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(Article begins on next page)

Decline of *Quercus robur* forests in northwestern Italy: current situation and tentative aetiology

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Abstract: *Quercus robur* decline is a widespread phenomenon in northwestern Italy. In order to determine the incidence, the severity and the evolution of the decline, *Q. robur* crown transparency was assessed starting from 2007 in 11 study sites. In 2007, the mean crown transparency ranged from 35% to 74% depending on sites. No significant variation was observed among crown transparency levels in the 3 sampling periods (2007-2008-2009) at any sites. Soil and climate conditions of study sites were investigated in order to find possible correlations with crown transparency. Drought in spring may be the main factor triggering off oak decline in northwestern Italy. Ongoing experiments indicate that the availability of water and light may have effect only in the medium and long time period.

Key words: oak decline, *Quercus robur*, crown transparency, climate

Introduction

According to recent estimations, in Piedmont, the largest northwestern Italian district, *Quercus robur* L. stands cover only 2% of the total surface of plain forests (Gottero et al., 2007). Furthermore since the 1980's a decline syndrome is threatening the survival of oak forests in Italy (Ragazzi et al., 2000), and especially of *Q. robur*, which has been identified as one of the most susceptible oak species (Ragazzi et al., 2000). The effects of the syndrome may be chronic or acute, in the latter case leading to the death of the tree in a few vegetative periods (Ragazzi et al., 2000). A wide range of abiotic and biotic factors are involved in forest decline (Manion, 1991) and much research has been undertaken to understand their role in the disease aetiology.

The aim of this study was to investigate the symptomatology, the distribution, the incidence and the severity of decline of *Q. robur* forests in northwestern Italy. We also examined possible relationships between soil types, climate conditions and the decline severity. Due to *Q. robur* autoecology, characterised by high light requirements and low tolerance to water deficit (Bernetti, 1995; Cellerino & Gennaro, 2000), further aetiological investigations were conducted by designing two experiments, the first based on silvicultural practises and the second on irrigation.

Material and methods

In order to determine the decline severity, three parameters were examined: crown transparency, level of branch desiccation (from 0% to 95%) and mortality (Müller & Stierlin, 1990; Bussotti & Bruschi, 2000; Durrant et al., 2006).

During summer 2007, linear transects each consisting of 80 *Q. robur* dominant trees were examined in 11 forest sites in Piedmont, northwestern Italy. A checklist of all visible symptoms was compiled. The regional forest type classification was adopted to describe sites from an edaphic and vegetational point of view (Camerano et al., 2008). Monthly mean temperature (°C) and total precipitation (mm) over the periods 1951-1986 (Cagnazzi e Marchisio, 1998) and from 1994 to present (ARPA Piemonte, 2009) were available for all sites. In order to investigate the relationship between climate and decline severity, we calculated the De Martonne's aridity index (De Martonne, 1926) based on the above data.

Three of the above sites were monitored as previously described in 2008 and 2009. In 2008, a new trial was designed in two homogeneous and contiguous plots in Racconigi (TO) to test the effects of light and silvicultural practises in the decline phenomenon. In the first area (S), a thinning was performed to better allocate solar radiation and reduce competition on *Q. robur* trees, while the second area (C_s) was left unthinned as a control. In 2009, we designed an experiment to investigate the effect of water deficit on the decline severity. Two homogeneous plots were located in Trino Vercellese (VC). In the first one (I), 4 irrigators were placed to uniformly sprinkle water thus imitating natural rainfalls, while the other area (C_i) was not subjected to any additional water supply. In order to regulate the water amount necessary to avoid water stress on oaks, a weather station was set nearby experimental plots.

Non parametric tests and indexes were adopted to analyse sample differences, variable relevance and correlations among parameters (Conover, 1980; Mehta & Patel, 1996; Klersy, 2001; Soliani, 2004). A 5% significance cut off was adopted to reject the null hypothesis. Analyses were performed using the softwares SPSS[®] (version 16.0) and XLSTAT[®] (version 7.5.2).

Results and discussion

Q. robur decline is a widespread phenomenon in northwestern Italy: all the examined forests showed decline symptoms. Crown transparency ranged from 35% to 75% (55% on average), the level of branch desiccation from 11% to 49% (29% on average) and the rate of mortality was comprised between 1% and 33% (10% on average). Significant Spearman's rank correlations ($p < 0.05$) were detected between crown transparency and levels of branch desiccation ($\rho = 0.46$) and mortality ($\rho = 0.52$), while crown transparency was not correlated to diameter at breast height ($p > 0.05$).

