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Ecology and History of a Wooded Landscape in Southern Spain

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An extensive oak woodland, of about 1000 km², dominated by evergreen cork oak (*Quercus suber*) and semideciduous *Q. canariensis*, is found in southern Spain, near the Strait of Gibraltar, and contrasts with the paradigm of deforested Mediterranean mountains. Several factors, ecological, geographical and historical, have contributed to the origin and maintenance of this forested landscape. The rough relief and the acidic, nutrient-poor soils (derived from Oligo-Miocene sandstone) made this area unsuitable for cultivation. The oceanic influence favours the growth of oak trees. In particular, the cork oak is well suited to acidic soils and the humid Mediterranean climate. Three historical milestones seem relevant to the preservation of this woodland. Its location at a frontier during medieval times (thirteenth to fifteenth centuries) discouraged villages and reduced human pressure on the woodland resources. The rise of the value of cork helped to preserve the cork oak woodland during early nineteenth century industrial times. Contemporary consciousness about the conservation of woodland landscapes (somewhat unusual in the Mediterranean region) led to their designation as Los Alcornocales (meaning 'The cork oak woodlands') Natural Park, devoted to the eco-development of the region.

Introduction

When one thinks about a Mediterranean mountain landscape, the usual image that comes to mind is barren limestone with some pines killed by fire, or perhaps overgrazed shrubland on eroded soils. Deforestation has been extensive and repeated all around the Mediterranean Basin, and it is often cited as a classical example of non-sustainable use of natural resources (Thirgood, 1981) (Table 10.1).

Despite this paradigm of generally deforested mountain landscapes in the Mediterranean Basin (McNeill, 1992) there are some significant exceptions;

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Table 10.1. Main agents of deforestation in the Mediterranean Basin (Thirgood, 1981).

Climatic change: Early twentieth century archaeologists (e.g. Huntington, 1915) believed that the decline of classical civilizations was due to a climatic deterioration and progressive desiccation.
Agricultural clearance: The increasing population growth and the improvement of agricultural technologies have caused an extensive transformation of forests into grasslands and croplands; this replacement has been almost complete in the lowlands.
Exploitation for timber and fuel: Especially important was the demand for ship building for the fleets of the Mediterranean naval powers (Phoenician, Greek, Roman, Venetian, Genovese, Spaniard and French) which was continuous until the end of the nineteenth century (e.g. Paola and Ciciliot, 1998). The need for fuel for the smelting of minerals has caused local significant impact in certain areas. More extensive has been the use of wood or charcoal for fuel, still important in rural areas of North Africa.
Wars and invasions: Woodland has suffered devastation by battling armies throughout history, and there are the present-day conflicts in the former Yugoslavia, the Near-East and Algeria.
Fire: Shepherds have traditionally used fires to improve grazing; nowadays, however, arsonists and negligent tourists start most of the summer forest fires.
Grazing: There is much literature about the pernicious action of the goat, the infamous 'black locust' of Mediterranean foresters, impeding woodland regeneration.

one is the extensive sylvo-pastoral *dehesa* covering about 55,000 km^2 in Western Iberia (Marañón, 1988; Rackham, Chapter 1, this volume). In this chapter we describe a lesser known oak woodland of about 1000 km^2 in the Strait of Gibraltar Region and propose a combination of ecological factors and favourable historical events to explain the exceptional survival of this wooded mountain landscape in the much deforested Mediterranean Basin. Why does this woodland exist and why has it not been transformed into a sylvo-pastoral savanna-like system?

Physical Factors

The southernmost tip of the Iberian Peninsula, the 'Gaditan Cape', lies between 36–37° N and 5–6° W, at the meeting point between the Atlantic Ocean and the Mediterranean Sea (Fig. 10.1). The climate is Mediterranean-type, with humid, cool winters and warm, dry summers. Most of the rain falls in winter, when temperature and evapotranspiration (ETP) are low, leading to an excess of water and runoff, but in summer the precipitation is almost nil, the temperature and thus ETP are high and, once the water stored in the soil is exhausted, there are two to three months of drought stress. The average annual precipitation is about 700 mm, but in the mountains it may increase locally up to 2000 mm, due to the geographical location (Fig. 10.1). The Guadalquivir valley and the gulf of Cádiz are open towards the Atlantic Ocean, facilitating the entrance of low-pressure, humid fronts coming from the southwest. When these prevailing, wet winds encounter the Aljibe and

