FORESTERRA

Enhancing FOrest RESearch in the MediTERRAnean through improved coordination and integration

Lisboa, 24th-25th november 20[illegible]6

Forest Carbon:

Knowledge, Uncertainty and Risks

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TOPICS

- Introduction
- Forest management and carbon sequestration
- Forestry strategies and carbon sequestration
  - Species composition (pure vs mixed stands)
  - Thinning
  - Rotation length
  - Forest conservation
  - Increasing forest area (afforestation & natural recovery)
- Uncertainty and risk of forest carbon sequestration
- Conclusions

INTRODUCTION

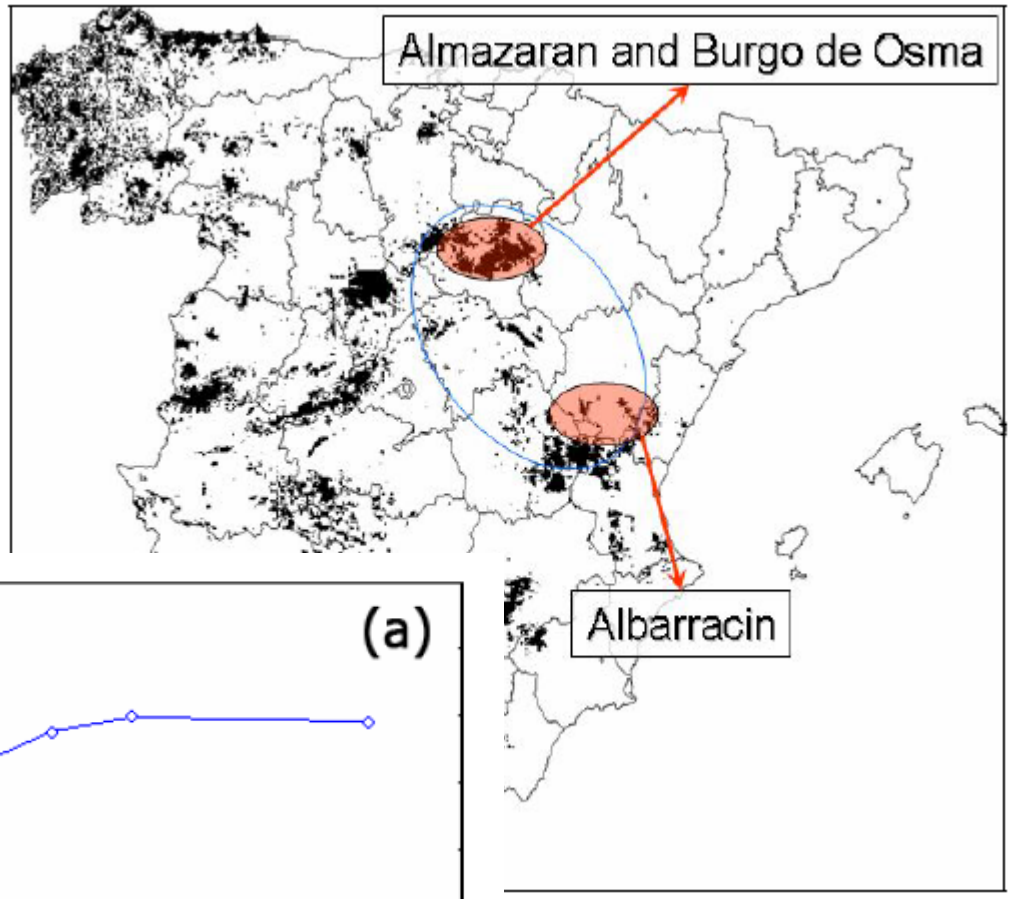
Climate change impacts forest growth and dynamics by modifying and generating uncertainty in key aspect as rainfall and temperature patterns

