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Pedunculate oak (*Quercus robur* L.) silviculture in natural stands of NW Spain: Environmental conditioners

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ABSTRACT

Forest management is often carried out in different ways, without any appropriate environmental restrictions. Stands of pedunculate oak (*Quercus robur* L.) in Galicia (NW Spain) have been harvested by alternating high forest and, mainly, coppice forest. However, some totally inappropriate silvicultural treatments have been used, such as thinning of the best trees and inadequate pruning. The objective of the present study was to analyse how environmental characteristics affect the management of oak forests in Galicia. For this, a botanical inventory was carried out in 39 selected stands of *Q. robur* and a total of 42 parameters were measured, 4 of which were physiographical, 12 climatic, 19 edaphic and 7 silvicultural. In order to analyse the possible relationships among these variables, the silvicultural data were compared with the other data, by canonical correlation analysis. All parameters were correlated with the silvicultural regime, although the correlation was weak for the floristic data. It is therefore evident that the environmental conditions affect how forest stands should be managed, although this does not imply that more profitable use of the stands cannot be achieved than at present, and alternative silvicultural methods must be found to enable appropriate management and conservation of oak stands.

1. Introduction

Forest management has a considerable influence on the stability and sustainability of forest ecosystems (Larsen, 1995; Johnson et al., 2002; Decocq et al., 2004). In the specific case of oak trees, the silvicultural practices applied form part of forestry mythology and should be considered with prudence (Bouchon and Trencia, 1990). The silviculture applied to *Quercus robur* L. are well developed and up to date in countries where the species is of great economic importance, such as France and Germany, where thousands of hectares of oak forest have been managed for centuries (Bary-Lenger and Nebout, 1993; Timbal and Aussenac, 1996; Harmer and Morgan, 2007). However, the situation in the study area is very different from that in the above-mentioned countries, as there is little knowledge about the type of silvicultural practices that should be applied to autochthonous broadleaf forests.

Galician oaks present a wide range of ages and qualities, as a result of the different uses and states of conservation (Díaz-Maroto et al., 2005). Coppice forest predominates and it requires continual management otherwise the stands will age and stagnate and may eventually disappear (Díaz-Maroto et al., 2006; Van Calster et al., 2007). Many of these oak forests have been intensively exploited (i.e. for the wood and firewood extractions for domestic and industrial uses or for the naval industry) (Manuel and Gil, 2001), and in many cases inappropriate silvicultural treatments have been applied (pollarding and felling of the best trees) (Díaz-Maroto et al., 2005).

The shipbuilding was prompted by the Spanish maritime expeditions, the commerce with Europe and the Indies, and the fishing activity. Due to transportation difficulties, the naval industry needed closer forests to fulfill their requirements. The wood proportion by ship was about 30–50% conifers, and about a 70–50% broadleaves, mainly oaks. The utilized trees had to have specific dimensions and they were of the best quality, and after their extraction, the rest was generally used for firewood or for vegetable coal, which contributed to the destruction of many forests (Aranda, 1990).

Most recently, as a result of rural depopulation, technological developments and social demands, there has been a change during the past century from overexploitation of many of these forests to a total lack of silvicultural intervention (Izco et al., 1990; Rodá et al., 1999; Reque and Bravo, 2007).

Oak forests (*carballeiras*), or pure stands of *Q. robur*, occupy an area of 187,789 ha, in Galicia, i.e. approximately 14% of the total

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forest area (DGCONA, 2001). Within the region, *Q. robur* behaves as a robust, light-demanding species, which does not tolerate shade at early stages of development and the seedlings of which languish quickly under cover. The largest oak stands are found on steep slopes, where they have survived largely because felling would be complicated owing to the topography (Ruiz de la Torre, 1991). Management of these stands must now be carried out in accordance with silvicultural criteria and any possible environmental restrictions (Decocq et al., 2004; Vila-Lameiro and Díaz-Maroto, 2005).

The starting hypothesis for the present study is that the environmental conditions in the study area do not preclude the application of alternative silvicultural practices in the management and conservation of oak forests, in order to obtain more profitable outputs rather than with traditional methods.

2. Materials and methods

2.1. Study area and sampling

The study area comprises the Autonomous Community of Galicia (NW Spain) (Fig. 1). The climate is generally oceanic, and the main characteristic is therefore high precipitation (Carballeira et al., 1983). The rocks in the area are siliceous (granites, schists, and slates), under deep soils, particularly cambisols (Díaz-Maroto and Vila-Lameiro, 2006).

The vegetation composition in the study area was examined in the *Mapa Forestal de España* (Ruiz de la Torre, 1991), obtaining the existing vegetation mosaics where *Q. robur* is present, and the sampling zones were selected from within these, with the help of information provided by forestry administration personnel and data reported in previous studies (Díaz-Maroto, 1997). Representative oak stands by each zone were chosen to replant the inventory plots. The minimum area of the stands considered ranged between 0.5 and 1 ha, which avoided problems associated with the edge effect. The resulting network of 39 rectangular plots (Table 1), of variable dimension (depending on the number of trees), contained at least 50 inventoriable trees ($Ø \geq 5$ cm) (Hummel et al., 1959).

