# Forest management and drought interaction on tree growth in black pine forests across the Mediterranean Basin

Eduardo Collado-Coloma[1], Miquel de-Cáceres-Ainsa[2], Javier de-Dios-García[3], Dušan Roženbergar[4], Andrea Barzagli[5], Roberto Rubio-Gutiérrez[3], Míriam Piqué-Nicolau[1]

1 Forest Science and Technology Centre of Catalonia (CTFC), Ctra de Sant Llorenç de Morunys, km 2, 25280 Solsona, Lleida, Spain

2 CREAF, Bellaterra (Cerdanyola del Vallès), Catalonia E08193, Spain

3 Castilla y León Wood & Forest Services Center (Cesefor), Pol. Ind. Las Casas, Calle C, parcela 4, 42005, Soria, Spain

4 Department of Forestry and Renewable Forest Resources, Biotechnical Faculty, University of Ljubljana (ULJ), Ljubljana, Slovenia

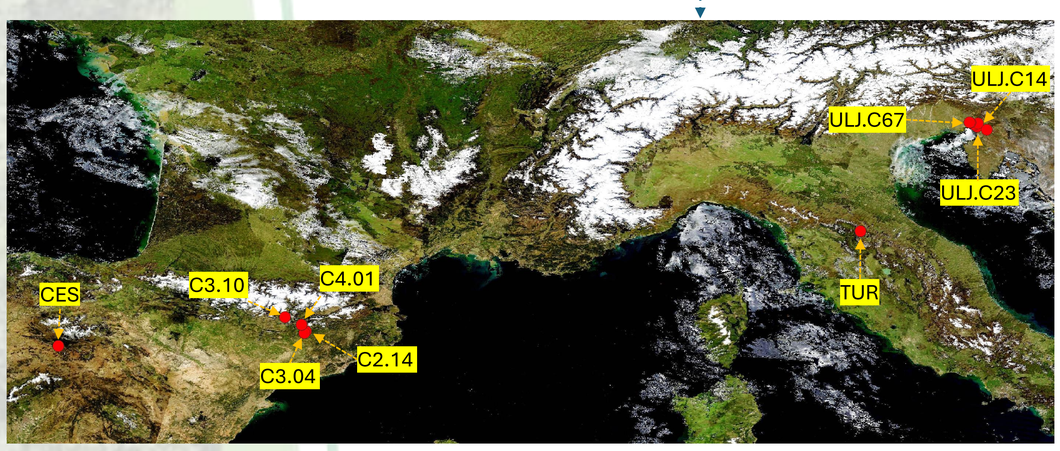
5 Tuscany Region (TUR), Italy

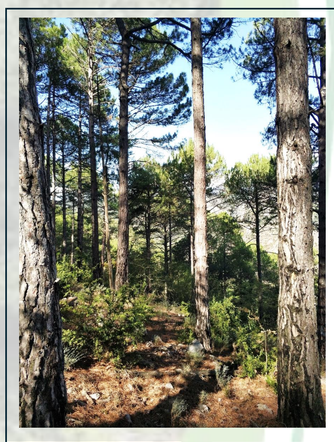
## Introduction

Black pine (*Pinus nigra*) is one of the most important conifers in the Mediterranean basin due to its high extension and historical use for wood production and is among the most affected pines species in the region by climate change (CC). Forest management, as a tool to adapt forest ecosystems to CC, reduces competition for water and nutrients and alters microclimate conditions and, thus, water flows (e.g., groundwater recharge and evapotranspiration). Here, we combine dendrochronological techniques and a forest ecosystem model (*MEDFATE*), configured to simulate plant and soil water balance, to disentangle the effect of past silvicultural treatments under drought conditions on tree growth and water stress. To that, we based on 20 managed and unmanaged black pine plots distributed across 3 Mediterranean countries (Spain, Italy and Slovenia).

## Methodology

3 countries (4 regions) → 7 typologies: natural / plantation x stand ages → 9 study sites (see map) → 20 plots: 8 unmanaged 12 managed

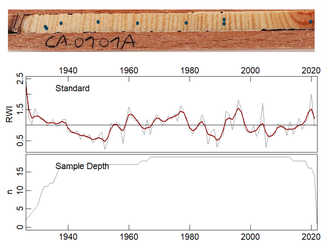


1- Tree and shrub data
2- Soil data
3- Climatic data
4- Topographic data

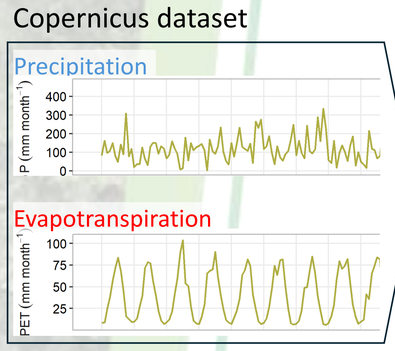
Daily water balance simulations (*MEDFATE*)

