, and the United Nations Convention to Combat Desertification) and sustainable economic use. Indeed, these conventions—the "three Cs"—are intimately interlinked and should be seen as a cluster, as was clearly expressed at Rio and recalled recently by Pagiola and Platais (2007).

As noted, acorn production, dispersal, and germination are critical bottlenecks in cork oak migration, such that recruitment of new mature individuals typically takes several years. Therefore, passive, low-cost restoration strategies and temporary grazing exclusion in sites set aside for self-regeneration are fundamental in planning. This is especially critical in small woodland remnants threatened by excessive fragmentation. However, in areas lacking seed-bearing cork oak trees in the vicinity or effective acorn dispersers, active restoration through plantation or seeding is needed. Although regeneration per se may be of little interest to many landowners—except for sentimental reasons—forest management certification will require measures to guarantee the sustainability of the cork oak populations. Furthermore, such activities may enhance both tourism-related benefits to landowners and their personal enjoyment and satisfaction. Nevertheless, public money will need to be invested on the basis of the externalities and services provided by cork oak woodlands to society.

Coping with Uncertainty

In southern Europe, most land use projections for the coming decades indicate that there will be extensive abandonment of arable land (Rounsewell et al. 2006; Figure 20.1). These projections were based on socioeconomic scenarios of greenhouse gas emissions in the framework of the Intergovernmental Panel on Climate Change (IPCC). The large cultivated areas expected to be abandoned offer great opportunities for forest expansion and carbon sequestration. However, the recent dramatic rise in cereal prices worldwide was not sufficiently considered in the "business as usual" IPCC socioeconomic scenarios that led to the prediction of land abandonment. If sustained, those price increases may change the picture dramatically, both in southern Europe and in arable portions of North Africa.

Ecosystem and landscape restoration projects intrinsically face high uncertainty, and in today's world this applies to conservation and other forms of land management as well. The highly variable and unpredictable nature of Mediterranean climate, uncertainties about soil conditions in afforestation, competition with extant vegetation, mycorrhizal interactions, grazing pressure, and the risk of pests and diseases, all make the fate of restoration actions highly uncertain. Furthermore, decisions to restore at a broad scale require a major and long-term commitment, and they typically involve multiple stakeholders and objectives, which compound the issues related to uncertainty. Finally, climate change projections are introducing still more uncertainty at a regional scale, and harsher conditions are expected in a general framework of aridization for the western Mediterranean (see Color Plate 16; Ulbrich et al. 2006).

One specific element of optimizing adaptation potential for species is the careful selection of genotypes in reproductive materials, to cope with variability and water stress. This is a critical step in the entire restoration process that has been underemphasized to date. But more challenging issues must be taken up at the policy and planning level. The emerging science, business, and practical restoration of natural capital (see Aronson et al. 2007) and the World Wide Fund for Nature (WWF)–IUCN approach of forest landscape

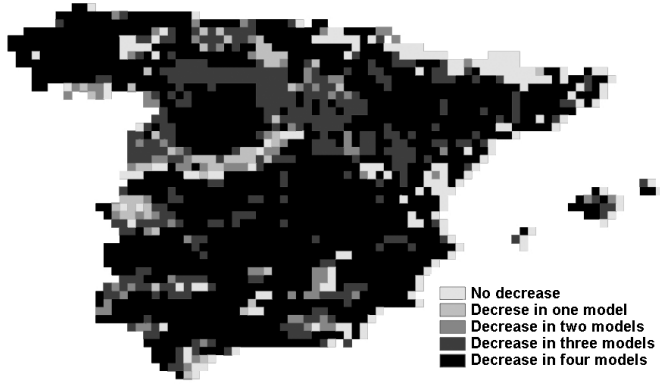

Figure 20.1. Projection of areas in Spain with decreasing crop land surface in the 2080 horizon, from climate models hda1, hda2, hdb1, and hdb2. In the hydrological discharge (HD) model, A and B are different climatic scenarios. The A1 and A2 families have a more economic focus than B1 and B2, which are more environmental; the focus of A1 and B1 is more global than that of the more regional A2 and B2. (Elaborated from European Union project Aquatic and Terrestrial Ecosystems Assessment and Monitoring, Vallejo and Alloza 2007, unpublished)

restoration (Mansourian et al. 2005) provide elements of a road map for this general task. However, much work will be needed locally, regionally, and internationally to put these ideas into practice in the context of the cork oak woodlands.

The Millennium Ecosystem Assessment (MA 2005a) suggests that proactive strategies for managing ecosystems of all kinds are needed in order to increase adaptation and mitigation to climate change and desertification threats while also fighting the loss of biodiversity (i.e., the "three Cs" of the 1992 Rio Conventions). In other words, pursuing any one of the "three Cs" in isolation may yield good results, but working on all three simultaneously should lead to far greater, longer-lasting results.

As Blignaut et al. (2008) noted, four enabling factors will determine the success or failure in the quest for synergy between the "three Cs": management tools and techniques, scientific knowledge, policy environments, and functional institutions. The first two of these factors have been discussed in various contexts in this book. With regard to the policy environment, clearly much more is needed, as is the case for functional institutions also. It now appears that various groups of investors could contribute to the conservation and restoration of representative, emblematic, and strategic cork oak woodlands, linked with the general economic development of the local people, by paying the communities to "farm" for nature's services. This could take the form of carbon credits or, better still, the newly emerging biodiversity and sustainability credits, as well as direct payment for ecosystem services, such as watershed and soil cover protection and reduction of fire hazards (Pagiola and Platais 2007).

Although cork oak woodlands are threatened by overexploitation, pests, wildfire, and climate change, proactive management and conservation measures are feasible in the current context of growing environmental awareness and concern for our collective future. When well managed, these socioecological systems harbor a great deal of biodiversity and a number of unique species and landscapes of heritage value. Well-managed trees and pastures (sown or improved) may durably stock or sequester large quantities of carbon to slow anthropogenic climate change and help in the struggle against desertification. Multiple uses may not be as profitable as specialization in the short term, but they may provide greater resilience and robustness in the face of rapid changes and an uncertain future. It is thus possible to envision public support for cork oak woodland restoration, as was the case in the late nineteenth century and the first half of the twentieth century, when several Mediterranean countries invested a huge amount of resources in ambitious afforestation plans for mountainous areas. A number of projects taking place

around the world exemplify the strength of a strategy for achieving the interlinked goals of combating desertification, protecting biodiversity, mitigating the consequences of climate change, and promoting the sustainable development of human communities. We hope this book will help advance those goals both regionally and globally.