

# RReShar: Regeneration and Resource Sharing. État d'avancement et perspective de développement du modèle

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# Climate change effects

Increase of the frequency and the severity of extreme weather events (*IPCC, 2013*)

→ E.g. increased fire frequencies, longer summer droughts for  
Mediterranean forests



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- Adaptive management strategies are needed to increase forest resilience  
(Millar *et al.*, 2007)
  - **Models** are useful tools to test these strategies, as they can study their long-term effects in relation to climatic conditions (FORCLIM, SILVA 2, RReShar..)

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**LACK OF FUNCTIONAL MODELS OF FOREST DYNAMICS FOR  
MEDITERRANEAN FORESTS**

## LACK OF FUNCTIONAL MODELS OF FOREST DYNAMICS FOR MEDITERRANEAN FORESTS

Developing a functional-structural model for Mediterranean pine stands

→ Adapting an existing model to the Mediterranean context



# RReShar : Regeneration and Resource Sharing

(P. Balandier, N. Donès, F. De Coligny)

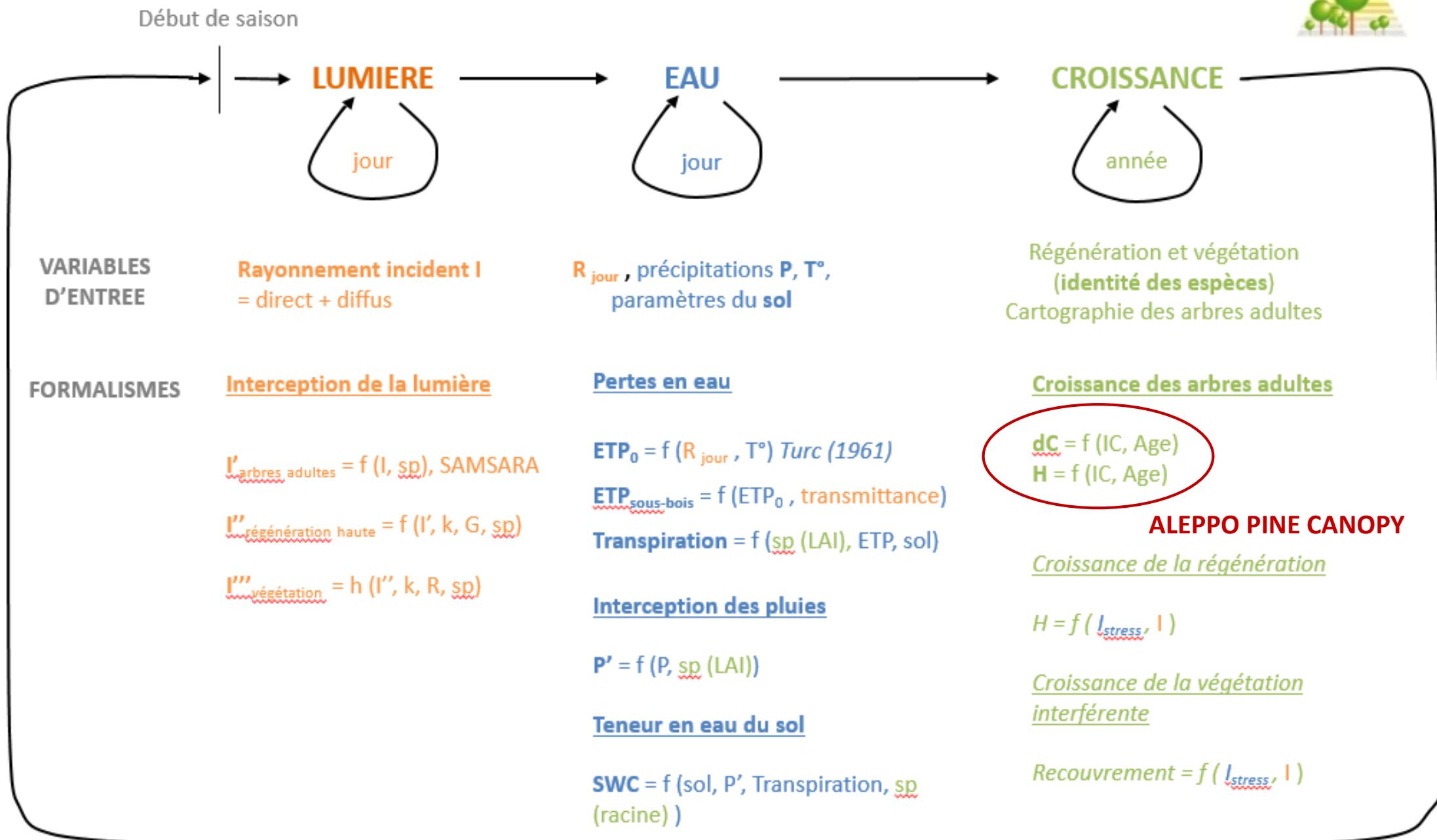
- A functional-structural model aiming at simulating forest dynamics according to interactions with the understorey vegetation and resource availability
- All strata are described: adult trees, regeneration, and herbaceous/shrubby vegetation
- A radiation model is included (SAMSARA, B. Courbaud) as well as a forest water balance (Granier *et al.*, 1999)

