Predicted impacts of climate change on growth and production of Mediterranean Stone pine

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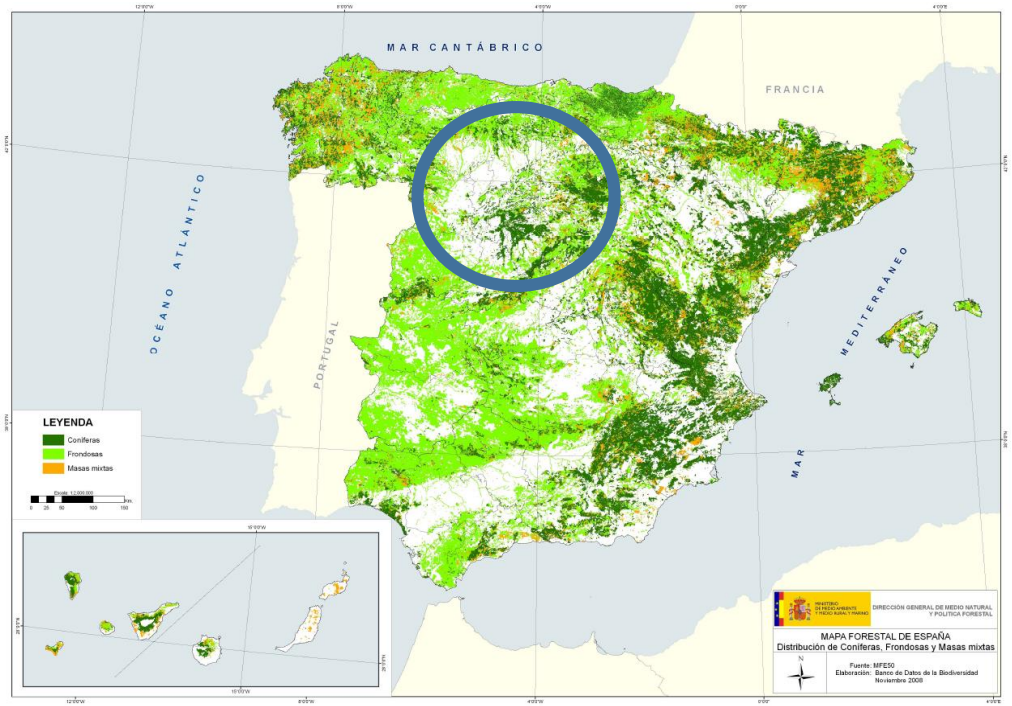
- Mediterranean forests threatened by climate change
- Adaptive capacity and vulnerability
- Multifunctionality: key characteristic of Mediterranean forest management







