Towards a systematic and continuous monitoring of climate change impacts on forest productivity in Europe

Presentation · October 2021

DOI: 10.13140/RG.2.2.32818.73923

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Towards a systematic and continuous monitoring of climate change impacts on forest productivity in Europe

Clémentine Ols[1], T. Gschwantner[2], K.Schadauer[2], J.-D. Bontemps[1]

1- IGN, France; 2- BFW, Austria

Monitoring forests' productivity and their responses to climate

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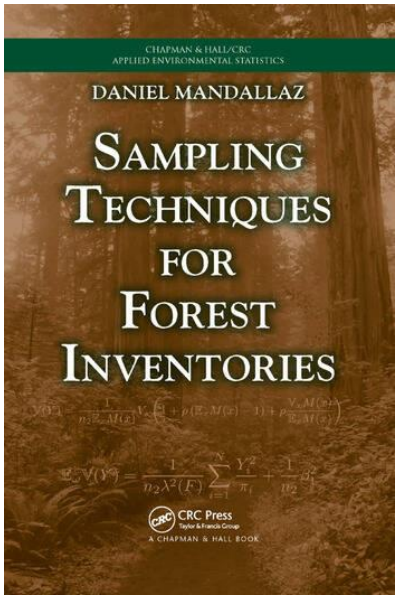
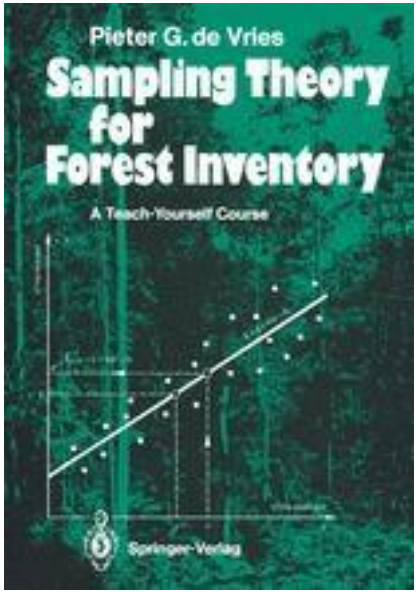
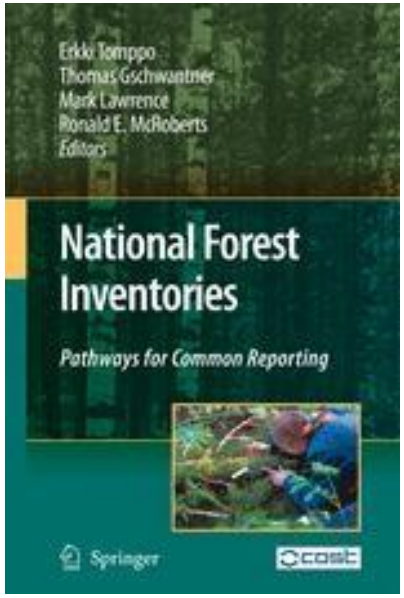
- Forest inventory and sampling theory

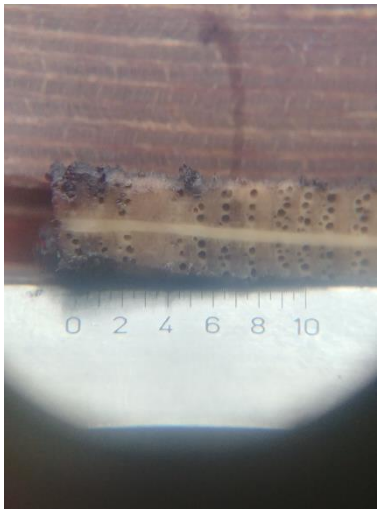






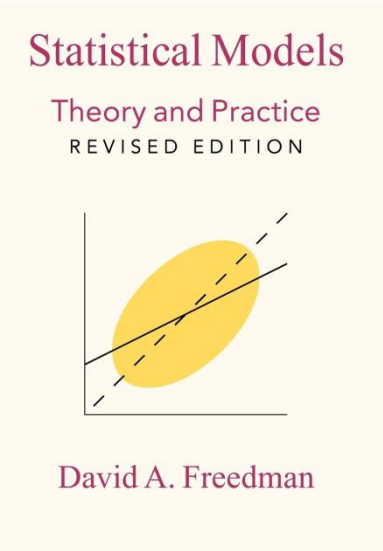
Monitoring forests' productivity and their responses to climate

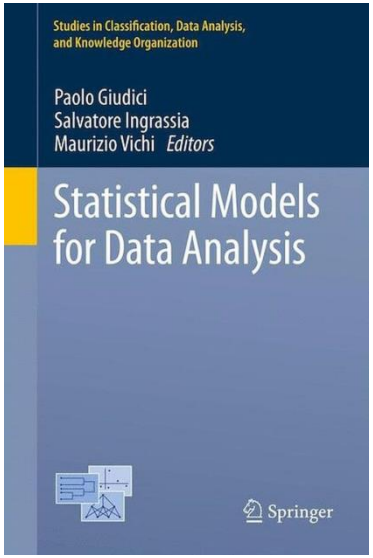
- Forest inventory and sampling theory
- Dendrochronology



Monitoring forests' productivity and their responses to climate

- Forest inventory and sampling theory
- Dendrochronology
- Statistical modelling





R Programming

Monitoring forests' productivity and their responses to climate

- Forest inventory and sampling theory
- Dendrochronology
- Statistical modelling

→ FORGET ABOUT SATELLITE IMAGES
JUST SEND PEOPLE OUT TO THE FOREST
TO SAMPLE SOME GROUND TRUTH ☺!

Monitoring forests' productivity and their responses to climate

Why do we need ground truth ?

Monitoring forests' productivity and their responses to climate

Why do we need ground truth ?

- Tree growth is constrained by numerous environmental factors
  - Tree size (diameter, height)
  - Soil type
  - Competition of neighboring trees
  - Forest structure and composition
  - Climate

Monitoring forests' productivity and their responses to climate

Why do we need ground truth ?

- Tree growth is constrained by numerous environmental factors
  - Tree size (diameter, height)
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  - Competition of neighboring trees
  - Forest structure and composition
  - Climate

→ Isolating climate change effects on tree growth requires a precise description of the growing environment

Field inventory needed !

