Resource use efficiency: Lower stand density can mitigate damages by extreme climate events *[also]* in Mediterranean pine forests.

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Background

Predictions of climate change effects on terrestrial ecosystems and species

- **General responses** on **changes in mean climate variables**:
  Composition, Structure, Growth and Biogeography [*niche models*, etc.]
- **Species-specific** impacts of **singular extreme weather events:**
  Episodic **tree crown-diebacks and mortality** due to
  increasing **frequency and severity of drought and heat** stress ***(2005, 2009, 2012 < 250 mm/yr)***

Mediterranean forests on the *rear (xeric) edge*, moreover

- extended forest areas are managed only extensively, or unmanaged (**rural abandonment**).
- **primordial ecosystem services** of Mediterranean forests might be diminished or lost:
  essential regulation of water cycle, soils protection, wildlife, sequestered carbon

Scientific uncertainties about the fine scale processes of extreme event impacts hinder accurate predictions of **crown dieback and tree mortality** in response to climate change
[cf. Martinez-Vilalta & col.]

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QUESTIONS

Do extreme climate events leave marks
in Mediterranean pine trees and stands?

Can their impact be mitigated
by management and treatments
balancing resource availability and demand?

Species

Mediterranean pinewoods

area increments (XX c.)

mainly **encroachment of former pastures and fallow** farmland

but they are themselves often **non-profitable** for the owner,

inducing abandonment and **overstocking** (...fire risk)

A special case: **Mediterranean stone pine, *Pinus pinea***

Its forest or plantation area has been widely **increased by man**

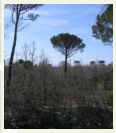
(e.g. **+70%** in Spain, **+350%** in Portugal since 1970, Turkey...),

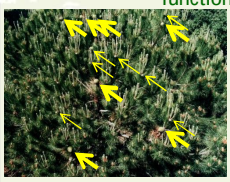
due the profit from highly- priced **pine nuts**.

Even-aged plantations (though often still high planting densities).

Species

- **The umbrella crown shape of *Pinus pinea***
  an open, polyarchic savannah-tree type crown (OGT)
  but with a dense upper canopy layer with smooth surface
- a singular adaptative trait, being a conifer, that favours:
  - escape from ground fire in Mediterranean woodlands (~poster Rigolot)
  - WUE: light harvest by a compact *lawn* of upward needles
    that reduces transpiration loss (water, not light is limiting factor)
  - maximised reproductive effort (cones - dyszoochory by nucivorous)
  - less impact of shoot loss by droughts or pests (crown resilience),
    functional crown type persists even if the stem tip/tree top is





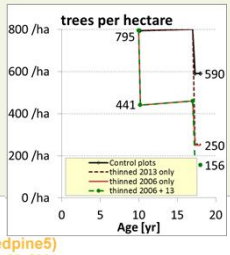
1.- Drought (and blight?) -> 2.- Collateral growth or juvenile resprout 3.- Result frequently: forks or candelabra

e.g., **¿WHICH WAS THE LEADER SHOOT HERE?**

MATERIALS & METHODS

Stone pine early thinning trial *Olmedo*

- **Site**
  Northern Plateau (Central Spain)
  flat sandy area, Alt. 775 m, p 440 mm, T 12.2 ºC
- **Stand**
  planted in 1996 after a wildfire in 1994
  Grid 4 x 2 m (→ 800 trees/ha alive in 2006)
- **CRB Design**
  - ✓ 3 blocks, factorial 2x2: 12 plots (0.1 ha),
  - ✓ Treatments in 2006
    Age 10 years; H_o 3 m; dg 3 cm; BA 0.6 m^2/ha; SDI 26
    Thinning: ~50% (many cut trees < 1.5 m)
    Low Pruning: max. 1 m; max ½ Ht
  - ✓ Treatments in 2013
    age 17 yrs; H_o 6 m; dg 11-14 cm; BA 7 m^2/ha; SDI 171



MATERIALS & METHODS

Stone pine early thinning trial *Olmedo*

- **Measurements**
  - Whole-plot inventory

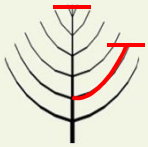
    2006, 2010, 2012 — diameter, height, reproductive maturity (♂/♀), cone count, survey for leader lost and other damages

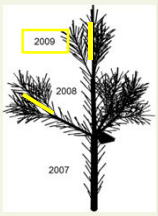
    2010 — crown diameters

  - 10 sample trees per plot

    2006-2010 — shoot length (stem, marked branch), branch tip height, crown diameters (→ Crown architecture ~poster Turrión)

    2006-2009(monthly) — diameter (seasonal growth patterns)





