Adapting the GIS-coop experimental networks to the climate change challenge

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Sessile oak as an example

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1. Introduction: GIS coop

GIS coop founded in 1994: '**cooperative of data on forest stands growth**'

- Members: CPFA, FCBA, IDF-CNPF, AgroParisTech, INRA, Irstea, ONF and supported by the ministry of agriculture and forest

Aims:

- Acquisition and pooling of data on trees and stands growth in order to model growth and productivity of forests stands
- By setting up and monitoring long term experiments covering all environmental and sylvicultural conditions

Studied systems:

Sessile and pedunculate oaks

Laricio pine

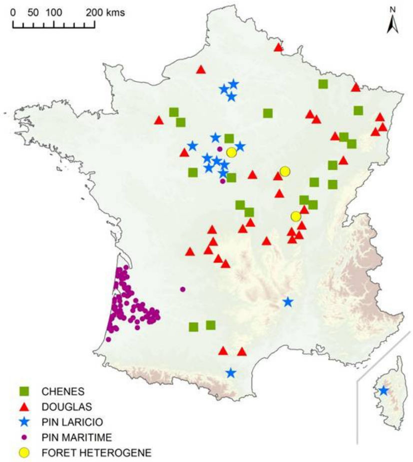
Maritime pine

Douglas

Mixed forests

1. Introduction: GIS coop

Experimental design:

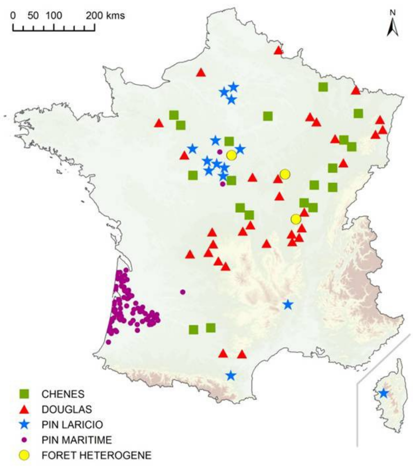


Ressource

Sampling design: covering the whole production area

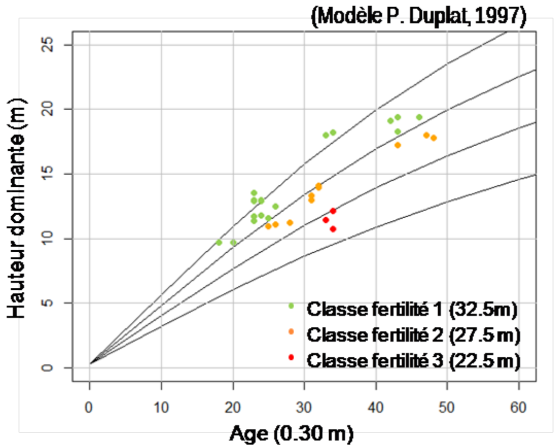
1. Introduction: GIS coop

Experimental design:



Ressource

Sampling design: covering the whole production area
Site-index based sampling design in each region



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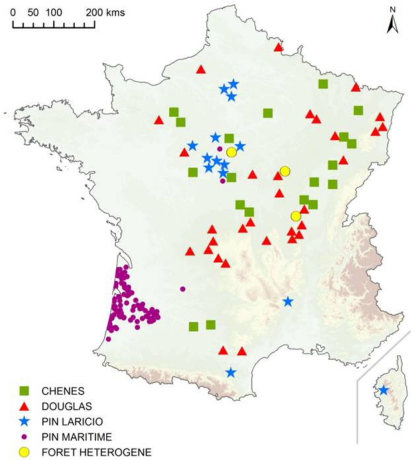

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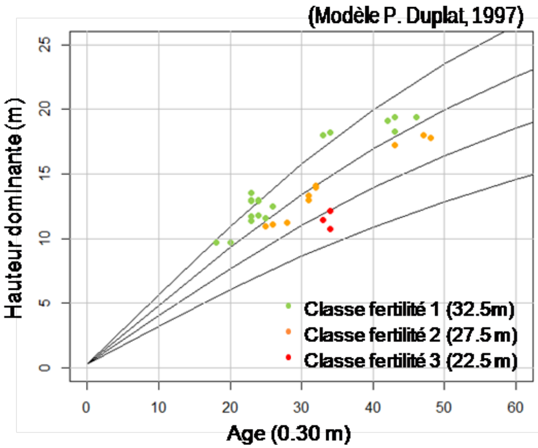

Ressource

Stand

Long term sylvicultural experiment
Stand densities experiments

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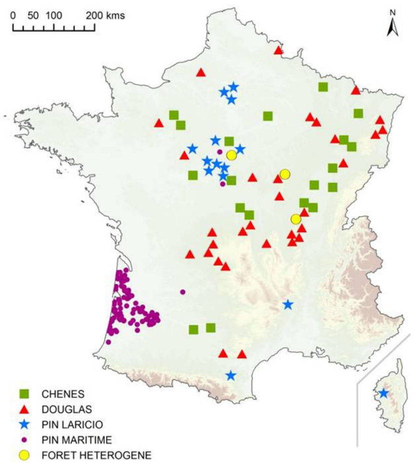
Experimental design:



