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Structural overshoots and post-drought recovery depend on site- and species-specific characteristics in Mediterranean mixed forests

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1-OVERVIEW

Forest dieback phenomena occur worldwide and have been mainly attributed to droughts and extreme heat waves (Allen et al., 2010, Allen et al., 2015). These phenomena are more pronounced in the Mediterranean basin, where increasing drought severity is affecting forest health leading to changes in structural and ecophysiological responses resulting in dieback. These conditions lead to an erosion of forest resilience (Senf et al., 2021), making them more vulnerable.

In this work, we used field data on tree ring width to assess the effects of the summer 2017 drought on some Mediterranean tree species in southern Italy (*Fraxinus ornus*, *Quercus pubescens*, *Acer monspessulanum*, *Pinus pinaster*).We examined six sites (mixed forests), impacted by the 2017 drought (Coluzzi et al., 2020), in the southern Apennine mountain range to study the response to forest vegetation growth using resilience indices (Lloret et al., 2011). While we used remote sensing data (NDVI) to characterise canopy cover conditions during the 2017 drought event. By comparing radial growth and resilience indices we found that growth responses to drought depend not only on tree species but also on site conditions, also highlighting a possible phenomenon of structural overshoots.

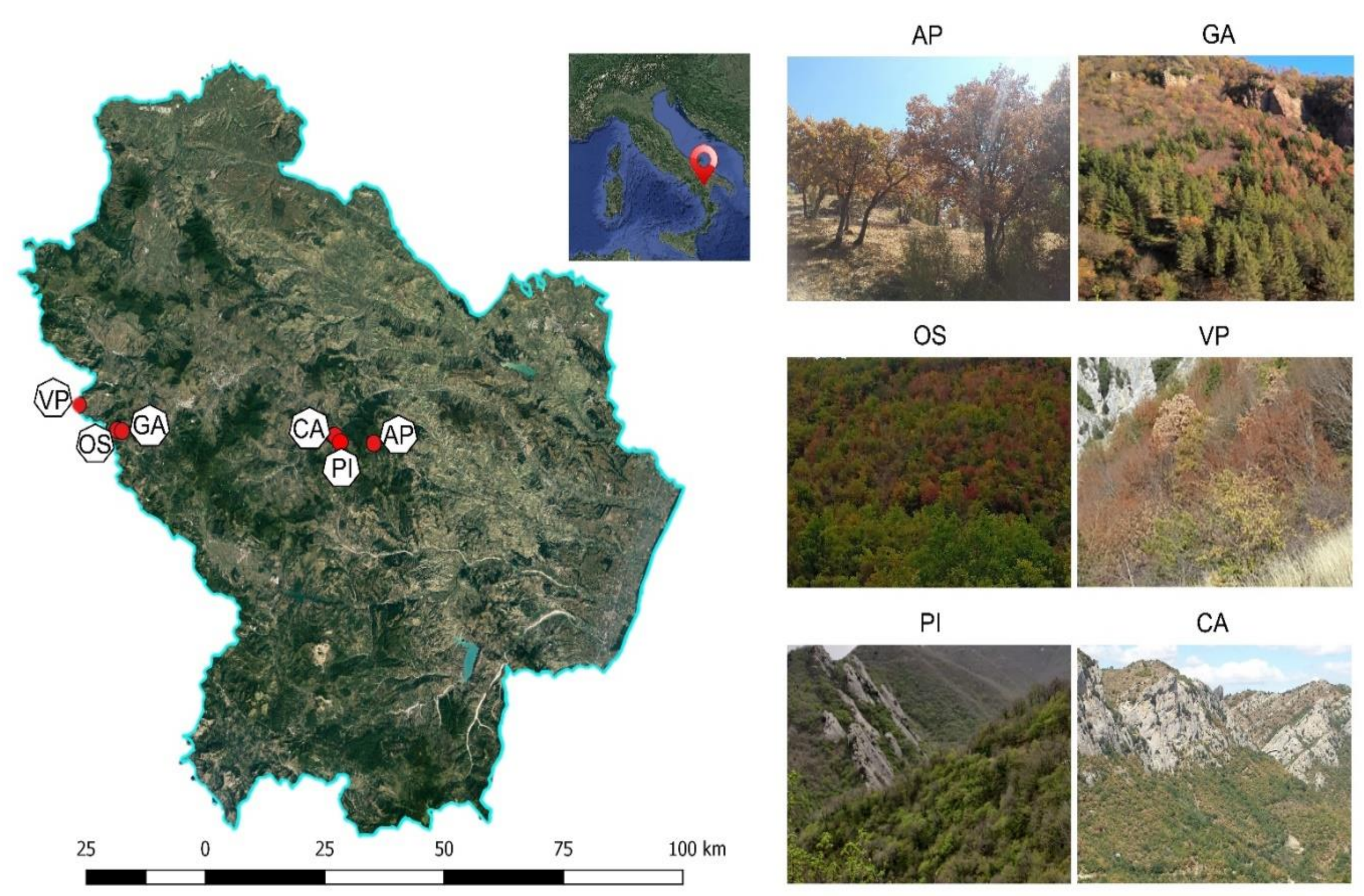

Figure 1. Map showing the location of the six study sites in Basilicata region (southern Italy) and images showing impacts of the 2017 summer drought (brown crowns, leaf shedding) at each site.

2-METHODS

Climate data

The SPEI (The Standardised Precipitation and Evapotranspiration Index with a resolution of 0.5° http://spei.csic.es/index.html) was used to characterise the climate (**fig.2**) showing minimum values in 2003, 2012, 2017, while the lowest values in the series were recorded in **2017**. Low relative humidity values, measured by nearby weather stations, (daily data from 2012 to 2021) are especially evident in **2017** (**fig.3**). Temperatures show increases over time (**fig.4, A**) and precipitation is highly variable (**fig.4, B**), with precipitation significantly increasing in spring and significantly decreasing in **2017** (E-OBS climate dataset ver. 22.0).