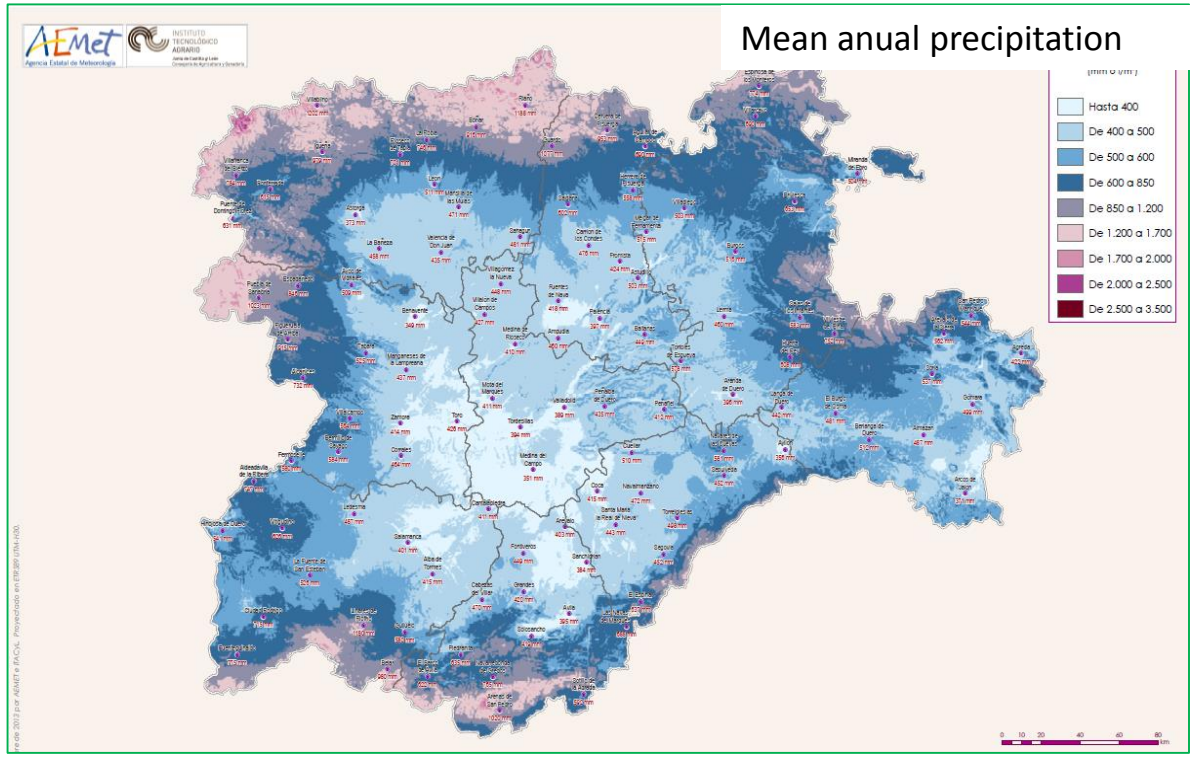

Our study area: Stone pine in the Spanish Northern Plateau



- Flat area
- Central part of river Duero Basin
- 600 m – 900 m altitude
- 25 habitants / km^2
- Agricultural land (Tierra de Campos): cereal, vineyards, sunflower: rainfed crops
- Sandy soils, low WRC
- Low contents of C, N and O.M.
- Pure stands: 60,000 ha
- Mixed stands: 40,000 ha

- Fragmented patches of pinewoods and rainfed crops
- Severe process of deforestation between Middle-Age and XIXth century
- Artificial and natural recovery of the forest during 20th century