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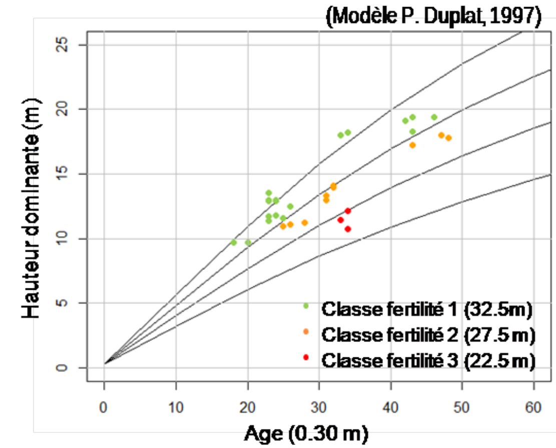


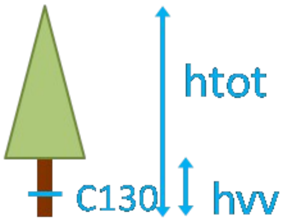
Ressource

Long term sylvicultural experiment
Stand densities experiments

Stand

Spatial scales

Tree



Studying recruitment/growth/mortality processes

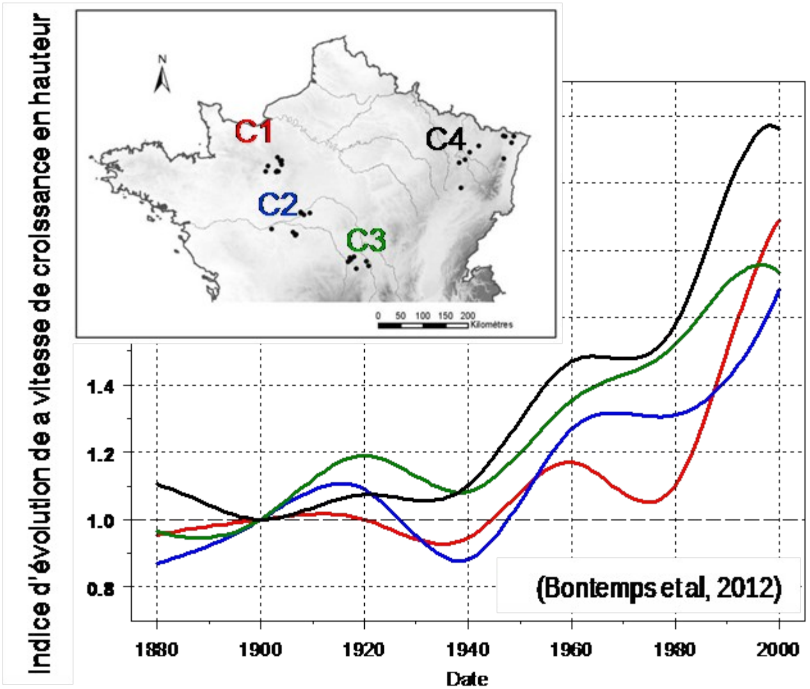
1. Introduction: evolution of needs

Why do we want to change anything?

- Environmental changes: how sylvicultural practices can modulate their effects
- Including environmental factors in growth models

Site index is not enough:

- Productivity changes: temporal variability of site index
- A single site index may correspond to different environmental conditions



1. Introduction: evolution of needs

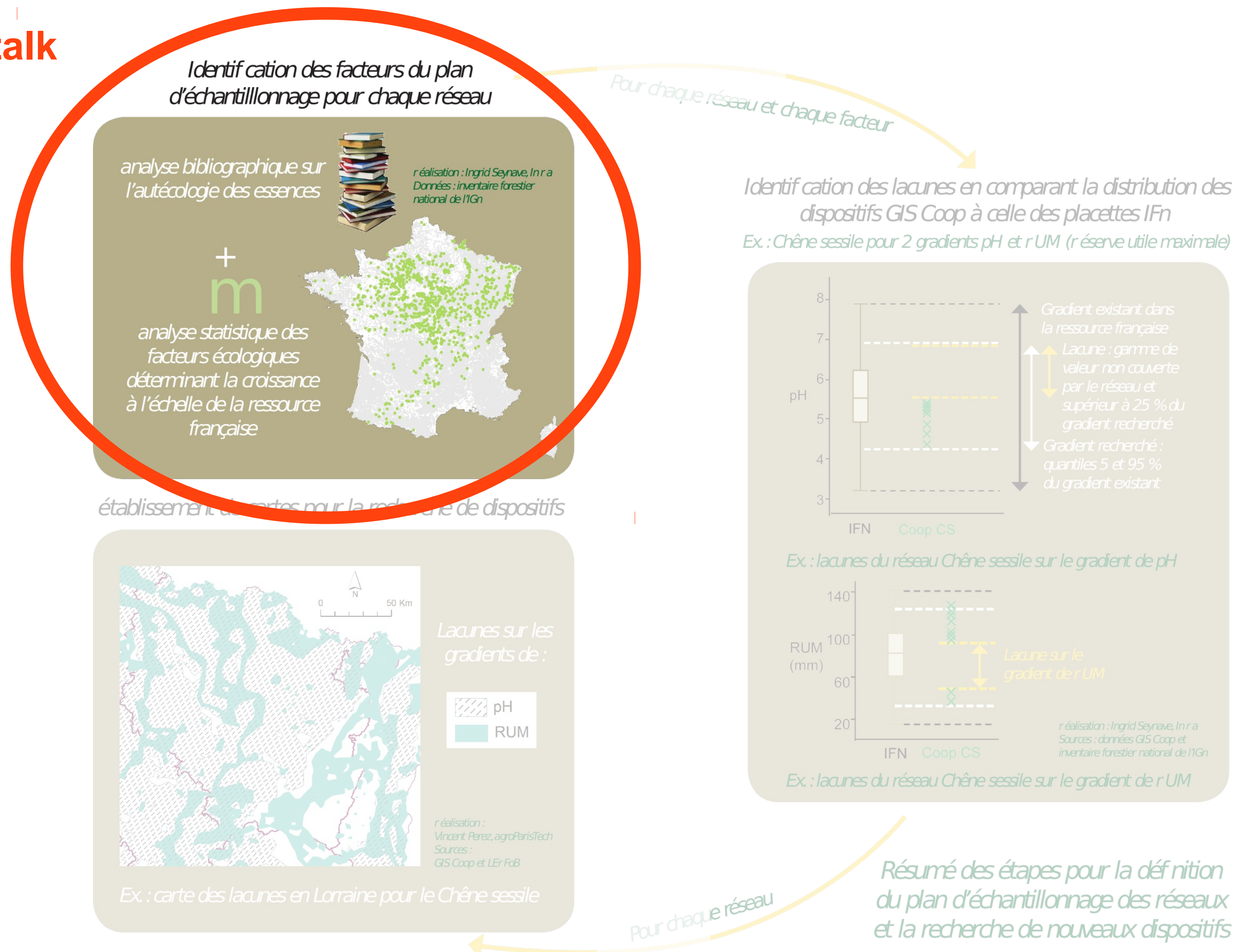
→ Changes in aims of the GIS coop: a better consideration of environmental conditions in experimental networks

