STReESS – Studying Tree Responses to extreme Events: a SynthesiS

Predicting tree mortality from wood density parameters

STSM Report

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Brief background and aims

When water availability decreases, the first reaction of a tree is the decrease of transpiration by stomatal closure, generally accompanied by growth reduction, changes in cambium activity and consequently wood formation and wood basic properties (Rozenberg et al. 2002). In softwoods, wood produced at the beginning of the growing season (earlywood) is made of cells with thin walls and large lumen, whereas wood produced at the end of the growing season (latewood) is made of thick-wall, small lumen cells. The shift from early- to latewood is closely related to the availability of soil moisture and triggered by drought stress (Domec and Gartner 2002). There is evidence that in some species xylem structure and basic wood properties are involved in survival to drought (Martínez-Meier et al. 2008). In this sense die-offs of adult trees following drought events are good opportunities to study the relationship between annual-ring density variables and fitness.

From the beginning of the XXI century, the Canary Islands have suffered periodic droughts and in general there has been a tendency to longer dry periods in summer and less precipitation during winter, particularly in the southern slopes of the eastern islands. The growing season between 2009 and 2011 were extremely dry with less than 60 mm from March to October in the south of Gran Canaria. The Forestry Service detected several cases of tree mortality of Canary Island pine (*Pinus canariensis*) in this area during 2012, including a provenance trial of the species in a xeric location with less than 300 mm of average annual precipitation which has been established in 1999. *P. canariensis*, endemic to the Archipelago, grows across a wide climate envelope: from xeric conditions, with barely 300 mm of rain in south-western slopes, to mixed forest with the monteverde in north-eastern slopes, influenced by the humid trade winds (Climent et al. 2002). Thus, despite its restricted distribution area, clime and topography may have shaped adaptive structures which can be shown in provenance trials.

In this STSM I pretend to trace a density profile of Canary Island pine individuals which had died in 2012 and their neighbouring surviving trees with X-ray and anatomical imaging data in collaboration with Dr. Philippe Rozenberg´s team at INRA Orleans. We will use two set of samples: on the one hand adult trees with more than 50 years and on the other hand 14-year old trees growing in a provenance trial.

Description of the work

Plant Material

For the first set of samples, we have chosen 28 dominant adult trees that were dead during 2012. All dead trees presented the same damage, a total foliage necrosis. A wood slice from each of the dead trees was obtained coupled with two wood cores from the nearest dominant living tree. Wood samples were collected between January and March 2014.

The second set of samples belonged to a *P. canariensis* multi-site provenance trial established in 1999 and representative of the most xeric locations inhabited for the species (more details can be found in López et al. 2007). Although mortality rates were high until 2003 (*c.* half of the trial), after this year we have not detected more dead trees until 2012. In August 2012 only 21 trees in the trial have survived without a clear pattern between provenances. We collected increment cores of six trees and branches of all of them. Basal slices of 54 dead trees were also taken.

All the slices and cores were dried at room temperature and transported to INRA Orléans.

Methodology

In the wood laboratory at INRA Orléans samples were sawn to 2-2.5 mm thickness and resin was extracted with pentane during 48 h. Afterwards, wood samples were analysed by indirect X-ray densitometry and the resulting Xray films were scanned at a 1000 dpi resolution with 8 bits depth per pixel. The digital images were processed with WinDENDRO (Regent Instruments Inc.), obtaining a final spatial resolution of 25 mm. The density profiles were used to estimate diameter growth for each tree. Microdensity data were computed yearly from 1980 to 2012 rings in adult trees and from the pit to 2012 in trees from the provenance trial by using a function written in R language (R Development Core Team, 2008). We described each of the tree-rings of this period by seven descriptors: ring width, mean ring density, minimum ring density, maximum ring density, earlywood density, latewood density and latewood proportion (Figure 1). Earlywood and latewood densities were taken as the average density of their respective ring portion computed by the mean of the extreme density values in each ring.