National Forest Inventories : powerful monitoring tools

National Forest Inventories : powerful monitoring tools

- Statistically designed
- Performed systematically across space

Sampling bias overestimates climate change impacts on forest growth in the southwestern United States

Klesse et al. Nature Communications 2018

National Forest Inventories : powerful monitoring tools

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- All forest types covered
- Tree species described in diverse climatic contexts

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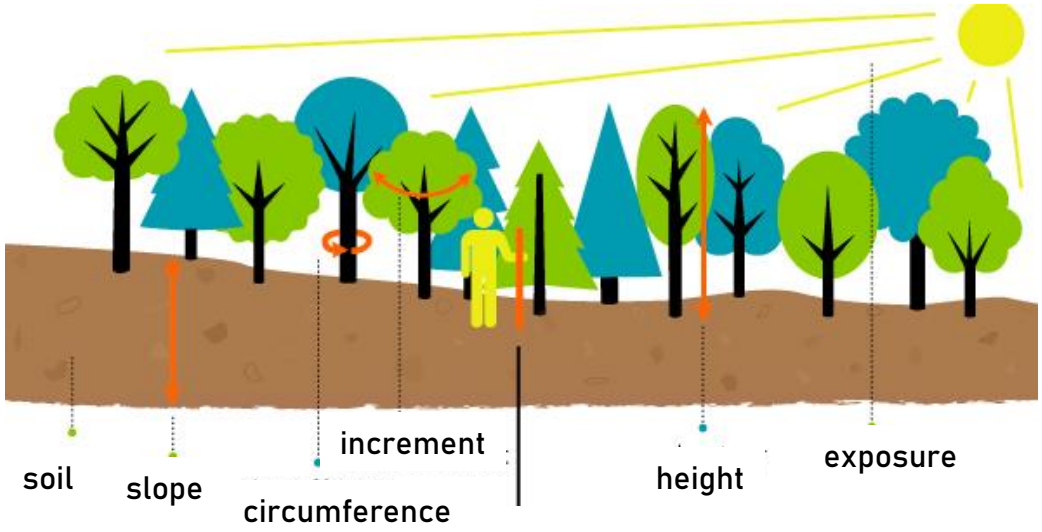

Forest stand description
Habitat determination

Soil description

Tree measurements

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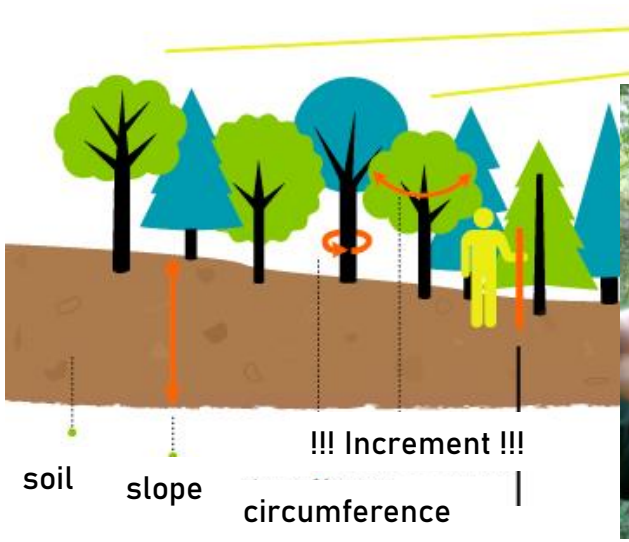
Tree measurements