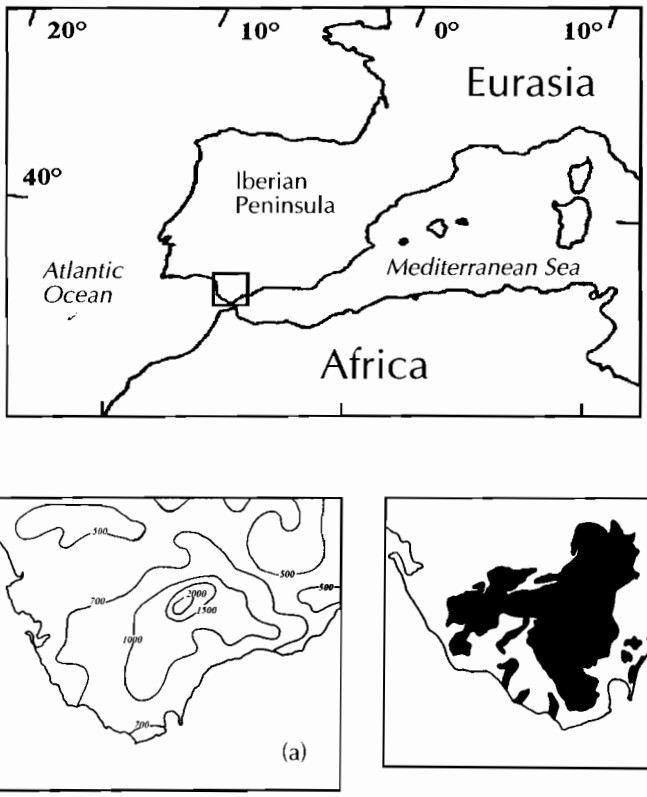

Fig. 10.1. Location of the Gaditan Cape, in the south of the Iberian Peninsula, and insert maps of annual precipitation isolines (a) (after JA, 1995) and of the Oligo-Miocene sandstone formation (b) (after Didon *et al.*, 1973).

Grazalema mountains, they discharge heavy, orographic rains. Another important weather peculiarity is the frequent formation of clouds and fogs during the summer in these mountains, which reduces the severity of the drought stress.

The Gaditan Cape is also peculiar in its geological features. Unlike the limestone mountains of the Alpine orogenesis that generally fringe the Mediterranean Basin, a sandstone rock of the Oligocene–Miocene period (Aljibe formation) forms a rough relief with heights of up to 1092 m (Aljibe peak), which is covered by thin, acidic, nutrient-poor soils (Fig. 10.1; CSIC, 1963; Didon *et al.*, 1973).

Oak Woodland

This physical scenario contains a woodland dominated by evergreen cork oak, *Quercus suber*, with an average density of 163 trees ha^{-1} and average trunk diameter of 23 cm (Ojeda *et al.*, 1994). *Q. suber* is a West-Mediterranean

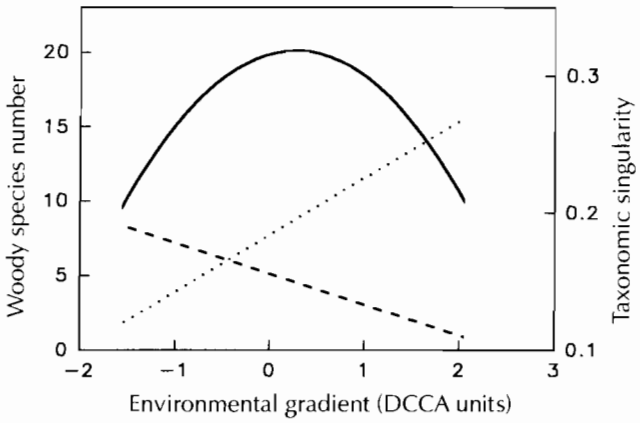

Fig. 10.2. Ecological trends of woody species richness (solid line), endemic species richness (dashed line) and taxonomic singularity (dotted line). Modified from Ojeda *et al.* (1994).

oak tree favoured by a less dry climate and acidic soils. A deciduous oak, *Q. pyrenaica*, also of West-Mediterranean distribution, but frost-tolerant, occupies a few thickets at altitudes higher than 900 m above sea level. In the more fertile and humid valley bottoms, the semi-deciduous, Iberian–North African oak, *Q. canariensis*, is dominant, probably displacing the cork oak by competition. Another two oak species are present in the area: the acidity-tolerant prostrate shrub, *Q. lusitanica*, found mostly in heathlands on ridges, and the calcicole shrub, *Q. coccifera*, at the fringes of the sandstone formation, on marl and clay soils (Ojeda *et al.*, 1994). Surprisingly, the otherwise common holm oak, *Q. rotundifolia*, is absent from the area although it grows on limestone mountains nearby.