- **Data analisis**
  - General and Generalised Lineal Models

RESULTS

Stone pine early thinning trial *Olmedo* – Mediterranean climate

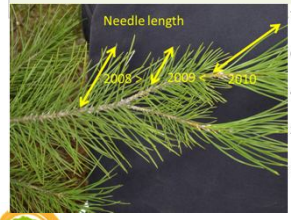
climatic average **"p 440 mm, T 12.2 ºC"**

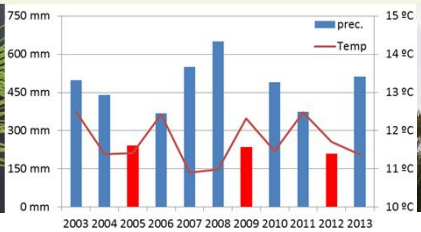
2003-2013: **p 210 - 650 mm/yr (erratic)**

T 10.9 - 12.5 ºC

2005, 2009, and 2012: severe lasting droughts (< 250 mm/yr$_{Sep-Aug}$)

- needle length reduction
- needle loss and crown dieback (10-12% trees in un-thinned controls)
- no tree mortality





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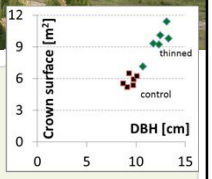
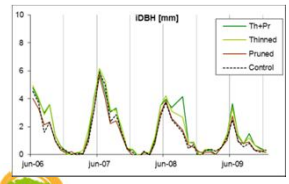


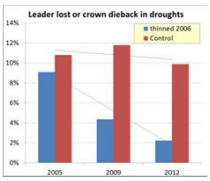
Effects of opening stand density (-50%)

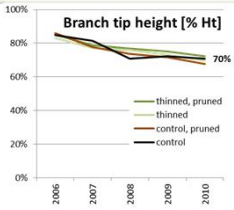
Individual tree growth, health and development

- size increment by release of competition: Dg +30%, Crown surface +64%
- more sustained growth in summer (less water stress)
- less crown dieback: 2% vs. 10% = 120/ha multi-stem trees vs. 250/ha 2013 before thinning
- enhanced reproductive maturity: 6% vs. 3% with cones

  [*cf.* Moreno-Fernández *et al.*, 2013: thinning at 20 yrs. to 300/ha: 23% vs. 10%]
- no effect of pruning on crown form/architecture (same leader dominance)







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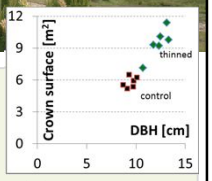
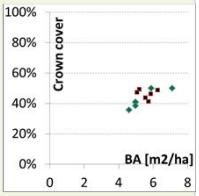


Lower stand density

Individual tree growth, health and development

- size increment by release of competition: Dg +30%, Crown surface +64%
- more sustained growth in summer (less water stress)
- less crown dieback: 2% vs. 10% = 26/ha multi-stem trees vs. 80/ha 2013 after thinning
- enhanced reproductive maturity: 6% vs. 3% with cones =15/ha vs. 16/ha after 2013

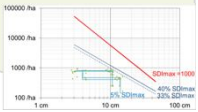
  [*cf.* Moreno-Fernández *et al.*, 2013: thinning at 20 yrs. to 300/ha: 23% vs. 10%]
- no effect of pruning on crown form/architecture



per-hectare growth and stand variables

- growth concentrated on remaining trees (nearly compensated)
- minor effect of thinning on BA (-3%) and crown cover (-7%)
- Reinecke's SDI 15-20% → 5%-10% SDI_{max}

  Silvicultural recommendation for the species have been about 33-40%



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OUTLOOK

1.- operative silviculture applied practises already experimental findings

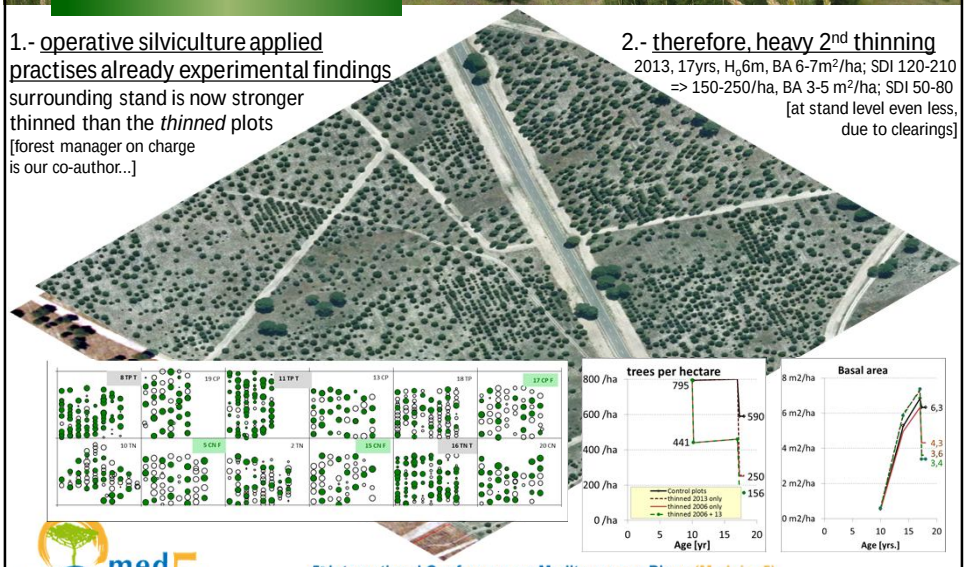
surrounding stand is now stronger thinned than the *thinned* plots

[forest manager on charge is our co-author...]