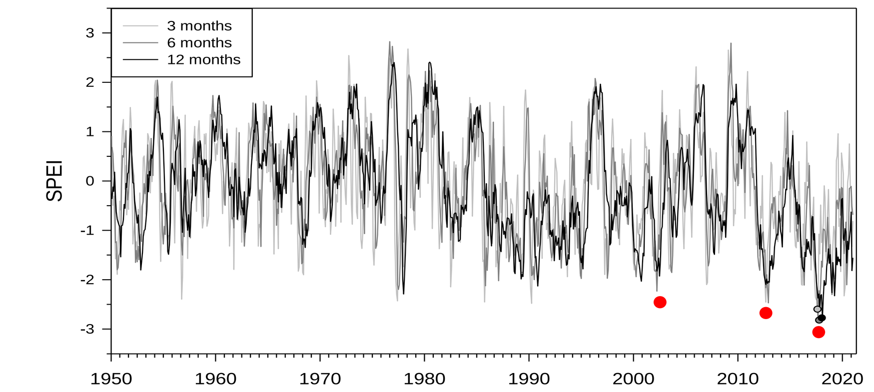

Figure 2. SPEI

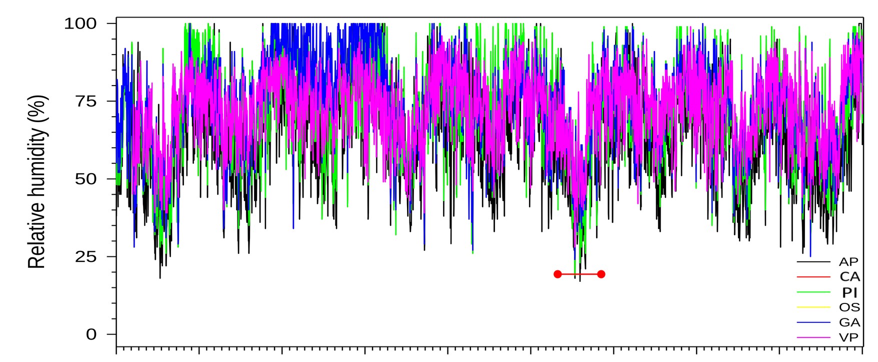

Figure 3. Relative humidity

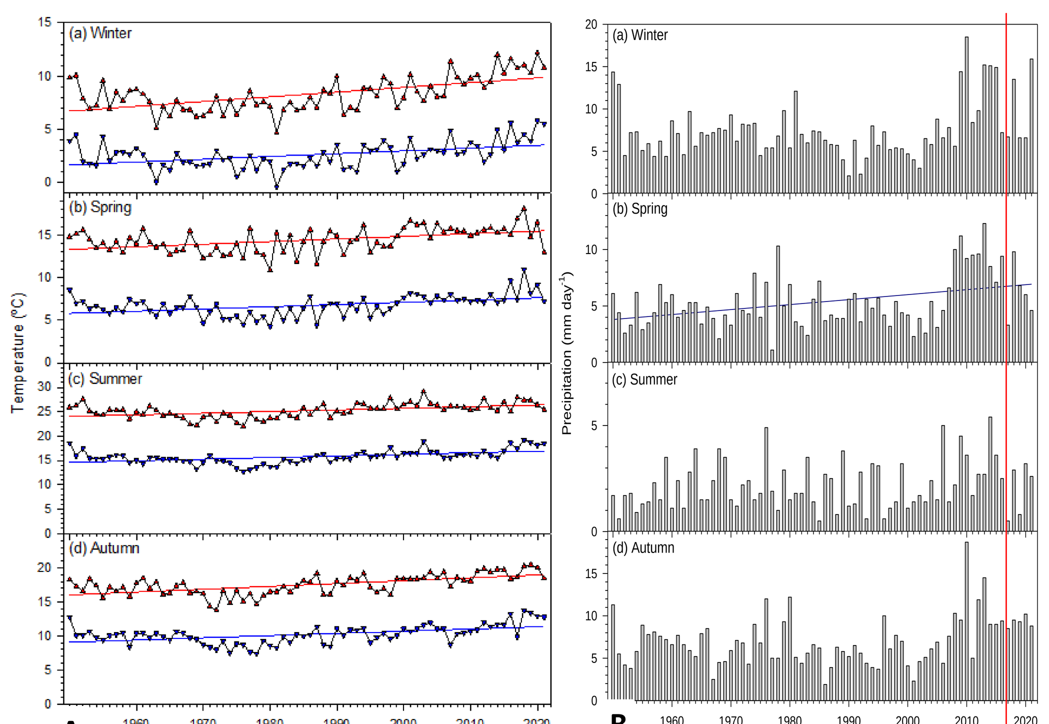

Figure 4. Temperatures (A) and precipitation (B)

Dendrochronological data

Figure 1 shows the 6 experimental sites analysed, for each site 15 wood samples were taken for each of the 2 most representative species. For each species, dendrochronological analysis was performed respectively, Tree Ring Width measurement with LINTAB-6 dendrochronograph and TSAPWin software and subsequent statistical validation of cross-dating with the COFECHA programme. For each forest species, the Basal Area Increment (BAI) was estimated in order to assess the vegetation response in terms of radial growth increments.

The resilience indices (**fig.7**) were calculated using the BAI increases three years before and three years after 2017. To get an idea of the drought events, other drought years 2003 and 2012 were also taken into account, but always **focusing on 2017.