The diversity of the tree species is low; one to four species were recorded on average in a set of 100 m transects. Exceptionally, up to seven species, including tall arborescent shrubs, were sampled in riparian forests (Ojeda *et al.*, 1994). European forests were decimated during the glaciations; only a few tree species persisted in refuges and were able to recolonize northwards (but see Adams and Woodward (1989) for an alternative explanation).

The shrub understorey is relatively species-rich. In a study measuring lineal cover in 100 m transects, up to 25 woody species per sample were recorded, and a trend towards higher species richness at intermediate levels of the environmental gradient, in the cork oak woodland, was found. Most of the endemic species were found at one of the gradient extremes, in the heathlands on ridges. At the other gradient extreme, in the understorey of *Q. canariensis* woodlands, shrubs tend to belong to less-diversified genera, that is they are more isolated from the taxonomic point of view (Fig. 10.2; Ojeda *et al.*, 1994, 1996; Arroyo, 1997).

The Gibraltar area is located at the western edge of the Mediterranean region, which borders with the Euro-Siberian (north), the Saharo-Arabian

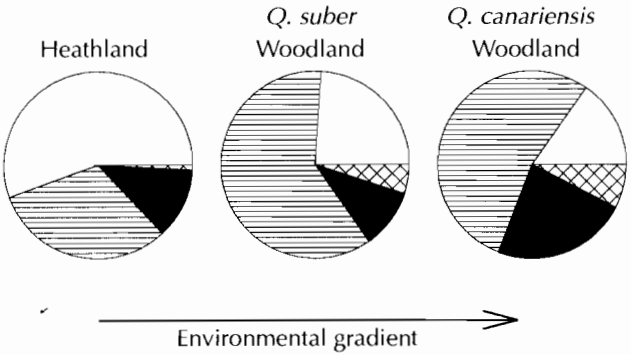

Fig. 10.3. Proportion of endemic (white), Mediterranean (horizontal lines), Mediterranean–Euro-Siberian (black) and Mediterranean–Macaronesian (crossed lines) species in three dominant types of woody plant communities. Modified from Ojeda *et al.* (1994).

(south), the Macaronesian (west) and the Irano-Turanian (east) regions. Most of the shrub species have a Mediterranean distribution. Endemic species are more numerous in heathlands on ridges than in woodland. Euro-Siberian species are important (but still less than 25%) only in the more humid, deciduous *Q. canariensis* woodland. There are few species with Macaronesian connections, but none with Saharo-Arabian or Irano-Turanian distributions. In summary, most of the woody species in these oak woodlands are truly Mediterranean, a considerable portion is endemic to the South Iberia/North Morocco region, and the influence from neighbouring floristic regions seems small (Fig. 10.3; Ojeda *et al.*, 1994, 1996).

Historical Milestones

The ecological history of the oak woodlands in the Strait of Gibraltar region from the last glaciation until the present is poorly known. There are few palaeoecological studies in the area (Gutiérrez *et al.*, 1996) and researchers have to deal with the added difficulties of finding suitable organic-rich sediments in this semi-arid environment, and distinguishing between several *Quercus* species of similar pollen types but contrasted habit and ecology (deciduous vs. evergreen, trees vs. shrubs). Precise documentation of woodland types and the extent of this area have been available only since the Cadastre of Marquis of Ensenada, which was produced as recently as 240 years ago (Bauer, 1991).

Given the general deforestation of the Mediterranean Basin, why does this extensive oak woodland of about 1000 km^2 persist? Why has it not been clear-cut, burnt, ploughed or overgrazed? We propose three 'favourable' historical events that have contributed to the preservation of this woodland.

