Assessing the potential impact of climate change on tree mortality in France through a spatial approach

Dead oaks in Vierzon state forest – France, December 2016

CAQSIS 2017, Bordeaux, 28/03/2017

Adrien Taccoen, Christian Piedallu, Jean-Claude Gégout, Anne Gégout-Petit, Ingrid Seynave, Vincent Pérez.

AgroParisTech

La Région Lorraine Office National des Forêts

UMR 1092 LERFoB – Nancy - France

Context

- ▶ Climate change

- ▶ Predicted shifts in species distribution

- ▶ Consequences on trees health ?

« You have to know the past to understand the present »

Today's talk

- ▶ Main results of the 1st part of the thesis

What ?

→ Is there an effect of climate change on observed mortality and in what extent ?

Where ?

→ France (Including Corsica)

How ?

→ Through a spatial approach (Generalized Linear Model)

What species ?

→ Main forest tree species in France (20 species)

« Do we observe, for each tree species, more mortality in areas where climate has changed the most over the last 30 years ?»
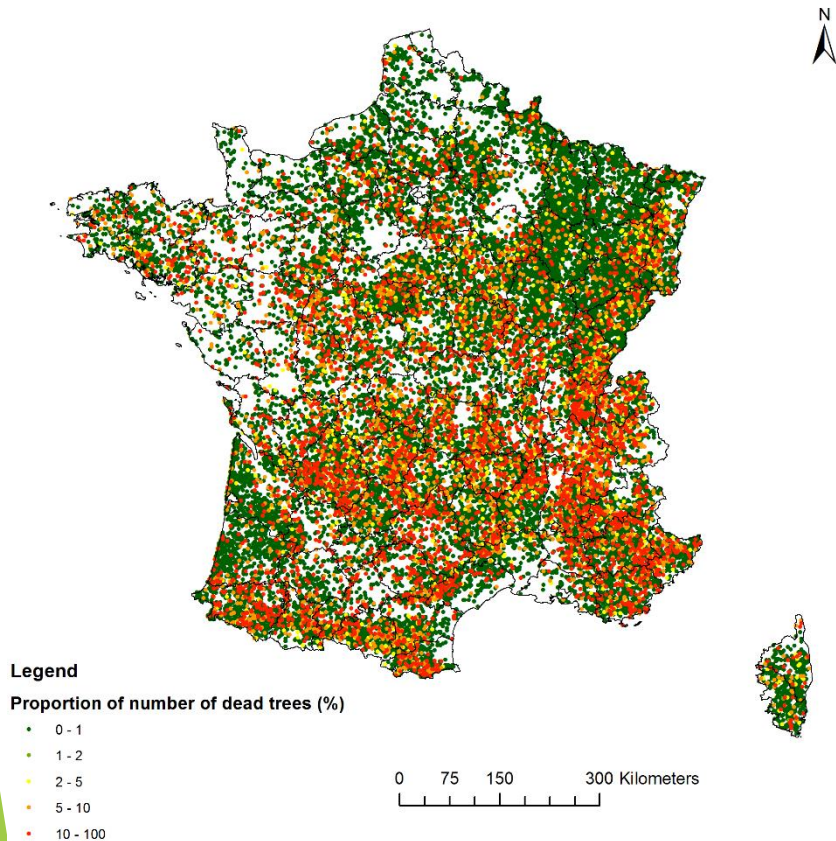
Data

- ***"National Institute of Geographic and Forestry Information" (IGN)***

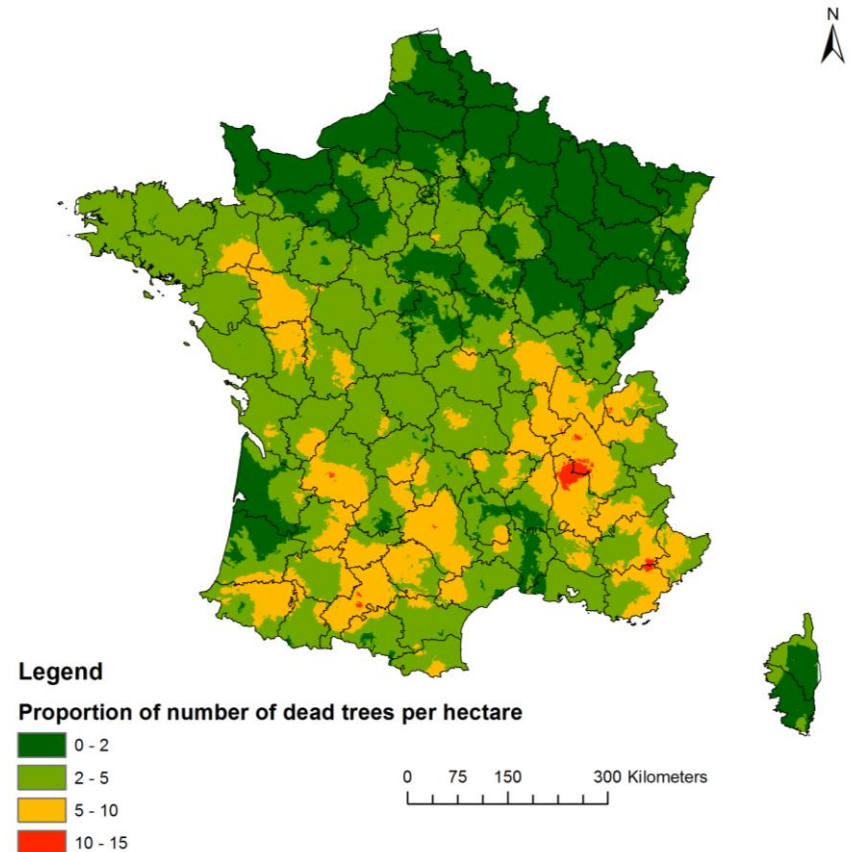→ Forest Inventory plots 2006-2015 (700 000 trees / 60 000 plots)