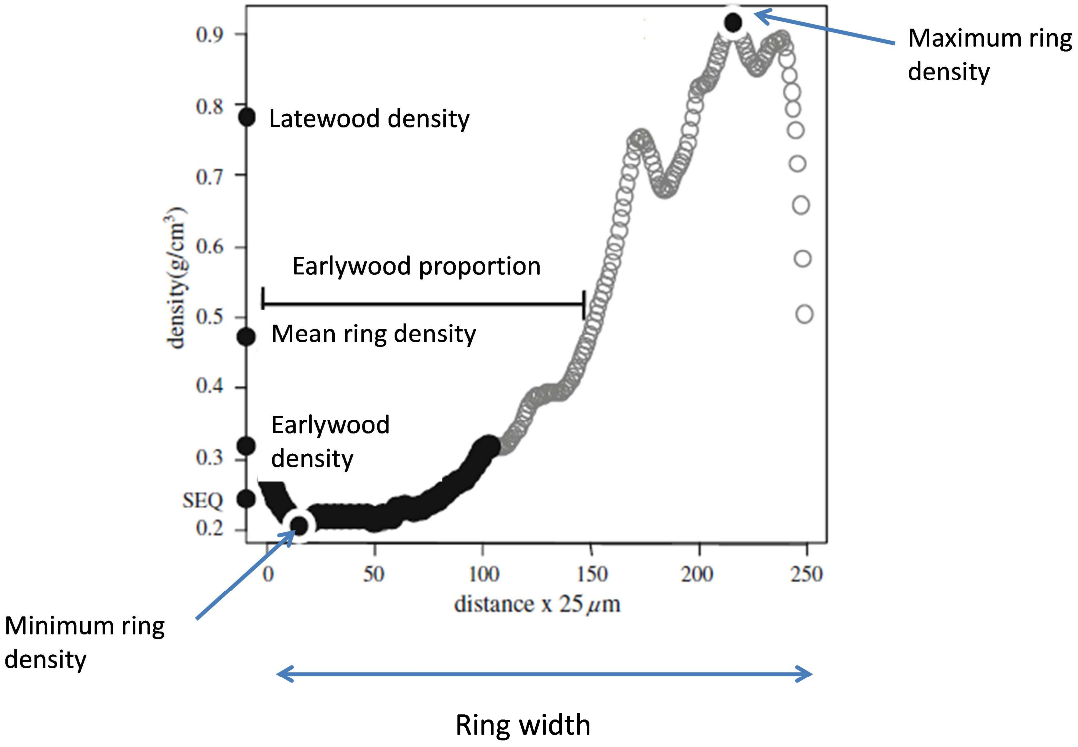

Figure 1. Tree ring's density values calculated from a microdensity profile

Preliminary results

During this STSM I have constructed 110 microdensity profiles. One example is presented in Figure 2.