Extracting climate effects on productivity

Modelling framework

RAW INVENTORY SIGNAL **FILTERS** **MONITORING SIGNAL**

$$BC(RI) = \sum_{k=1}^{n} a_k f_k(var_k) + Year$$

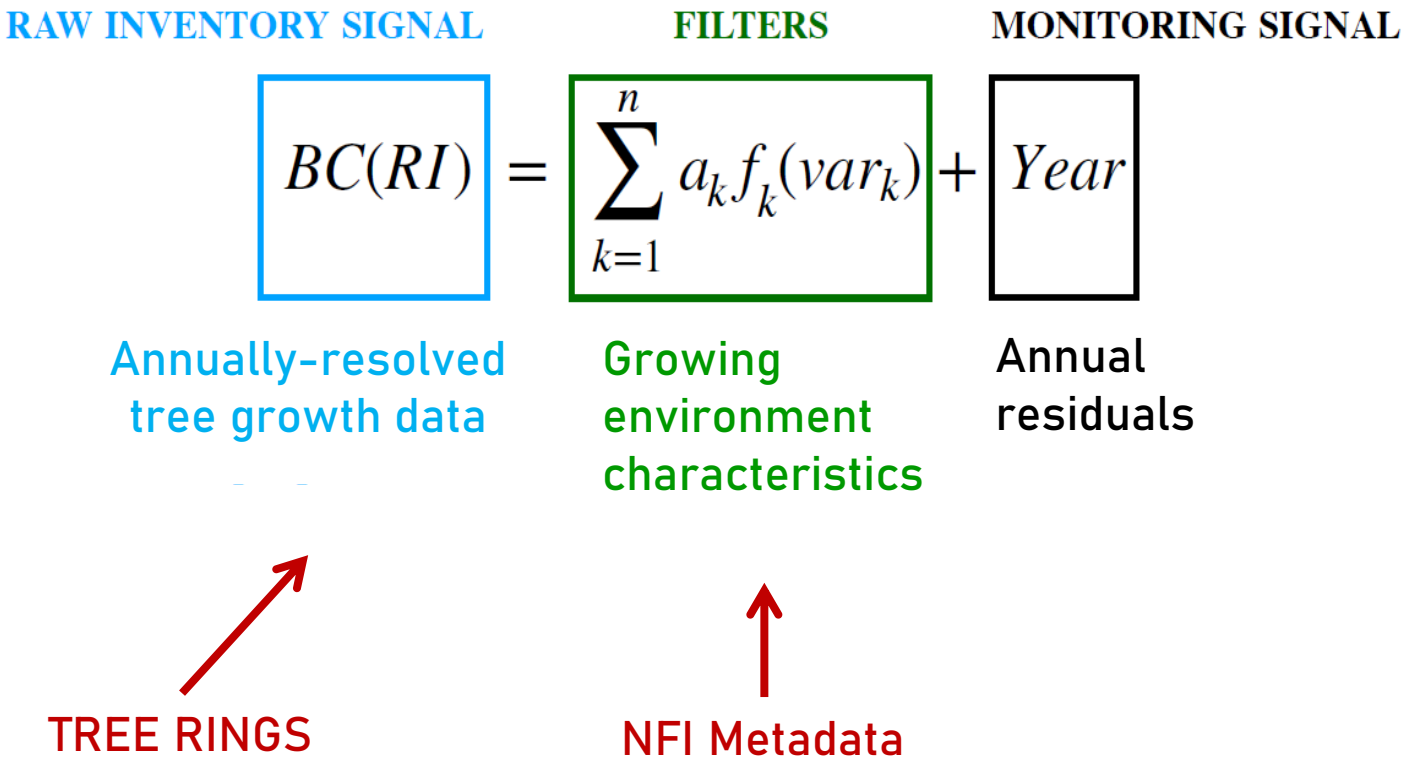
Annually-resolved tree growth data

Growing environment characteristics

Annual residuals

Extracting climate effects on productivity

Modelling framework



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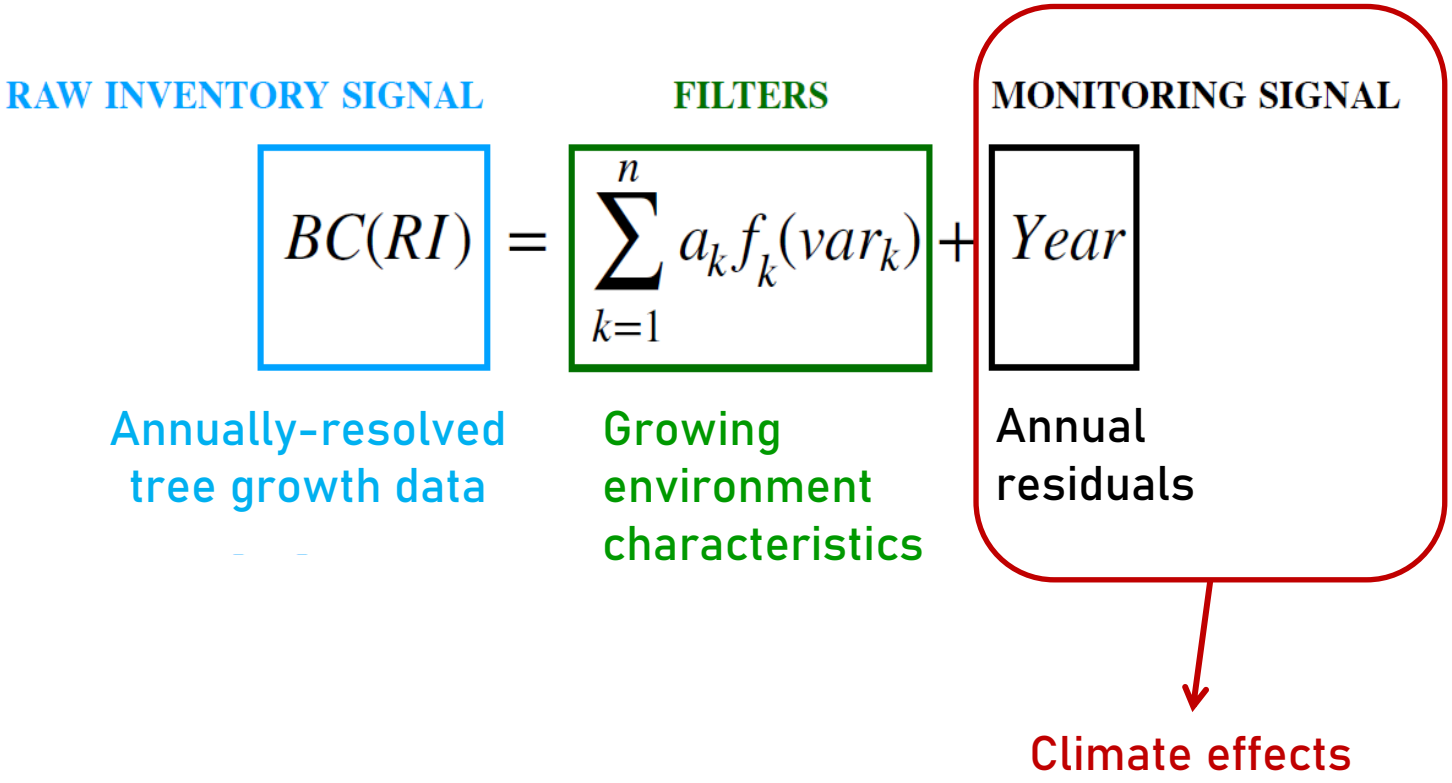


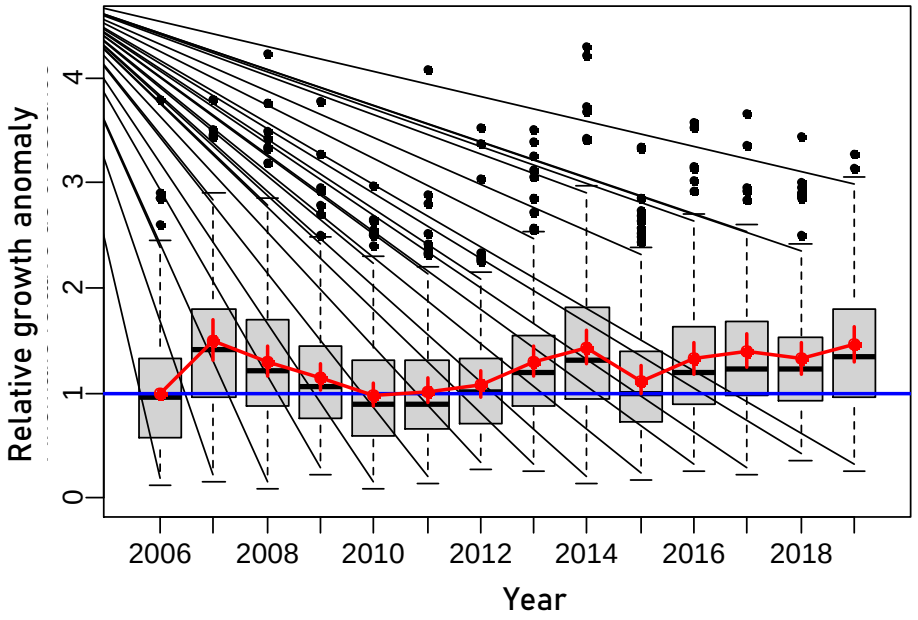
Extracting climate effects on productivity

