STSM Report

Drought as a driver of tree population dynamics in a Neotropical dry forest

COST Action: Studying Tree Responses to extreme Events: a SynthesiS (STReESS)

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Beneficiary: Hooz Angela Chaparro Mendivelso
Pyrenean Institute of Ecology (IPE-CSIC), Zaragoza (Spain)

Host: Prof Dr Pieter Zuidema and Dr Ute Sass-Klaassen
Forest Ecology and Forest Management Group
Wageningen University, Wageningen (The Netherlands)

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Introduction

Recently, we analyzed the effects of drought at different time-scales on radial growth of seven timber tree species (*Acosmium cardenasii*, *Anadenanthera macrocarpa*, *Aspidosperma tomentosum*, *Caesalpinia pluviosa*, *Centrolobium microchaete*, *Tabebuia impetiginosa*, *Zeyheria tuberculosa*) coexisting in the Chiquitano tropical dry forest (Bolivia). In this forest, annual rings are formed in response to a long dry season (7 months). We found that radial growth responded differently to short- and to long-term droughts, which suggests that these tree species are particularly sensitive to multi-annual droughts and that such sensitivity differs among species (Mendivelso et al. 2014). This finding raises the following general question: how can these multi-annual droughts drive forest dynamics? Specifically, what are the consequences of persistent droughts for population dynamics in long-lived dry forest species?

The use of matrix models (popular tool for demographic analysis of plant species) can help us to answer the questions above. However, the application of classical matrix models to long-lived, slow-growing species is hampered by the fact that the model output is highly sensitive to categorical width. A solution for this problem lies in the use of Integral Projection Models (IPMs), which is an extension of classical matrix models (Zuidema et al. 2010).

Purpose of the STSM

The main purpose of my STSM was to evaluate the effect of droughts on population dynamics of four tropical dry forest tree species (*Acosmium cardenasii*, *Aspidosperma tomentosum*, *Caesalpinia pluviosa* and *Centrolobium microchaete*) using IPMs. To achieve this, I had to combine dendrochronological data and information on climate-growth relationships with data gathered from permanent sample plots monitored for 10 years (Chiquitano tropical dry forest, Bolivia).

The inclusion of a new drought index (standardized precipitation-evapotranspiration index, SPEI) in the IPMs is turning into a big challenge. However, the valuable information that will be obtained will allow me to evaluate the effect of the droughts on the population growth rate and the stable population structure, and will enables to determine if this effect is species-specific.

Description of the work carried out during the STSM

In order to scale up the drought effects on population level I combined the information gained from dendrochronology with those from inventory data. Therefore, this drought effect were evaluated on tree growth, tree survival, and new recruits abundance.

Specifically, the activities carried out during my STSM were:

- To evaluate the drought-growth relationship at a short-time scale in individuals of different sizes using dendrochronological data. Previously, I learned to use the dplR package in R program (Bunn 2008). I calculated residual chronology per tree. Then, I made a linear regression between drought index (SPEI) and residual chronology per tree (only for the period 1950-2010). Finally, Pearson's correlation was calculated between slope values (from linear regression) and the tree's dbh in 2010 (Fig 1).

- To determine if the number of new recruits (trees > 10 cm dbh) was related to drought intensity using permanent plots data. I made a Pearson's correlation between new recruits abundance and SPEI values.

- To evaluate the drought-survival relationship per species I was using permanent plots data. Before this, I learned to make survival analysis in R program.

Currently, I am building the survival-growth and fecundity matrices that will be used in the IPMs. Although IPMpack in R program includes functions that can calculate them (Metcalf et al. 2012), the nature of my data (coming from permanent plots and dendrochronological data together) does not allow me to use it directly. After, I will use the IPMs to make simulations for evaluating the effect of different climate scenarios (e.g. multi-annual droughts from two to 10 years) on the population growth rate and on the stable population structure.

Main results

The radial growth sensitivity to water availability was size-dependent in the shade-tolerant species, *Acosmium cardenasii* and *Caesalpinia pluviosa*. Individuals of larger sizes showed a greater sensitivity to water availability in both species (Fig. 1). *Centrolobium microchaete*, a shade-intolerant species, not showed a significant relationship; although there are some individuals that are not sensitive to drought, the majority of them were sensitive to water availability in all sizes (Fig. 1). Looking at the three species, their responses to drought from individuals of small sizes seem to be associated to the ecological guilds that they belong. This can be supported by a recent study in the same forest that showed a positive correlation between drought and shade tolerance of the species in saplings (Markesteijn et al. 2011).