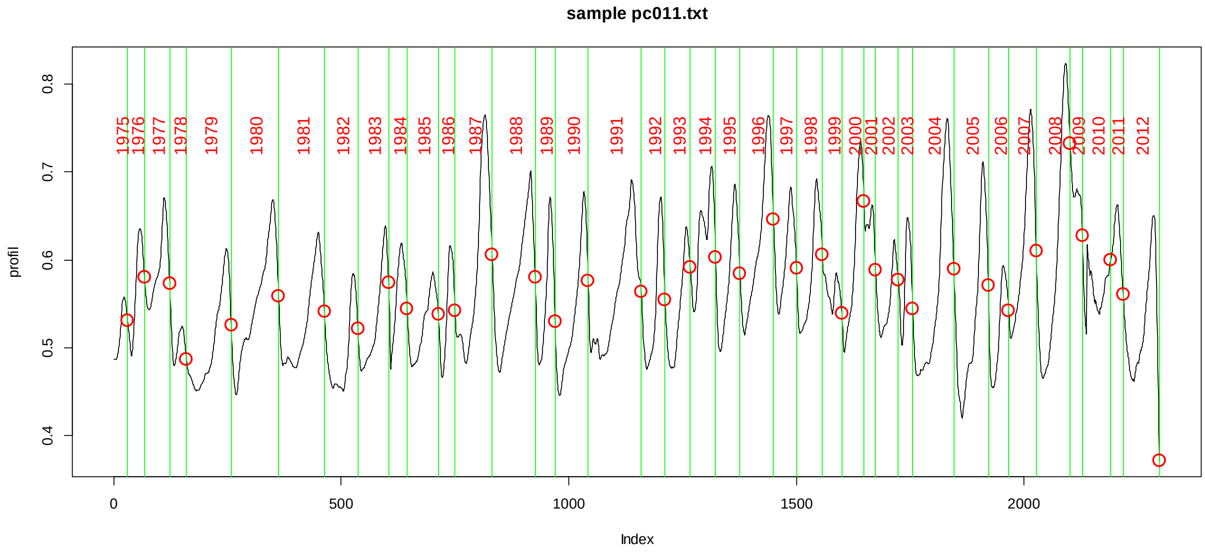

Figure 2. Typical microdensity profile of an adult tree of *Pinus canariensis*.

For all the surviving trees in the field, the last complete ring in the microdensity profiles was the ring before the collection date, ring 2013. For most of the dead trees, the last complete ring was that of 2012. Both earlywood and latewood widths decreased with time. In general live trees formed widest rings with more earlywood and latewood than dead trees (Figure 3 a-c). Wood density seemed to be a less plastic parameter since we did not detect significant differences among years. However, live trees tended to form denser wood, particularly in latewood (Figure 3 d-e).

In the provenance trial, differences between dead and live trees were less pronounced because of smaller sample size of live trees and also due to the age of the trees. Dead trees formed wider rings from 2000 to 2005 with more earlywood and latewood, but from 2006 live trees equalled these traits (Figure 4 a-c). Regarding wood density, although from 2000 to 2005 dead trees formed denser wood, from 2006 this tendency was reversed and live trees constructed denser wood, with more significant differences between groups in the earlywood (Figure 4 d-e).