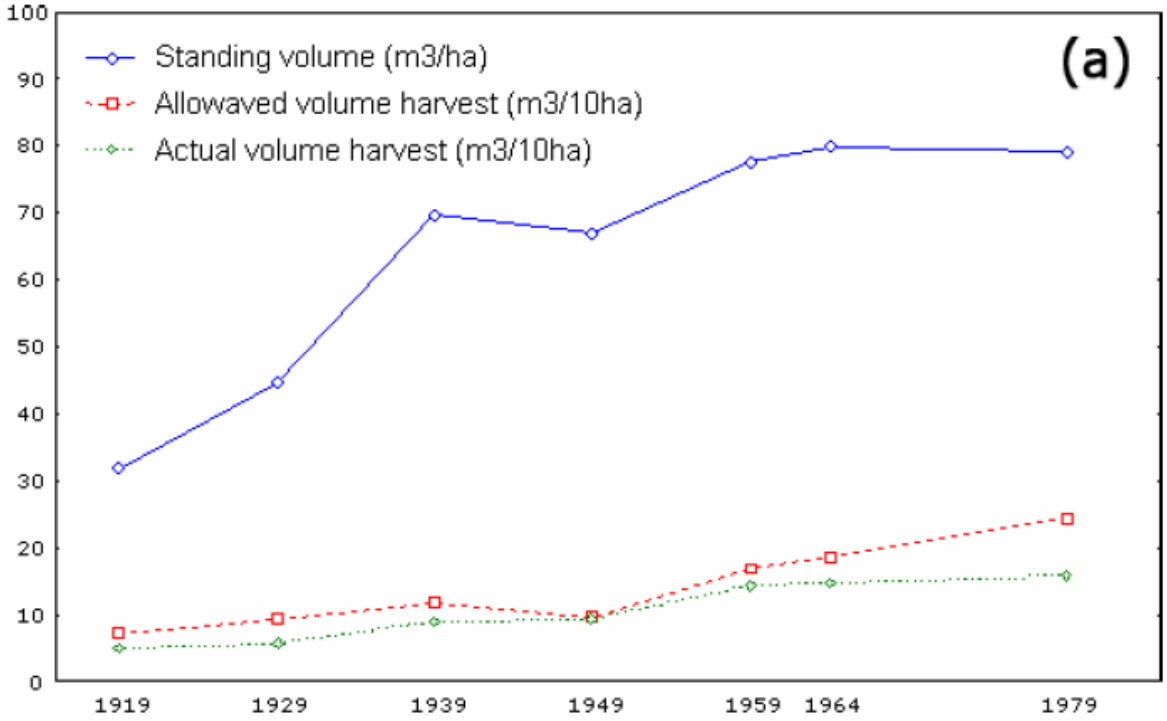
In light of such uncertainty, **adaptive management** holds potential for developing adequate, operational forestry strategies in a world of constant **social and ecological change**.

FOREST MANAGEMENT AND CARBON SEQUESTRATION

Stable forest management practices contribute to biomass accumulation

while provision of wood and other ecosystems services are ensured





Bravo et al, 2010

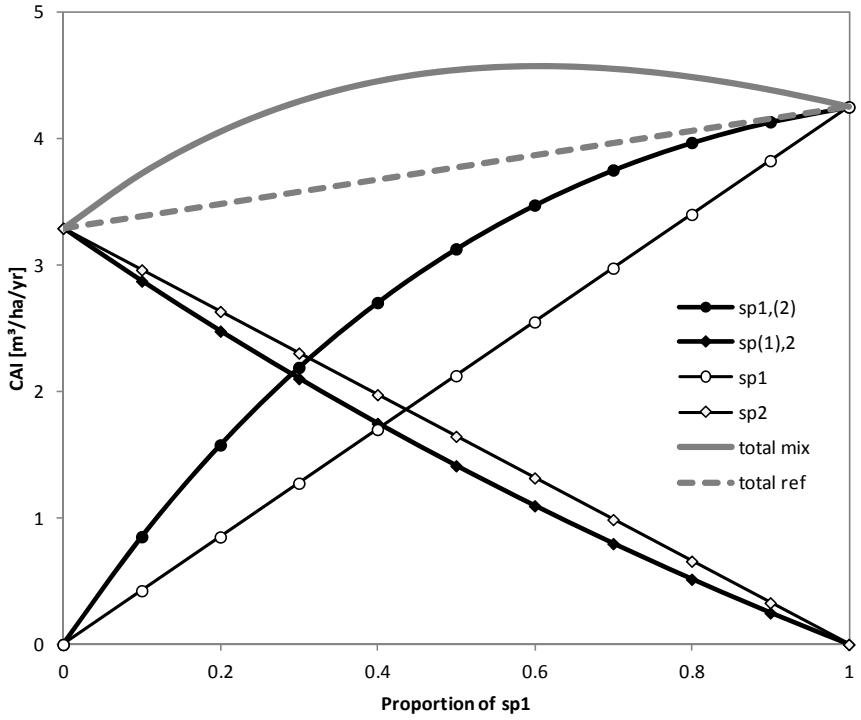
Soils contain the largest carbon stock in terrestrial ecosystems

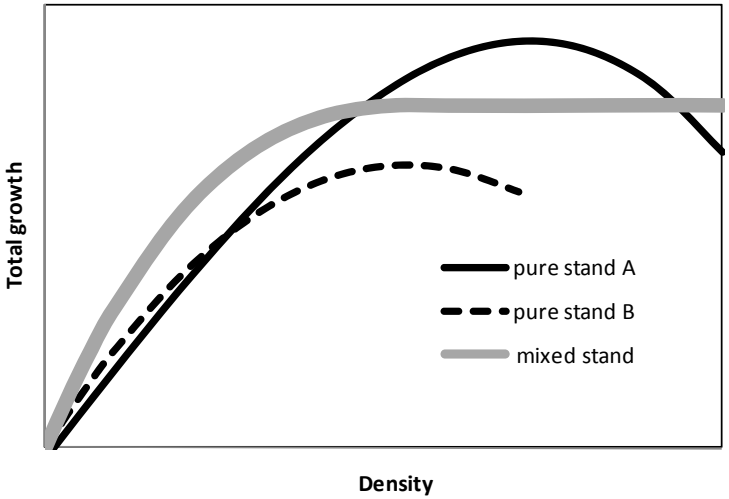
representing :
~ 50 % of total carbon in tropical forests
~ 63% in temperate forests
~ 85% in boreal forests

Conserving soil carbon,
we can reduce CO_2 emissions and contribute to climate change mitigation.