→ Changes in protocols:

- Increase the geographical range of networks
- Improving the description of environmental conditions
- **Modification of the sampling strategy: stratifying networks by environmental factors**

1. Introduction: rethinking the sampling strategy

Today's talk



Travail initié par Valentine Lafond en 2009

2. Modelisation

Aim: to highlight major environmental factors explaining growth

Comparison of two modelling methods: GAMs and Random Forests

- Improve robustness of results
- Random Forests integrate all candidate variables

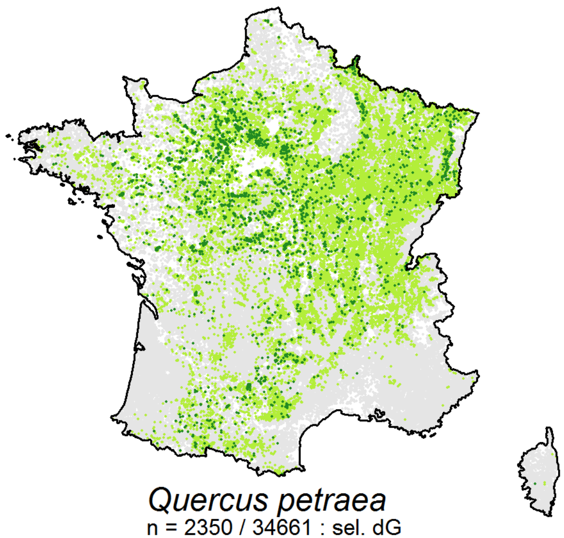
Comparison of two growth parameters: basal area increment and site index

- Site index less dependant on sylvicultural practices
- Differences in environmental factors affecting these two parameters?

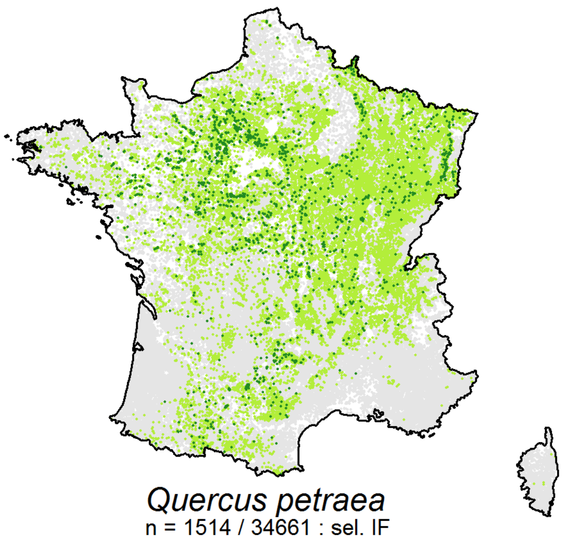
2. Modelisation: data

NFI data: 167,876 forest plots between 1987 and 2014

- 34,661 stands with sessile oak across France
- 2,350 pure and even-aged stands: basal area increment (BAI)
- 1,514 pure and even-aged stands: site index (SI)



