Climatic signals of tree-ring in *Quercus gussonei* (Borzì) Brullo in the Mediterranean Region

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INTRODUCTION

Change in growth is among the primary response of trees to environmental variation. Tree-rings contain a wealth of information related to climatic conditions and have been often used to investigate the effects of global changes on forest ecosystems (Helama et al., 2009; Di Filippo et al., 2010).

Quercus gussonei (Borzì) Brullo is an endemic deciduous oak restricted to small areas in N and W Sicily. It shows several morphological affinities with its relative *Q. cerris* L., but differs markedly for a more thermophilic behavior. Since the last decades symptoms of decline, involving crown transparency up to tree death, have been observed in populations from the Nature Reserve of "Bosco della Ficuzza, Rocca Busambra, Bosco Del Cappelliere, Gorgo Del Drago" (W Sicily) (FIG. 1) (Sala et al., 2011). In order to assess if these phenomena could be related to climate changes, dendrochronological and carbon isotopes investigations were carried out on these trees populations in the aim to establish if necessary proper criteria for forest conservation management.

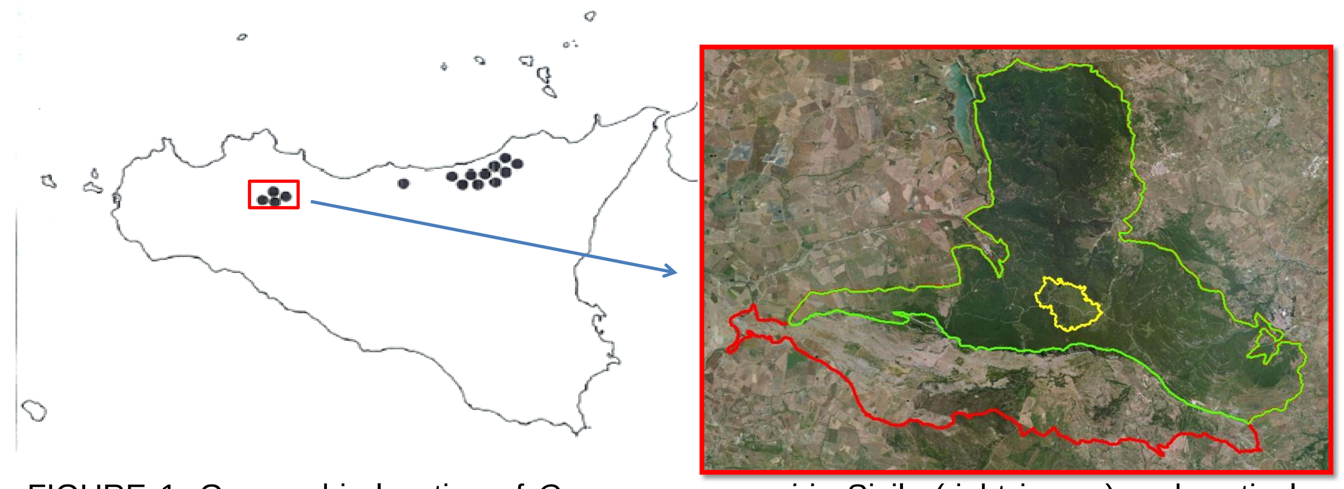

FIGURE 1. Geographic location of *Quercus gussonei* in Sicily (right image) and particular distribution in the Nature Reserve of Ficuzza (sampling area is highlight with yellow line).

OBJECTIVES

- ✓Evaluate tree-ring *vs* climate relationships
- ✓Assess the role of climate in oak decline

FIGURE 2. Evidences of oak decline.

MATERIALS AND METHODOS

Three cores per tree were sampled by an increment borer from ten healthy plants, whereas one trunk disk was collected at DBH from each of five recently dead plants.

Total ring width (TRW) was measured (1/1000 mm precision) on cores and disks; additionally, earlywood (EW) and latewood width (LW) were measured on healthy trees. Crossdating within and between trees was performed by both visual and statistical analyses, using the program COFECHA (Holmes, 1983). Therefore in order to remove age-related growth trends and competition effects, each individual ring-width series was standardized by a two-step detrending method: a negative exponential, in order to remove the long-term trend related to tree ageing, and a cubic smoothing spline function with a 50% frequency response of 30 years. To remove the previous year effect, an autoregressive model was fitted to the standardized indices. To reduce the influence of isolated outlier value, mean chronologies for healthy and dead trees, respectively, were obtained by averaging the index series using a biweight robust mean. Response functions between healthy trees and climate data were computed using DendroClim2002 program (Biondi and Waikul, 2004).