Modelling outputs

MONITORING SIGNAL

Year

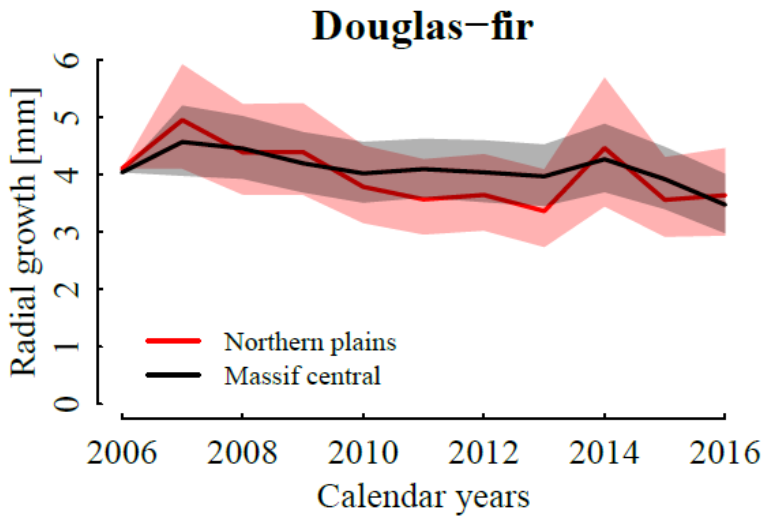
Annual residuals

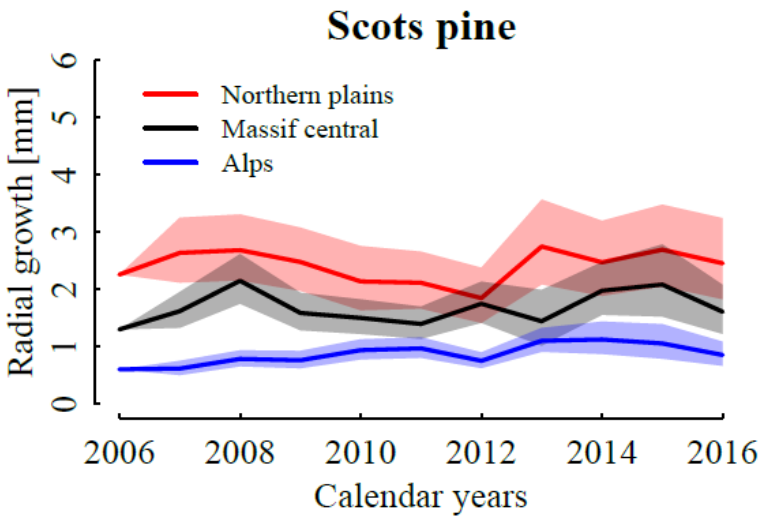


Extracting climate effects on productivity

Modelling outputs

For each forest system == a 'climate-driven' productivity chronology





Extracting climate effects on productivity

Modelling outputs

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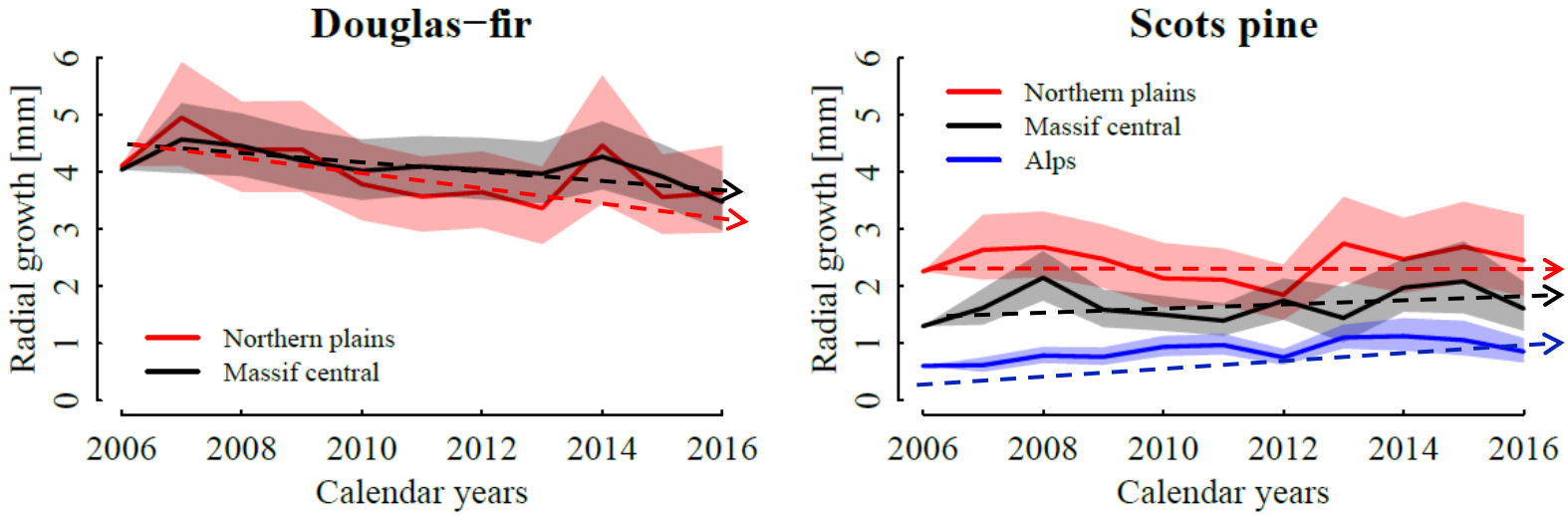
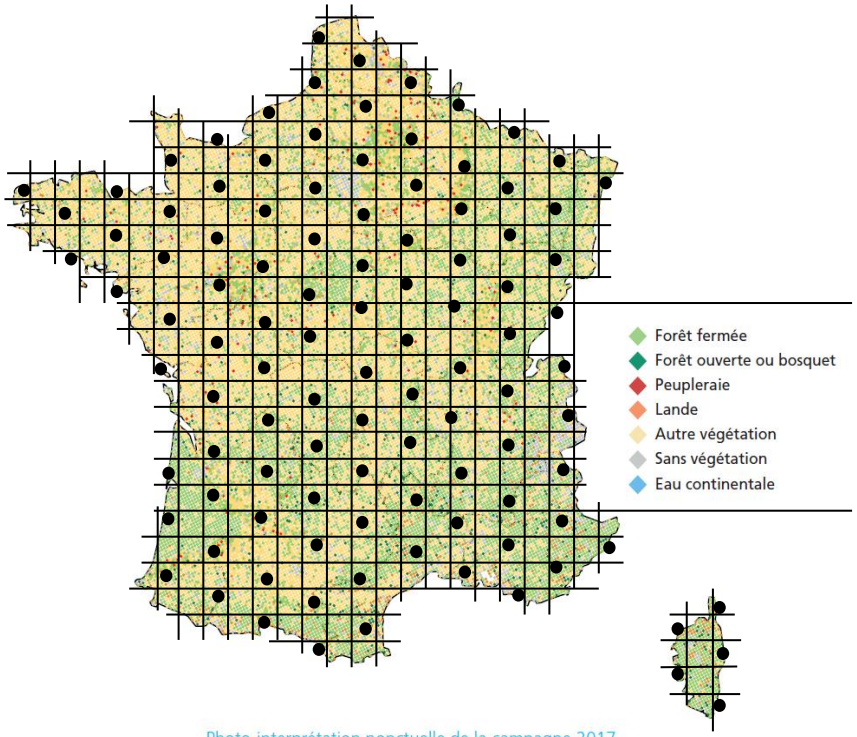


- Extract growth trends for a given regional forest system
- Compare growth trends across forest systems
- Compare growth trends to recent climate changes

Case study I : Conifers in France

The French NFI

- 1 km x 1 km sampling grid
- Annual inventory
- Temporary plots
- 5,000 forest plots visisted / year
- Regardless of ownership
- More than 230 variables measured /plot