Data

❖ Extreme events (storms, forest fires…) and local perturbations excluded
→ 200 000 trees and 17 000 plots excluded
→ 34 000 plots and 430 000 trees remaining

Proportion of number of dead trees - IFN plots - 34 376 plots

Legend
Proportion of number of dead trees (%)
- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 100

0   75   150   300 Kilometers

Proportion of number of dead trees - IFN plots - 34 376 plots

Legend
Proportion of number of dead trees per hectare
- 0 - 2
- 2 - 5
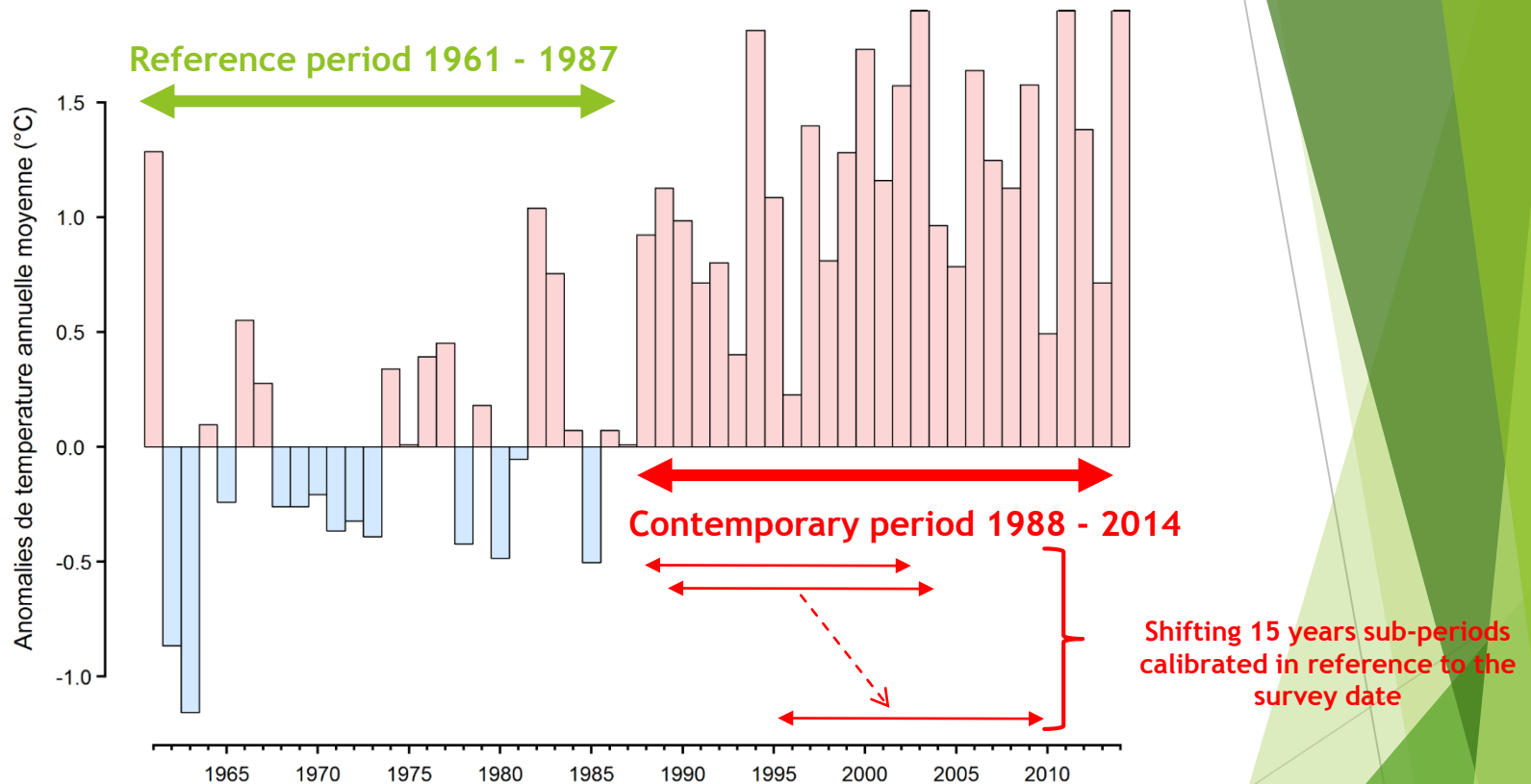- 5 - 10
- 10 - 15

