Human impacts on *Quercus suber* habitats in Sardinia: Past and present

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Abstract

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Quercus suber L. is a species confined to the centre and western Mediterranean basin. On the island of Sardinia its distribution is limited mainly by soils. Apart from its economic significance to local communities, cork oak habitats are recognised as having both cultural and biodiversity value at a European level. Although traditionally associated with human activities these habitats are today under increasing threat. Among the problems that affect cork oak habitats on the island are soil erosion and loss of organic matter due to ploughing and seeding for pasture. Stock numbers have increased while grazing cattle have been replaced by sheep and are proven to be particularly damaging especially to cork oak regeneration. Although the species is a passive pyrophyte, frequent fires render the trees susceptible to fungal and defoliator attacks and destroy the understory leading to soil degradation and erosion. This paper provides a review of these threats and explores their link to the changes resulting from abandonment of traditional farming methods and different management systems used in Sardinia.

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Key words: agro-silvopastoral systems, cork oak, habitat quality, landscape changes, sclerophyllous forests.

Introduction

Mediterranean ecosystems are a high priority in biodiversity research and conservation (HEYWOOD 1995). Within these ecosystems certain species, such as cork oak (*Quercus suber* L.), play key ecological and socio-economic roles. The distribution of *Q. suber* is confined to the centre and western Mediterranean basin. Sclerophyllous forests of cork oak have unique ecological roles since they host diverse animal and plant communities with many endangered species (GONCALVES 2000). The economic role of these habitats arises from direct benefits derived from cork exploitation and/or parallel activities carried out under cork canopies that are of considerable social importance as they are associated with traditional agro-silvopastoral practices in "Less Favoured Areas of the European Community" (COMMISSION OF THE EUROPEAN COMMUNITIES 1997). These traditional agro-silvopastoral systems of the Mediterranean represent a sustainable balance between

human activities and natural resources and have created landscapes of high heterogeneity and cultural value. There is, therefore, increasing recognition of their importance at European level (COUNCIL OF EUROPE 1992, 2001). However, concern about their future is also growing along with their continuing degradation. The aim of this paper is to provide a review of the major changes in cork oak habitats in Sardinia (Fig. 1) with particular reference to the effects of human impacts on habitat quality.