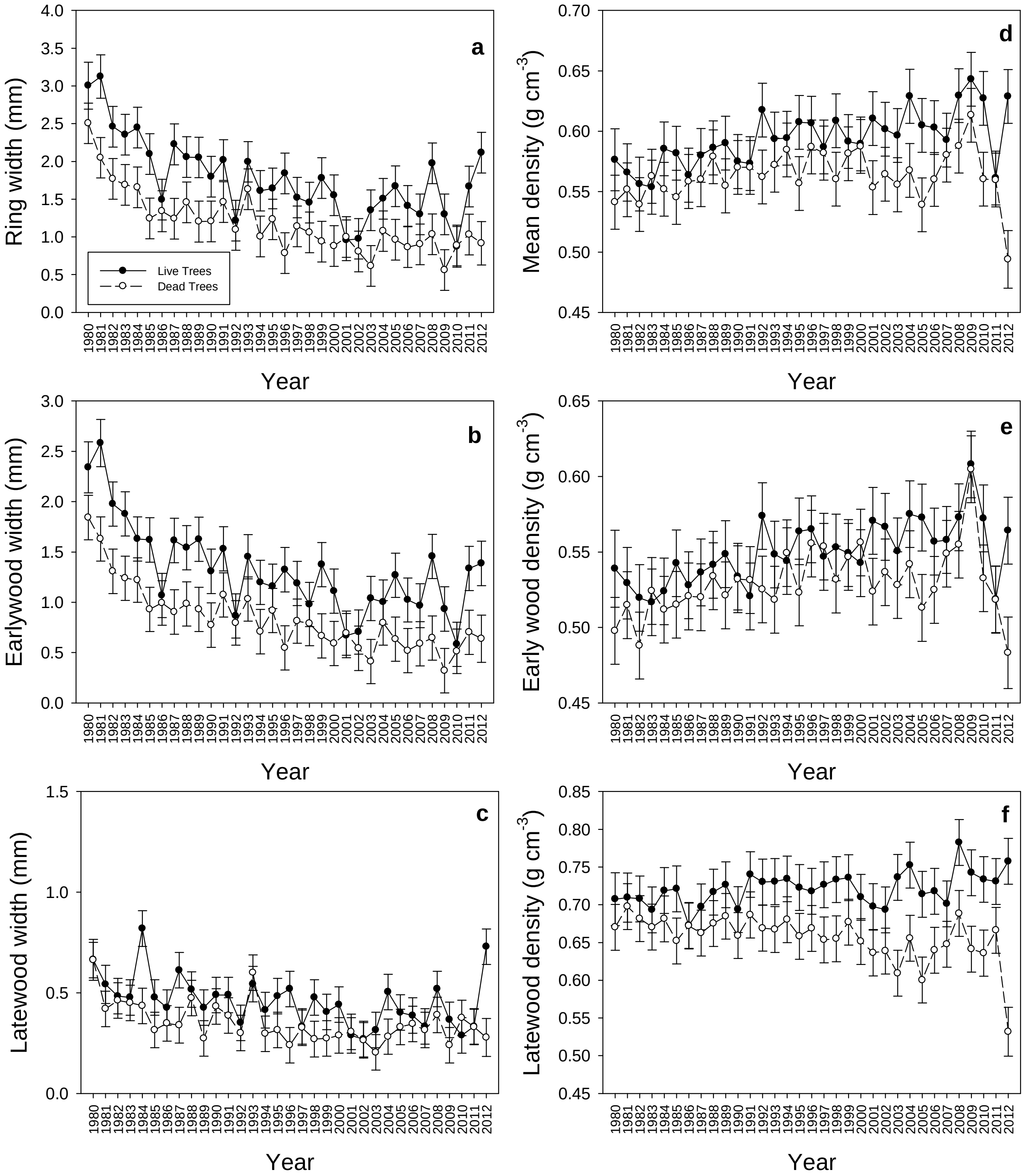

Figure 3. Mean ring width (a), earlywood width (b), latewood width (c), mean density (d), earlywood density (e), and latewood density (f) of live and dead *Pinus canariensis* trees in the field from 1980 to 2012.