0   75   150   300 Kilometers

Data

- IFN plots
- Environmental data

Data

- IFN plots

- Environmental data

- Climate evolution : Meteo France homogenized temperature and rainfall records
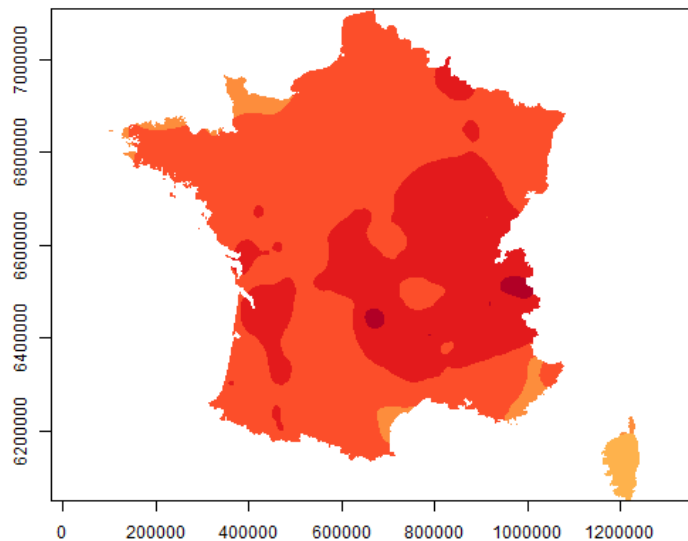
Climate evolution data

Mean annual temperature difference reported to the mean annual temperature of the reference period 1961-1987
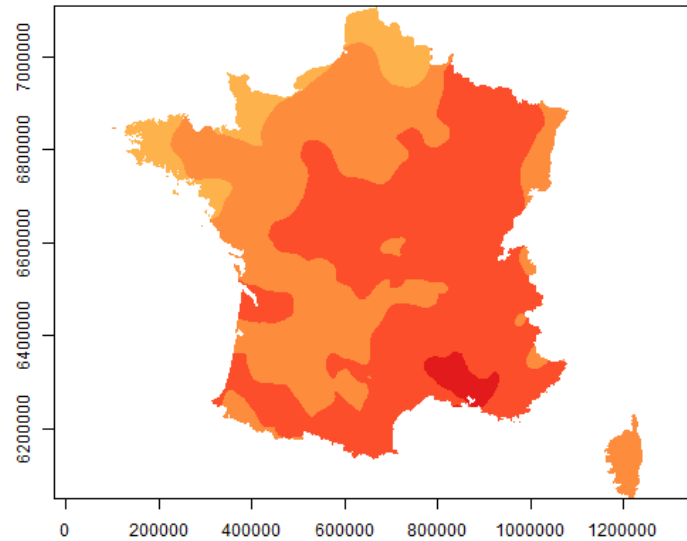
(Meteo France homogenized data)

6

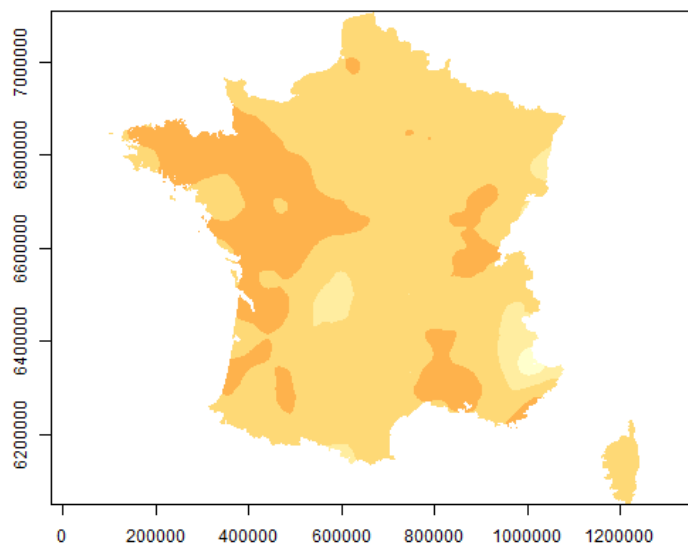# Mean temperature evolution by season between 1961-1987 and 1988-2014