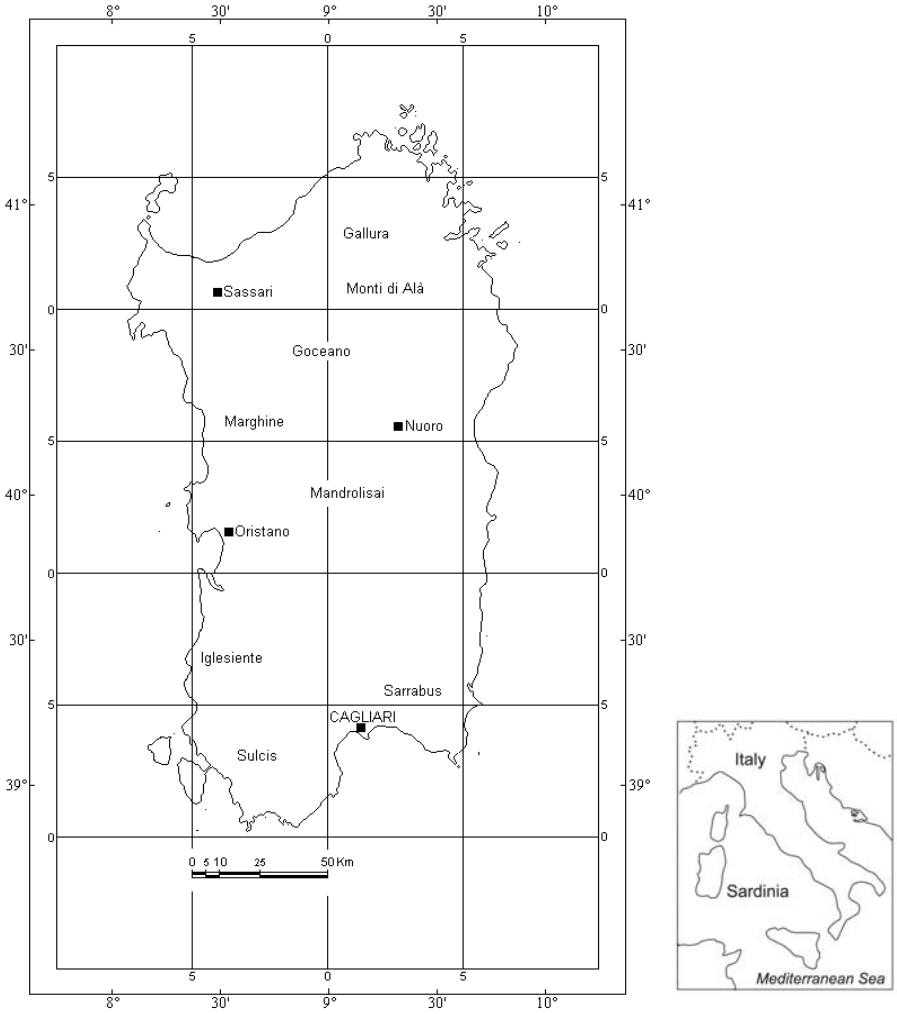

Fig. 1. The principal nuclei of cork oak distribution in Sardinia. (UTM reference system with 5 km grid superimposed.)

Ecology and synecology

Quercus suber is an evergreen tree that grows up to 20 m in height, with downy twigs, a rather sparse leaf canopy, and a very thick and deeply ridged bark that can

reach diameters greater than 1.5 m. In Sardinia, *Q. suber* is mainly confined to non-calcareous substrates, in particular granitic, extrusive volcanic and metamorphic types. The main nuclei of the distribution of the species from north to south occur in Gallura, Monti di Alà, Marghine and Goceano, Madrolisai, Iglesiente, Sulcis and Sarrabus (Fig. 2).

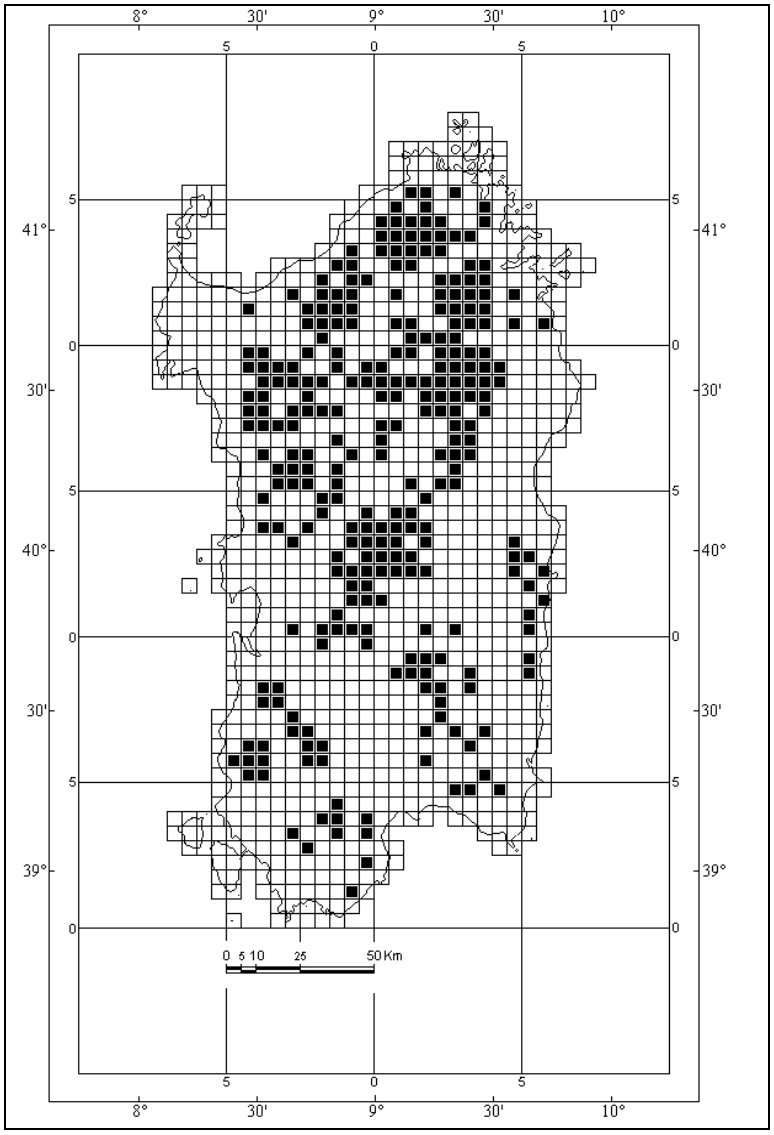

Fig. 2. Distribution of cork oak forests in Sardinia (modified from ARRIGONI 1968). (UTM reference system with 5 km grid superimposed.)