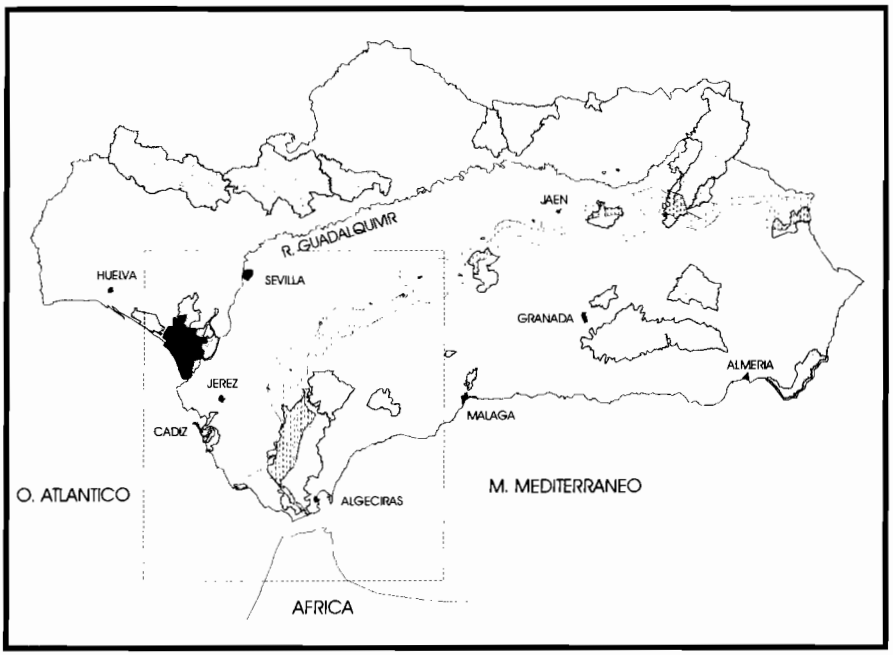

Fig. 10.4. Medieval frontier (after Torres, 1974) and location of Natural Parks (outlined areas). In the insert map, communication flows from Algeciras Bay are drawn. See also contrasted village patterns at both sides of the frontier.

Medieval frontier

The Arabs invaded North Africa and most of the Iberian Peninsula in the eighth century, and during the subsequent 700 years there were battles and moving frontiers between Arab and Christian territories. The last stronghold of the Arabs was the kingdom of Granada, which had a relatively stable territory for about 200 years, until it was conquered at the end of the fifteenth century. Between the Arab and Christian border lines (Fig. 10.4) there was a

no-man's land. On both sides of that frontier we find villages today that still retain as part of the name a reference to their historical location (Spanish 'frontera' for frontier), for example Castellar de la Frontera and Jimena de la Frontera on the old Arab side, and Jerez de la Frontera and Arcos de la Frontera on the Christian side.

The between-frontiers situation impeded the settlement of villages, reduced the pressure of agriculture and grazing, and favoured the regeneration and persistence of wooded lands (López Ontiveros *et al.*, 1991). The present-day distribution of towns and villages is largely inherited from this medieval period. In fact, there are no human settlements inside the limits of the present 1700 km^2 of the Los Alcornocales Natural Park. Moreover, the fewer and larger villages in the old Christian territory can still be distinguished from the smaller and more dense villages on the old Arab side. Five present-day Natural Parks – Grazalema, Subbética, Mágina, Cazorla and Sierra María (Fig. 10.4) – are wooded areas following approximately that old frontier strip.

Historically, the Aljibe mountains have also been isolated from neighbouring towns. Although the nearby Bay of Algeciras harbours two very active ports, Algeciras and Gibraltar, it has very little relation with this abrupt, little inhabited area; instead it is more connected with the coastal towns of Cádiz and Málaga, and with the inland Ronda by the Guadiaro river (Fig. 10.4). However, a highway is currently being planned between Algeciras and Jerez crossing through this woodland.

Value of cork

A second historical milestone started with the invention in France, in about 1750, of the cork stopper for glass wine bottles. By the middle of the nineteenth century, the fabrication of cork stoppers, and thus the harvesting of cork oak bark, was industrialized on a large scale. In 1865 the harvesting of cork in public woodland in southern Spain was put out to tender for the first time (González *et al.*, 1996).