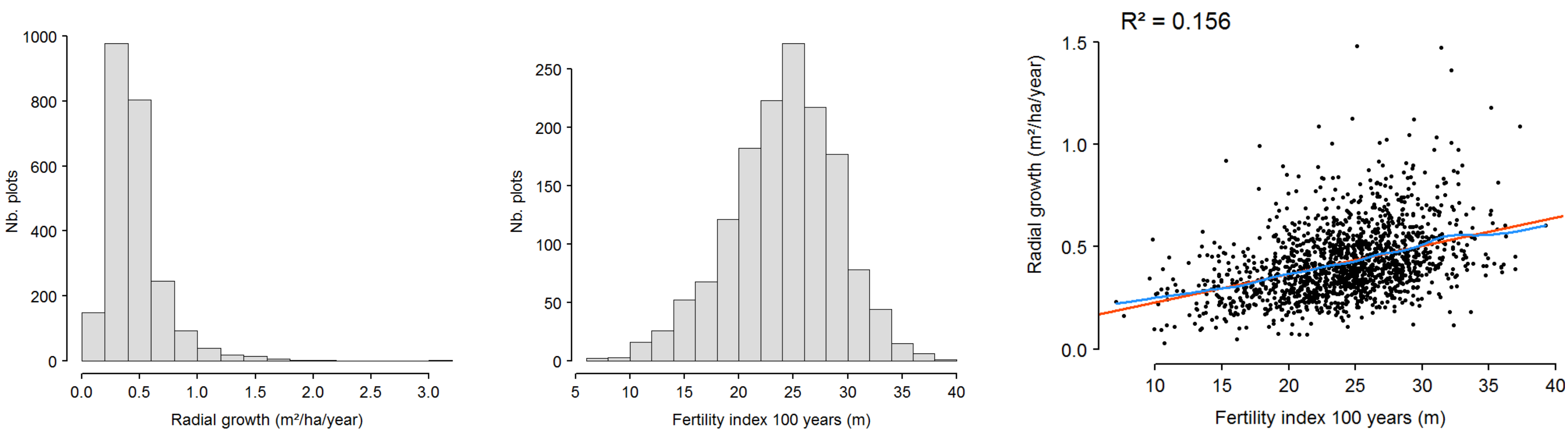
Basal area increment selection



Site index selection

2. Modelisation: data

- Basal area increment: from 0 to 3.2 m²/ha/year
- Site index: from 5 to 40 m at 100 years (Duplat)
- Weak relationship between basal area increment and site index...



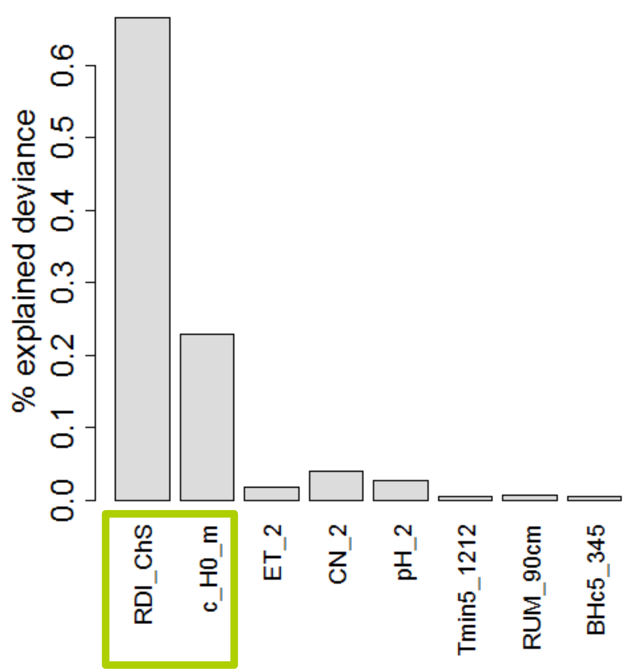
Environmental factors included in models:

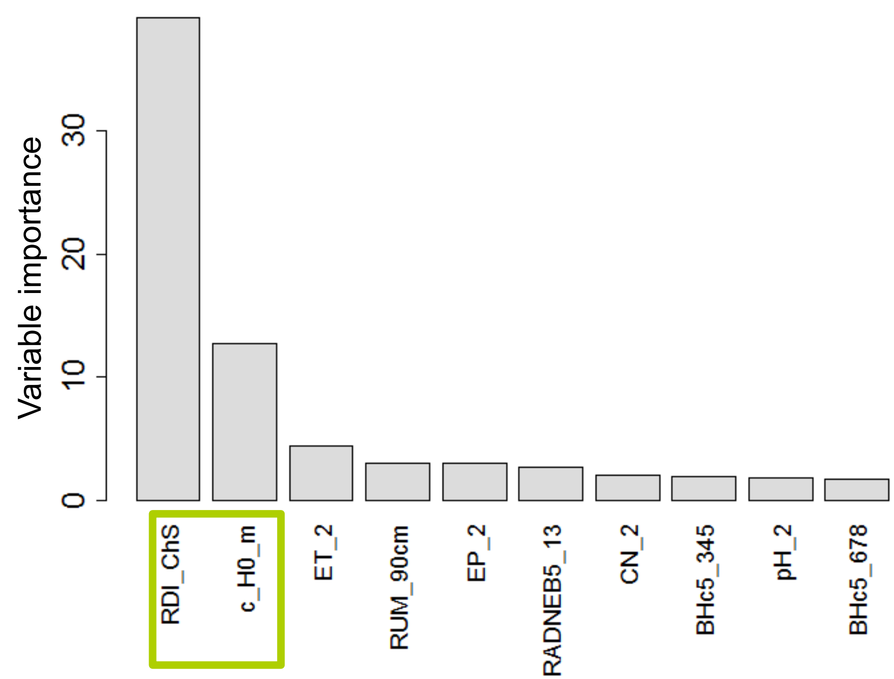
- Climatic: (seasonnal) mean, min and max temperature, precipitations, climatic water balance and annual radiations
- Soil: soil water capacity, C:N ratio, pH, S:T ratio, permanent and temporary waterlogging
- Stand RDI and dominant height (BAI) or dominant age (SI)

2. Modelisation: basal area increment

	GAMs	RandomForests
Nb. variables:	8	32 (all)
Expl. dev.:	54 %	54 %
Expl. dev. stand:	43 %	28 %
Expl. dev. enviro:	11 %	26 %