FORESTRY STRATEGIES AND CARBON SEQUESTRATION

SPECIES COMPOSITION (MIXED VS PURE STANDS)





Rio et al, 2016

THINNING [To do or not to do?]

Unthinned stands present higher carbon stocks in tree biomass than thinned stands (Skovsgaard *et al.,* 2006; Powers *et al.,* 2011; Ruiz-Peinado *et al.,* 2013 and 2014)

But stand high density it may also increase the risk of natural disturbances (Jandl *et al.,* 2007).

Increasing off-site carbon storage via thinning may prove a better strategy, especially in high risk areas.

N**o significant influence of thinning on total ecosystem carbon stock, when compared to unthinned stands at the end of the rotation period has been also reported (**Ruiz-Peinado *et al.,* 2013 and Bravo-Oviedo *et al.,* 2015)

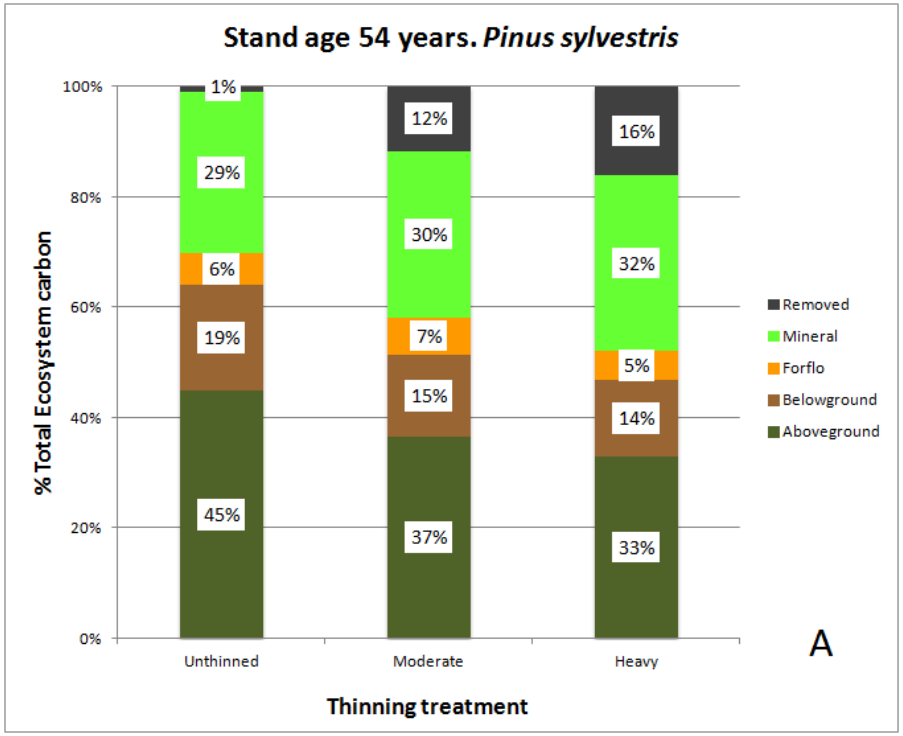
THINNING [How to do?]

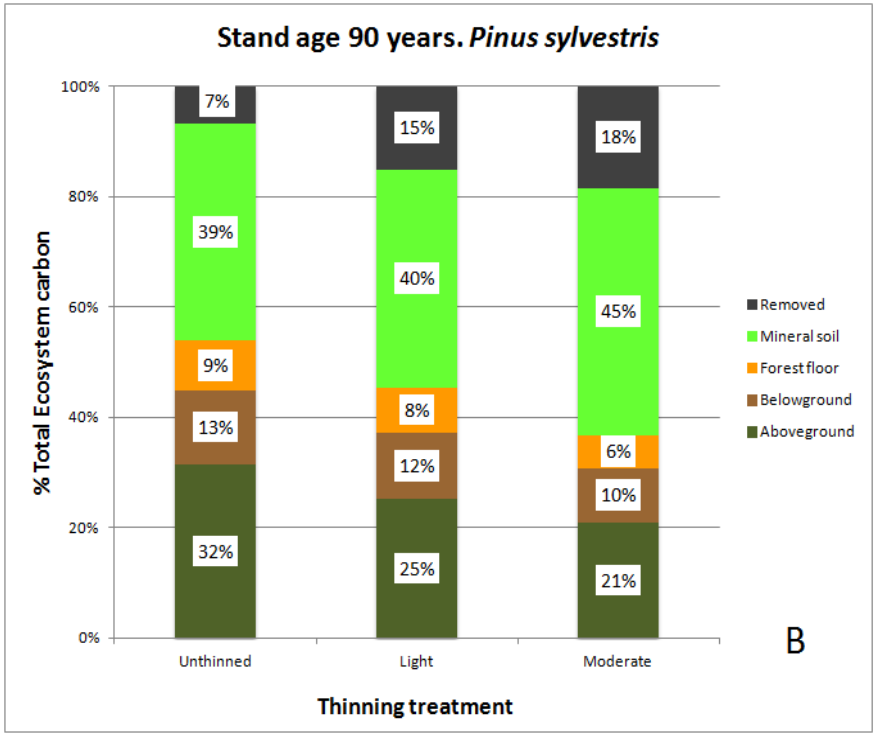
Thinning from below presented higher carbon stocks in tree biomass than thinning from the middle or from above
Hoover and Stout (2007)

Similar amounts of carbon in tree biomass with thinning from below as with a combination of thinning from above and from below (i.e., multiple thinning events) over the long term (D'Amato *et al.,* 2011)

THINNING [How to do?]