Our study area: the Spanish Northern Plateau

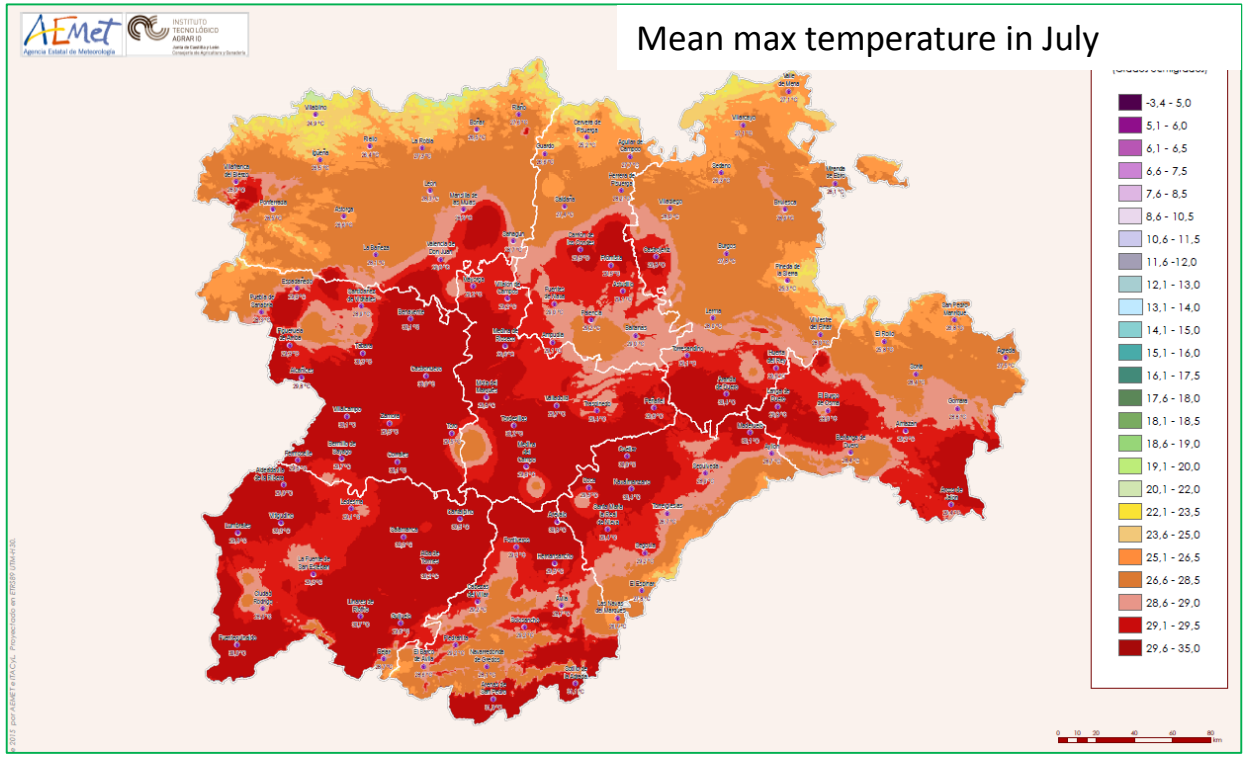


Mediterranean continental climate

Annual rainfall < 400 mm, heavy ETP

Summer droughts

Semiarid-zones => limit for forest tree species

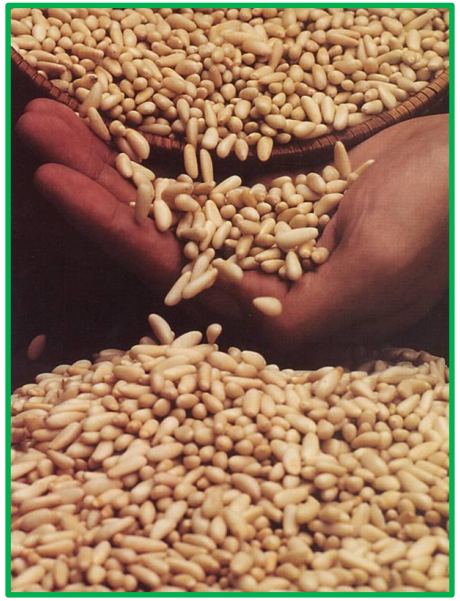


High termal oscillation: Winter minimum < - 10ºC to summer maximum > 40 ºC

Soil temperatures > 50ºC

Two vegetative periods: spring and autumn

Management of pinewoods: *Pinus pinea*



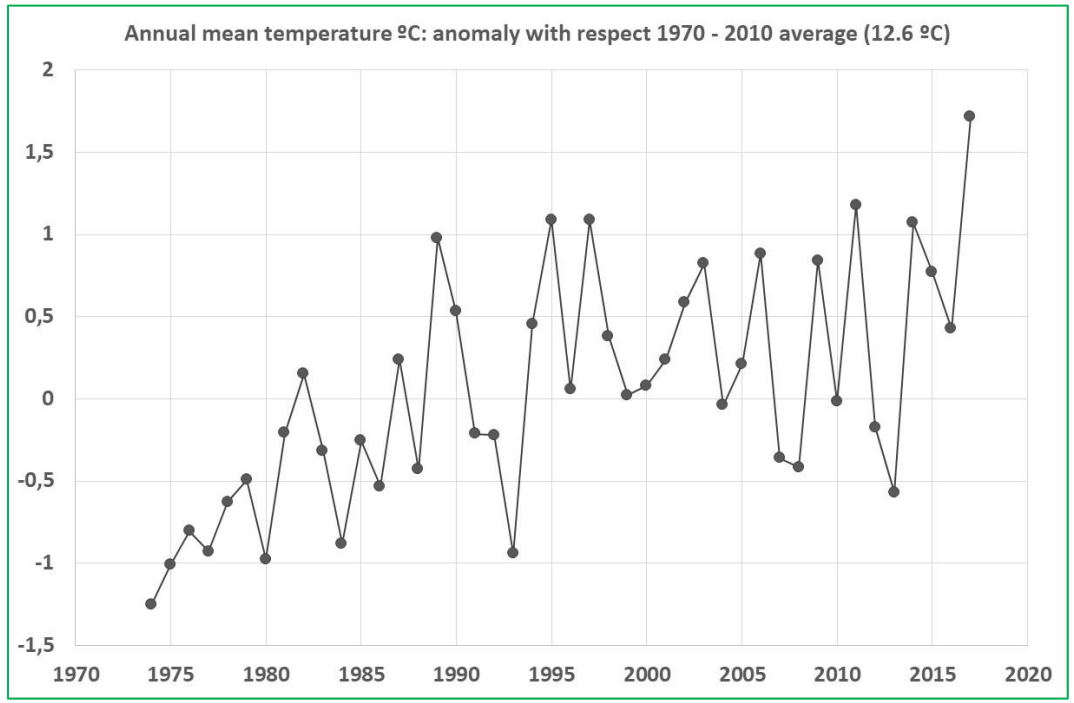
- Pure, even-aged stands
- Open forests to promote joint cone-timber production (BA < 15 m^2 ha^{-1})
- Rotation length: 100 - 120 years
- Intensive & early thinnings
- Strip clearcutting & shelterwood system