Stand effect





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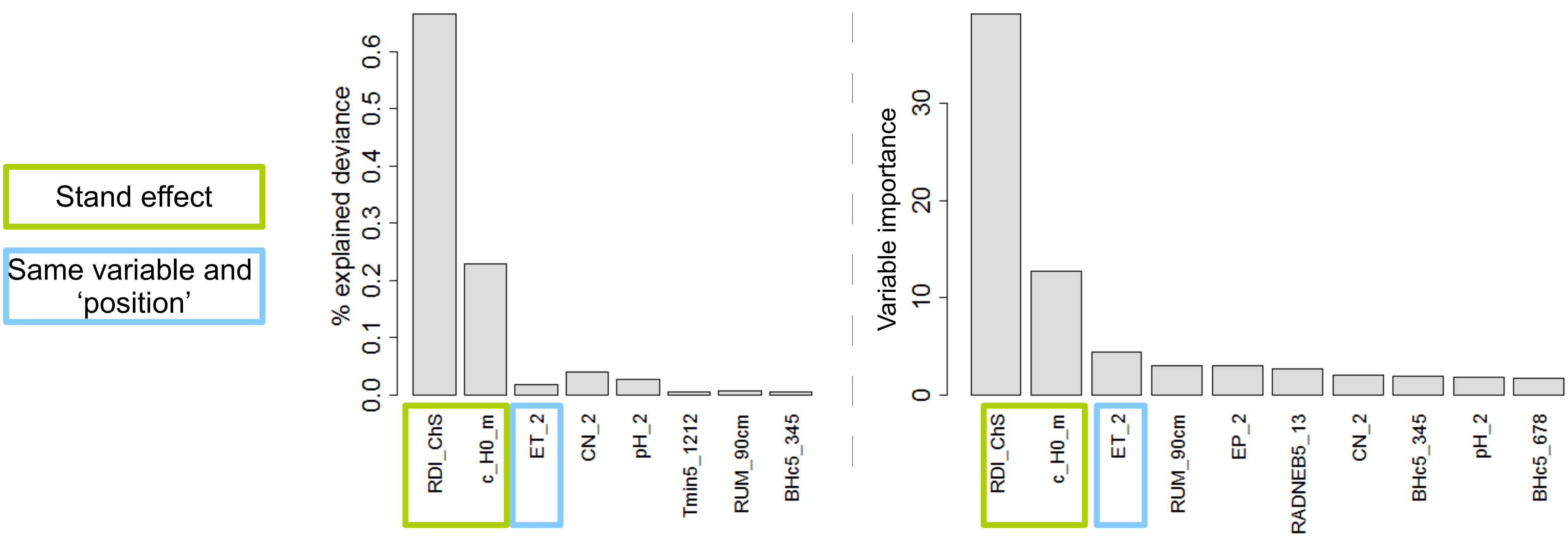

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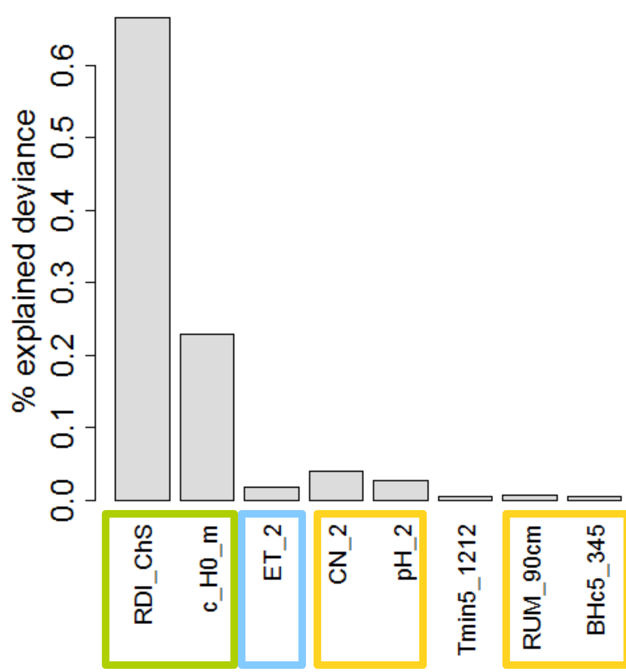
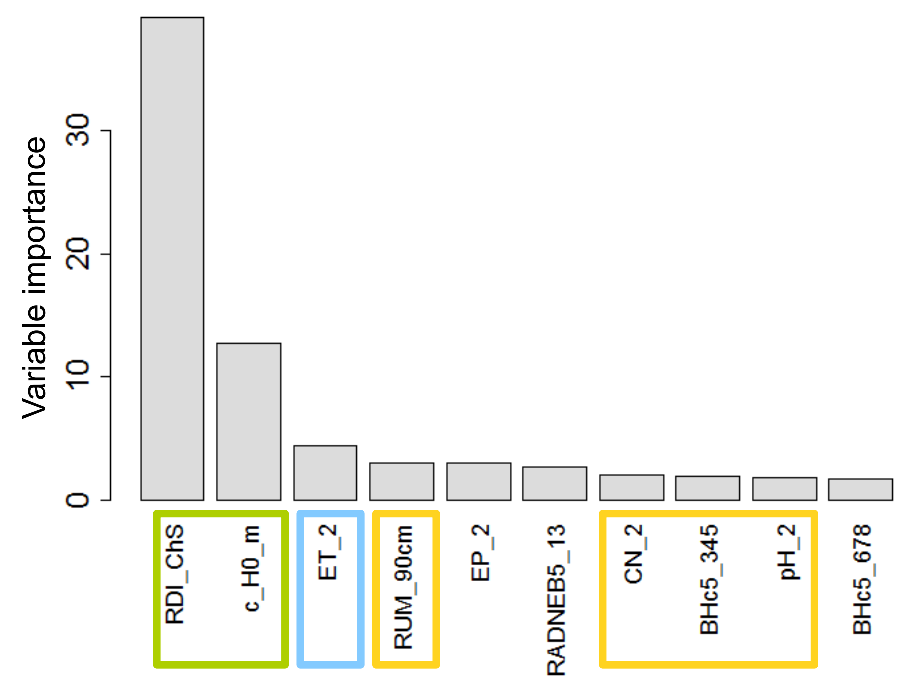