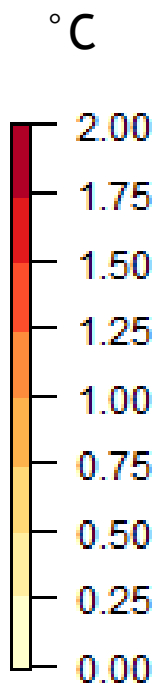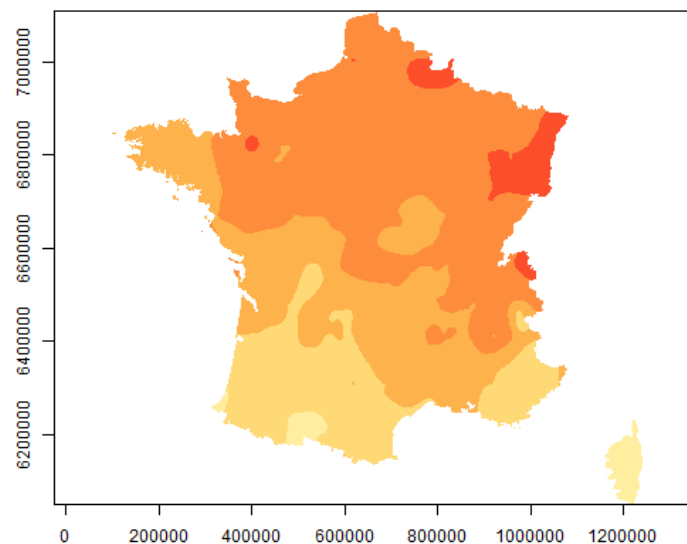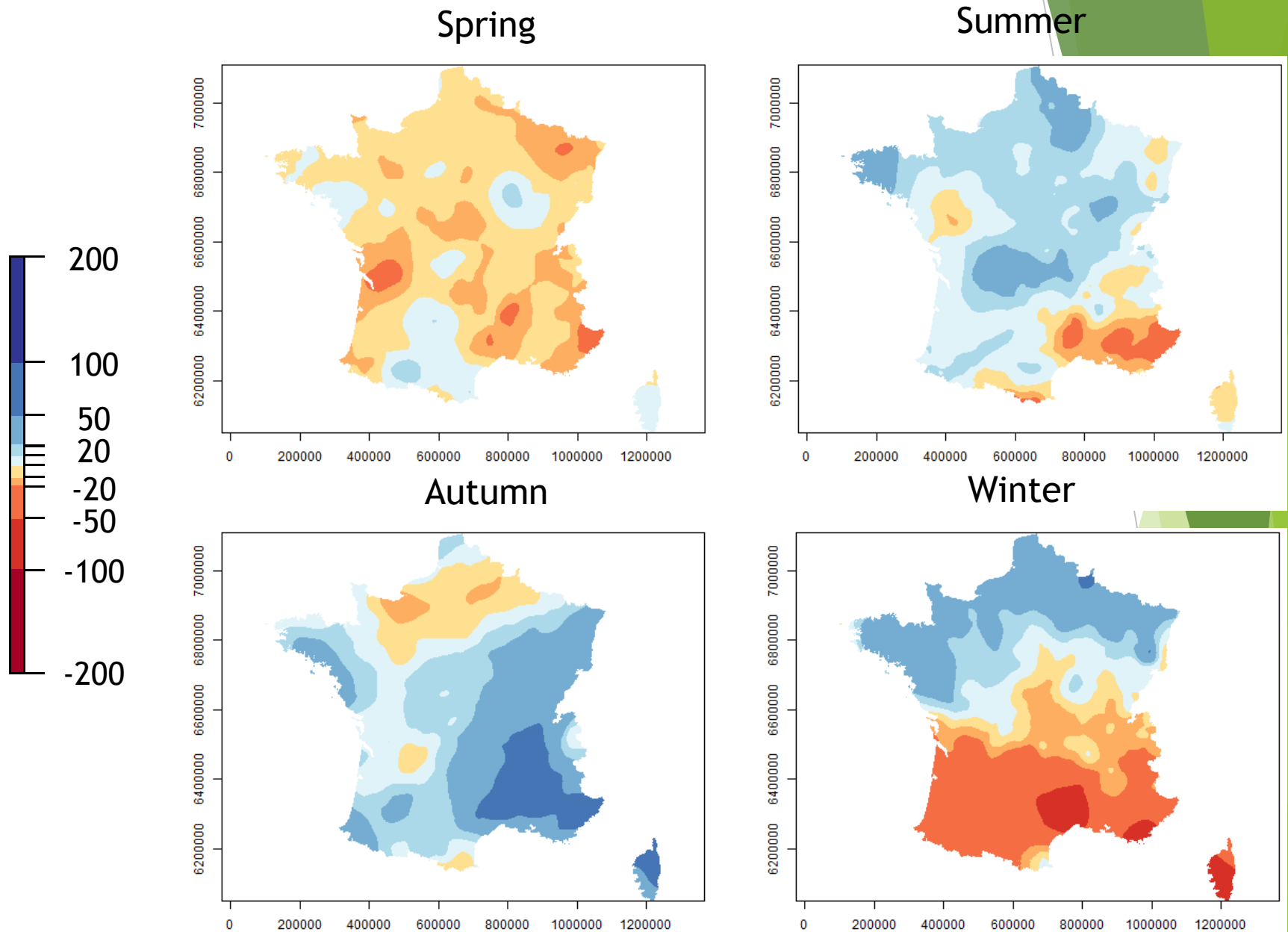# Mean rainfall evolution by season between 1961-1987 and 1988-2014