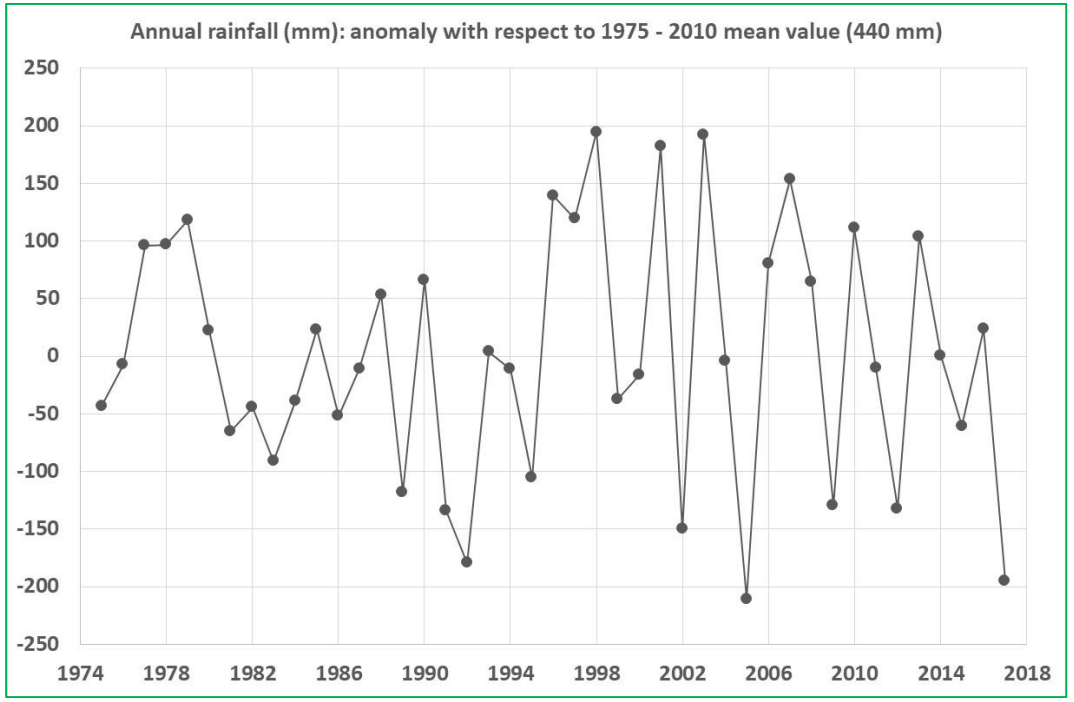
- MAI: 2 m^3 ha^{-1} $year^{-1}$
- Timber harvesting: 1 m^3 ha^{-1} $year^{-1}$
- Cone production: 200 kg ha^{-1} $year^{-1}$