**RReShar**

LIGHT

WATER

GROWTH





## Focus on the Aleppo pine development

Can we link *Pinus halepensis* growth with competition and water availability, via competition and water stress indices?

Which indices do perform better?

## Experimental site of Saint-Mitre-les-Remparts



Google Maps

Meso Mediterranean climate

P (mm): 570 mm with high inter-annual variability

T°C: 14°C

*Pinus halepensis* with an understorey mainly composed of *Quercus coccifera*,  
*Filaria angustifolia*

## Three pine cover conditions obtained by thinning



**Control  
Dense cover**  
 $G = 32 \text{ m}^2/\text{ha}$



**Moderate thinning  
Medium cover**  
 $G = 19 \text{ m}^2/\text{ha}$

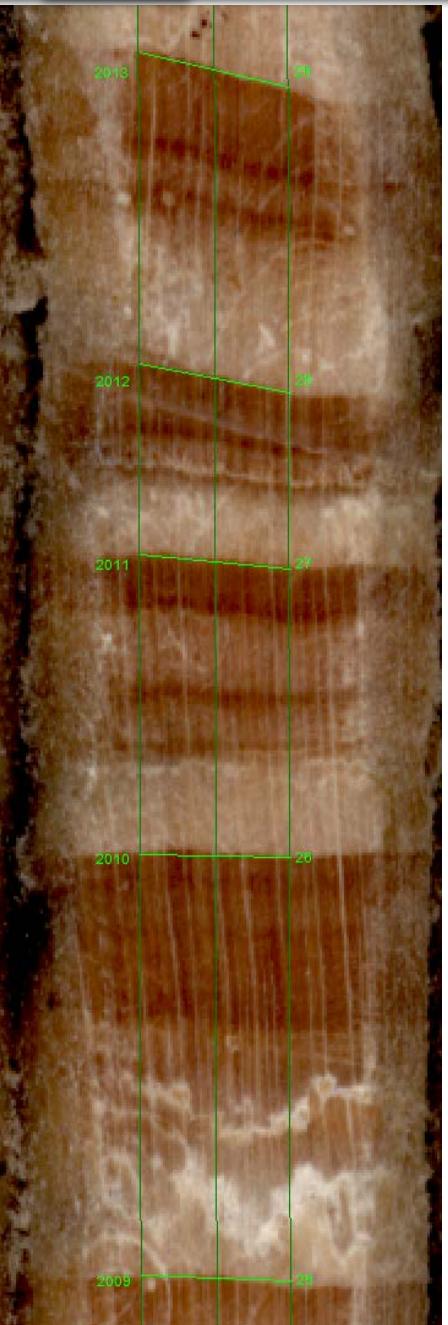


**Heavy thinning  
Low cover**  
 $G = 10 \text{ m}^2/\text{ha}$

Total 12 plots ( $25\text{m} * 25\text{m}$ ), 4 plots per treatment

All trees were spatialized in 2017

175 pines were cored to analyse their radial growth increment (autumn 2017)