Methodology

- Generalized Linear Model
  - 0 = Live tree
  - 1 = Dead tree
  - → Logistic regression

- 2 approaches :
  - Tree/stand scale
    - Dominating vs Dominated trees

Explanatory variables used

Category	subcategory	Description	
Forest dynamics	Tree dynamics	Vegetative/Seed	**17 variables**
		Size	
		Social status	
	Stand dynamics	Density	
		Structure	
		Species purity	
		Forest exploitation intensity	
Ecological conditions of the area	Temperature	High temperature	**20 variables**
		Low temperature	
	Water	Waterlogging	
		Water availability	
	Nutrition	pH	
		c/N	
Climate evolution	Temperature	High temperature	**13 variables**
		Low temperature	
	Water	Water availability	

|		Plots where the species is present	Plots with at least one dead tree of the species	Climate (reference periode)		Climate evolution	
				Mean annual temperature (°C)	Mean annual precipitation (mm)	Mean annual temperature (°C)	Mean annual precipitation (mm)
Deciduous species	Larix decidua	525	51				
	Sorbus aucuparia	461	66				
	Sorbus aria	1159	121				
	Fagus sylvatica	8423	377				
	Betula pendula	3459	329				
	Quercus petrae	8085	619				
	Carpinus betulus	6925	258				
	Acer campestre	2196	69				
	Prunus avium	2213	159				
	Quercus robur	9670	812				
	Robinia pseudoacacia	1111	198				
	Quercus pubescens	3867	506				
Non deciduous species	Pinus uncinata	317	72				
	Abies alba	3361	320				
	Picea abies	3146	438				
	Pinus sylvestris	4453	805				
	Pseudotsuga menziesii	1268	196				
	Quercus ilex	1145	91				
	Pinus pinaster	2194	218				
	Pinus halepensis	591	80				

Results

- Consistency of the tree/stand approaches

Results

- Consistency of the tree/stand approaches
  - Comparison of the deviance explained by climate evolution variables for 20 species