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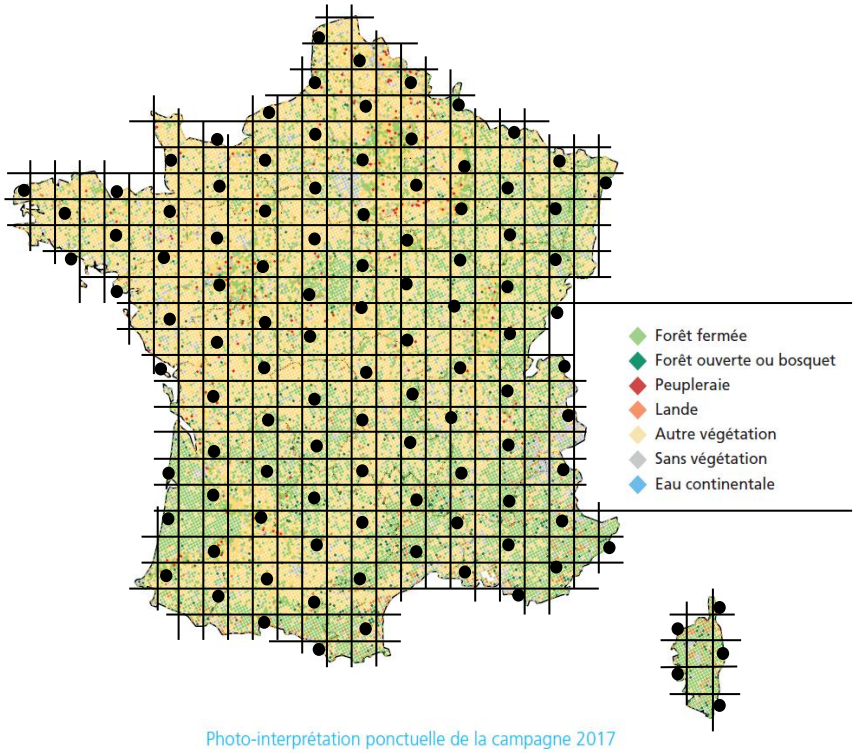
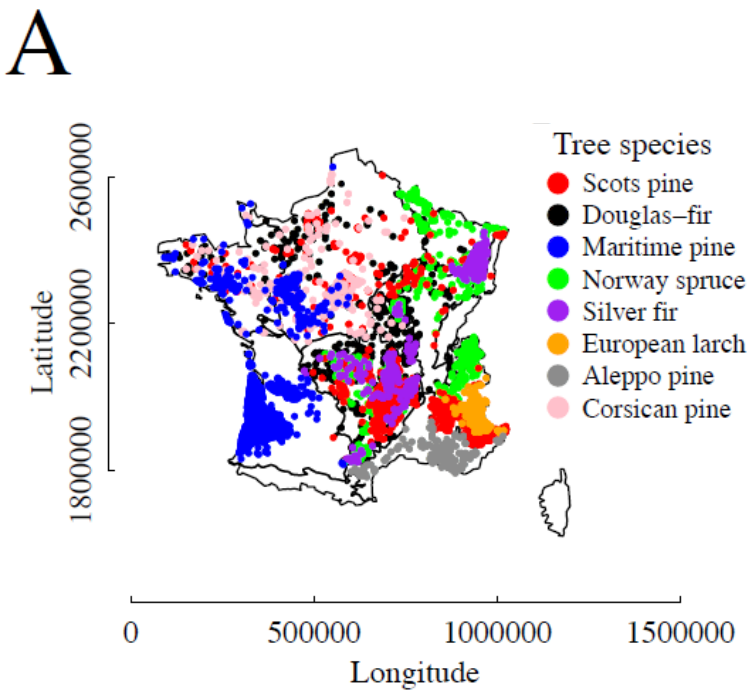


➢ Two dominants trees cored for annually-resolved tree growth data

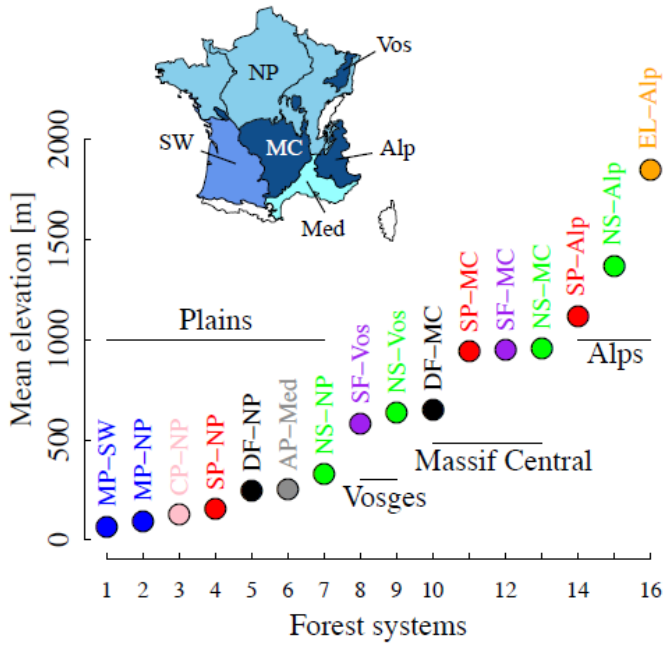
Case study I : Conifers in France

8 conifer tree species in pure and even-aged forests over 2006-2016

> 10 000 radial growth measurements

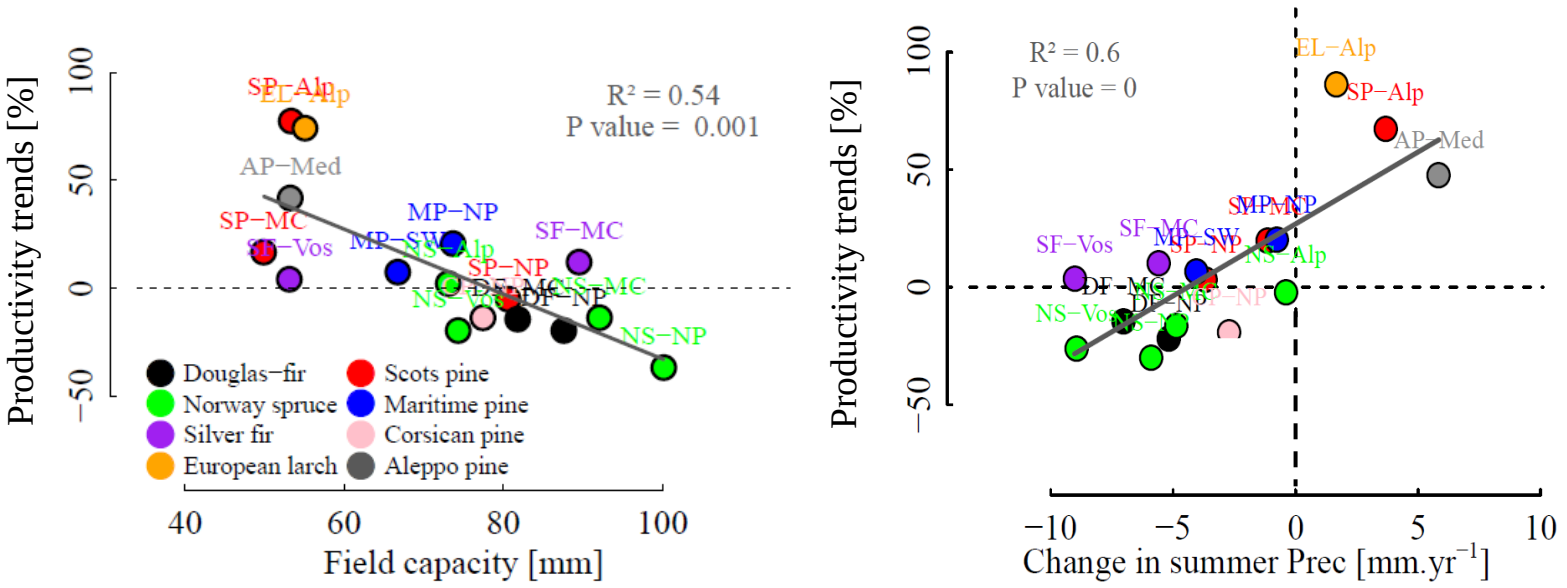


16 regional forest systems



Case study I : Conifers in France

Water resource limitation: a relative 'advantage' to withstand climate change



Ols et al. 2020. Recent growth responses of European conifer tree species under strong control of thermal and water constraints and favored by forest structure heterogeneity. *Science of the Total Environment*, 742 – 140453, https://doi.org/10.1016/j.scitotenv.2020.140453