2.2. Variables measured and parameters calculated

Once the plots were replanted, a floristic inventory was carried out and an abundance index was assigned to each (Braun-Blanquet, 1979); abiotic (physiographic, climatic and edaphic) and biotic (dendrometric and silvicultural variables) data were then recorded. The physiographic and climatic data – adapted to each plot according to the method of Carballeira et al. (1983), and for the period 1960–2000 – and the results of the edaphic analyses – corresponding to the samples obtained from the soil profiles – enabled compilation of a total of 35 abiotic parameters for each plot (Table 2). The parameters that describe the physiography of each area (Díaz-Maroto et al., 2005, 2006) are: altitude and mean slope, soil depth and distance from the sea. The climate was described by the following parameters (Retuerto and Carballeira, 1990, 1991): precipitation: annual, winter, spring, summer and autumn total values; temperature: mean annual, annual mean of absolute maximum and minimum temperatures, maximum value of the absolute maximum mean temperatures and minimum value of the absolute minimum mean temperatures (mTAB), and annual

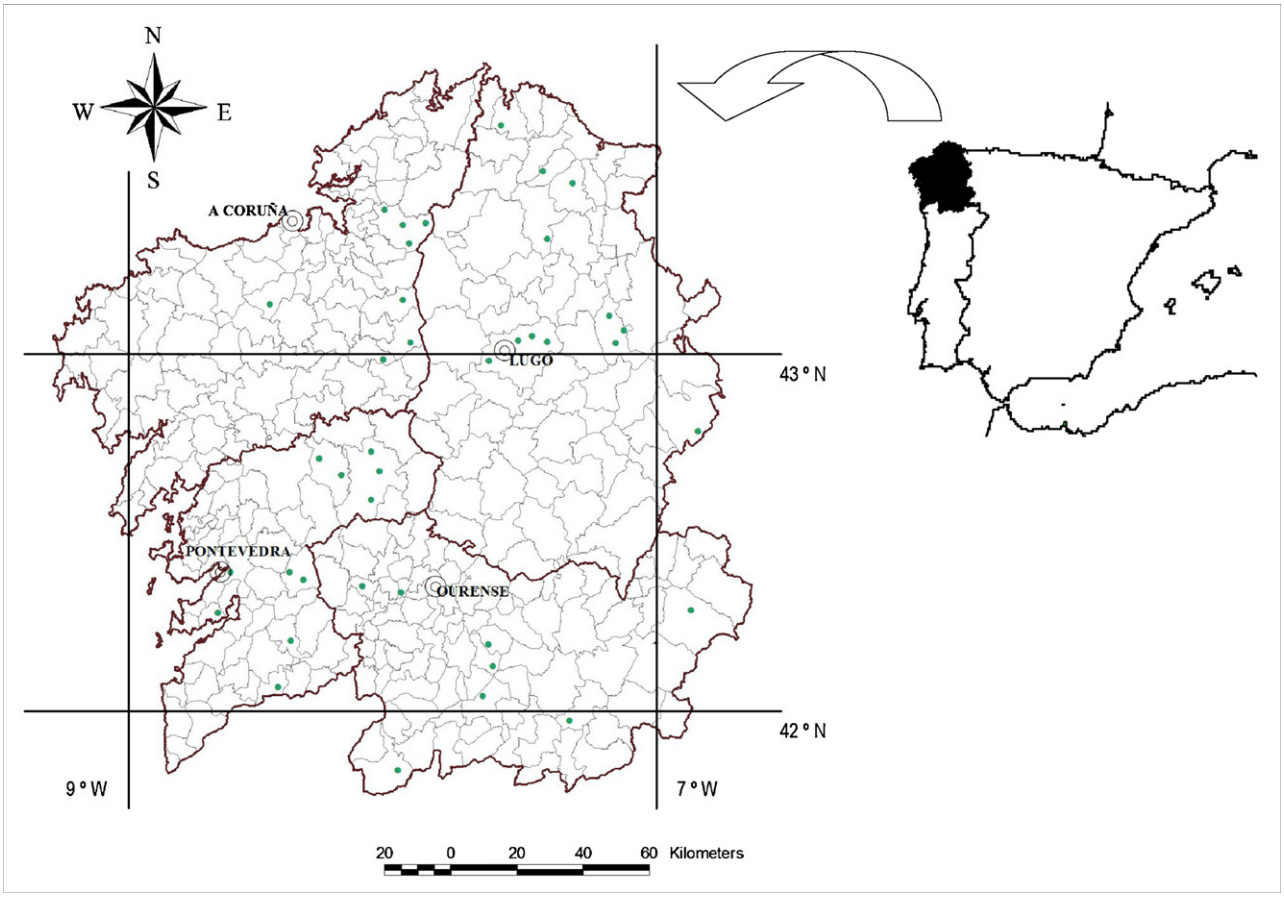

Fig. 1. Distribution of the stands in the study area, Autonomous Community of Galicia, NW Spain.