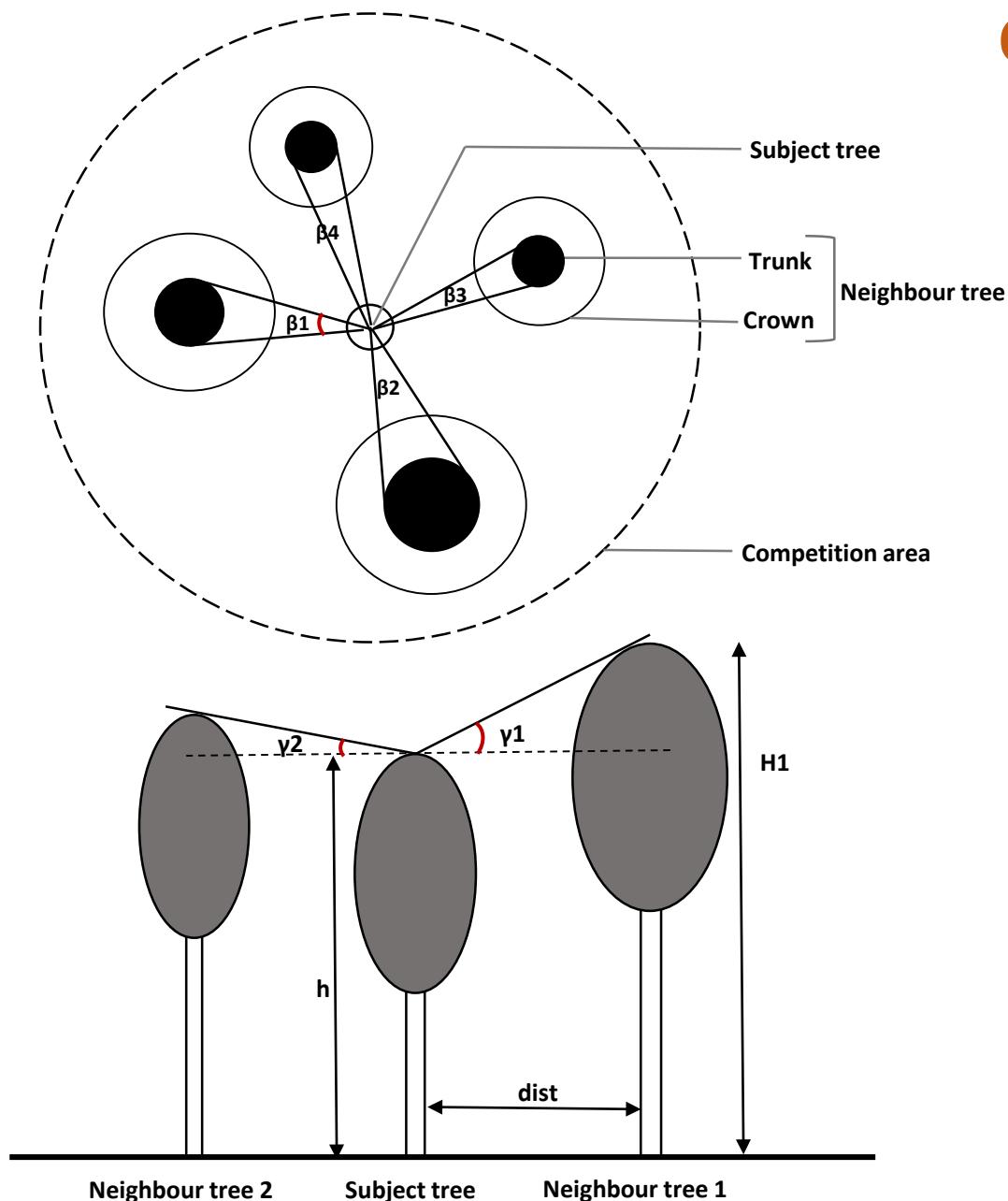


## Cores analysis

- Rings interdatation
- Radial increment (mm) was extracted
- Basal area increment ( $\text{mm}^2$ ) was thus calculated