**DROUGHT STRESS**




**TREE-RING WIDTH (DETRENDED; TRWi)**

Copernicus dataset



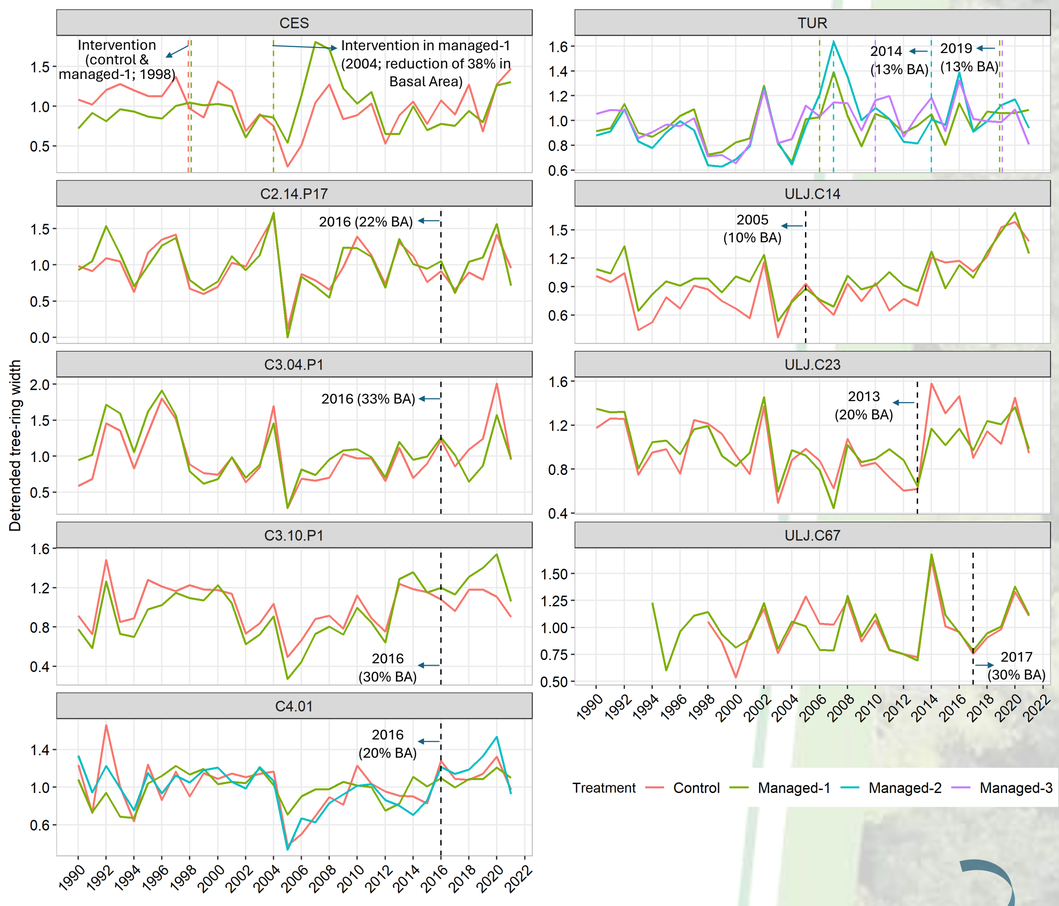

**SPEI (Standardised Precipitation-Evapotranspiration Index)**

**Linear Mixed-Effects models**

| Predicted variables | Fixed effects | Random effects |
|---|---|---|
| *TRWi* | *SPEI* OR *Stress* | *Tree core* |
| | *Pre-Post-intervention* | AND/OR |
| | *Paired-plot* | *Study sites* |
| | *Treatment* | |

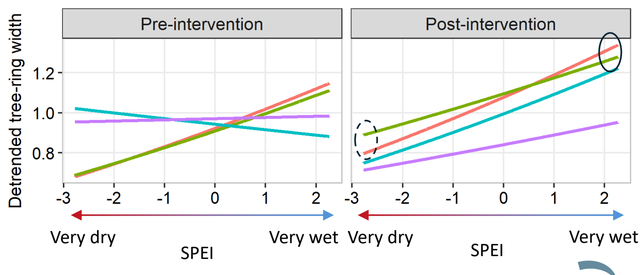
## Results

A



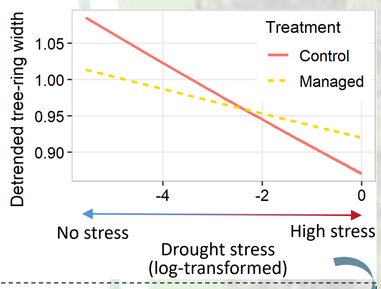

- Treatments (forest thinning) had generally an effect on tree growth (TRWi).
- The effect was usually positive in most of the Spanish and Italian sites.
- In Slovenia, treatments showed different results on TRWi (no effect, positive effect and negative effect).

B




- But, the impact of forest management on TRWi was positive or negative depending on weather conditions (SPEI):
  - In drought years, thinning increased TRWi (see dashed circle).
  - In rainy years, unmanaged plots showed higher TRWi than in thinned plots (see solid circle).

C




- The simulated maximum drought stress, mediated by annual weather conditions, negatively affected TRWi.
- In general, the effect of drought stress, like SPEI, on TRWi is modulated by thinning.

## Conclusions

Black pine, as one of the most productive and drought-tolerant conifer, has been managed differently throughout the Mediterranean region for different purposes. The forest management implemented in different black pine plots across three Mediterranean countries generally increased tree vitality (growth) during drought periods. Reduced tree competition usually alleviated drought stress, with cascading positive effects on the tree growth in most of study sites.

## Bibliography

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