- Anual income timber: 25 € ha^{-1}
- Anual income cone: 40 € ha^{-1}

Pine kernel end price: 60 – 80 €/kg
Kernel yield < 2%

Climate change in the Northern Plateau



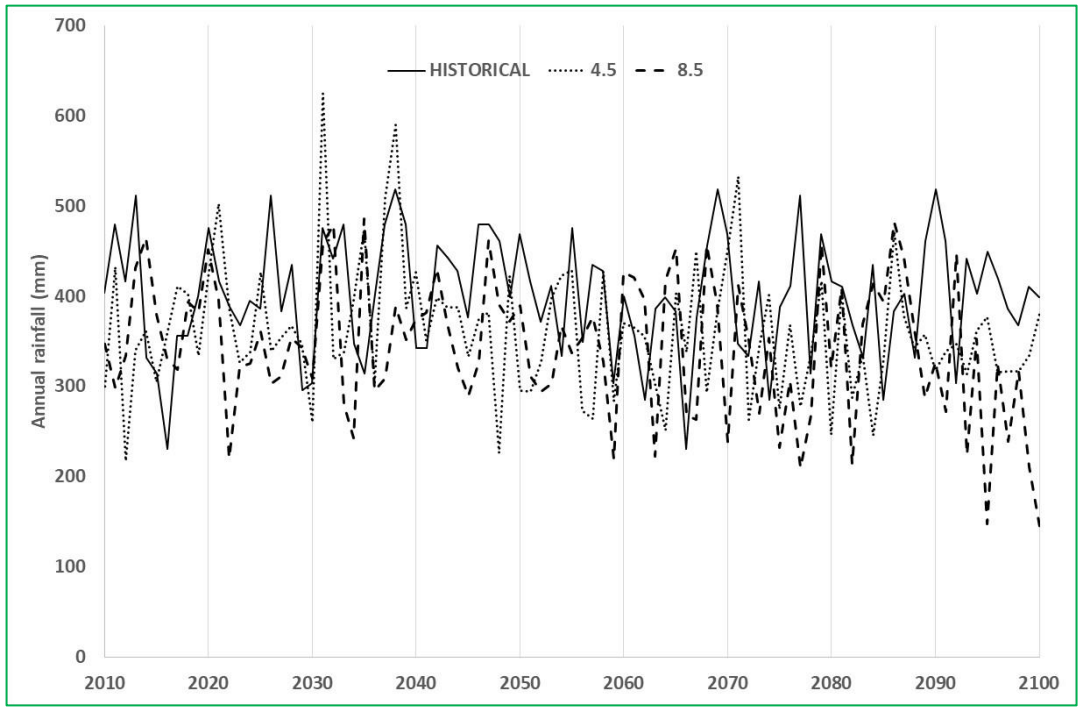


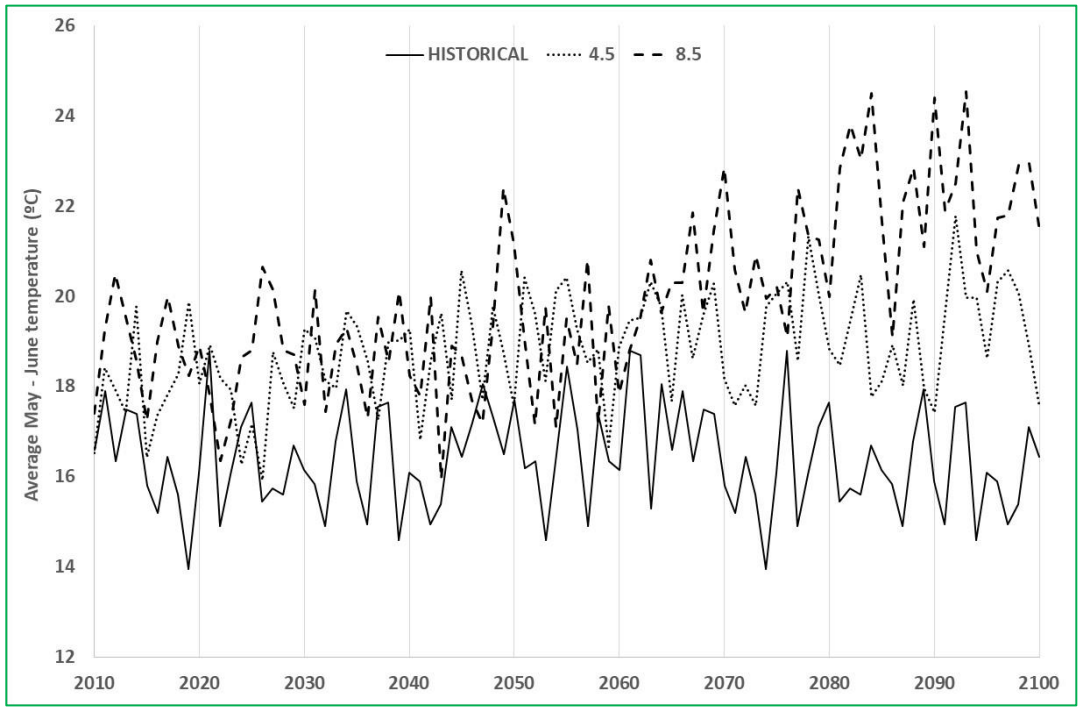
- Increment on mean annual temperature ≈ + 1.5 º C
- 2017: warmer year in the history
- More evident increment: spring maximum daily temperatures (+ 3ºC)
- Reduction in the number of extreme freezing events (< -5ºC)

- 2017: up to 25 “extreme hot days” (Tmax>35ºC)
- More frequent heatwaves
- Increasing risk of fire

- Not a general trend
- Increase on the irregularity
- More frequent extreme dry years: < 300 mm (2002, 2005, 2009, 2012, 2017)

Climate change in the Northern Plateau: projections





- Increase in the frequency of extreme dry years (< 300 mm)
- Shift to aridity (precipitation < 250 mm)
- Increase in the frequency of severe summer droughts

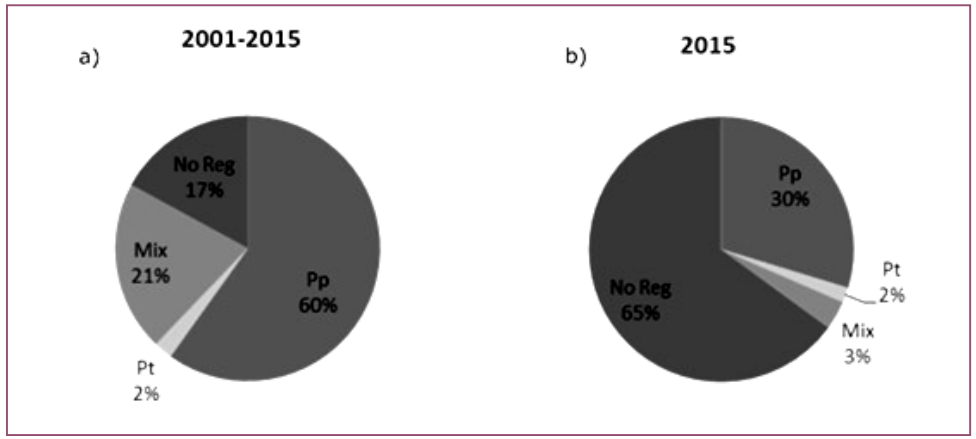
- Increase in 1 ºC (+2ºC spring) in 2050
- Increase in 4ºC (+6ºC spring) in 2100
- More frequent extreme hot days, heatwaves
- Increase in ETP