## Competition indices



Distant-dependant indexes:

Hegyi:

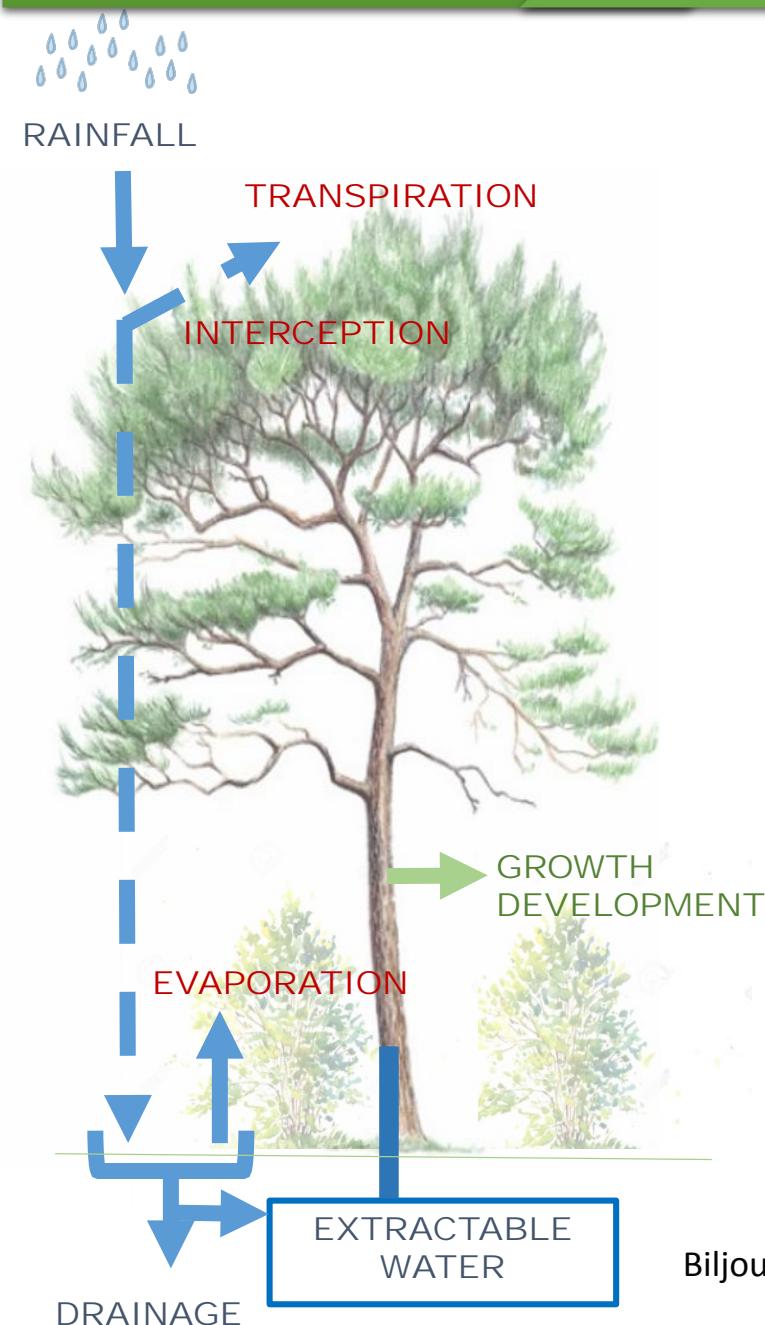
$$IC_i = \sum_{\substack{j=1 \\ j \neq i}}^n \frac{C_j}{C_i d_{ij}}$$