Disk of dead plants were used to investigate water-use efficiency (WUE) variations and the expression of possible plant adaptive traits through the analysis of stable isotope discrimination of carbon ($\Delta^{13}C$) in the wood. At this aim a small amount of wood from each yearly growth ring was milled and subsamples were used for isotopic determinations by means of a continuous flow isotope ratio mass spectrometer.

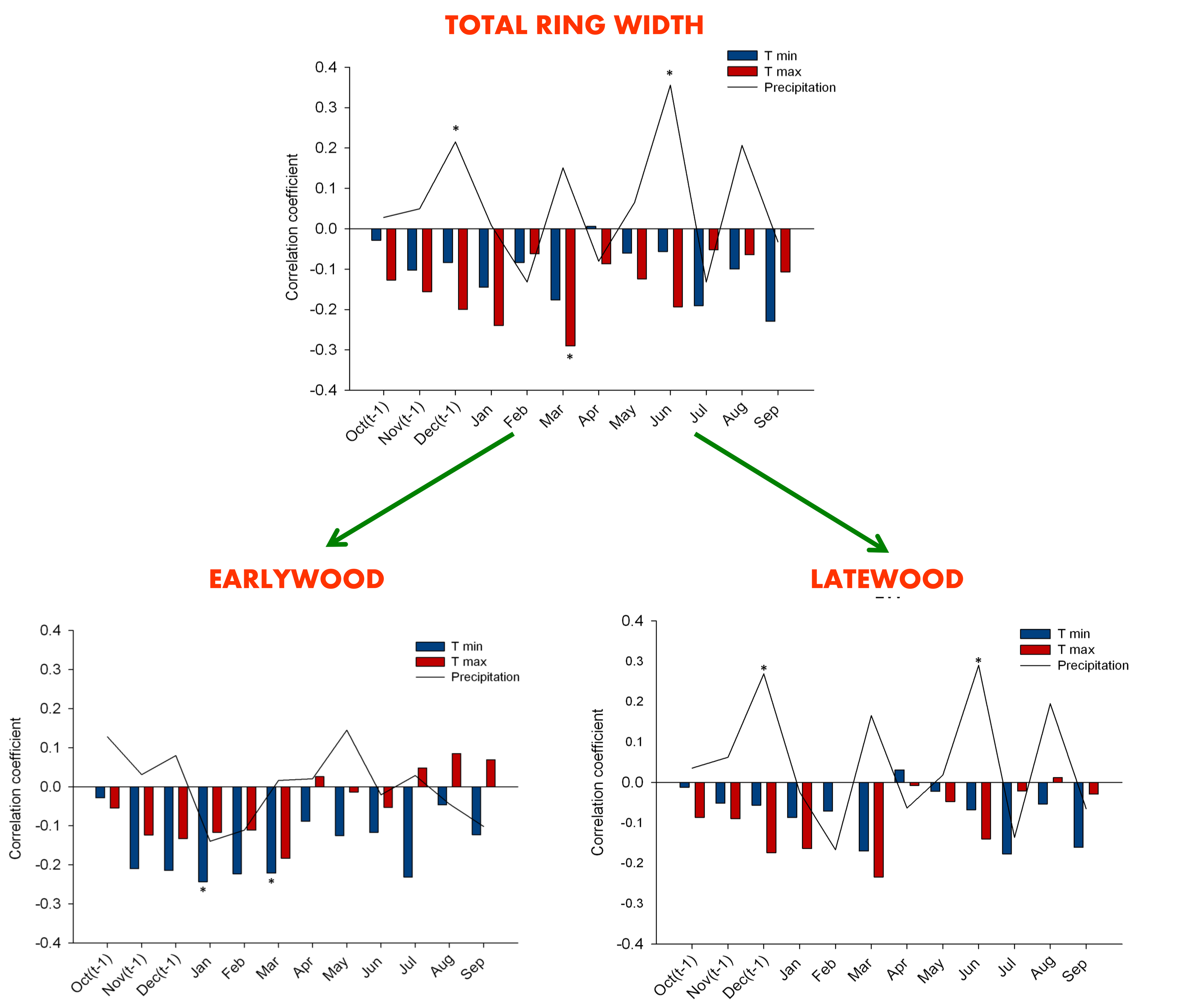

FIGURE 3. Response functions for TRW, EW and LW chronologies in the period 1951-2008. The stars indicate significant correlation ($P < 0.05$).