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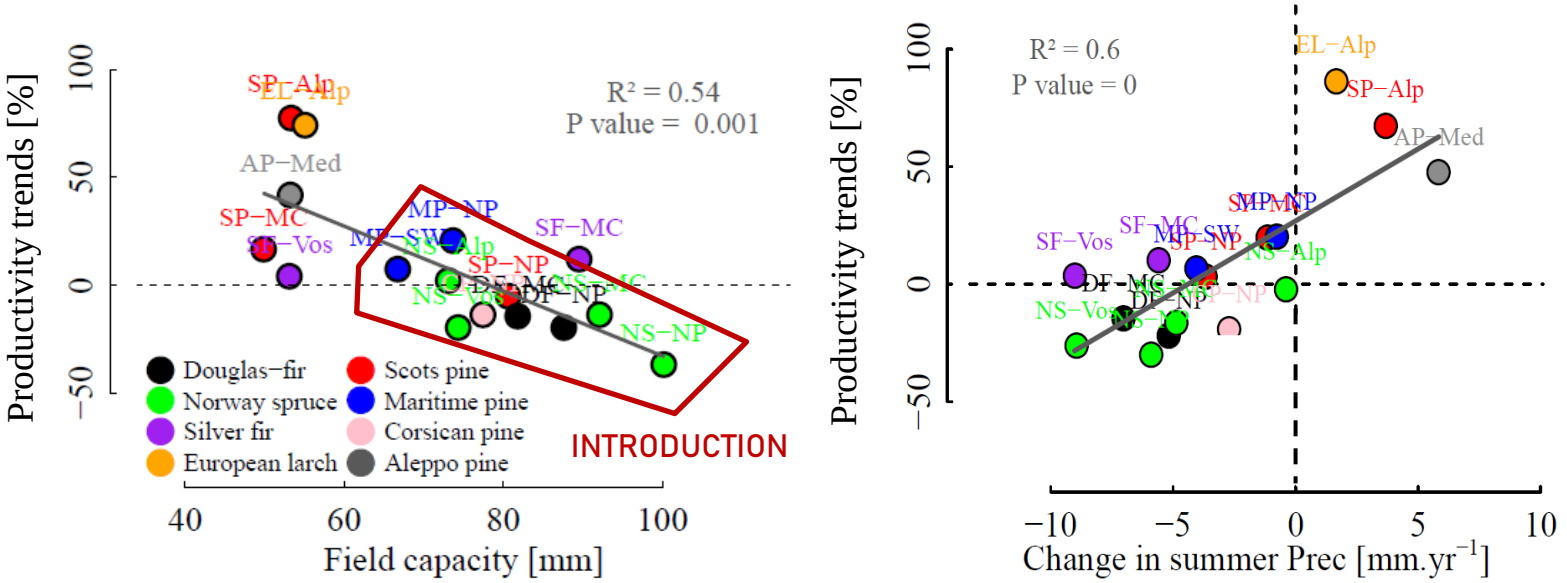


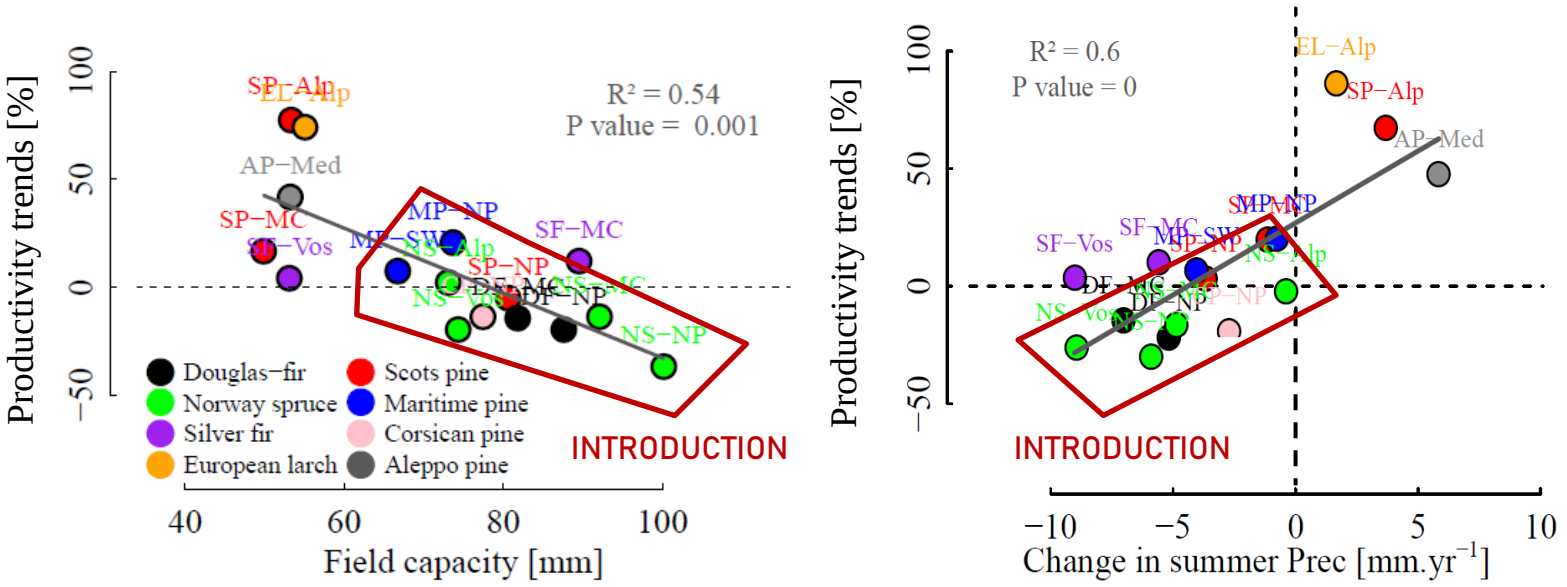
Fast-growing conifers introduced at lower altitudes in the mid XX^{e} == improved 'conditions'