Carbon pool after 3 thinning interventions (during 30 years)





Afforested stand in Spain (Ruiz-Peinado *et al.*, 2014).

Natural stand in Spain (Bravo-Oviedo *et al.*, 2015)

THINNING

Effect of thinning on soil carbon stocks is not quite significant, but…

•a high degree of variation exists according to species, harvesting methods, soil types, etc.
•living biomass decreased with the thinning interventions in the long-term (reduction of tree density)
•in areas with high risk of fire or other disturbances (winds, heavy snow, pests, diseases,…) may endanger the ecosystem

moderate or heavy thinning helps maintain tree cover and improve carbon sequestration on-site as well as off-site, in wood products or as bioenergy.

ROTATION LENGTH

Although, generally carbon pools in old-growth forests are considered to be in a steady state,

Zhou *et al.,* (2006) based on Chinese forests data, suggested that a **longer rotation length may increase soil carbon**, even though living biomass accumulation may have reached an asymptote.

INCREASING FOREST AREA (AFFORESTATION & NATURAL RECOVERY)

Increased forest area …., has led to increased carbon reserves in living biomass as well as in the soil

China presented the highest rate of forest expansion
(1.5 million ha year^{-1} between 2010 & 2015)

this rate is currently slows down

Between 2000 and 2005, **Mediterranean countries** (Spain, Portugal, Italy and Greece), **Vietnam** and **China** were the greatest contributors to increases in forest area in the world,

while **tropical countries** were the greatest contributors to decreased forest area.

Bravo et al, 2016

FOREST CONSERVATION

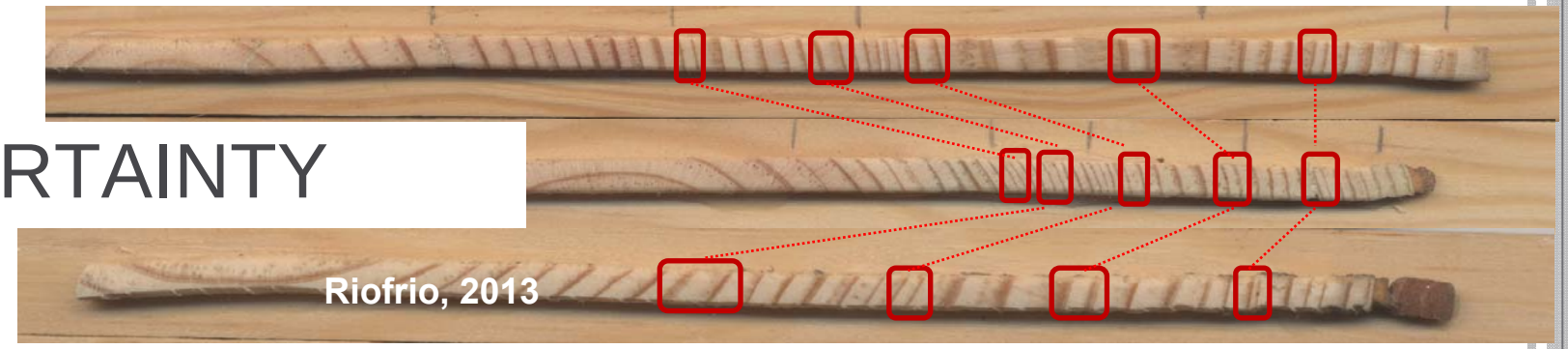
Preserve current forests by reducing deforestation outweigh the benefits of increasing forest area in terms of carbon mitigation benefits.

REDD +

Forest Carbon partnershit Facility (FCPF) – World Bank

UNCERTAINTY AND RISK OF FOREST CARBON SEQUESTRATION

UNCERTAINTY



Precipitation is the main factor influencing tree growth in Mediterranean forests

Pinus pinaster showed the highest correlations between **precipitation** and growth.
Wet periods during winter previous to the growth season and spring induced higher growth rates in *P. halepensis* & *P. pinaster*
P. sylvestris is mostly influenced by **summer precipitation**