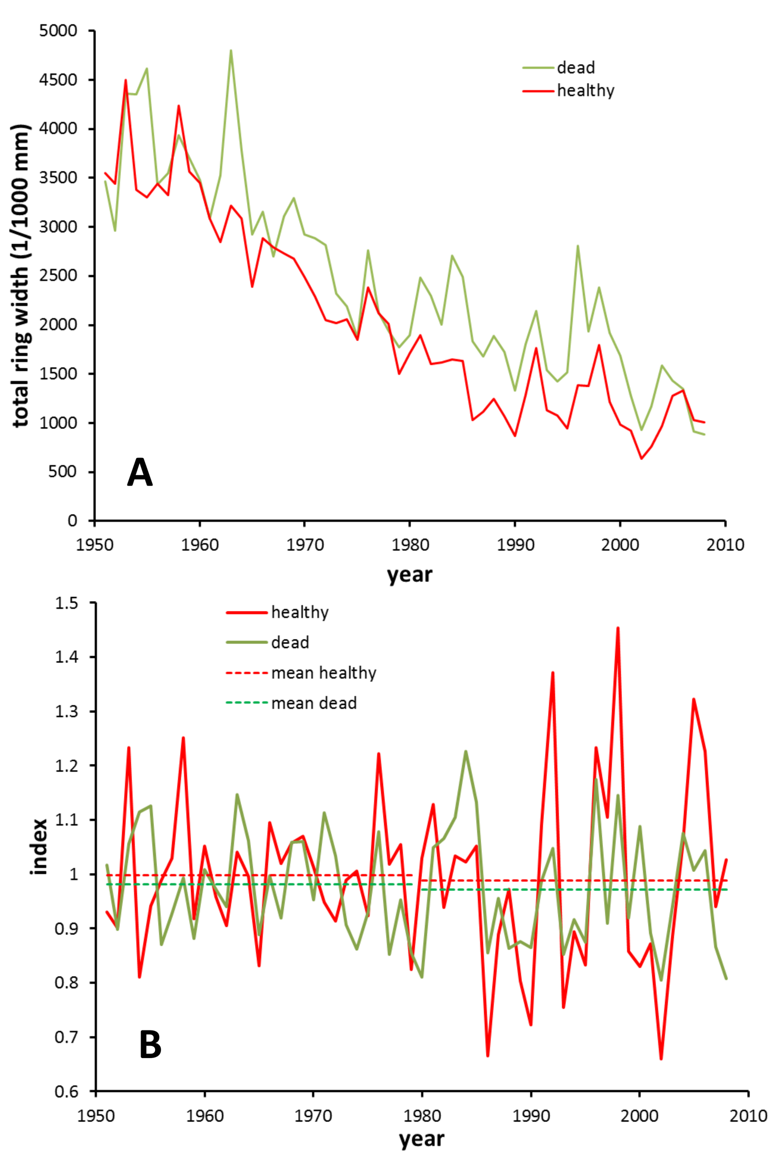

FIGURE 4. Mean raw (A) and indexed (B) ring-width chronology of healthy and dead trees. Dashed lines indicate the mean indexed growth in the periods 1951-1979 and 1980-2008

RESULTS AND DISCUSSION

The two investigated tree groups both covered a time span of 58 years, from 1951 to 2008. TRW is positively correlated to precipitations of December (year t-1) and June (year t); on the contrary temperatures of March (year t) affect negatively growth. More in detail, EW growth appears to be inversely correlated to minimum temperatures of January and March (year t), whereas LW seems depending more directly by precipitations of December (year t-1) and June (year t) (FIG. 3).

These results are quite consistent with the ecology of many typical species of the Mediterranean climate area (Martinelli et al., 1994; Garfì, 2000; Di Filippo al., 2010). In our study case, particularly, the negative influence of late winter/early spring temperatures on early wood could be related to the anticipated triggering of the growth season, possibly stopped later on in the season due to unexpected late frost following temperature drop. Such events often involve the ineffective consumption of reserves that will be no longer available when growth resumes after temperatures raise. Precipitations of December have a major role in restoring underground water supply, which will be essential during the summer growth, in addition to the precipitations of June.

