ON THE COEXISTENCE OF MEDITERRANEAN OAK TREES HAVING DIFFERENT HYGROPHILIA

Di Paola A.[1], Paquette A[2]., Trabucco A.[3], Valentini R.[4] and Paparella F.[5]

1.Euro-Mediterranean Center on Climate Change (CMCC), IAFENT Division, Viterbo–Italy; 2.Centre for Forest Research (CFR), Université du Québec à Montréal, Montréal (Québec), Canada; 3.Euro-Mediterranean Center on Climate Change (CMCC), IAFENT Division, Sassari–Italy ; 4.Director of Division of Climate Change Impacts on agriculture, forests and natural ecosystems. Euro-Mediterranean Center for Climate Change (CMMC). Lecce, Italy; 5.Department of Mathematics and Physics "Ennio De Giorgi", University of Salento, Lecce, Italy

INTRODUCTION

Co-occurrence of species having different adaptations to water stress is common in Mediterranean region, and is regarded as one of the distinctive features of Mediterranean diversity. In a previous work [1] we have defined a mathematical model able to explain the observed co-occurrence of Mediterranean oak trees having different *hygrophilia* (i.e. drought sensitive / drought tolerant). The model predicts a stable coexistence within niches defined by mean annual evapotranspiration (AET).

AIM

We aim to test the validity of the model by analyzing the distribution of Mediterranean oak species, broadly distinct in evergreen and deciduous groups according to their adaptive strategies against water stress, with respect to the actual evapotranspiration (AET) derived from MODIS.

METHODS

DERIVING THE INEQUALITIES FOR A STABLE COEXISTENCE

The model[1] predicts that a stable forest with the occurrence of both the species (*Deciduous oaks as Hygrophilous* species and *Evergreen oaks as Non-Hygrophilous* ones) must have an evapotranspiration ranging between the characteristic evapotranspiration of a stable forest composed only by deciduous group and that of a stable forest composed only by evergreen ones.

$$AET_{Evergreen} < AET_{Coexistence} < AET_{Deciduous}$$

WHERE

Within the Mediterranean climate type (i.e. Csa and Csb according to the Köppen Climate Classification) where plant species face to summer drought and prolonged wet winter.

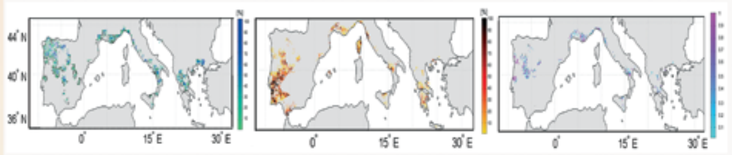

Fig. 1. Mediterranean oaks distribution (expressed as percentage of land cover). Blue: deciduous species (*Q. cerris, Q. frainetto, Q. pyrenaica, Q. faginea, Q. pubescens, Q. petraea* and *Q. robur*). Red: evergreen oaks species (*Q. ilex, Q. coccifera, Q. suber, Q. trojana* and *Q. rotundifolia*). Violet: co-occurrence of both deciduous and evergreen oaks. Data provided by the ECJRC. Map designed in Gall-Peters projection.

VALIDATION DATA

1) The Global Potential Evapotranspiration (PET) dataset provided by the CGIARS-CSI consortium[2] at resolution of 30 arc sec (~1-km);
2) MODIS Actual Evapotranspiration Global Maps [3], from which we derived the mean annual evapotranspiration (AET, period 2000-2011, resolution of 30 arc'' (~1-km);
3) The European Tree Species Distribution [4] provided by the European Commission's Joint Research Centre (JRC), see Fig. 1.
4) Mean Annual Precipitation (P), covering the time period 1950-2000, provided by WorldClim [5] at resolution of 30 arc sec (~1-km);
5) Digital elevation model (DEM) from the Shuttle Radar Topography Mission (SRTM), also provided at 30 arc sec (~1-km) spatial resolution [6].