Horizontal angles:

$$IC_i = \sum_{\substack{j=1 \\ j \neq i}}^n \beta_i$$

Vertical angles:

$$IC_i = \sum_{\substack{j=1 \\ j \neq i}}^n \gamma_i$$



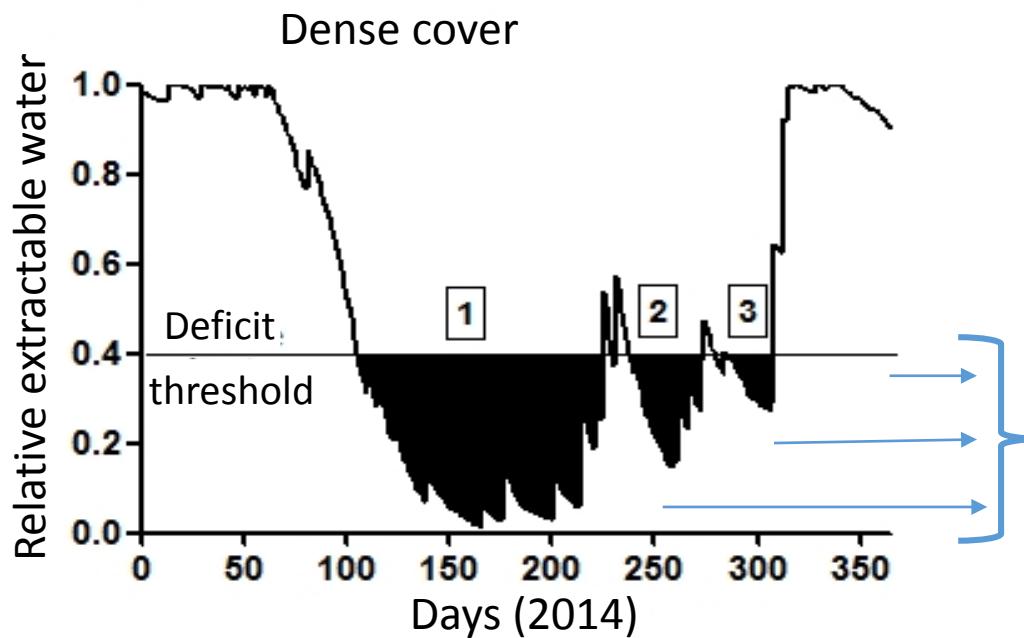
## Two strata forest water balance

$$\Delta EW \text{ (mm)} = \sum \text{inputs} - \sum \text{outputs}$$

One of the useful outputs of the water balance model is the **water stress index**, further used for pines growth dynamics.

Biljou (INRA)