Impacts on Stone pine in the Northern Plateau: decay & dieback

- Generalized decay and dieback
- Defoliation, lack of vigour on terminal shoots
- Presence of mistletoe
- P. *pinea*: small groups or individuals

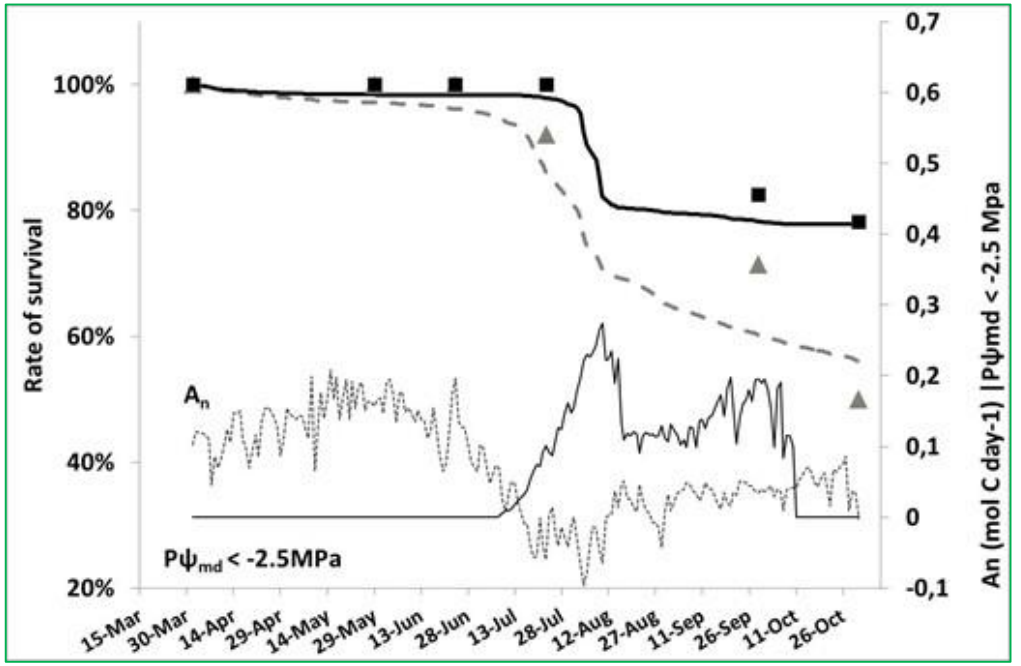
- More obvious following a dry period
- Joint action of climate – pathogens (phytoptora) – bark beetles
- Shown in other species: Quercus sp. *"La seca"*

