

PLANNING AND MANAGEMENT OF DECIDUOUS HARDWOODS STANDS IN NORTH-WESTERN SPAIN: A BASIS FOR SUSTAINABLE RURAL DEVELOPMENT

Ignacio J. DIAZ-MAROTO, University of Santiago de Compostela, High Polytechnic School, University Campus s/n, E-27002 Lugo, Spain, ignacio.diazmaroto@usc.es (corresponding author)

Pablo VILA-LAMEIRO, University of Santiago de Compostela, High Polytechnic School, University Campus s/n, E-27002 Lugo, Spain

The climax vegetation that currently covers the north-western Spain is the deciduous hardwoods forests characterized by different oak species. Galician oaks present a wide-ranging range of ages and qualities, as a result of the different uses and status of conservation. Many of these forests were intensively exploited, and in many cases inappropriate management practices have been applied. However, today these forests comprise a habitat of interest to the European Community and should be conserved, remain basic, in many areas to implement sustainable rural development. Common oak forests (*Quercus robur* L.) occupy an area of 246,445 ha in Galicia, 18 % of the total forest area. The current location of a lot of oak stands in steep zones indicates that they have remained in such areas from immemorial times because it was not possible the harvesting and these stands are now very important in ecological and landscape terms. The best sites for *Quercus robur* correspond to zones where the climatic characteristics combine optimally higher minimum temperature, lower thermal amplitude and higher precipitation. Known the present silvicultural status of these forests, alternative methods must be proposed for its management, which will range from a conversion to high forest to recovery of the most deteriorated stands by reforestation.

Keywords: deciduous hardwoods forests; management; NW Spain; Quercus robur; rural development

INTRODUCTION

In the north-western Spain, the climax vegetation that at present covers this area is the deciduous hardwoods forests characterized by various oak species (Buide et al., 1998). The species of genus *Quercus* dominates a large part of the forests in the temperate zone of the Northern hemisphere and in subtropical transition areas. Today, about 400 species are recognized, most of which present in Mexico and extend all over North America, Europe and Asia (Diaz-Maroto et al., 2005). According to palynological studies, these forests were established in the NW Spain between five and seven thousand years ago. Historical factors, site conditions, and requirements of the species give rise to different forest types with various floristic compositions (Peterken and Game, 1984). All the forests belong to *Quercus-Fagetea* class (Atlantic Province) with the maximum possible degree of evolution, and they would remain in the current state if environmental conditions did not change.

The forest planning and management has a considerable influence on the sustainability of forest ecosystems (Johnson et al., 2002; Decocq et al., 2004). In the case of deciduous hardwood forests in general and oak forests specifically applied silvicultural practices are part of the forest tradition (Bouchon and Trencia, 1990). The silviculture utilized to common oak (*Quercus robur* L.) are well developed and up to date in European countries where the species is of great economic importance, 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 awfully different from that in the above-mentioned countries, as there is minor knowledge about the management treatments that should be applied to autochthonous broadleaf forests. Galician oaks present a varied range of ages and qualities, as a result of the different uses and status of conservation (Diaz-Maroto et al., 2005). Coppice forest predominates and it requires continual management otherwise the stands will age and stagnate (Diaz-Maroto et al., 2006; Van Calster et al., 2007). Many of these forests were intensively exploited (i.e. for the wood and firewood extractions for domestic and industrial uses or for the naval industry), and in many cases inappropriate silvicultural practices have been applied (pollarding and felling of the best trees) (Ruiz de la Torre, 1991). Most recently, as a result of rural depopulation, technological developments and social requests, there was a change during the past century from overexploitation of many of them to a total lack of exploitation (Rodá et al., 1999; Reque and Bravo, 2007). The status of these forests has changed recently and there is now a high social demand for its conservation (Diaz-Maroto

et al., 2005). As outlined in Council Directive 92/43/EC, these forests comprise a habitat of interest to the EC and should be conserved; remain basic, in many areas of north-western Spain, to implement sustainable rural development.

Common oak forests, pure stands of *Quercus robur* or mixed with other deciduous, occupy an area of 246,445 ha in Galicia, i.e. approximately 18 % of the total forest area (MAGRAMA, 2011). Within the region, *Quercus robur* behaves as a robust, light-demanding species, which does not tolerate shade at early stages of development and the seedlings languish quickly undercover. The most important 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).

The main objective of this work is to explain the importance of common oak forests as key for sustainable rural development in many areas of Galicia.

RESEARCH METHODS

Study area

The study area comprises the Autonomous Community of Galicia, located in the NW Spain, with a surface of ~ 3 million ha. The mean altitude is 508 m and slopes of more than 20% present in half of the territory. The lithological composition is varied, although there is a dominance of siliceous substrates, such as, granite, schist, slates and quartzite; the climate is diverse, but generally classified as Humid Oceanic, with a certain Mediterranean influence in some zones. Annual precipitation varies between 600 to more than 3000 mm (Diaz-Maroto et al., 2006).