Results

Deviance explained by climate evolution for dominated trees - tree vs scale stand - R^2 = 0,7
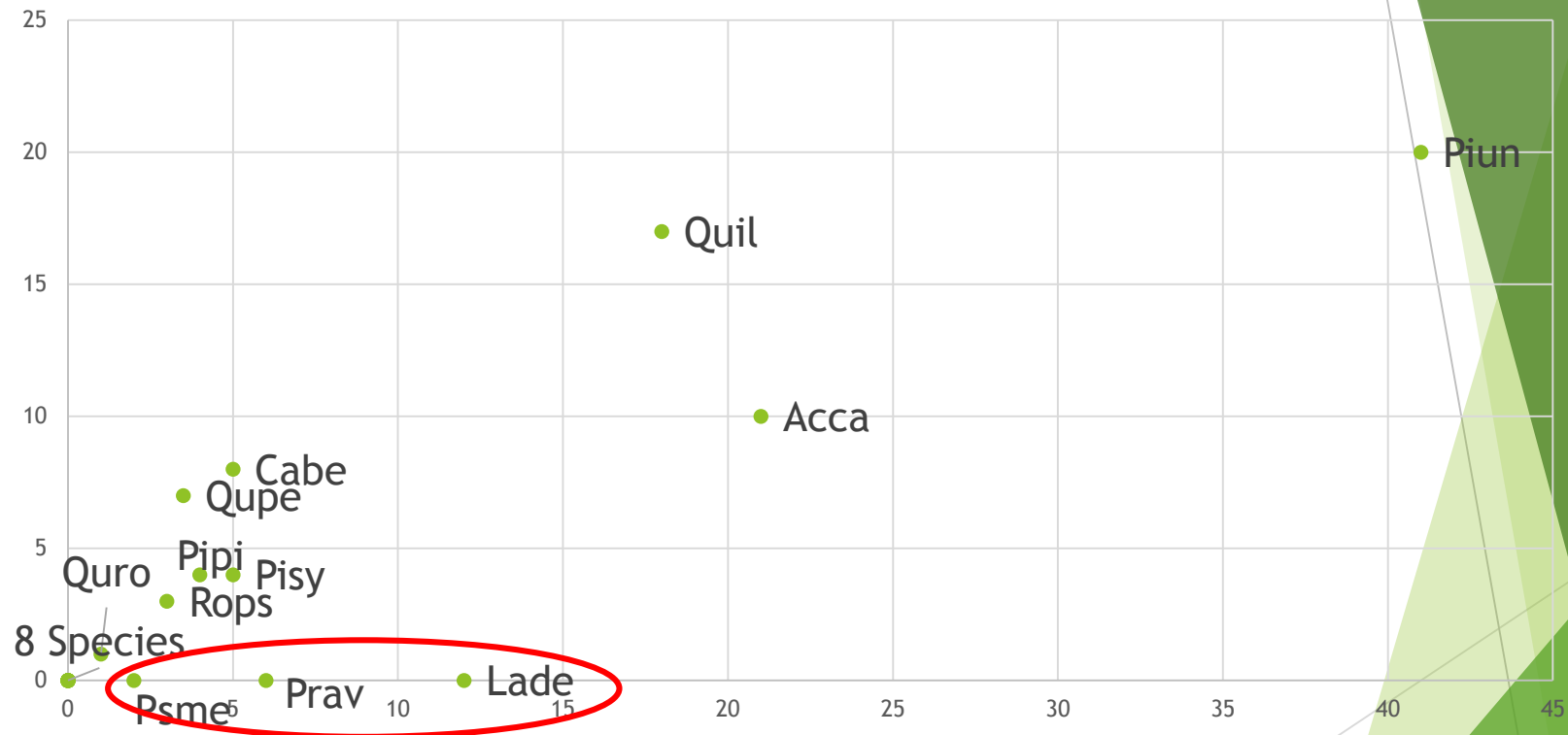
→ 9 species = consistency in the effects
→ 8 species = consistency in the absence of effects
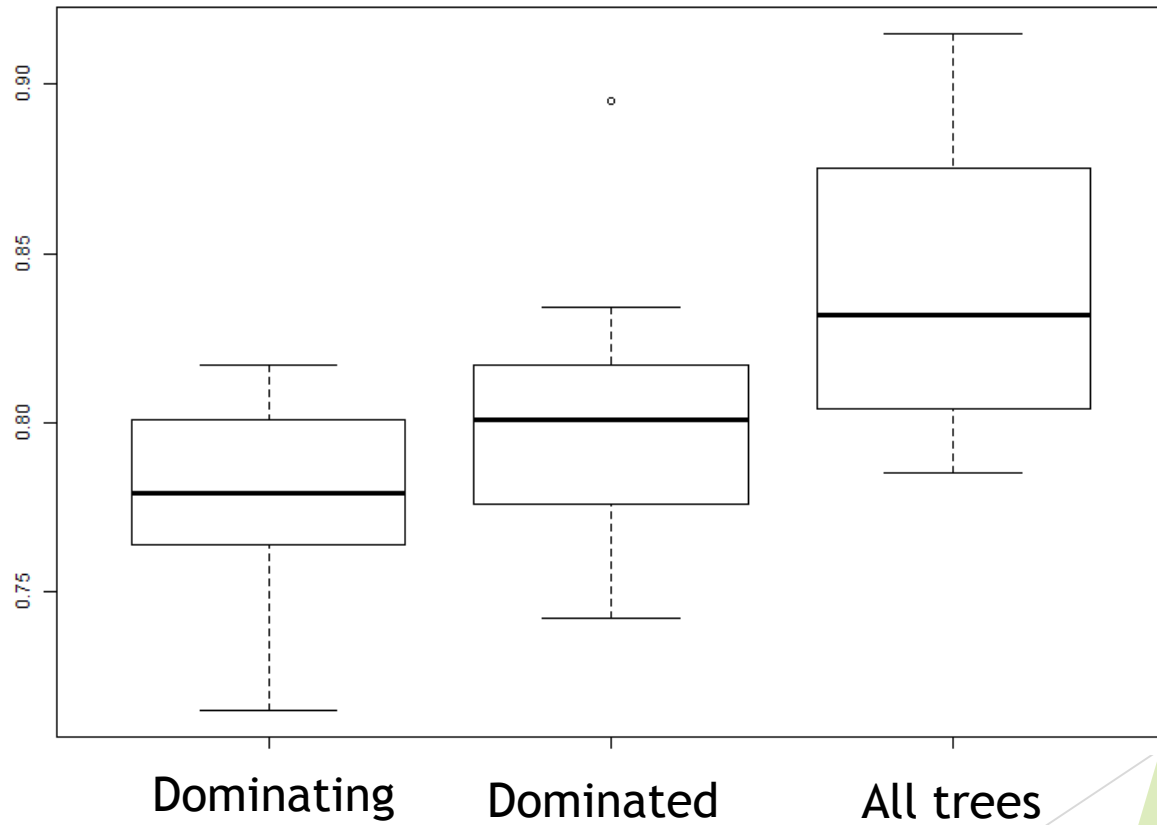→ 3 species = differences