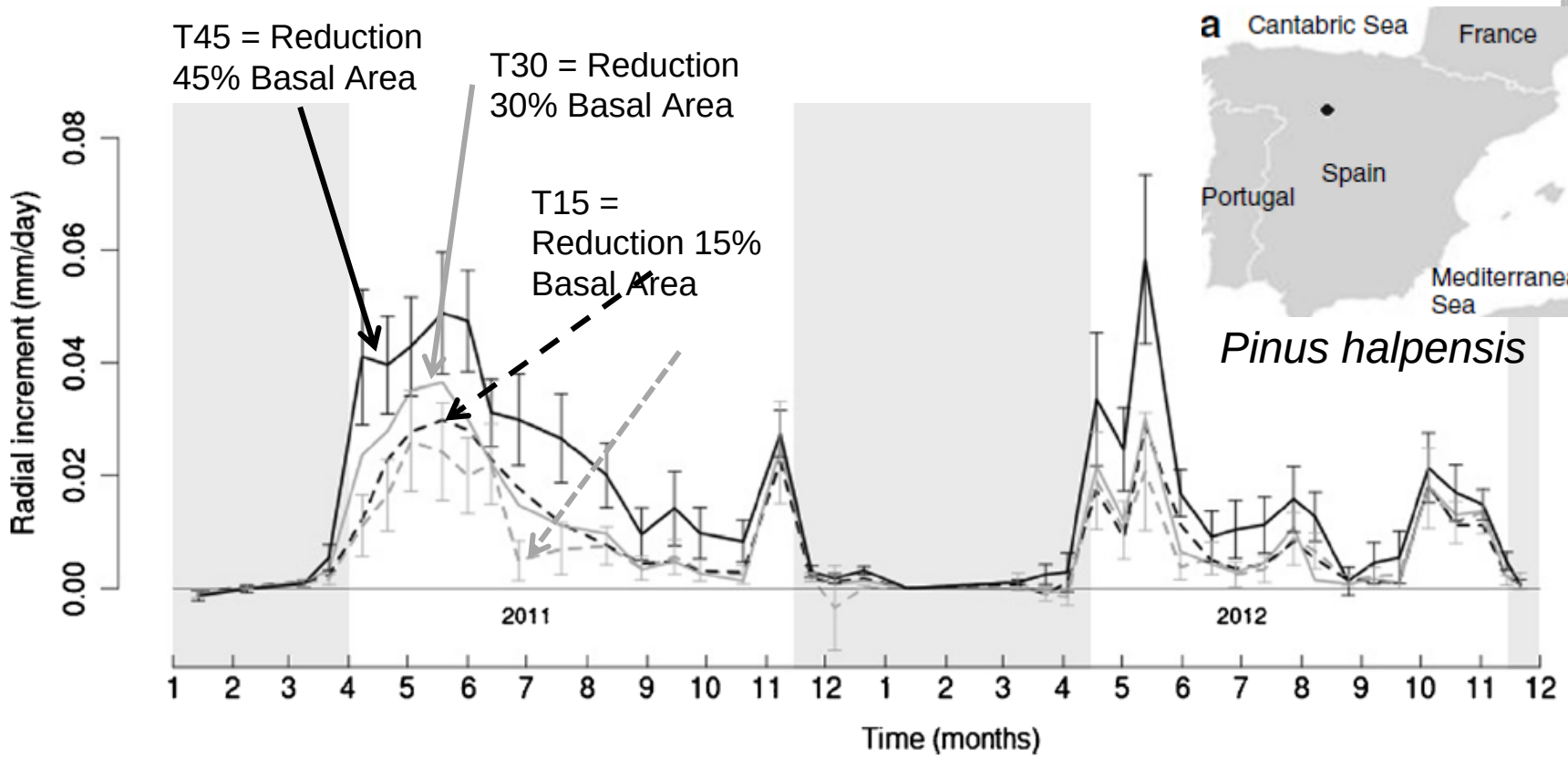
During the second half of the 20th century,

Increase of winter and climatic conditions during summer enhanced the importance of precipitation at the beginning of the growing season on the growth of species growing under drought conditions

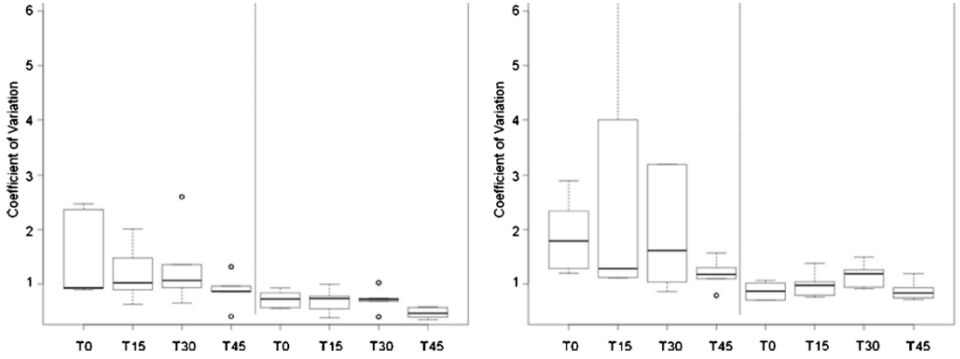
Olivar et al, 2015. Forest Systems 1:9 pages
http://dx.doi.org/10.5424/fs/2015241-05885

UNCERTAINTY

Tree Growth:
Interaction between **silviculture** (thinning intensity and timing) y **climate**