Cork is the outer layer of the bark of *Quercus suber*, and can be stripped off relatively easily. In this process the cambium must be left undamaged, allowing a new layer of cork to be regenerated. The extraction takes place every 9 years and, although it may shorten the life of the tree, it is not destructive for the woodland, that is, cork is a renewable resource.

The pricing of cork was crucial at that time because the period coincided in Spain with a political movement towards a general privatization of public lands, then owned by the Crown, the church or, in some cases, the village. The purpose of this 'desamortización' was to improve the productivity of the lands by taking them out of so-called 'dead hands'. Despite the laudable intentions the result was catastrophic for the woodland, because most of the newcomers buying the land immediately clear-cut the forest for profit, and cultivated the land – not always with success (Bauer, 1991; Blanco *et al.*, 1991).

In contrast, in the cork oak woodland of southern Spain, government foresters designed a woodland management plan, starting in 1890, to renew

the population of oaks and to rationalize the harvesting of cork. That planning ended the chaotic traditional use of public woodland: cutting for fuel or for tannins (for the leather industry), or burning to improve the grazing. However, this 'production' management of woodland brought some negative effects, such as the elimination of ancient oaks, classified as non-productive after 160–200 years old. With this widespread practice we lost many witnesses of our woodland history. Another undesirable effect of the foresters' plan was the selective elimination of *Quercus canariensis*. This species had been used for pollarding and for acorn-feeding of pigs, but after about 1950 its economic value decreased and it was partly cleared out, despite its high ecological value (González *et al.*, 1996). Management plans need to take into account the effects of different silvicultural practices on biodiversity.

The historical interactions between humans and oak forests have resulted in two dominant wooded landscapes in southern Spain: the oak-savanna *dehesa* and the cork oak woodland (Ojeda, 1989). The holm oak, *Quercus rotundifolia*, produces valuable acorns, traditionally used to feed free-range pigs, so that the oak forest has been historically transformed into a savanna landscape of pruned trees and grassland understorey (Avila, 1988; Marañón, 1988). On the other hand, the acorns of cork oaks, *Quercus suber*, are less valuable as a foodstuff and the tree's main value resides in its cork, and as a result, a relatively dense woodland landscape is selected, which can be considered as a partly 'reconstructed' woodland (Avila, 1988).

Woodland conservation

The transition to a democratic regime in Spain coincided with an international sensitivity towards nature conservation which was recognized in the new Spanish Constitution (BOE 1976, article 45). Later, a national Law for the Conservation of Natural Areas and Flora and Fauna was passed (BOE, 1989). A model of autonomic regions is now being built in Spain and environmental policy is decided by regional governments. The Andalusian Region (in southern Spain) has a Law for the Inventory of Protected Natural Areas (BOJA, 1989), in which different types of protected landscape are recognized (e.g. Natural Park, Natural Reserve and Natural Monument), and protected areas now cover some 17% of the region. The regulation of environmental planning is established in the Law through the application of a set of plans (e.g. Plan for the Ordination of Natural Resources, and Plan for Use and Management).

Los Alcornocales Natural Park was declared in 1989, partly to protect the unusual wooded landscape, and partly because of its high biodiversity and richness in endemic species. About 23% of its area is publicly owned and 77% is private. More than 100,000 people live near the Park and use its natural resources. One of the objectives of the Park is to promote eco-development, by regulating traditional uses such as cork extraction, grazing by free-range cows, pigs and goats, hunting, harvesting of piñon-pine cones and heath burls (for pipe wood), and promoting new activities such as eco-tourism (Sánchez, 1994).

Table 10.2. Environmental and historical factors preserving oak woodlands in the Gaditan Cape (southern Spain).

Physical	Rough relief with peaks up to 1092 m
	Sandstone substrate covered by acid, nutrient-poor soils
	High annual precipitation (700–2000 mm) with summer fogs
Ecological	Dominance by *Quercus suber*
	High plant biodiversity and endemic richness
Historical	Location as medieval frontier (thirteenth–fifteenth century)
	Value of cork (nineteenth century)
	Woodland conservation (twentieth century)

Conclusion

The existence and preservation of this 1000 km^2 oak woodland in the much-deforested Mediterranean is the result of a combination of physical, ecological and historical factors (Table 10.2). The rough relief, sandstone substrate and high precipitation set the conditions for both a woodland dominated by *Quercus suber* and a high biodiversity and richness in endemic plants. The location as a medieval frontier limited the establishment of villages in this wooded area; the pricing of cork protected these cork oak woodlands in a period of woodland privatization and deforestation; and finally the future of the woodland seems optimistic with its legal declaration as a Natural Park in 1989.