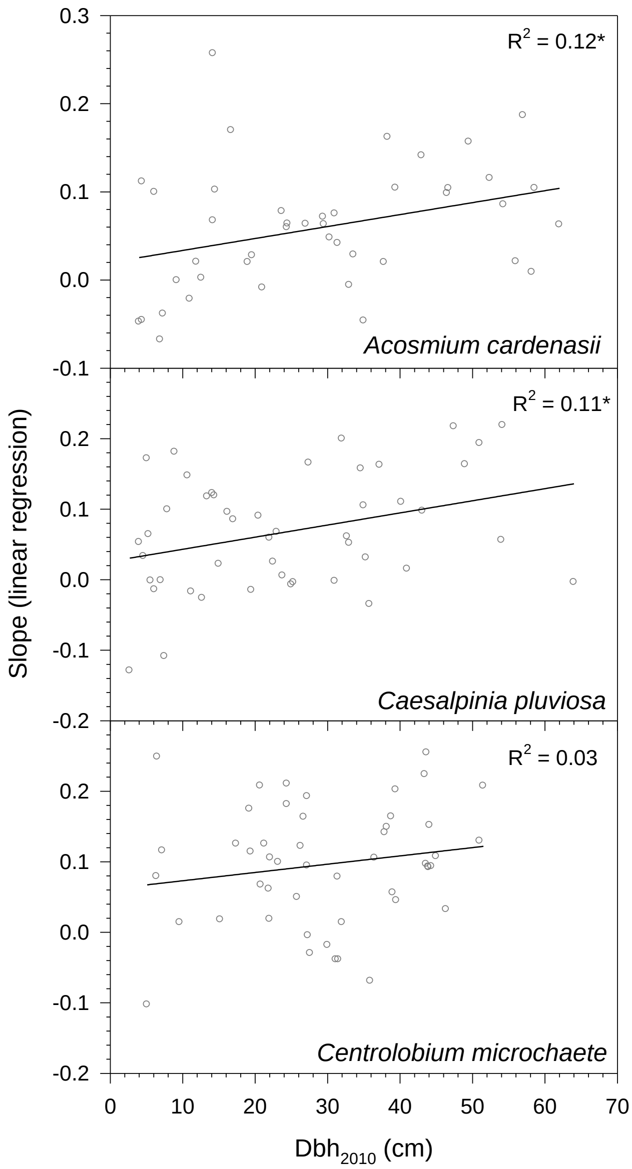

Figure 1. Relationships between slope and the trees' dbh. The slope values were obtained from a linear regression between drought index (SPEI) and residual chronology per tree.

Contribution to the action aims

In this STSM I proved the potential to use dendrochronogical data to investigate the impact of droughts on radial growth of individuals belonging to different size and age classes. These novel results reinforce the idea of the enormous potential of Dendrochronology to study effects of extreme events, such as droughts at population level, since species responded differently to drought through their ontogeny. This enforces the importance of gathering dendrochronological information as a tool to respond to ecological questions addressed by STREeSS.

This STMS strengthened the collaboration between the Action members Dr. Sass-Klaassen (WUR) and Dr. J. Julio Camarero (Pyrenean Institute of Ecology, CSIC, Spain), who are currently interested in working about drought effects on tree growth and population dynamics of tropical tree species.

Projected publication from the STSM

Once I complete the population dynamic analyses using IPMs, I will prepare a manuscript based in all the results of my STSM. This manuscript will be the last chapter of my PhD dissertation and it will also be submitted to an international peer-reviewed journal. Furthermore, all these results will form an output for the COST Action, FP1106, STREeSS and would be presented in the next EuroDendro and/or WorldDendro conferences, where the relevance of the droughts in the tree population dynamics could be discussed among world experts.

Acknowledgments

I am grateful to my supervisors Prof Dr Pieter A. Zuidema and Dr Ute Sass-Klaassen (both belonging to the Forest Ecology and Forest Management Group, Wageningen University, The Netherlands) who are well known researchers and experts in tropical dendrochronology and demography, respectively. I thank M. Jansen and M. Decuyper for their help in the use of R program. I would also like to thank the COST Action, FP1106, STREeSS for financed this scientific visit and for giving me the opportunity to work in the Forest Ecology and Forest Management Group (Wageningen University).

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This report may be posted on the action website.

The confirmation letter by the host institution of successful execution of the STSM is attached separately.