## Water Stress Indices

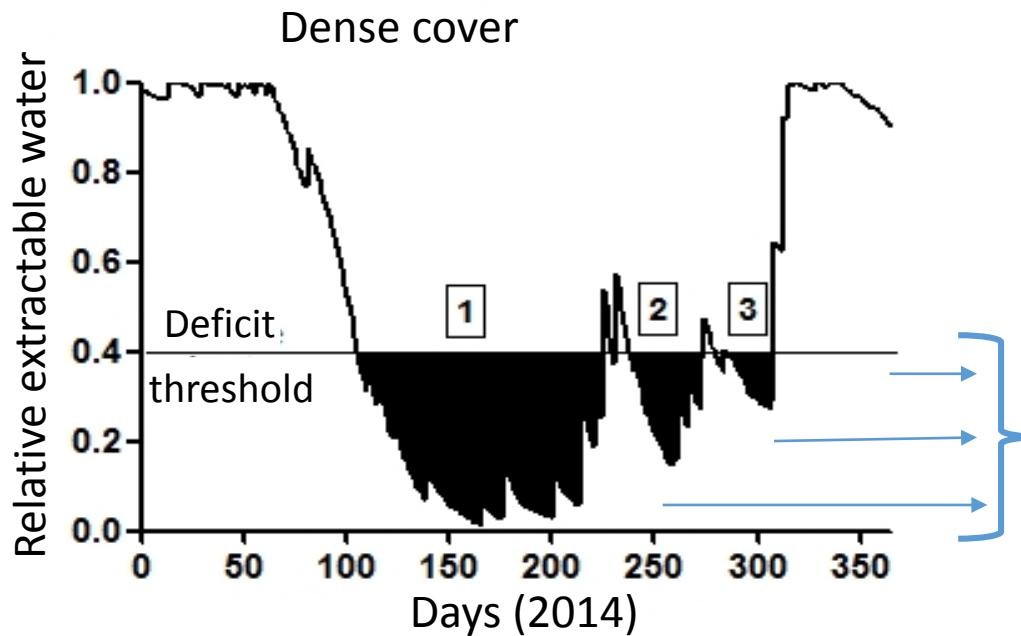


**WSI** = sum of the daily differences  
(Granier *et al.*, 1999)

$$WSI_1 = \sum 0.4 - REW_i$$



## Water Stress Indices



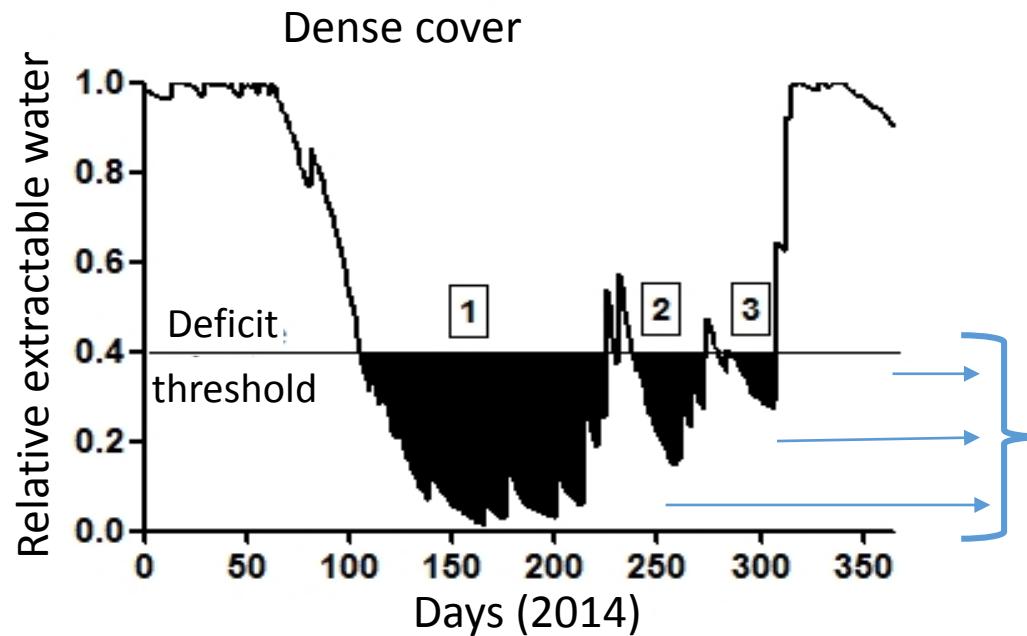
**WSI** = sum of the stress days  
(Fatichi *et al.*, 2013)

$$WSI_1 = \sum 0.4 - REW_i$$

$$WSI_2 = \text{Number of WS days}$$



## Water Stress Indices



**WSI** = sum of the daily differences  
(weighed per season)  
(Mina et al., 2016)

$$WSI_1 = \sum 0.4 - REW_i$$

$$WSI_2 = \text{Number of WS days}$$

$$WSI_3 = \sum \left( \frac{\text{Number of WS days}}{\overline{SWC}} \right)_{\text{season}}$$

## Data analysis

We used data taken between 2008 and 2018:

175 trees \* 10 years: **1750 BAI**, associated with a water stress index and a competition index.