RESULTS

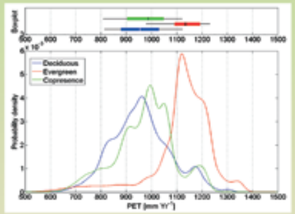

Fig. 2. Distributions of deciduous (blue line), evergreen (red line) and co-occurrence (green line) of both the groups with respect to PET. Top: Boxplot. On each box, the central line is the median, the edges of the box are the 25th and 75th percentiles, the whiskers extend to the 10th and 90th percentile; Bottom: Probability density functions estimated from data.

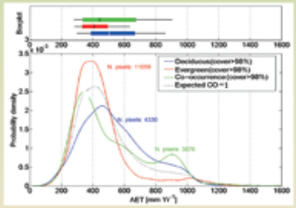

Fig. 3. Distributions of deciduous (blue line), evergreen (red line) and co-occurrence (green line) of both the groups with respect to MODIS AET. Symbols and colors as Fig 4.; The "expected co-occurrence" is given by the arithmetic mean of the blue and red lines

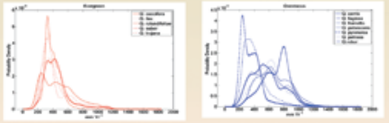

Fig 4. Probability density functions of single evergreen (red lines) and deciduous (blue lines) oak species with respect to the Evapotranspiration derive from MODIS.
Q. pyrenaica and Q. faginea seem more similar to the evergreen when compared respect to AET.

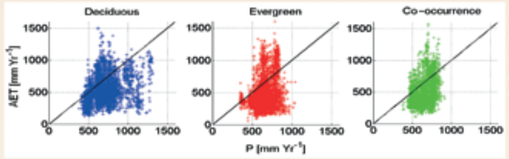

Fig. 5. Scatter plot between P and AET. The black line is the bisector. *Values of AET>P are dubious for forest ecosystems, although not impossible, because they suppose other sources of water than rainfall.*

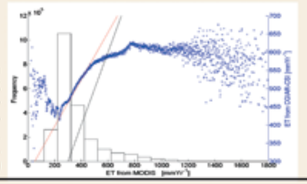

Fig. 6. Histogram of MODIS AET and scatter plot between MODIS AET (physiological derived model) and AET-CGIAR (water balance derived) The red line represents the relation AET-CGIAR =268+AET x 1.55^{-1}, the black one the relation 1:1.
Within 250-1100mmYr⁻¹ the datasets show a deterministic relation (spread <50mmYr⁻¹)

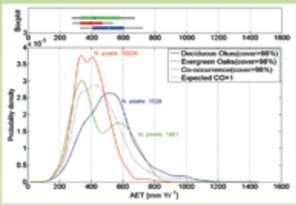

Fig. 7. As Fig. 3 but excluding data of *Q. pyrenaica* and *Q. faginea* (according to Fig. 4, blue panel) and excluding data of AET larger than P (according to Fig. 5).

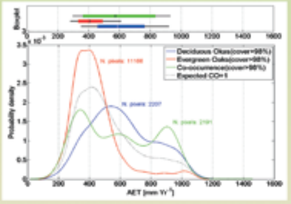

Fig. 8. As Fig. 3 but excluding data of *Q. pyrenaica* and *Q. faginea* and data of AET>1100mmYr⁻¹ (according to Fig. 4 and 8)

SUMMARY RESULTS

1) leaf habit (Deciduous vs. Evergreen) is a reasonable proxy to distinguish species having different *hygrophilia* (Fig. 2);
2) the model is broadly consistent with data (Fig 3, 7 and 8)
3) The main influences on resulting PDFs are given by:
- the presence/absence of Iberian oaks (Fig. 4, blue panel) visible at lower values of AET (compare Fig. 3 with Fig. 7-8) ;
- a ratio AET/P >1 at higher values of AET (compare Fig. 3 with Fig. 7)
4) co-occurrence of deciduous and evergreen oak groups at unusually high rates of mean annual AET (green peak at 800-1000mm/Yr⁻¹ of Fig. 3 and 8) is an unexpected result thath totally depend on including pixels that have AET larger than P.
5) co-presence has a wider diffusion respect to of the two individual species: the green box is hidden behind those blue and red, the median is always including between those of the individual species but the extension of the whiskers exceeds those of the individual species hinting that some mechanism of facilitation/complementary might be at work.

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