Impacts on the pinewoods of Northern Plateau: lack of natural regeneration

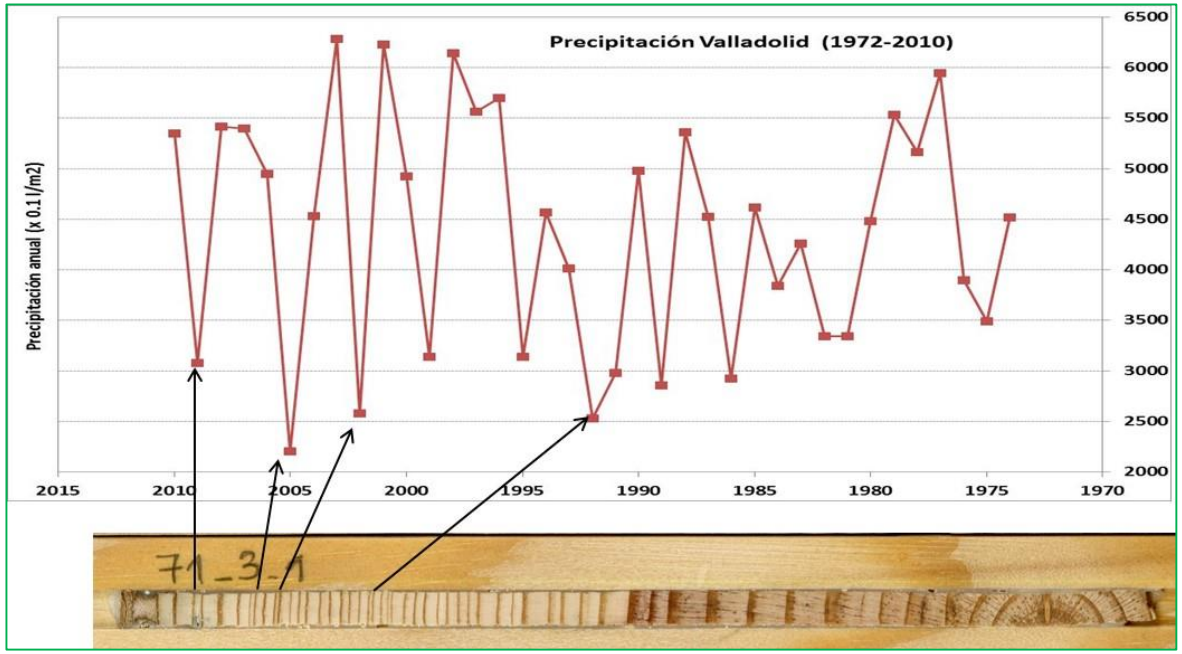


- Main part of the territory under regeneration is not regenerated (65%)
- High rates of seedling mortality (>90%)
- Presence of gaps with no regeneration

- Seed dispersal limitations (not climatic)
- Climatic control over fruiting, germination & summer seedling survival



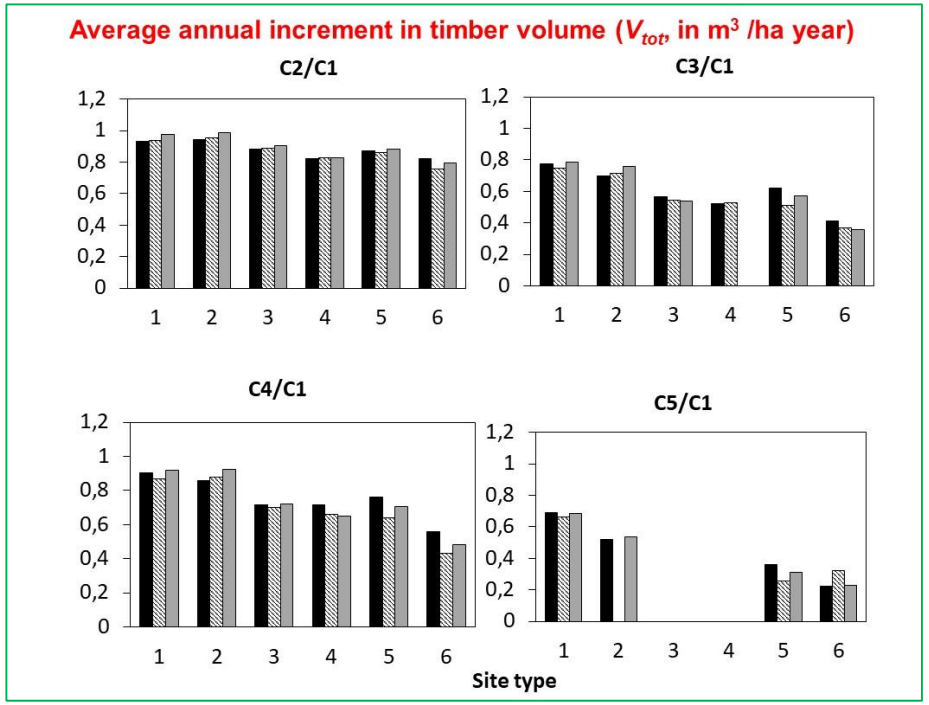
Impacts on the pinewoods of Northern Plateau: losses of productivity



