Cork Oak Restoration: Developing Techniques to Enhance Establishment of a Threatened Ecosystem (Spain)

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Aging populations and low regeneration rates are among the many factors threatening cork oak (*Quercus suber*) ecosystems in the western Mediterranean basin. On the eastern Iberian Peninsula, for example, cork oak is scarce, in part due to the lack of suitable, noncarbonated soils. However, many areas that are suitable for cork oak in that region were cleared and terraced in the past for agricultural crops. Some areas where cork oak and cork production have remained have experienced massive wildfires that killed many trees recently stripped of their bark for cork production.

These losses raise real concerns because cork oak ecosystems are recognized for their ecological and biodiversity values (cork oak is a protected species by the European Commission, Habitat 92/43/EC) and their socio-economic and agroforestry values. These woodlands have tremendous potential as sustainable management ecosystems. Furthermore, their capacity to resprout following fires makes cork oak ideal for restoration in the fire-prone ecosystems found in the eastern Iberian Peninsula (Pausas 1997, Pausas 2004, Pausas and others 2004, Vallejo and others 2004). With these factors in mind, the European Union has financed a project aimed at increasing our knowledge of the economic importance, physiology, ecology, and genetics of cork oak, and directing this knowledge into sound restoration techniques (see Conservation and Restoration of European Oak Woodlands Project [CREOAK], www.isa.utl.pt/def/gemf/CREOAK).

The three main cork oak areas in the Valencia region of the eastern Iberian Peninsula decrease in size from north to south, and cover between 16,000 and 23,500 acres (ca. 6,500-9,500 ha). By overlapping a geological map of the area with a digital elevation model, we have delimited suitable bedrock types and altitude range, and estimated that cork oak forest could potentially cover between 37,000 and 44,500 acres (ca. 15,000-18,000 ha). Our challenge is to develop scientific-based methods and techniques for the success of cork oak restoration.

We have divided potential cork oak restoration sites within these three main areas into three categories according to the current vegetation types: Oldfields, pine woodlands (including plantations), and shrublands (Figure 1). Cork oak seems to easily colonize recently abandoned oldfields, especially during the first few years after abandonment, because the main oak dispersal agent, the Eurasian jay (*Garrulus grandarius*), seeds acorns in these open spaces. We hypothesize that these sites would require relatively moderate levels of management (low levels of external energy input), such as introducing grazers (livestock or game) to create more open areas for oak regeneration and/or providing acorns that would then be seeded by jays. We also found considerable cork oak regeneration in pine woodlands, although oak does not grow well under dense canopy cover. Thus, restoration prescriptions for these sites may include thinning of some pines in order to increase the survival and growth of oak seedlings (intermediate levels of external energy input required). We expect that the highest level of external energy input will be required in shrublands, where cork oak regeneration is very low because this is not a preferred habitat for jays to scatter acorns, there is significant acorn predation by mice, and there is also aggressive competition from other plant species.

CREOAK-supported researchers are currently testing these hypotheses on the relationship of vegetation types to cork oak establishment. Our projects include quantifying

seedling establishment, acorn production, dispersal, and predation in the various habitats; conducting experiments on the effect of clearing and planting using different techniques for improving seedling quality; and performing nutrient experiments to better understand the effects of different soil types on cork oak growth and the potential for expanding its distribution. Initial findings suggest that although the jay has been considered a forest bird, its maximum densities occur in a landscape mosaic with 40-60% forest cover, a high number of patches and the presence of fields with early summer fruiting trees. Acorn predation is basically related to the *Apodemus sylvaticus* mouse density, which is in turn related to shrub cover; this is why jay selects open habitats for seeding acorns. Rodents may also contribute to dispersal, but at short distance and in masting years only. These findings support the initial hypotheses and suggest that appropriate management (including fauna management) may help oak regeneration. When finished, the results of all CREOAK experiments will be directed to produce guidelines for ecological restoration of cork oak landscapes.

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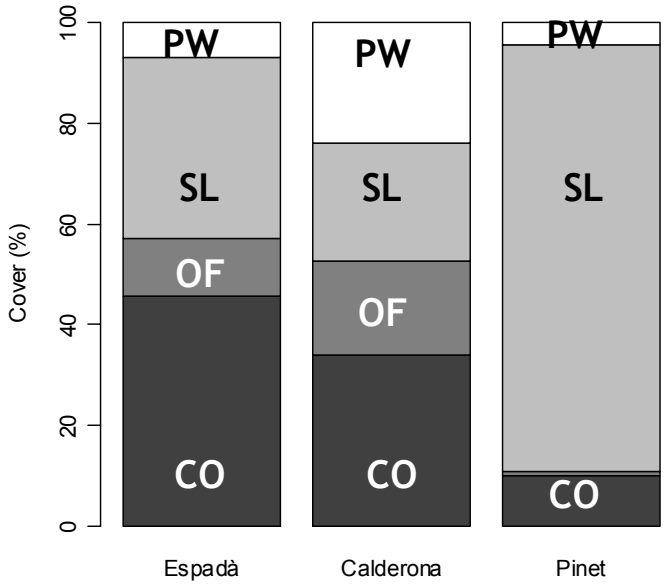

Figure 1. Proportion of cork oak (CO, including a small proportion of holm oak *Quercus ilex*), oldfields (OF), shrublands (SL) and pine woodlands (PW) in the three main potential cork oak areas in Valencia (eastern Iberian Peninsula).