Cork is a product of a secondary meristem. Its extraction takes place when the individual tree reaches an age of 25-30 years with the bark stripped every 10-15 years after the initial extraction (PINTUS 1996). The island of Sardinia is the biggest producer of cork in Italy (CHIAPINI 1985, RUJU 2002). The main uses of cork are for wine bottles and insulation material. *Quercus suber* has been considered a more thermophilous species than *Quercus ilex* and the cork-oak woods as transitory and not always dynamic, degradation stages of ancient Holm-oak woods (ARRIGONI & al. 1996, MOSSA 1985). Therefore, the Sardinian cork-oak woodlands have not been recognised as autonomous syntaxonomic entities until recently. SERRA & al. (2002) assigned the cork oak formations of the Sulcis-Iglesiente area (SW Sardinia) to two existing associations, the *Myrto communis-Quercetum suberis* and the *Cytiso villosi-Quercetum suberis*. These associations represent the most developed phases of an edaphic special dynamic series. They are in sequence with the climatic principal series and the edaphohydrophilic calcifugal series of Sardinia, typical of the thermo-meso-Mediterranean bioclimatic plains. Moreover, a recent study by BACCHETTA & al. (2004) described two new associations on the island, namely the *Galio scabri-Quercetum suberis* and the *Violo dehnhardtii-Quercetum suberis*.

Human impacts to cork oak habitats

In recent years cork oak habitats in Sardinia have undergone major changes, mainly due to human factors. Grazing has contributed to the evolution and shaping of vegetation in the Mediterranean Basin. In the cork oak habitats of Sardinia grazing is the main activity under the cork canopy, together with sowing of forage plants to improve pasture. On the other hand cultivation, such as that in the *dehesas* and *montados* of Spain and Portugal, is a rare phenomenon on the island possibly due to a predominant pastoral culture in the north, and occurs mainly in Gallura and Marghine e Goceano even on steep slopes.

Long-term studies in northeastern Sardinia (D'ANGELO & al. 2001) showed that the period 1955-96 was marked by an increase in improved pastures at the expense of cork woodlands. As pointed out by GROVE & RACKHAM (2001) the removal of forest to make pasture is followed by cultivation and subsequently by abandonment. With a few exceptions, such as the area of Gallura where cattle grazing is still practised (PAMPIRO & al. 1991), sheep grazing has taken over and intensified since the 1950's (MORI 1972). Sheep grazing is reported as more damaging to cork woodland structure than cattle grazing but both are equally damaging for cork oak regeneration (RUIU & al. 1995, PAMPIRO & al. 1991). Ownership seems to play an important role on land management. There is a contrast between land in private ownership where landowners seek to improve productivity, and community land where there is no control and intervention is difficult. As a result of the EU Common Agricultural Policy (CAP) in the 1980's, subsidies were linked to the number of animals and this contributed to a general increase in their numbers. Thus, in recent decades these habitats have been subject to irreversible deterioration through intensification, extensification and land abandonment in Sardinia. Traditional agro-pastoral activities have been replaced by contemporary intensive agro-industrial practices. In recent decades the introduction of mechanised farming has led to deep ploughing of extensive areas that were not subject to intense agriculture in the past. This leads to the destruction of the shrub

layer and a loss of organic matter resulting in soil exposure and erosion, particularly on steep slopes.

Grazing, which in some cases is accompanied by fire, is by far the major human impact in the study area. The presence of increasing numbers of domestic animals in the forest usually results in a deterioration of the forest resources, especially when accompanied by cultivation of forage species. Soil compaction, reduction of water infiltration capacity, increased runoff and sheet erosion are some of the consequences. Comparative studies between different land uses in Sardinia (VACCA 2000) have demonstrated that cork oak forests have well-developed soil horizons with high organic matter whereas in habitats of silvopastoral use soils are poorly developed with poor organic matter, with the exception of some "islands" under the *Quercus suber* canopy. Although nutrient contents appear to be higher in the latter this is attributed to higher supply of grazing animal excreta.

As in most Mediterranean areas fire has played a significant role in the shaping of the Sardinian landscape. By 1970 one third of Sardinia was burnt (RUJU 2002) while official statistics suggest that between 1950 and 1985 the area burnt has increased tenfold (GROVE & RACKHAM 2001). The wooded areas reported burnt has also increased from one eight of the total burnt area in 1970 to one third in 1980. GROVE & RACKHAM (2001) argue that what appears to be an significant increase in forest fires, could be due to the change in the definition of wooded areas over the years and the increase in access (road building) which allowed the recording of fires wherever they occurred. The effects of fire on the cork oak woodlands may have positive selective influence that promotes the distribution of the species (SERRA & al. 2002). Since the species is a passive pyrophyte most trees survive fire. Studies from Spain have showed that the probability of stem death is negatively related to tree diameter; and recovery is positively related to tree diameter and to bark thickness (PAUSAS 1997). The impact of fire cork oak forests depends also on the time which has passed since the last cork stripping with trees being extremely vulnerable in the first years following stripping. Following fire, traditional trunk coppicing seems to be the intervention that facilitates the most post-fire recovery in Sardinia (BARBERIS & al. 2003). However, recurrent fire events promote habitat deterioration through soil loss and susceptibility to pest attacks (SECHI & al. 2002a).