Sampling and data measured

The total area was considered as a single unit, where zones for data collection were selected, taking care to include an adequately representative number of oak stands, on the basis of the data included in the Forest Map of Spain (Ruiz de la Torre, 1991). Representative oak stands were chosen to replant the 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 of variable dimension and contained at least 50 trees ($\varnothing > 5$ cm) (Hummel et al., 1959). Dendrometric data were recorded, and a set of 14 stand parameters that describes the forest site and the present management status was calculated to evaluate the structure and the management of these forests (Rubio et al., 1997; Lebourgeois et al., 2004).

Specifically, the following stand parameters were calculated: 1) number of trees per hectare; 2) basal area per hectare; 3) mean arithmetic diameter; 4) mean quadratic diameter; 5) dominant diameter; 6) mean arithmetic height; 7) mean quadratic height; 8) Assmann's dominant height (Assmann, 1970); 9) standard deviation of the diameter distribution; 10) coefficient of variation of the diameter distribution; 11) standard deviation of the height distribution; 12) coefficient of variation of the height distribution; 13) Hart's index; 14) Czarnowski's index (Timbal and Aussenac, 1996; Claessens et al., 1999).

Statistical analysis

The parameter data allowed the establishment of a database on the silvicultural characteristics of *Quercus robur* stands in Galicia. To explain which of these parameters best characterize the silvicultural treatments and present situation of Galician oak forests, two types of bivariate analysis were carried out. The first compared between them the stand parameters, management features, and the second with the environmental descriptors (Collins and Carson, 2004). On the basis of the results, the silvicultural status of the stands was modelled using stepwise multivariate linear regression analysis.

RESEARCH RESULTS

Management characteristics

The age and site quality of the oak stands were very varied, as a result of its different uses. More specifically, there was high variability in the parameters number of trees and basal area per hectare, and Czarnowski's index, with a coefficient of variation higher than 50 %; in the other parameters related to normal diameter (mean arithmetic diameter, mean quadratic diameter, standard deviation of the diameter distribution, coefficient of variation of the diameter distribution and dominant diameter), and especially to the total height (mean arithmetic height, mean quadratic height, standard deviation of the height distribution, coefficient of variation of the height distribution, dominant diameter, Hart's index and Czarnowski's index), the variability was lower.

Relationship between stand parameters and biotope descriptors

From the set of stand parameters selected to describe the use and present status of the oak stands, the dominant height must be eliminated, as well Hart's index, which depends on the former. This is because dominant height is affected by certain unsuitable silvicultural treatments to which the stands have been subjected, such as pollarding and felling of trees to provide firewood and food for livestock. Finally, only four stand parameters remained for common oak (mean arithmetic diameter, mean quadratic diameter, mean arithmetic height and mean quadratic height). All of these are closely related to the following biotope descriptors: altitude, soil depth to the parent rock, mean annual temperature and annual mean of absolute minimum temperatures, even with the mean arithmetic diameter and mean quadratic diameter at a level of significance of 99 %.

CONCLUSIONS AND DISCUSSION

The present location of many oak stands in steep zones indicates that they have remained in such areas from immemorial times because it was not feasible the harvesting and these stands are now very valuable in ecological and

landscape terms. However, the results show that with lower values of altitude, slope and distance from the sea, the stand density is greater and the spacing between trees is lower. Therefore the best sites for *Quercus robur* in NW Spain correspond to thalweg zones or intermediate slopes with an important oceanic influence and, where the climatic characteristics combine optimally higher minimum temperature, lower thermal amplitude and higher precipitation. This is related to the growth period of the species and guarantees its adequate development.

Regarding to the stand parameters, the four parameters discussed previously, are suitable for correctly defining the features of common oak stands in Galicia (Lévy et al., 1992; Timbal and Aussenac, 1996; Rubio et al., 1997), and it can be established that the distribution of the stands are more closely related to the physiographic and climatic characteristics than to edaphic factors probably because the substrates' character on which the stands develop is similar (Diaz-Maroto et al., 2005, 2006).

The statistical relationships between stand and ecological parameters revealed by multivariate regression analysis showed that, although it is possible to establish close correlations with climatic factors, it is the physiographic parameters, slope, distance from the sea and depth of soil, that best define the present status of these forests (Diaz-Maroto et al., 2005, 2006).

Given the present silvicultural status of these stands, alternative methods must be proposed for its management, which will range from a conversion to high forest to recovery of the most deteriorated stands by reforestation (Rondeux, 1993). Finally, the following recommendations can be made for right management of these forests: i) conversion of coppice forest to seedling/high forest for subsequent management; ii) many of the present stands in coppice forest are old and genetically impoverished and its conversion would be unviable from an economic point of view; such stands could be managed as protection forest or for recreational use; iii) in stands whose conversion to high forest would be economically more feasible, it would be necessary for the Forest Administration to create a way of managing these forests, which does not exist at present; and iv) favour reforestations with deciduous broadleaved species in general, and in particular with oak species that make up the climax formations in the study area.

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