** We chose 3-year intervals and BAI data to calculate these indices, as it has been shown that legacy effects are strong 1-3 years after drought (Anderegg et al., 2015). Specifically, we considered the mean values of BAI 3 years before (PreDr), during (Dr) and 3 years after (PostDr) the drought.

Indices of resilience *(Lloret et al., 2011)*

Resistance → Rt = Dr / PreDr

Recovery → Rc = PostDr / Dr

Resilience → Rs = PostDr / PreDr

Relative resilience → Rr = (PostDr – Dr) / PreDr

Impact → I = (PreDr – Dr) / PreDr

Remote sensing information

Normalized Difference Vegetation Index (NDVI) data (Sentinel-2, 10x10 m, MSI: Multi Spectral Instrument, Level-1C) were only used to get information about the state of the canopies sites during the 2017 drought sites (geospatial dataset Google Earth Engine).

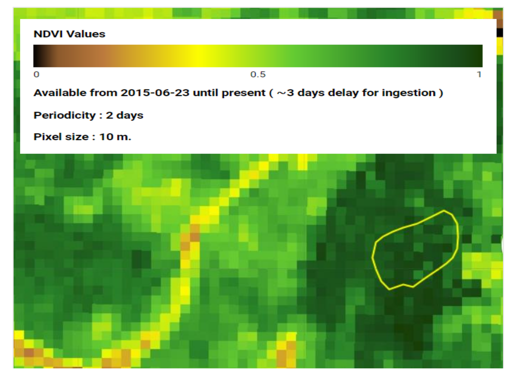

Figure 5. Example of NDVI Image (Earthmap.org Image, satellite information geospatial dataset Google Earth Engine).
https://earthmap.org/?map=%7B%22center%22%3A%7B%22lat%22%3A0%2C%22lng%22%3A0%7D%2C%22zoom%22%3A3%2C%22mapType%22%3A%22roadmap%22%7D