Douglas fir
Norway spruce

Deeper soil
Higher field capacity
Warmer growing conditions

Case study I : Conifers in France

Water resource limitation: a relative 'advantage' to withstand climate change



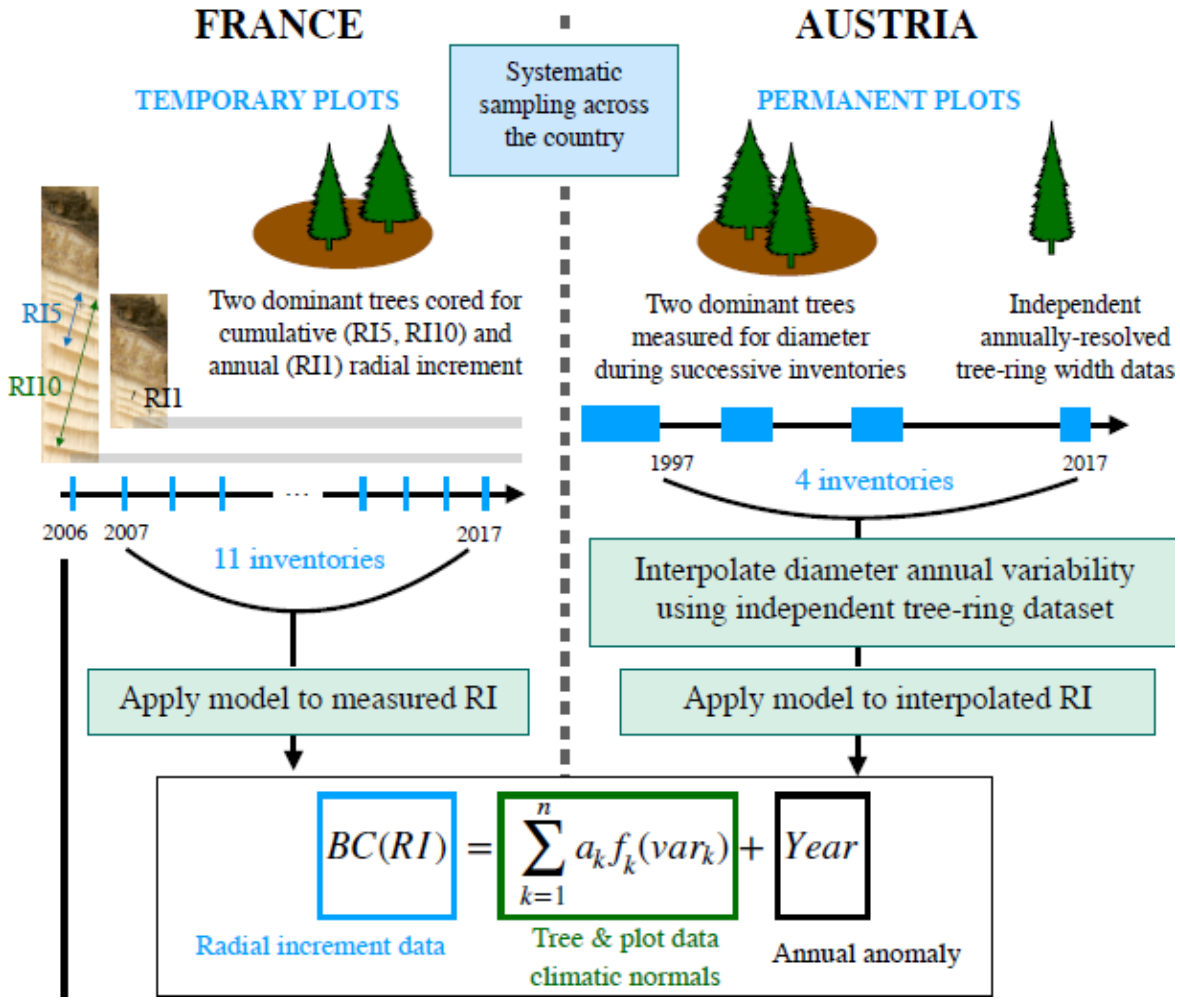
Fast-growing conifers introduced at lower altitudes in the mid XX^{e} == improved 'conditions'

Lower altitudes/Plains contexts now facing stronger climatic stress

On the need to rethink afforestation programs ?