**Mixed models** have been used:

$$\text{Log(BAI)} \sim \text{log(G(t-1))} + \text{log(CI} + 1) + \text{log(WSI)} + (1 | \text{Tree})$$

## Results of the regressions

**Basal area, Hegyi competition index and the number of water stress days are the best predictors of the basal area increment.**

Variables used	Marginal R <sup>2</sup>	Conditional R <sup>2</sup>
BAI ~ G(t-1) + CI1 + WSI2	0.579	0.787



## Hegyi CI:

- Widely used in the literature (Contreras *et al.*, 2011; Sanchez-Salguero *et al.*, 2015)
- Easy to compute: based on the diameter
- Works well for tree-based model (Prévosto, 2005)

## Number of water stress days:

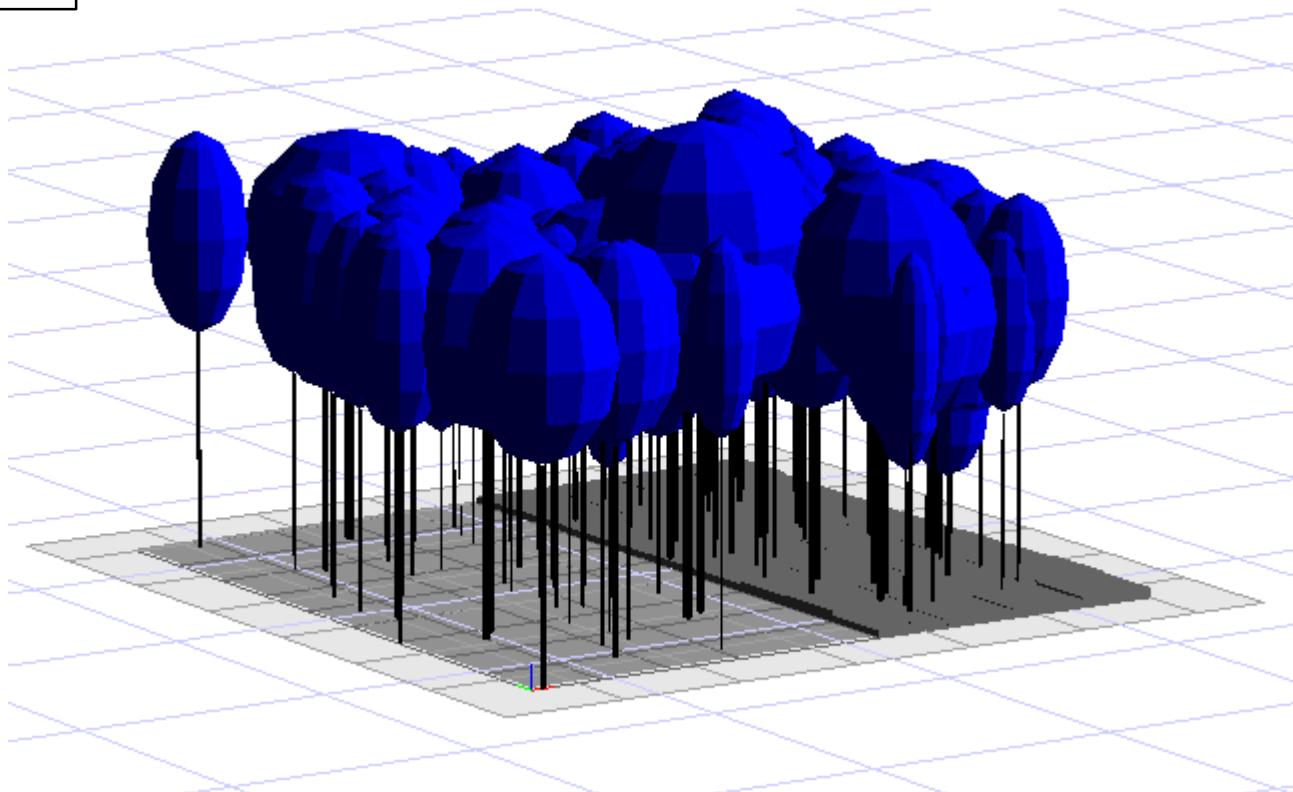
- Growth is not source-driven (correlated with carbon assimilation) (Lempereur *et al.*, 2015; Leuzinger *et al.*, 2013)
- *P. halepensis* controls strongly its transpiration during dry periods
- *P. halepensis* is polycyclic