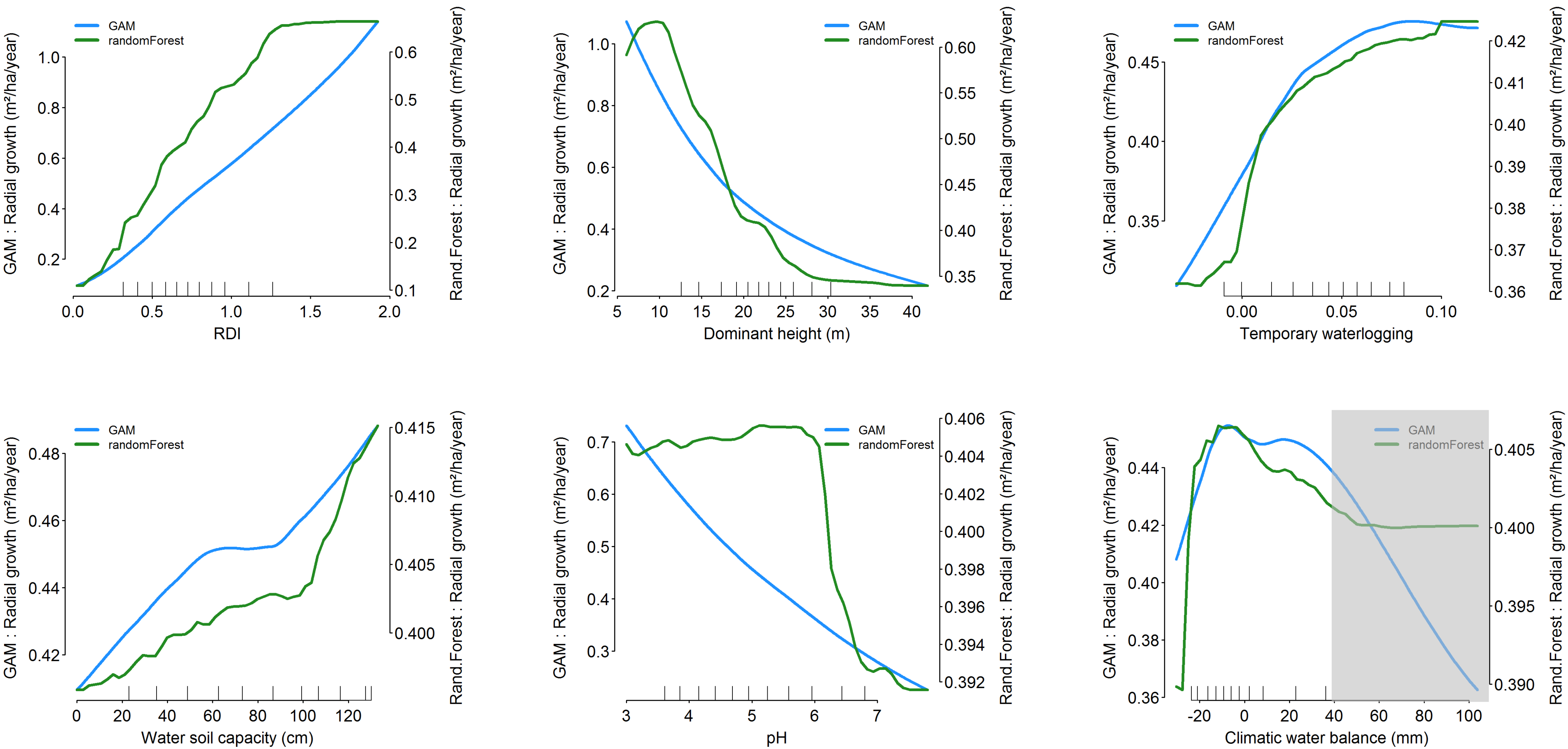
Stand effect

Same variable and 'position'