Site	Sampled species	Code	Longitude E	Latitude N	Elevation (m)	Slope (%)	Aspect	Soil / substrate	Dbh (cm)	$NDVI_{2017}$ / $NDVI_{2016}$
Accettura Palazzo	*Fraxinus ornus*	APFO	16.148	40.516	790	15	W	Sandstone	14.0	1.178
	Quercus pubescens	APQP							20.0	
Grotta dell'Angelo	*Fraxinus ornus*	GAFO	15.558	40.570	760	30	N-NW	Clay	13.0	1.064
	Pinus pinaster	GAPP							33.0	
Orto Siderio	*Fraxinus ornus*	OSFO	15.546	40.573	600	35	N-NW	Clay	10.0	1.049
	Quercus pubescens	OSQP							20.0	
Vietri di Potenza	*Acer monspessulanum*	VPAM	15.460	40.617	530	30	NW	Limestone	19.0	0.939
	Quercus pubescens	VPQP							22.0	
Pietrapertosa	*Fraxinus ornus*	PIFO	16.058	40.533	625	35	N-NW	Sandstone	10.0	0.963
	Quercus pubescens	PIQP							17.0	
Castellmezzano	*Fraxinus ornus*	CAFO	16.054	40.534	665	50	S-SE	Sandstone	12.0	0.897
	Quercus pubescens	CAQP							20.0	

Table 1. Characteristics of the six study sites.

3-RESULTS and CONCLUSION

The growth response of forest stands to the 2017 drought is influenced by site conditions and species characteristics, but at most sites, the species studied showed rapid recovery after the drought. *Quercus pubescens* showed greater resilience than *Fraxinus ornus* during the 2017 drought, while *F. ornus* showed high recovery rates. *Acer monspessulanum* trees showed similar drought responses to *Q. pubescens*. In general, deciduous trees showed a better response than *Pinus pinaster*.

While the negative effects of drought were found at sites of low quality (exposure, slope, soil, lower NDVI). In these sites, the trees showed high growth rates before drought, in response to the previous favourable winter-spring wet conditions. This result could represent a structural overshoot phenomenon that could predispose the stand to drought damage.

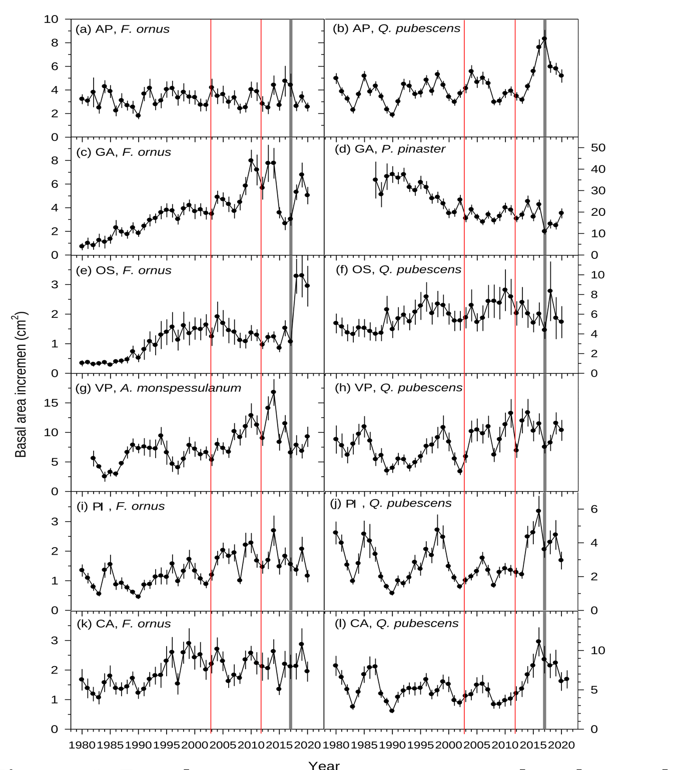

Figure 6. Basal area increment measured at the study sites. Vertical grey line indicate 2017, red lines 2003 and 2012.