The gypsy moth (*Lymantria dispar* L.*)* in particular is one of the most devastating pests for cork oak habitats in Sardinia, with ecological and socio-economic implications (PROTTA & al. 1992). Although defoliation intensity depends on a variety of parameters, from the individual tree's condition to regional temperatures, it is widely accepted that habitats containing a high proportion of preferred food species are more likely to be defoliated than those with more species variability. Moreover, recent studies have demonstrated the importance of the quality of the landscape matrix on the dispersal of the species and the subsequent resulting levels of defoliation (MUZIKA & LIEBHOLD 2000). The interplay of the aforementioned factors leads to a simplification of the natural ecosystem to an agro-ecosystem, often monoculture, destabilising the system and diminishing the homeostasis. In turn, these changes have resulted in habitat loss, a decrease in landscape heterogeneity with a subsequent decrease of plant and animal diversity but also consequent economic losses. For example, estimates from Sardinia suggest that

there is a decrease in cork growth of around 60% during the year of defoliation and around 32% in the following year (PROTTA & al. 1992).

Monitoring of cork oak stands has shown a trend of deterioration following the drought of the last 10 years (SECHI & al. 2002a). This has been attributed to poor edaphic and vegetation conditions and the lack of common forest management. The study by SECHI & al. (2002b) demonstrated that the cork oak stands with the highest index of decline were located between 200 and 400 m, with SW aspects and soils of granitic origin. These were usually pure stands with even-aged plants, where natural regeneration was nearly absent, grazed, and frequently attacked by defoliating pests.

Discussion

The changes in the cork oak habitats of Sardinia have generally followed the trend in other parts of Southern Europe in the last fifty years. Habitat quality, (including structure, floristic composition and cork oak regeneration) is threatened by increased stock numbers and the replacement of cattle by sheep. Although fire can be damaging for the cork oak habitats, the absence of a detailed forest inventory/map and the pitfalls in fire recording make it difficult to quantify fire effects. Agricultural intensification has deteriorated habitat quality and that of the landscape matrix leading possibly to an increase of defoliator attacks.

Table 1. Natura 2000 sites in Sardinia where cork oak habitats are protected.

Site	Area (ha)	Code
Mountain Limbara*	16,0588.147	ITB001109
Campo di Ozieri Pianure comprese tra Tula & Oschiri	20,437.104	ITB001113
Catena del Marghine & Goceano	14,983.502	ITB001102
Media Valle del Tirso & altopiano di Abbasanta	8,998.692	ITB001104
Giara di Gesturi*	6,392.693	ITB001112
Monte Arcuentu & Rio Piscinas*	11,486.842	ITB000031
Monte Linas*	23,625.681	ITB001111
Foresta di Monte Arcosu*	30,352.634	ITB001105
Monte dei Sette Fratelli & Sarrabus*	9,289.496	ITB001106

* sites that are also Regional or Natural Parks

Some of the valuable cork oak habitats in Sardinia are protected under Regional Parks or Natura 2000 sites (Table 1). Regional legislation, such as law L.R. 73/89, set a production and environmental protection framework for cork oak cultivation on the island (PUNGETTI 1996) but National and local agricultural policies have favoured the shift from traditional to more intensive agricultural systems (D'ANGELO & al. 2001). Therefore there is a need to revise policy and legislation to resolve these contradictions. At a management level there is a need to compare land suitability and current land uses in order to identify areas sensitive to land degradation where land resource conservation programmes can be developed. Moreover, mitigation measures can be used i.e. appropriate strategies to protect the soil from erosion when modern harvesting techniques are employed (VACCA 2000) as well as appropriate evaluation of a sustainable capacity of the land for grazing practices (D'ANGELO & al. 2001).

Recent European legislation now considers the conservation status of the wider countryside, including both its biological and landscape diversity (COUNCIL OF EUROPE 1992). The loss and fragmentation of semi-natural habitats in the wider landscape is a major factor in the decline of biodiversity. In light of the above, evaluating the contribution of landscape structure and habitat attributes to habitat ecological quality becomes a key issue in the case of cork oak habitats.

This will ultimately enable the development of a better understanding of ecosystem/landscape functioning, to understand and minimise the negative impacts of human activities on cork oak habitats, assist future habitat restoration efforts and ensure sustainable management of natural resources in Sardinia.

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