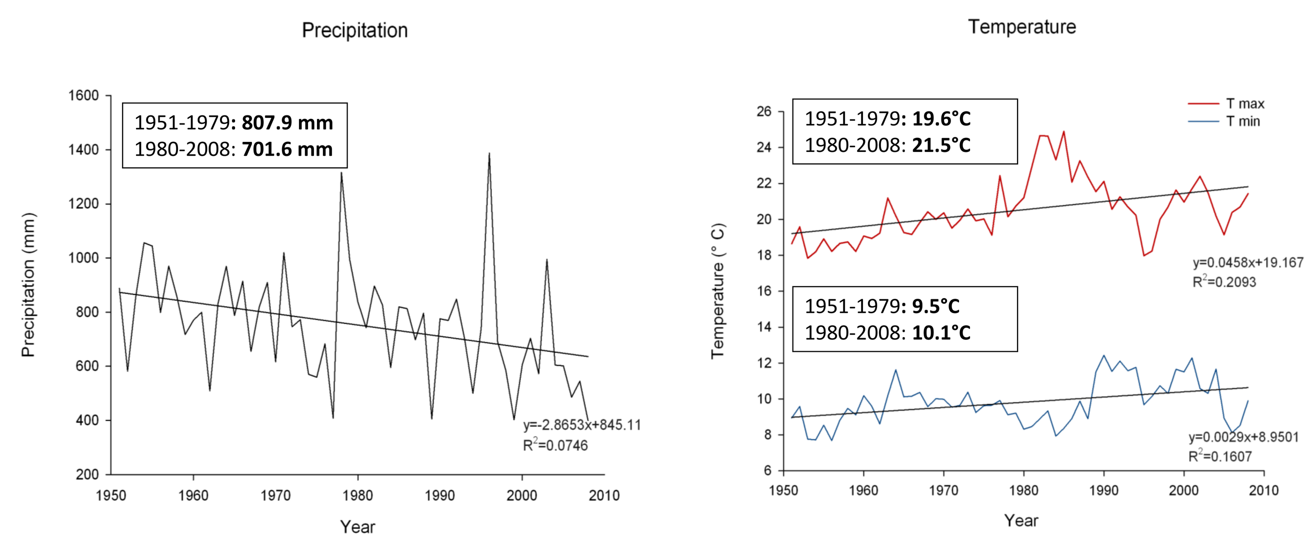

FIGURE 5. Trends in precipitations and maximum and minimum temperatures in the investigated period 1951-2008