Same variable

2. Modelisation: basal area increment

Concordance between partial response curves



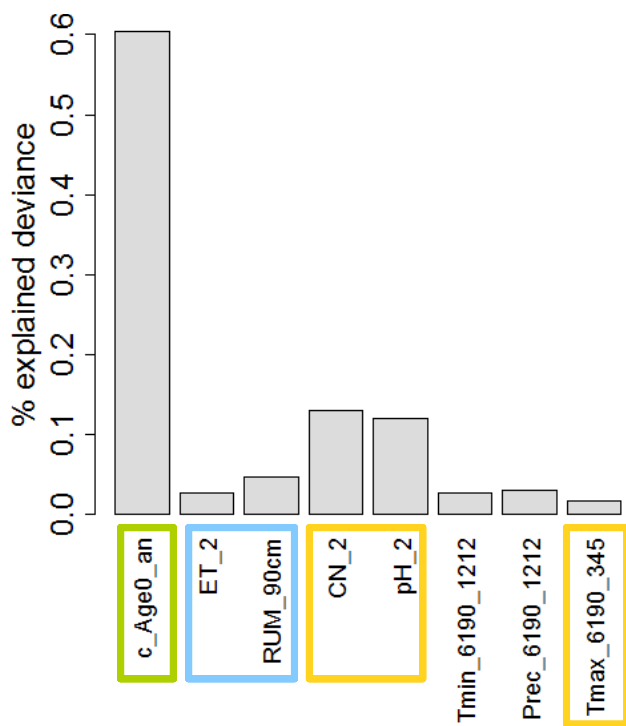
2. Modelisation: site index

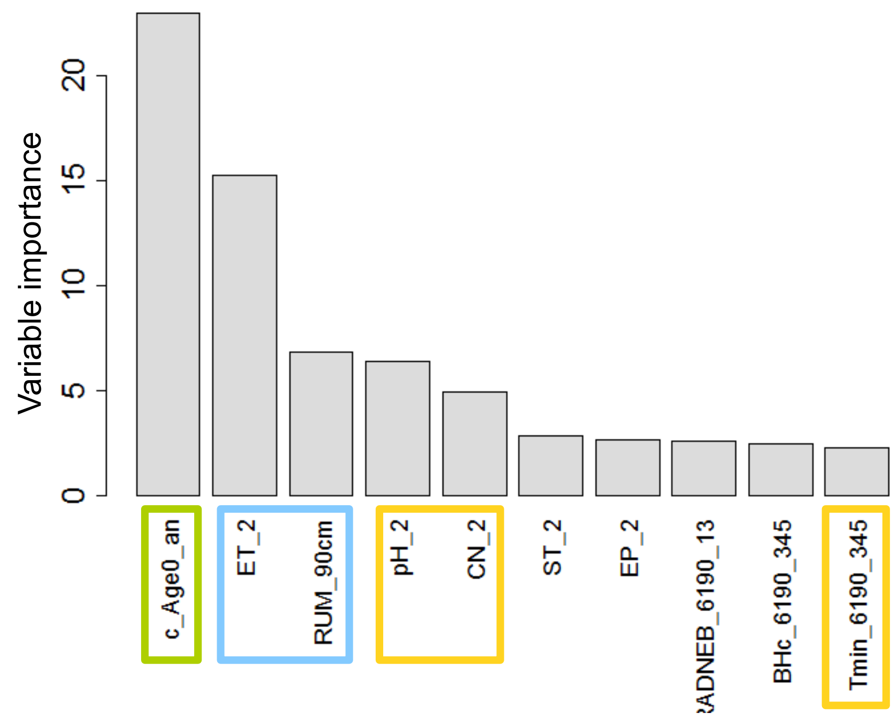
	GAMs	RandomForests
Nb. variables:	8	31 (all)
Expl. dev.:	51 %	45 %
Expl. dev. stand:	17 %	10 %
Expl. dev. enviro:	34 %	35 %

Stand effect

Same variable and 'position'

Same variable





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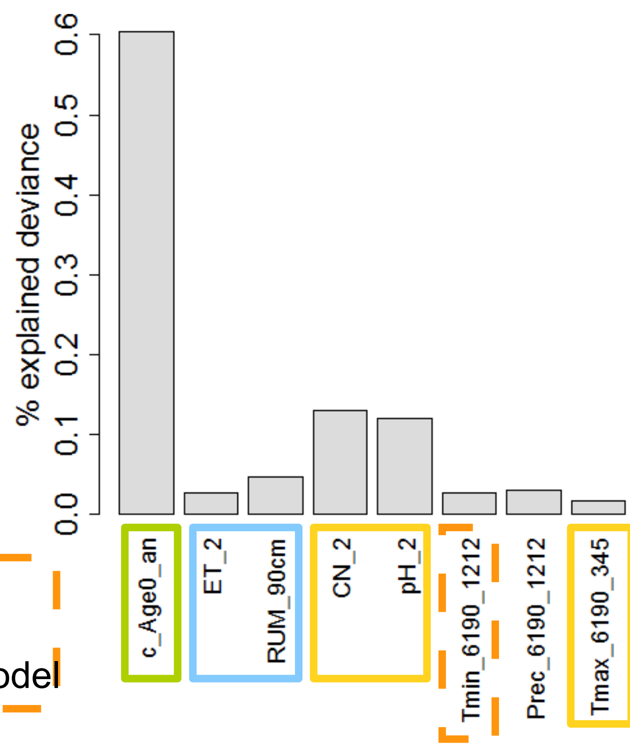
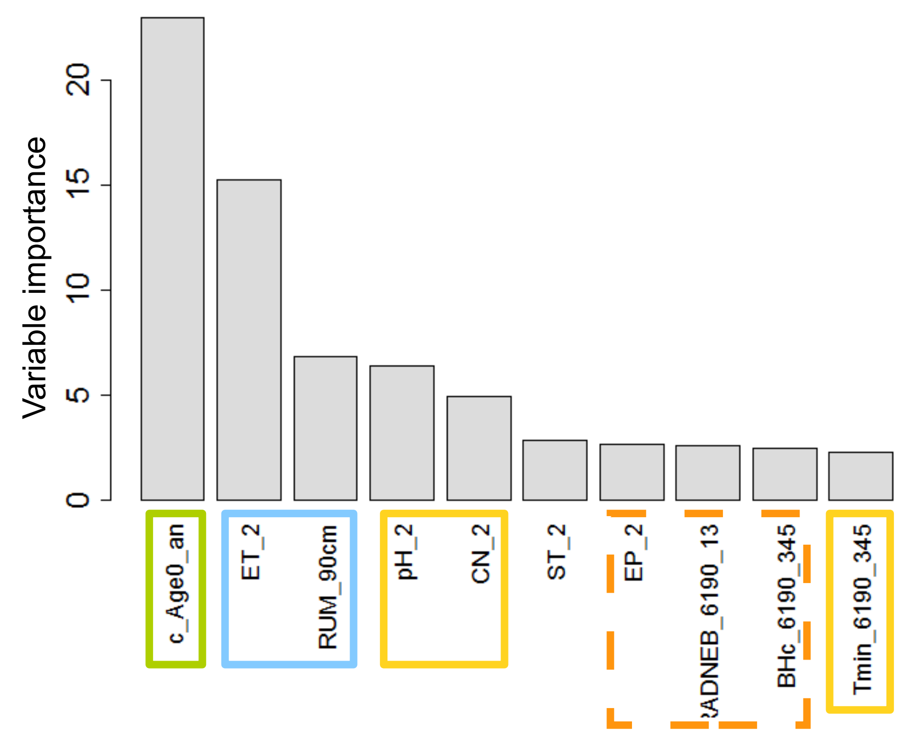
Stand effect