## Aleppo pine growth

- Radial increment (Age, CI, WSI):

$$dR(Age) = \frac{1}{0.28 + 0.00954 \cdot Age} e^{5.6} \cdot (CI + 1)^{-0.434} \cdot WSI^{-1.31}$$

- H (age, CI)
  - $H = H_{max} \times (1 - e^{-0,021 \times Age})^{1,5385}$
- Crown (Tree diameter)
- Crown Height (Tree Height)



A wide-angle landscape photograph showing a vast green field in the foreground, a bright blue sky with scattered white clouds in the middle ground, and a range of mountains with patches of snow and green vegetation in the background.

**THANK YOU FOR  
YOUR  
ATTENTION!**

Models	Random Effect	Marginal R2	Conditional R2	AIC
T.ba	Tree Name	0,252	0,948	3442,753
<b>T.ic1</b>	Tree Name	<b>0,416</b>	<b>0,679</b>	<b>3422,237</b>
T.ic2	Tree Name	0,224	0,679	3509,424
T.ic3	Tree Name	0,230	0,679	3508,137
T.wsi1	Tree Name	0,153	0,771	2847,652
<b>T.wsi2</b>	Tree Name	<b>0,160</b>	<b>0,776</b>	<b>2806,396</b>
T.wsi3	Tree Name	0,148	0,769	2861,845
T.wsi4	Tree Name	0,101	0,791	2902,3
<b>T.ba.ic1</b>	Tree Name	<b>0,398</b>	<b>0,895</b>	<b>3266,983</b>
<b>T.ba.ic2</b>	Tree Name	<b>0,306</b>	<b>0,930</b>	<b>3373,802</b>
<b>T.ba.ic3</b>	Tree Name	<b>0,309</b>	<b>0,931</b>	<b>3378,7</b>
T.ba.wsi1	Tree Name	0,430	0,720	2815,627
<b>T.ba.wsi2</b>	Tree Name	<b>0,525</b>	<b>0,755</b>	<b>2717,929</b>
T.ba.wsi3	Tree Name	0,514	0,745	2774,765
T.ba.wsi4	Tree Name	0,125	0,880	2896,618
<b>T.ba.ic1.wsi1</b>	Tree Name	<b>0,532</b>	<b>0,793</b>	<b>2738,805</b>
<b>T.ba.ic1.wsi2</b>	Tree Name	<b>0,579</b>	<b>0,787</b>	<b>2680,881</b>
T.ba.ic1.wsi3	Tree Name	0,571	0,780	2734,949
T.ba.ic1.wsi4	Tree Name	0,460	0,850	2724,444
<b>T.ba.ic2.wsi1</b>	Tree Name	<b>0,474</b>	<b>0,753</b>	<b>2785,447</b>
<b>T.ba.ic2.wsi2</b>	Tree Name	<b>0,550</b>	<b>0,769</b>	<b>2703,354</b>
<b>T.ba.ic2.wsi3</b>	Tree Name	<b>0,540</b>	<b>0,760</b>	<b>2759,333</b>
<b>T.ba.ic2.wsi4</b>	Tree Name	<b>0,283</b>	<b>0,866</b>	<b>2828,097</b>
<b>T.ba.ic3.wsi1</b>	Tree Name	<b>0,461</b>	<b>0,752</b>	<b>2798,975</b>
<b>T.ba.ic3.wsi2</b>	Tree Name	<b>0,539</b>	<b>0,767</b>	<b>2714,777</b>
<b>T.ba.ic3.wsi3</b>	Tree Name	<b>0,530</b>	<b>0,758</b>	<b>2770,263</b>
<b>T.ba.ic3.wsi4</b>	Tree Name	<b>0,288</b>	<b>0,862</b>	<b>2829,85</b>