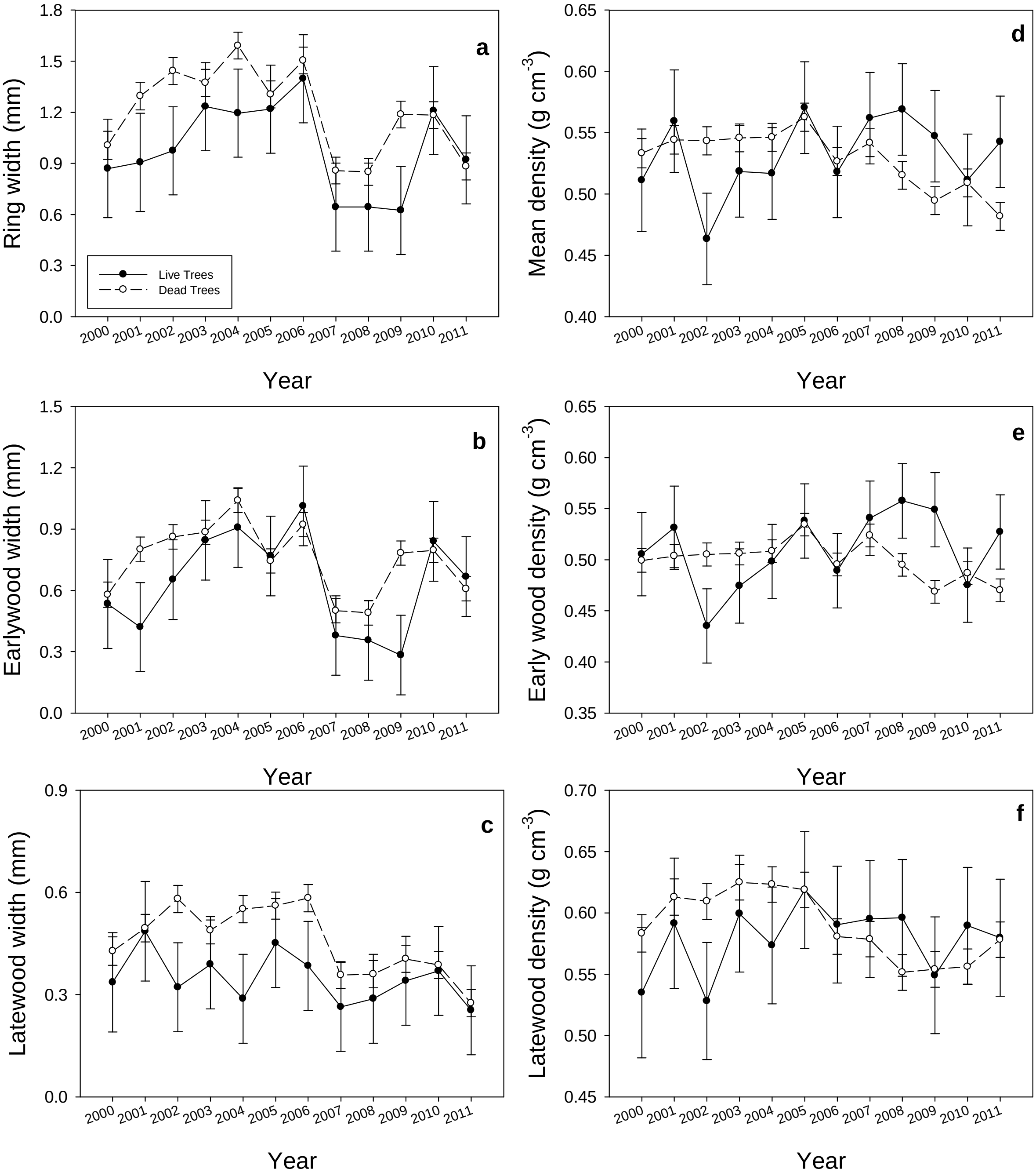

Figure 4. Mean ring width (a), earlywood width (b), latewood width (c), mean density (d), earlywood density (e), and latewood density (f) of live and dead *Pinus canariensis* trees in the provenance trial from 2000 to 2011.

Contribution of the STSM to the Action FP1106 aims

This research will generate data directly related with topic groups (TG) 7 (tree mortality) and 10 (Forest Genetics). Our results will contribute to better understanding some mechanisms underlying tree mortality under severe drought. We hypothesize that it may be possible to predict the susceptibility to extreme climates events on the basis of ring density parameters, thus density profiles could be good predictors of tree mortality. We will integrate two disciplines: dendrochronology and quantitative genetics. Growth ring measurements in dead and live trees will be used in the database of TG 7 and wood density variables in one of the objectives of TG 10. Moreover, we have available data of growth, survival and hydraulic parameters such as cavitation resistance in the provenance trial. With all these measurements together we will be able to construct a complete framework to study intraspecific variation and the relationship between bioclimatic characteristics and fitness traits.

Finally, this STSM will strengthen the network between scientists of the COST action. Since the last meeting in Sarajevo I am a coordinator of one of the objectives of TG 10, led by Dr Philippe Rozenberg. This STSM will help to discuss data and create the draft of the revision paper about ring density profiles and survival, which is one of the expected outputs of this TG.

Expected output

With the results of this stay we expect to prepare two manuscripts: one with the data of *Pinus canariensis* and other in collaboration with members in group 10 about the relationship between annual ring density variables and xylem hydraulic properties involved in resistance to drought.

Confirmation by the host institution of the successful execution of the STSM

Attached in a separated file

This report may be posted on the Action website

Acknowledgements

I would like to thank Dr Philippe Rozenberg for his warm welcome and fruitful collaboration, Frédéric Millier for helping me with sample preparation and X-ray microdensity profiles, Alejandro Martínez-Meier and Margarita Escobar Sandoval for introducing me to R and Guillermina Dalla-Salda for her valuable help with microscopy. I am also grateful to the Cabildo of Gran Canaria for its long-standing support in the study of Canary Island pine.

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