In agreement with previous reports (Bussotti & Bruschi, 2000; Cellerino & Gennaro, 2000; Ragazzi et al., 2000; Moriondo et al., 2006), a complex and variable pattern of symptoms was noticed: crown transparency, microphyllia, branch dieback, twig abscission, epicormic sprout development on stems and largest branches, localised dark exudations from bark, desiccation and mortality of crown sectors, premature death.

Sites on high terrace soils, low terrace soils, and floodplain soils (Camerano et al., 2008) resulted in different levels of decline severity (58.4%; 48.9%; 61.0% of crown transparency, respectively; 32.7%, 26.9%, 29.9% of branch desiccation levels, respectively; 16.7%, 8.2%, 7.7% of mortality rate, respectively). However, these differences were not significant (Kruskal-Wallis test; $p > 0.05$). Despite forest and vegetation types were diversified (Camerano

et al., 2008), the decline severity appeared to be quite homogeneous. This finding suggests that *Q. robur* decline is related to factors operating at a regional scale rather than locally.

Climate parameters over the period 1951-1986, when no oak decline had been reported in Italy, were compared with parameters of 1994-2007, when decline was observed (Fig. 1). Total annual precipitations decreased from 1040mm/yr to 800mm/yr while mean temperature increased from 12.3°C to 13.0°C. It is noteworthy that February, March, April and May shifted towards significantly marked chronic aridity conditions (Mann-Whitney test; $p < 0.05$). In agreement with other reports (Cellerino & Gennaro, 2000) our conclusion was that drought may be the main factor triggering off decline, especially because it has been occurring in spring, when water uptake by trees is generally relevant.

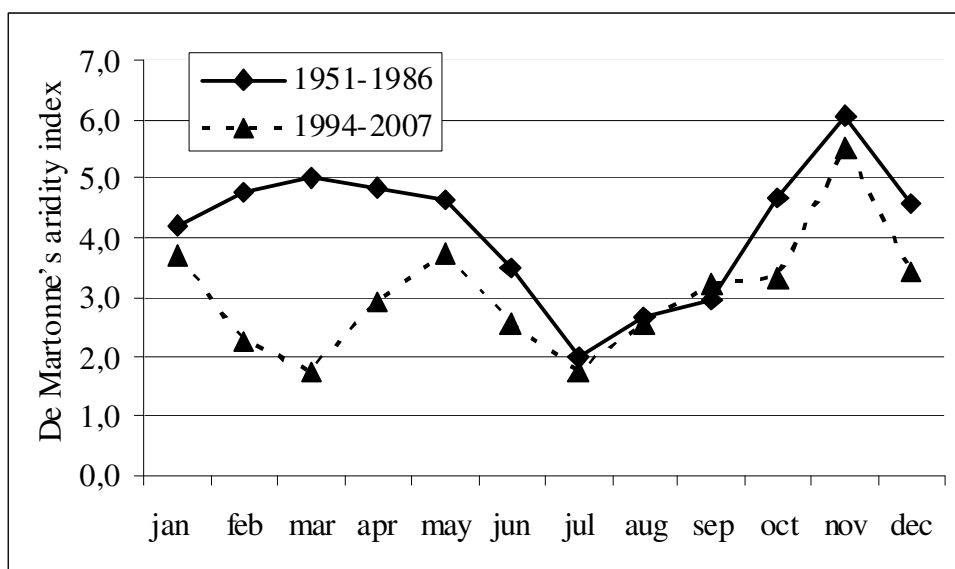


Figure 1. Monthly De Martonne's aridity index values over the period 1951-1986, when no decline was reported in Italy, and 1994-2007, when decline was observed.

In the three sites monitored over a longer period (2007-2008-2009), we did not observe significant variation of decline severity over time (Kruskal-Wallis test; $p > 0.05$) despite some significant fluctuations in climate parameters (Mann-Whitney test; $p < 0.05$). The same was true for S and C_s areas whose decline severity was comparable (Mann-Whitney test; $p > 0.05$) both in 2008 and in 2009 despite the S area was thinned. This result and some literature reports (Becker et al., 1994; Rozas, 2005) suggest that *Q. robur* reaction to climatic or anthropic disturbances is not immediate. Water deficit experiment of 2009 confirms this conclusion since no differences in decline severity (Mann-Whitney test; $p > 0.05$) were detected between areas I and C_i (38% transparency and 12% branches desiccation on average). Further studies are needed to detect the evolution of decline over longer time periods and to test whether thinnings may be suitable to mitigate oak decline.

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