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References

Adams, J.M. and Woodward, F.I. (1989) Patterns in tree species richness as a test of the glacial extinction hypothesis. *Nature* 339, 699–701.

Arroyo, J. (1997) Plant diversity in the region of the Strait of Gibraltar: a multilevel approach. *Lagascalia* 19, 393–404.

Avila, D. (1988) *Explotaciones agropecuarias en Sierra Morena Occidental.* IDR, Universidad de Sevilla, Sevilla.

Bauer, E. (1991) *Los montes de España en la Historia,* 2nd edn. MAPA, Fundación Conde del Valle de Salazar, Madrid.

Blanco, R., Clavero, J., Cuello, A., Marañón, T. and Seisdedos, J.A. (1991) *Sierras del Aljibe y del Campo de Gibraltar.* Diputación de Cádiz, Cádiz.

BOE (1989) *Ley 4/89, de 27 de marzo, de conservación de los espacios naturales y de la flora y fauna silvestre.* BOE, Madrid.

BOJA (1989) *Ley 2/89, de 18 de julio, por la que sea prueba el inventario de Espacios Naturales Protegidos de Andalucía y se establecen medidas adicionales para su protección.* BOJA, Sevilla.

CSIC (1963) *Estudio agrobiológico de la provincia de Cádiz.* CSIC, Sevilla.

Didon, J., Durand-Delga, M. and Kornprobst, J. (1973) Homologies geologiques entre les deux rives du détroit de Gibraltar. *Bulletin Societé Geologique Francaise* 15, 77–105.

González, A., Torres, E., Montero, G. and Vázquez, S. (1996) Resultados de cien años de aplicación de la selvicultura y la ordenación en los montes alcornocales de Cortes de la Frontera (Málaga), 1890–1990. *Montes* 43, 12–22.

Gutiérrez, A., Nebot, M. and Díez, M.V. (1996) Introducción al estudio polínico de sedimentos del Parque Natural de 'Los Alcornocales'. *Almoraima* 15, 87–92.

Huntington, E. (1915) *Civilisation and climate.* Yale University Press.

JA (1995) *Plan de Medio Ambiente de Andalucía.* Junta de Andalucía, Sevilla.

López Ontiveros, A., Valle Buenestado, B. and García Verdugo, F.R. (1991) *Caza y paisaje geográfico en las tierras béticas según el Libro de la Montería.* Junta de Andalucía, Córdoba.

Marañón, T. (1988) Agro–sylvo–pastoral systems in the Iberian Peninsula: *Dehesas* and *Montados*. *Rangelands* 10, 255–258.

McNeill, J.R. (1992) *The mountains of the Mediterranean World. An environmental history.* Cambridge University Press, New York.

Ojeda, J.F. (1989) El bosque andaluz y su gestión a través de la Historia. In: García, G.C. (ed.) *Geografía de Andalucía.* Tartessos, Sevilla, pp. 315–355.

Ojeda, F., Arroyo, J. and Marañón, T. (1994) Biodiversity components and conservation of Mediterranean heathlands in Southern Spain. *Biological Conservation* 72, 61–72.

Ojeda, F., Marañón, T. and Arroyo, J. (1996) Patterns of ecological, chorological and taxonomic diversity at both sides of the Strait of Gibraltar. *Journal of Vegetation Science* 7, 63–72.

Paola, G. and Ciciliot, F. (1998) Examples of woodland management related to timber supply for shipbuilding in the 18th century in western Liguria (NW Italy). In: Watkins, C. (ed.) *European woods and forests: studies in cultural history.* CAB International, Wallingford, pp. 157–163.

Sánchez, F.J. (1994) La gestión del Parque Natural de Los Alcornocales (Cádiz-Málaga): influencia en la población rural. In: *Simposio mediterráneo sobre regeneración del monte alcornocal.* IPROCOR, Mérida, pp. 23–26.

Thirgood, J.V. (1981) *Man and the Mediterranean Forest.* Academic Press, London.

Torres, C. (1974) *El antiguo reino nazarí de Granada (1232–1340).* Anel, Granada.