Résultats

- Consistency of the tree/stand approaches

Results

- Consistency of the tree/stand approaches
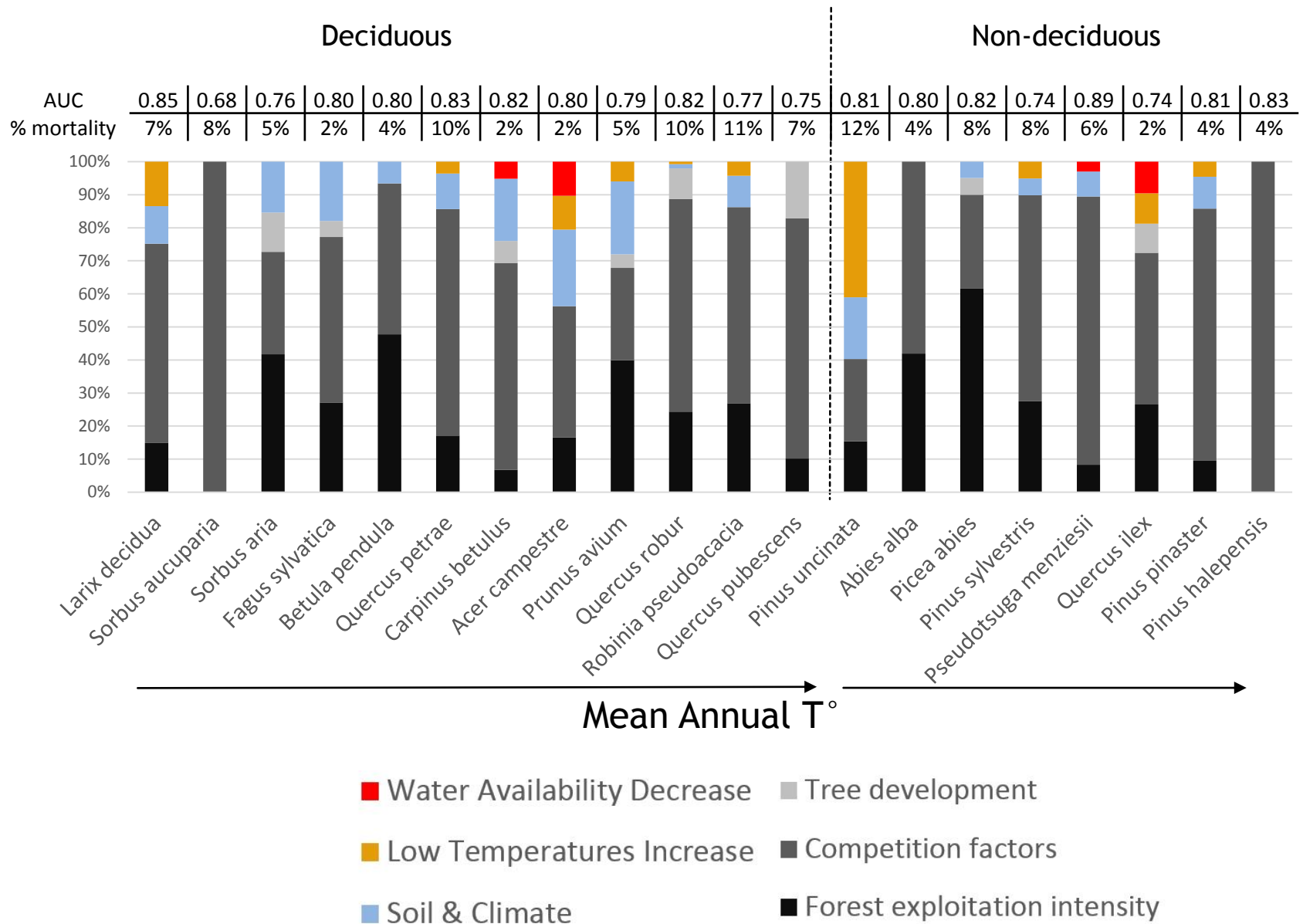- Results of the models for the 20 studied species