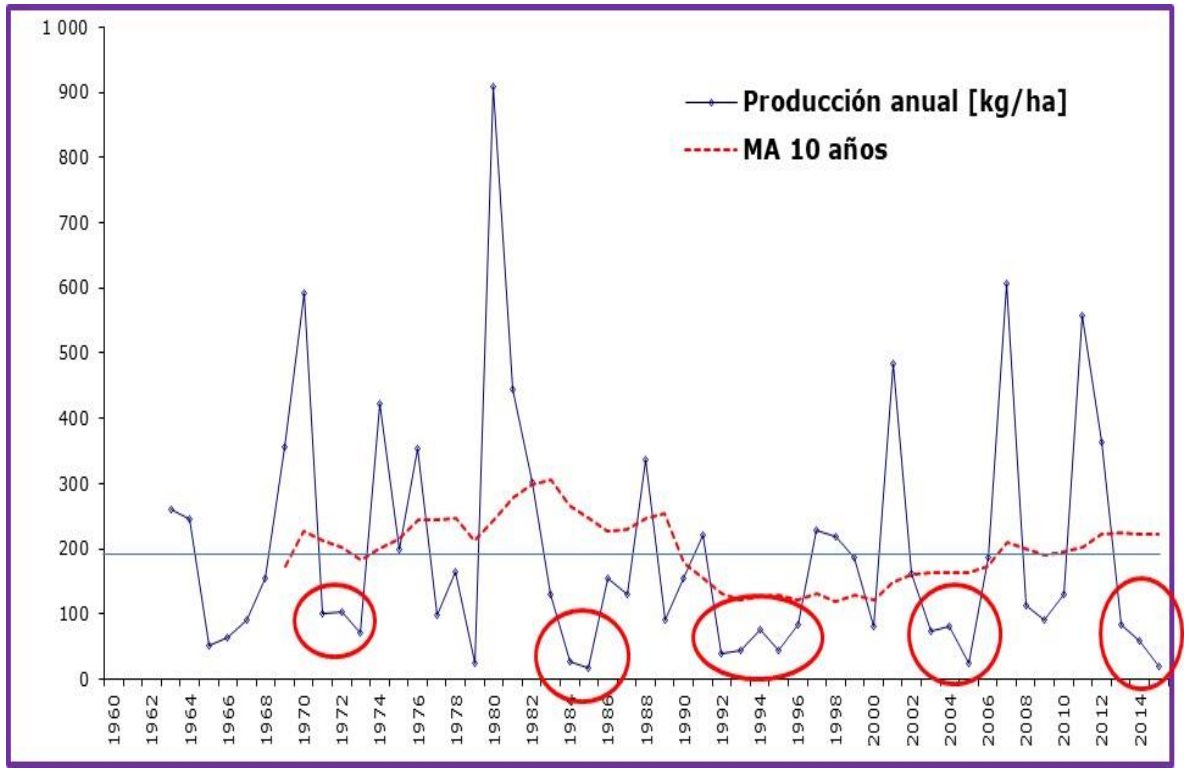
- Delayed effect of extreme dry years
- Shifts on site index

Our research:

- Empirical & process based models to define the impact of climate & management on productivity
- Identify factors affecting resistance and resilience: composition, competition, age…



Impacts on the pinewoods of Northern Plateau: decay on cone production



- Climate controlled masting habit
- High dependence on spring precipitations
- Significant decrease starting by 1990
- Recent effect of exotic pests

Our research:

- Empirical & process based models to define the impact of climate on cone production
- Identify factors affecting production

Impacts on the pinewoods of Northern Plateau: shifts on vegetation

P. pinea by:

- *J. thurifera*
- *Quercus ilex*

Our research:

- Analyze the response to climate vs management of the different species
- Inter and intraannual growth
- Physiological traits
- Seedling and sapling survival
- Current & simulated climate

Forecast optimal composition

Management options to reach it

Impacts on the pinewoods of Northern Plateau: native & exotic pests

- Changes in lifecyles & phenology
- Multivoltininsm
- Better conditions for exotic pests
    - Pine nematode
    - West conifer seed bug

- Quantifying the impact of pests on cone production
- Interaction pest x climate x silviculture

Planned adaptation in forestry

Integrate adaptation to climate change when planning the management of forest systems, including different subsectors and stakeholders (PNACC)

To modify management practices in order to adapt the forest to the expected climate conditions

- Favour the inherent adaptive capacity of the species and ecosystems
- Reduce the risk of occurrence of those processes enhancing forest vulnerability to climate change
- Increase resistence and resilience of forest systems
- Warrantee the provision of ecosystem services

The adaptation to climate change must be considered as an objective of SFM

"managing through adaptation"

Final remarks

"…. It is possible to adapt our forests, but it is necessary to have a plan allowing a quick and programmed response. Forest science should orientate policy makers and forest management programs"

World Forest Congress- 2009

" It is necessary to carry out studies on adaptive forest management, being programmed with enough anticipaition, and maintaint continuous monitoring of the forest state…"

IUFRO - 2008

" We must advance our work, to warrantee that EU forests will preserve their functions under changing climate conditions"

Libro Verde UE - 2010

Researchers

Policy makers

Industry

WE MUST ALL ROW IN THE SAME DIRECTION

Forest owners

Forest managers