Pinus halpensis



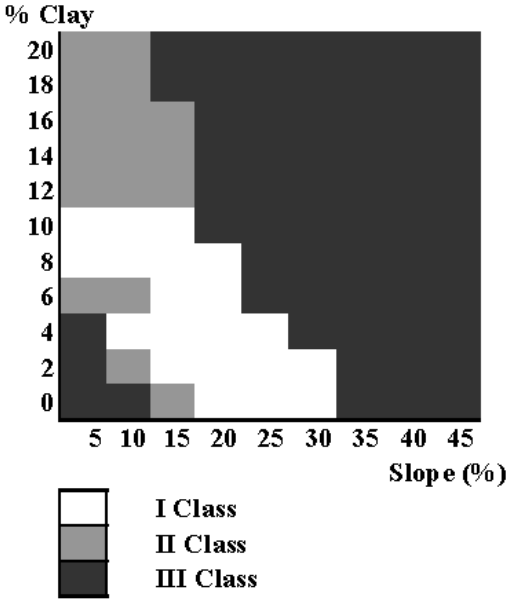
Olivar, Bogino, Rathgeber, Bonnesoeur & **Bravo** (2014) *Annals of Forest Science* 71:395-404

UNCERTAINTY

Site index is changing following climate changes

***Pinus sylvestris* productivity** in norther Spain is **related with latitude** (a proxy of precipitation) **and soil texture and porosity** as proxies of soil aeration and water retention