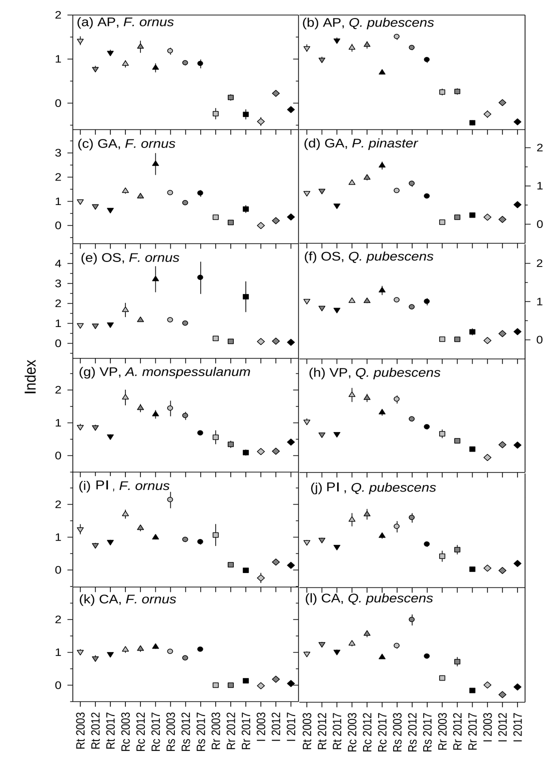

Figure 7. Resilience indices based on 3-year periods (pre- and post-drought).

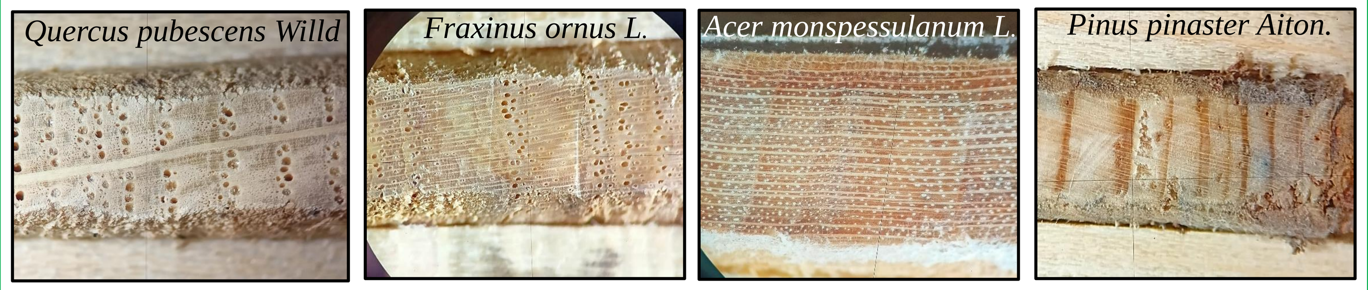

Figure 8. Wood samples of the forest species studied

This work provides further documentation of forest and site-specific dynamics to understand the responses and changes in Mediterranean forests to climate change. In addition, in this research we also report dendrochronological data of little-studied but relevant and responsive Mediterranean tree species, such as the ash tree (*F. ornus)* and the maple tree (*A. monspessulanum)*.

In order to interpret structural overshoots phenomena with certainty, which is still poorly understood, further field surveys and analyses will be required to rule out the influence of competition on plant response.

Sharing not permitted

References

- *Allen C. D., Macalady A. K., Chenchouni H., Bachelet D., McDowell N., Vennetier M., Kitzberger T., Rigling A., Breshears D. D., Hogg E. H., Gonzalez P., Fensham R., Zhang Z., Castro J., Demidova N., Lim J. H., Allard G., Running S. W., Semerci A., Cobb N., 2010. A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. Forest Ecology and Management 259, 660-684. doi:10.1016/j.foreco.2009.09.001*
- *Allen C. D., Breshears D. D. Breshears and McDowell N. G., 2015. On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene. Ecosphere 6(8):129* http://dx.doi.org/10.1890/ES15-00203.1
- *Lloret F., Keeling E. G. and Sala A., 2011. Components of tree resilience: effects of successive low-growth episodes in old ponderosa pine forests. Oikos, 120: 1909–1920. doi: 10.1111/j.1600-0706.2011.19372.x*
- *Senf C., Seidl R., 2021. Post-disturbance canopy recovery and the resilience of Europe's forests. Global Ecol Biogeogr. 00:1–12, DOI: 10.1111/geb.13406.*
- Anderegg W. R., Schwalm C., Biondi F., Camarero J. J., Koch G., Litvak M., ... & Pacala S., 2015. *Pervasive drought legacies in forest ecosystems and their implications for carbon cycle models. Science, 349*(6247), 528-532.
- *Coluzzi R., Fascetti S., Imbrenda V., Italiano S. S. P., Ripullone F., & Lanfredi M., 2020. Exploring the use of sentinel-2 data to monitor heterogeneous effects of contextual drought and heatwaves on Mediterranean forests. Land,* 9(9), 325.

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