Results

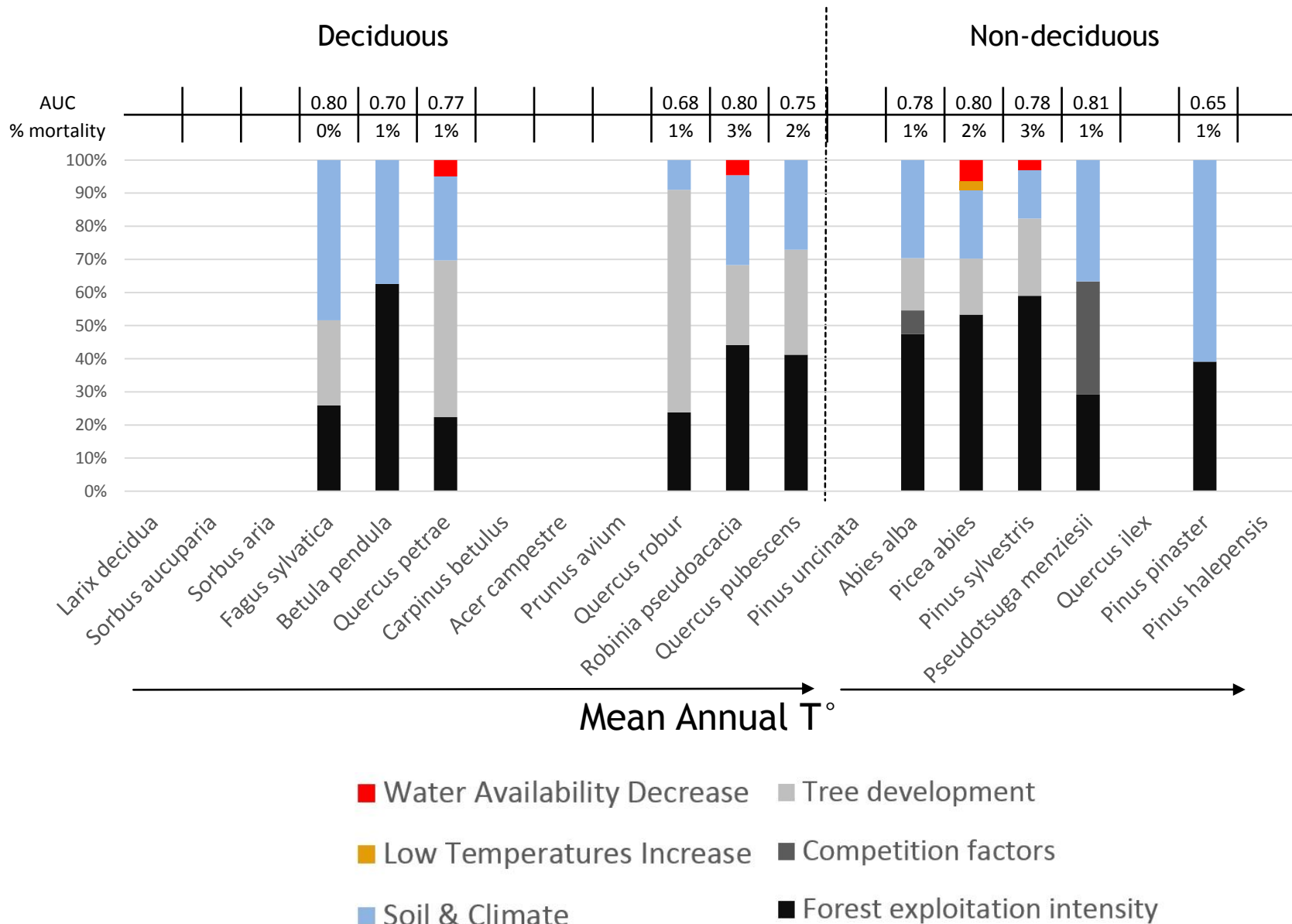Quality of the models – Mean AUC for all the species

Results — Amount of deviance explained by models by variable category
Dominated trees

Results — Amount of deviance explained by models by variable category — Dominating trees

Results :

Significant effects of climate change on mortality :

On dominated trees → 12/20 species

➢ Low temperatures increase effect on 10 species

➢ Water availaibility decrease effect on 4 species

➢ Low temperatures increase and water availaibility decrease effect on 2 species

On dominating trees → 4/11 species

➢ Water availaibility decrease effect on 4 species

➢ Low temperatures increase and water availaibility decrease effect on 1 species

Conclusion

→ Significant effect of **climate change** (rainfall decrease and low temperatures increase) on **certain species**.

→ Species behave differently if they are **dominating** or **dominated**

→ Most affected species (dominating scale) :

  → *Pinus sylvestris*

  → *Picea abies*

  → *Quercus petrae*

  → *Robinia pseudoacacia*

→ No effect on *Abies alba* and *Fagus sylvatica* ?

Future prospects

- Taking into account more potential effects
  - Winter and autumn rainfall increase

- Interactions between :
  - Climate evolution and...
    - Soil properties (waterlogging)
    - Forest management practices

- Comparison with results from the 16x16km permanent plots network of the « Forest Health Department ».
- Link between mortality models and predicted shifts in species distribution

Merci !