Bravo & Montero, 2001
Bueis et al, 2016

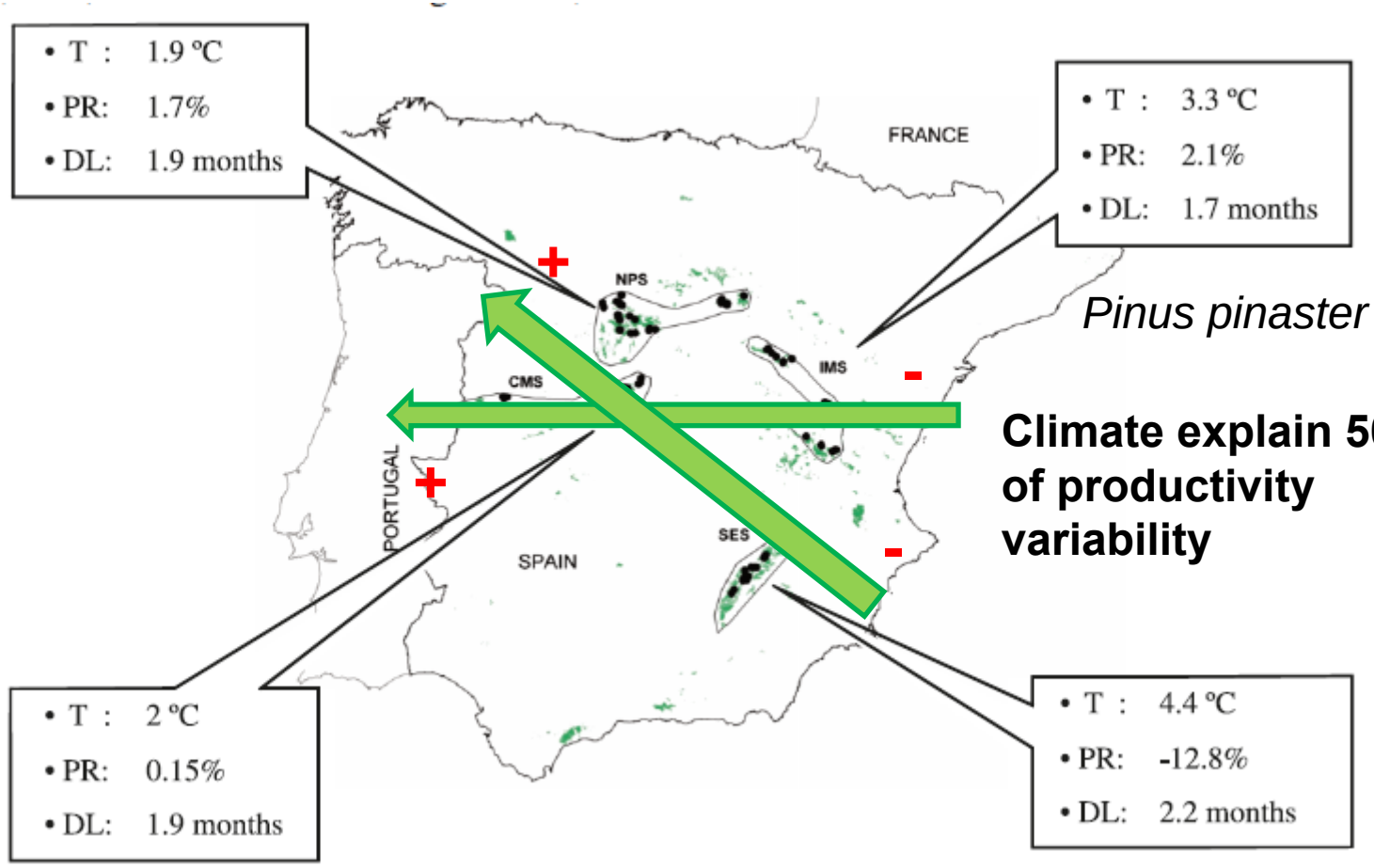


***Pinus pinea* productivity** in Calabria (Italy) is also **related with water availability**

Bravo et al, 2011

UNCERTAINTY

Site index is changing following climate changes



Pinus pinaster

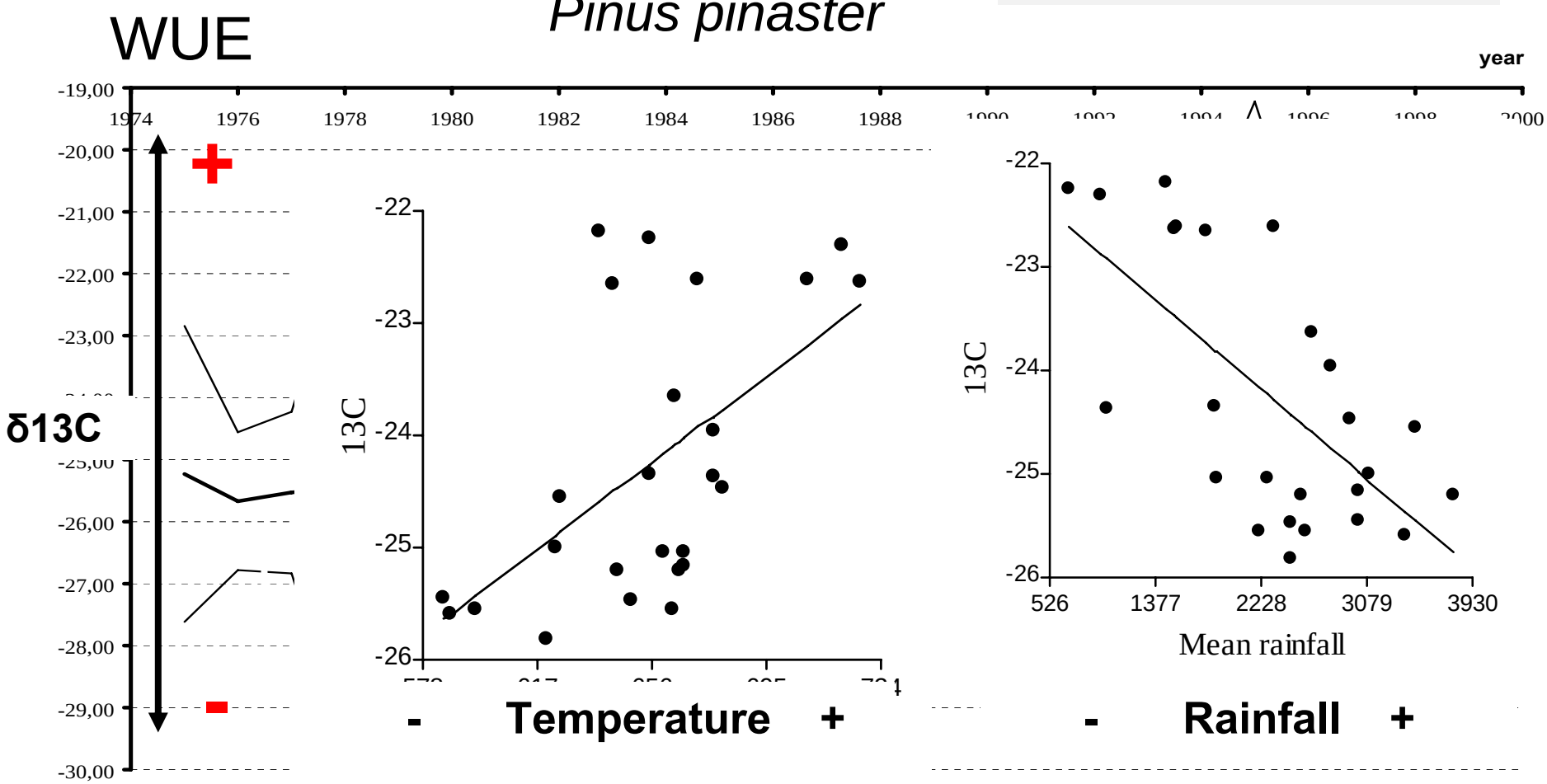
Climate explain 50% of productivity variability