Case study II : Conifers across France and Austria

Harmonizing input data : a modelling framework without boundaries

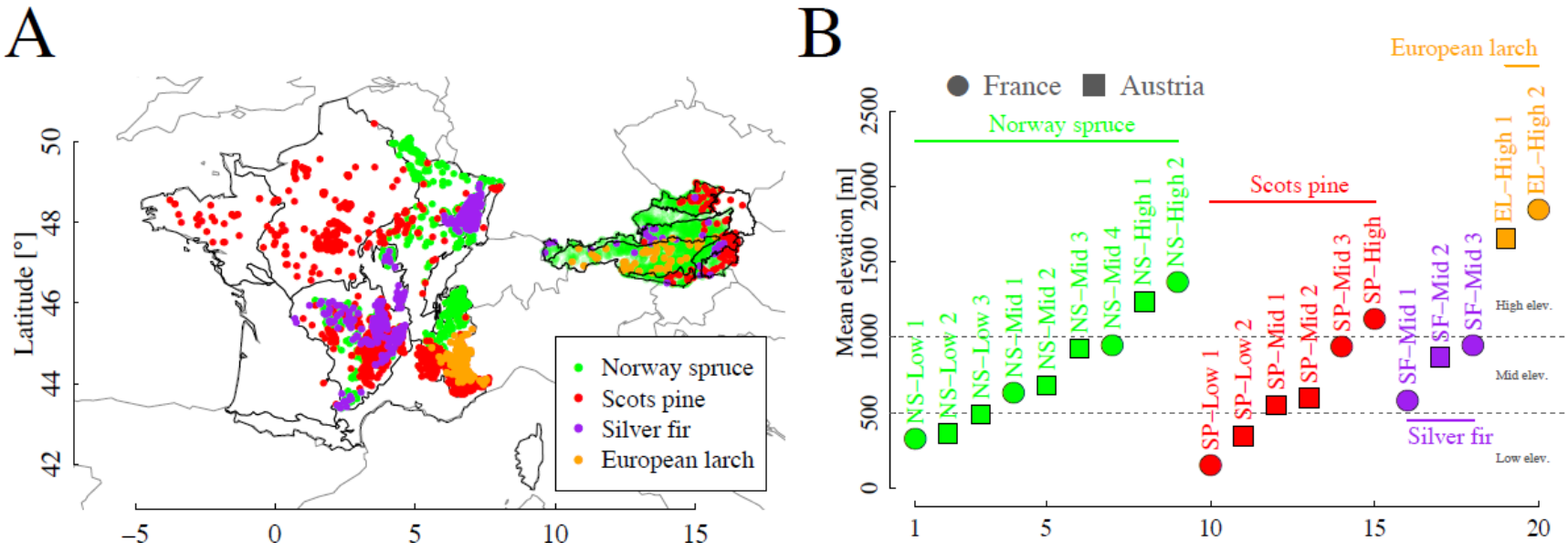


Case study II : Conifers across France and Austria

4 conifer tree species in pure and even-aged stands over 1996-2016

> 65 000 radial growth data

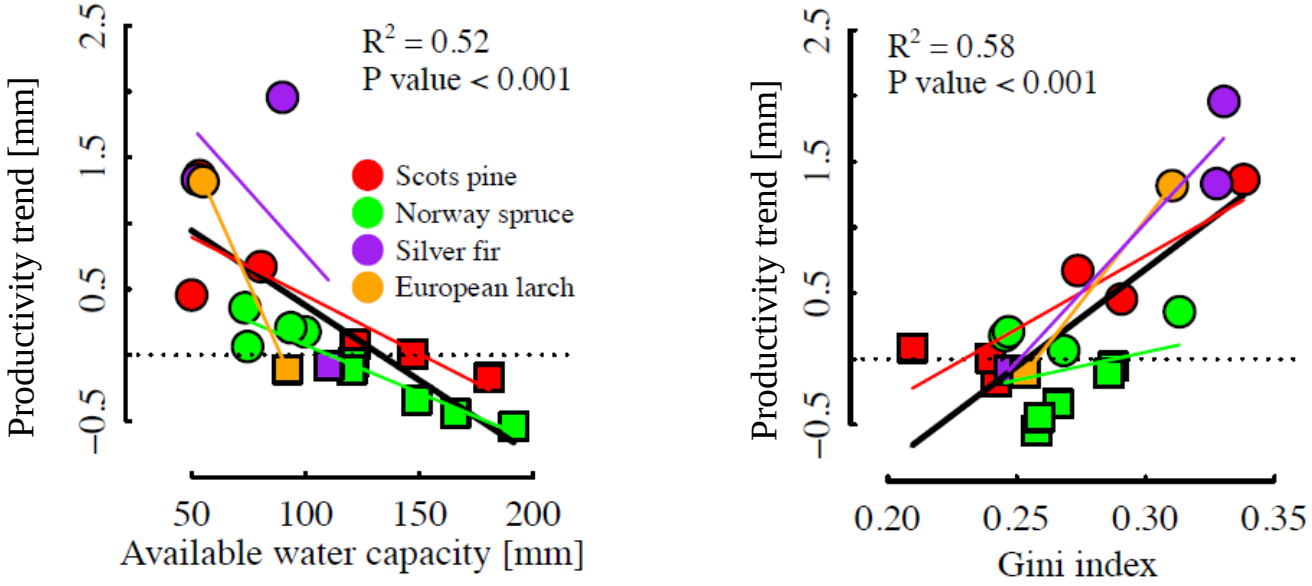
20 regional forest systems



Enlarging biogeographical and silvicultural gradients

Case study II : Conifers across France and Austria

Major drivers of productivity : water resource availability and structural heterogeneity



Ols et al. 2021. Unexpected negative effect of soil water availability on conifer forest growth trends detected across an oceanic–continental European gradient in a warming context. *Ecosystems*. https://doi.org/10.1007/s10021-021-00663-3

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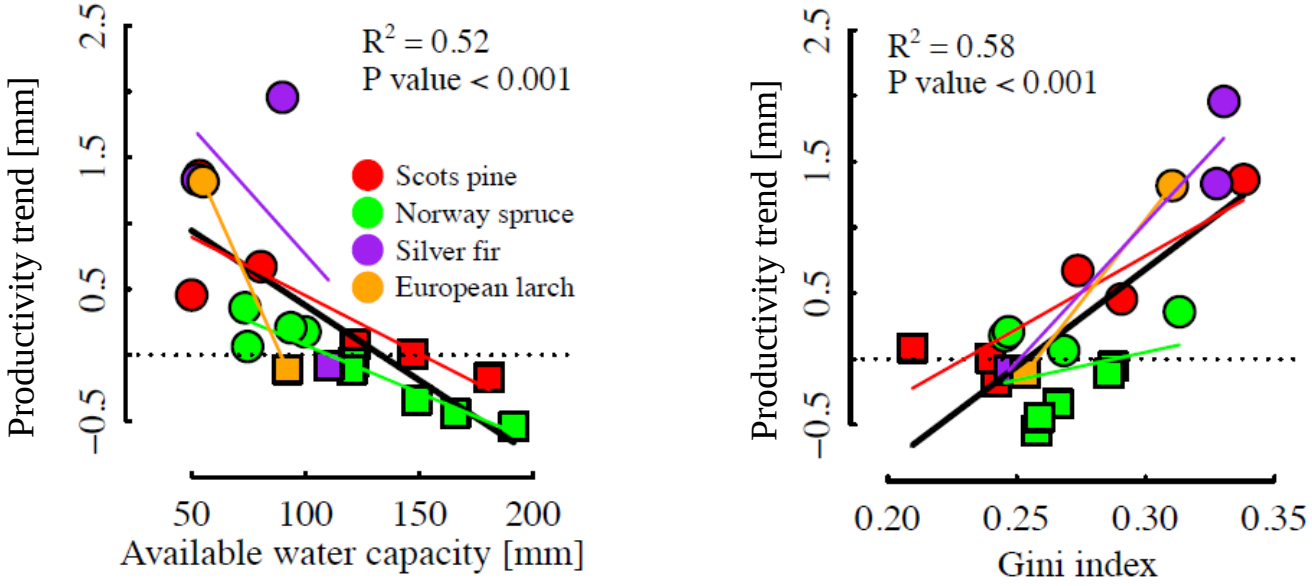


Regional adaptation to low water availability
Greater forest structural heterogeneity

→ higher resilience to climate change

Take home messages

Simplest is best !

A modelling framework simple and easily adaptable to any context

RAW INVENTORY SIGNAL | **FILTERS** | **MONITORING SIGNAL**

$$BC(RI) = \sum_{k=1}^{n} a_k f_k(var_k) + Year$$

Annually-resolved tree growth data

Growing environment characteristics

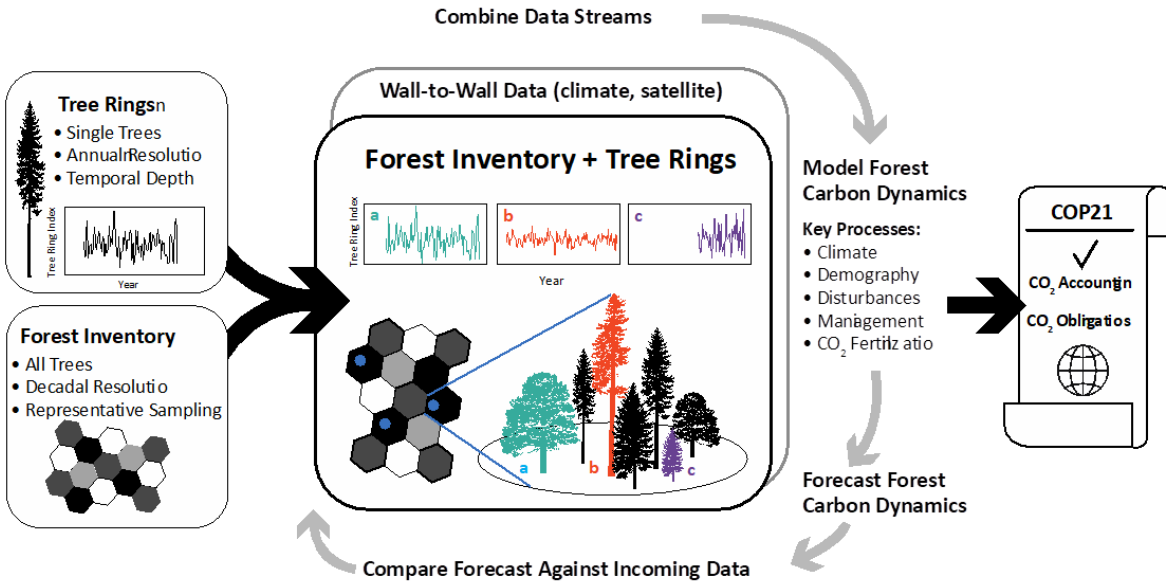
Annual residuals

Take home messages

To monitor forest productivity, all you need is :

~~Love~~

Tree rings and NFI !



Evans et al. 2021. The case for adding tree rings to North America's national forest inventories: an essential tool to guide drawdown of atmospheric CO2. *BioScience. In press.*

Perspectives

France, Austria, what's next ?

Europe !

Out of the 27 EU Member States, 23 have an ongoing National Forest Inventory (NFI)

- A European network of forest monitoring specialists and scientists
- 500,000 field plots
- Framework and solutions for strategic planning at European level

Perspectives

Towards European harmonized NFI data

- survey carbon sequestration dynamics across regional forest sinks
- alert on the weakening of these sinks
- implement large-scale climate-smart forest management
- adapt carbon sequestration strategies

Thank you for listening

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