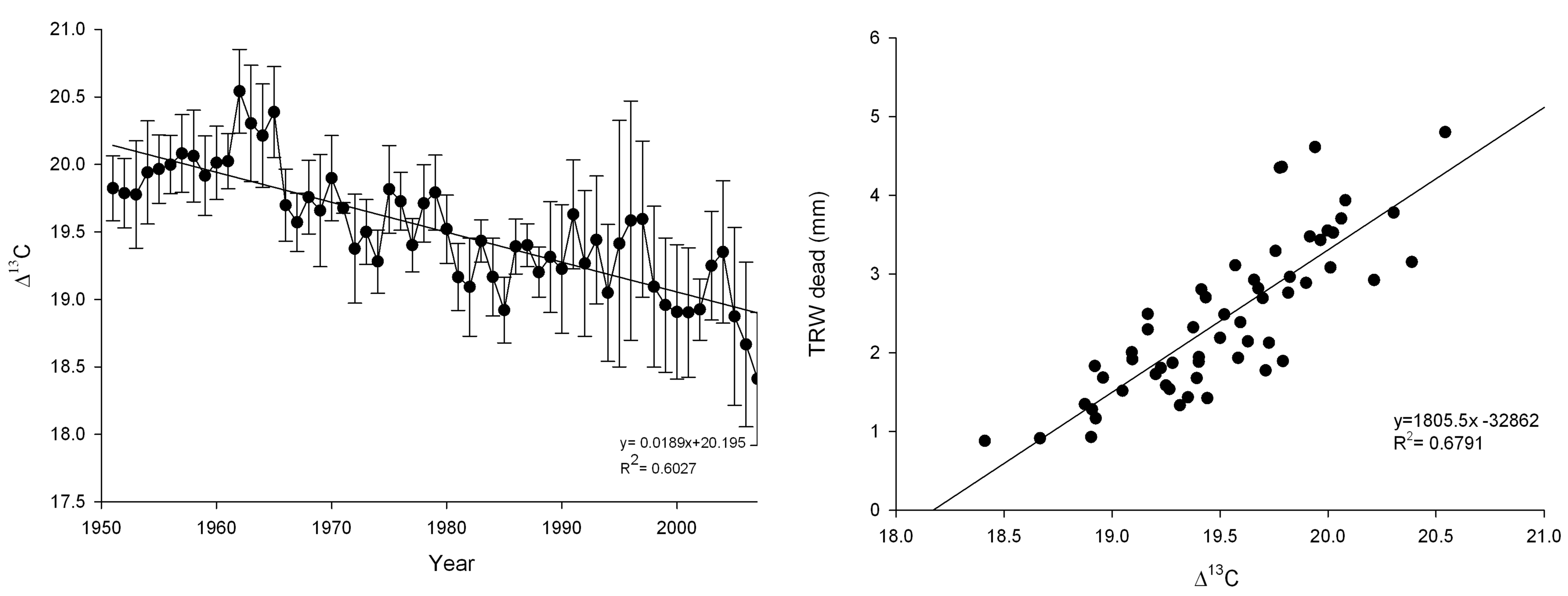

FIGURE 6. Carbon isotope discrimination $\Delta^{13}C$. each point represents the mean value of five trees. Bars represent standard error.

Growth rate of healthy and dead trees was rather comparable and no significant decreasing trend could be observed all along the investigated period in both plant groups (FIG. 4). On the contrary, climate data show remarkable changes: annual precipitations show a significant decrease (-13.2%) between the two periods 1951-1979 and 1980-2008, whereas in the same intervals the average minimum and maximum temperatures respectively raise by 0.6 and 1.9°C (FIG. 5). Apparently, such a climate change did not affect the growth of oak trees. Contrarily, $\Delta^{13}C$ showed a decreasing linear trend through time (FIG. 6). Since $\Delta^{13}C$ is inversely related to WUE (Farquhar et al., 1989), the oaks increased their water-use efficiency, maintaining physiological water potentials and rather good growth performances, notwithstanding deteriorations in environmental conditions. In this regard, two distinct mechanisms are likely to explain the acclimation of physiological responses: increased diffusive resistances through stomata and mesophyll restraining both CO_2 and H_2O gas exchanges, concomitantly to incremental adjustments in leaf area exposure. Finally, such a strategy could be lethal in the long term.

CONCLUSIONS

Despite oak decline has been observed since years in Sicily, climate changes in their wider meaning cannot be evoked as the direct responsible factor. Up to now, oak trees seem to retain a certain resilience to efficiently face less favorable environmental conditions. Considering that the appearance of the first decline symptoms have been usually observed just a couple of years prior the death of trees, it is suggested that opportunistic pathogens could become lethal just in coincidence of intermittent unfavorable climatic seasons. Impairment of xylem sectional area to that of photosynthetic tissues could likely explain what was observed: the sudden plant collapse.

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REFERENCES
Biondi F., Waikul K., (2004) DENDROCLIM2002: A C++ program for statistical calibration of climate signals in tree-ring chronologies. Computers & Geosciences, 30: 303-311.
Di Filippo A., Alessandrini A., Biondi F., Blasi S., Portoghesi L., Piovesan G., (2010) Climate change and oak growth decline: Dendroecology and stand productivity of a Turkey oak (*Quercus cerris* L.) old stored coppice in Central Italy. Ann. For. C., 67: 706-720.
Farquhar G.D., Ehleringer J.R., Hubick K.T., (1989) Carbon isotope discrimination and photosynthesis. Annu. Rev. of Plant Physiol. and Plant Mol. Biol., 40: 503-537.
Garfì G., (2000) Climatic signal in tree-rings of *Quercus pubescens* s.l. and *Celtis australis* L. in South-eastern Sicily. Dendrochronologia, 18: 41-51.
Helama S., Läänelaid A., Raisio J., Tuomenvirta H., (2009) Oak decline in Helsinki portrayed by tree-rings, climate and soil data. Plant and Soil, 319:1-2, 163-174.
Holmes R. L., (1983) Computer-assisted quality control in tree ring dating and measurement. Tree-Ring Bulletin, 43: 69-78
Martinelli N., Pignatelli O., Romagnoli M., (1994) Primo contributo allo studio dendroclimatologico del cerro (*Quercus cerris L.*) in Sicilia. Dendrochronologia, 12: 61-76.
Sala G., Giardina G., La Mantia T., (2011) I fattori di rischio per la biodiversità forestale in Sicilia: il caso studio del cerro di Gussone. L'Italia Forestale e Montana, 66 (1): 71-80.