Bravo-Oviedo et al, 2008 & 2010

UNCERTAINTY

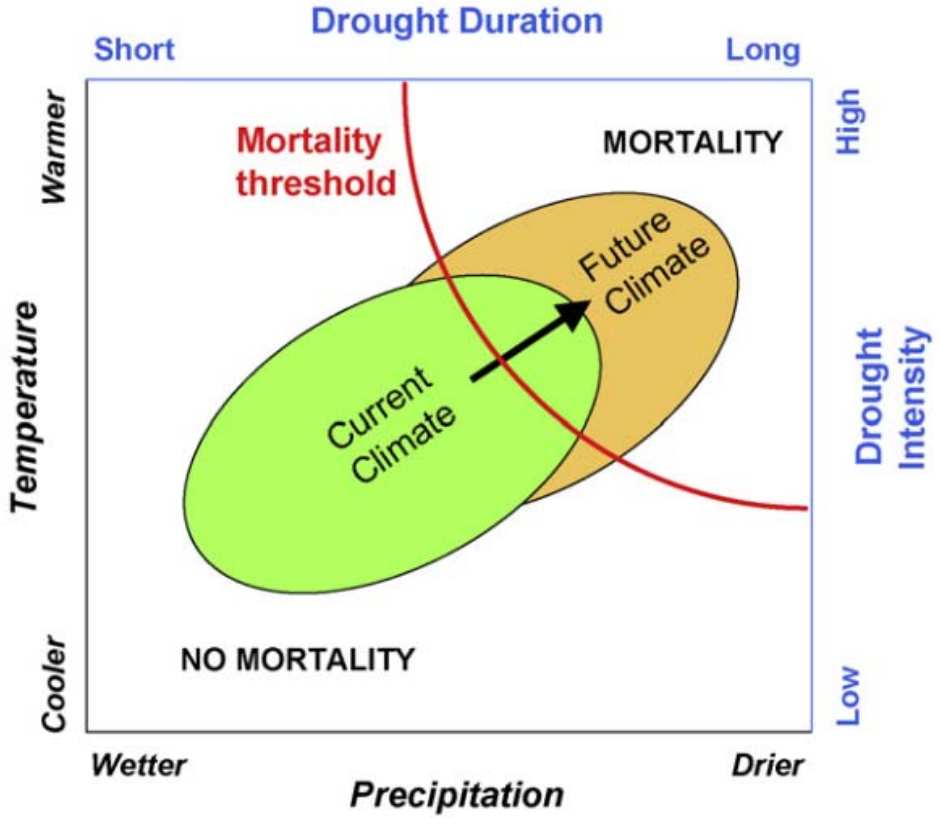
Water use efficiency is increasing

Pinus pinaster



Bogino & **Bravo** (2014) *Bosques* 35(2):175-184

RISK

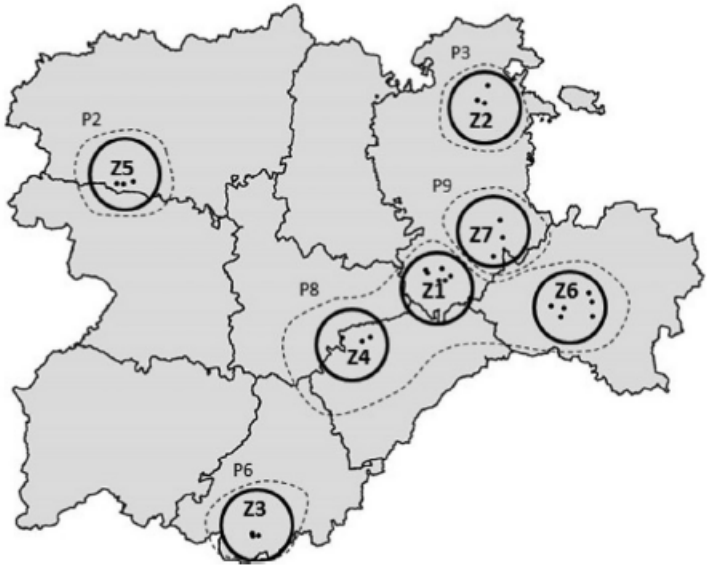


Allen et al, 2014 Forest Ecology & Management

Forest decline is a complex process caused by the interaction of a number of interchangeable factors (both abiotic and biotic), leading to gradual deterioration of the forest.

These factors have been classified as **predisposing, inciting or contributing factors**.

RISK



Stands close to their physiological tolerance threshold (as *P. pinaster* stands located in xeric sites in northern Plateau in Spain)

Thus, **decreased water availability** in the last few decades as a result of climate change and/or overuse of aquifers, **together with increased water requirements** (as a result of high stand densities) have **led to forest decline and long-term changes in tree species composition** (invasion of *Quercus ilex*)

Prieto-Recio et al, 2015

CONCLUSIONS

Climate change will impact [soon] forest growth responses dramatically and modify all the scenarios envisaged until now generating uncertainty in ecosystem responses

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The **impact of climate change** on forest growth, and the interaction of climate changes **with silvicultural treatments is differentiated across ecosystem**s

Adaptive management holds **potential for developing** adequate, **operational forestry strategies**

The combined effects of **reducing deforestation and forest degradation while promoting afforestation and forest management** contributing to **climate change mitigation and sustainable development**.

Bravo, Jandl & Lemay, 2016 **Managing Forest Ecosystems: the challenges of climate change** 2nd Edition Springer

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Stand and landscape-level carbon density **should be preserve and promote** through forest conservation, silviculture (thining, longer rotations,..), fire management, and pest and disease control.

Increasing **off-site carbon stocks** in wood products and promoting forest-based products to substitute fuel and other materials (e.g., biomass, building materials, etc.) **will help to mitigate climate change and promote adequate management**

Bravo, Jandl & Lemay, 2016 **Managing Forest Ecosystems: the challenges of climate change** 2nd Edition Springer

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Thanks! / Obrigado!

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