2.- therefore, heavy 2nd thinning

2013, 17yrs, $H_0$6m, BA 6-7m²/ha; SDI 120-210 => 150-250/ha, BA 3-5 m²/ha; SDI 50-80

[at stand level even less, due to clearings]



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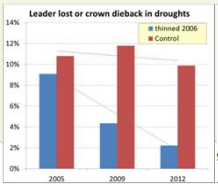
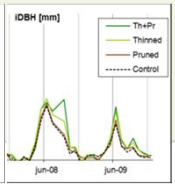
CONCLUSIONS

YES, extreme climate events do leave marks in Mediterranean pines, even in low stand densities (BA 4-8m²/ha)

BUT their impact can be mitigated by management and treatments, balancing resource availability and demand.

SO, former silvicultural standards must be revised / revisable (***adaptative management***).





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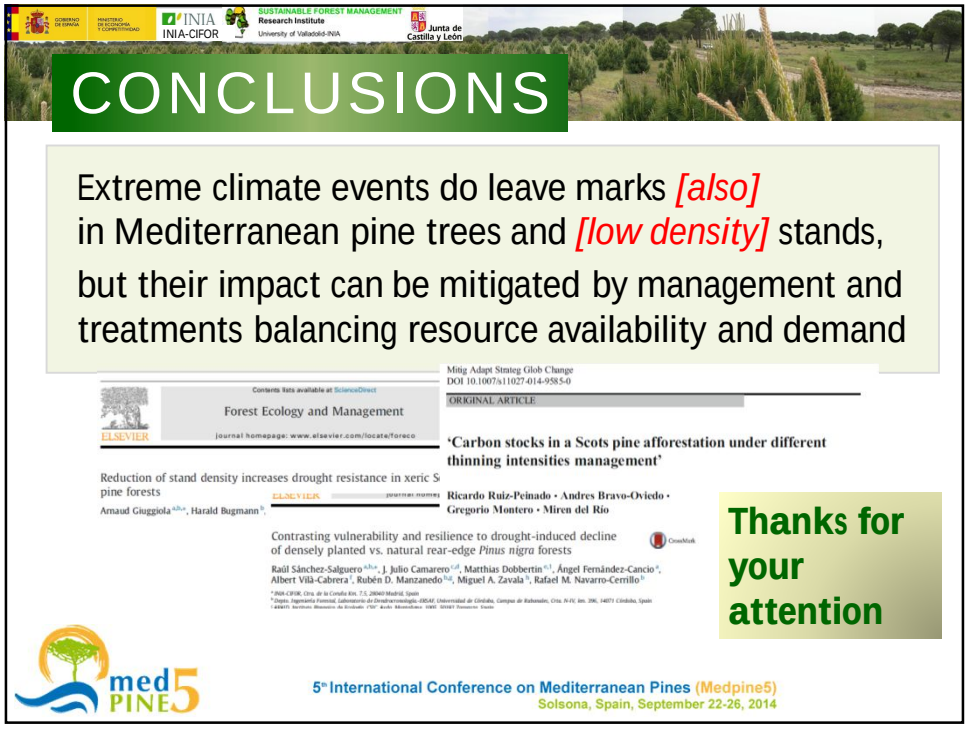
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CONCLUSIONS
Extreme climate events do leave marks [also] in Mediterranean pine trees and [low density] stands, but their impact can be mitigated by management and treatments balancing resource availability and demand
Forest Ecology and Management
Reduction of stand density increases drought resistance in xeric S pine forests
Arnaud Giuggiola, Harald Bugmann
Mitig Adapt Strateg Glob Change
DOI 10.1007/s11027-014-9585-0
ORIGINAL ARTICLE
'Carbon stocks in a Scots pine afforestation under different thinning intensities management'
Ricardo Ruiz-Peinado · Andres Bravo-Oviedo · Gregorio Montero · Miren del Rio
Contrasting vulnerability and resilience to drought-induced decline of densely planted vs. natural rear-edge Pinus nigra forests
Raúl Sánchez-Salguero, J. Julio Camarero, Matthias Dobbertin, Ángel Fernández-Cancio, Albert Vilà-Cabrera, Rubén D. Manzanedo, Miguel A. Zavala, Rafael M. Navarro-Cerrillo
Thanks for your attention
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