Same variable and 'position'

Same variable

Different variable but present in the basal area increment model





2. Modelisation: synthesis

GAMs vs. Random Forests

- Concordant results: (almost) same variables and shapes response curves
- GAMs: less variables for an equivalent quality

Basal area increment vs. site index

- Environmental factors more important for site index

Primary environmental factors for growth of sessile oak:

- Soil: temporary waterlogging, soil water capacity, pH, C:N ratio
- Climate (weak influence): spring climatic water balance (RF) and temperature, winter minimal temperature (GAMs)

3. Bibliographic analysis

Aim: to highlight major environmental factors explaining growth

Based on published studies linking growth to environmental factors.

Studying the whole distribution of species.

Questions:

- Do we observe similarities between studies?
- Are environment-growth relationships spatially coherent?

3. Bibliographic analysis: method

Bibliographic database investigated:

- Web of knowledge
- Docpatrimoine (AgroParisTech)

Requests criteria: species, growth, environment

Selection criteria: title, abstract, whole article

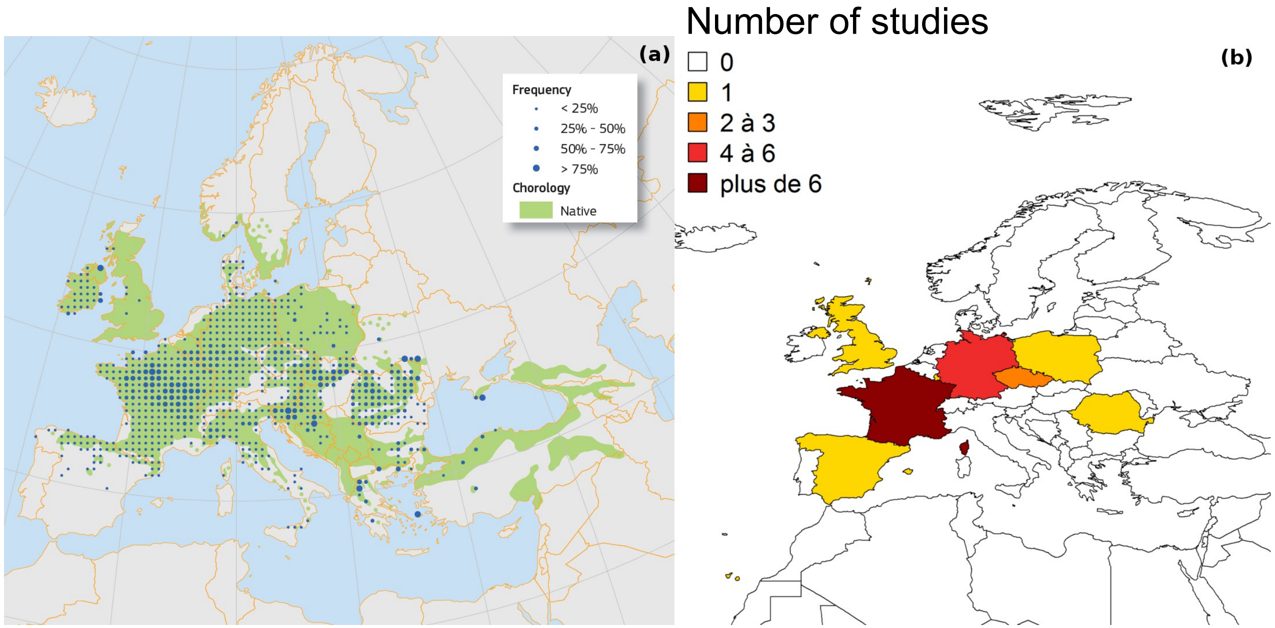
Two levels of studies included in the bibliographic database:

- Qualitative analysis → reading notes
- Quantitative analysis → extraction of relationships data: significance, signs of the relationships

3. Bibliographic analysis

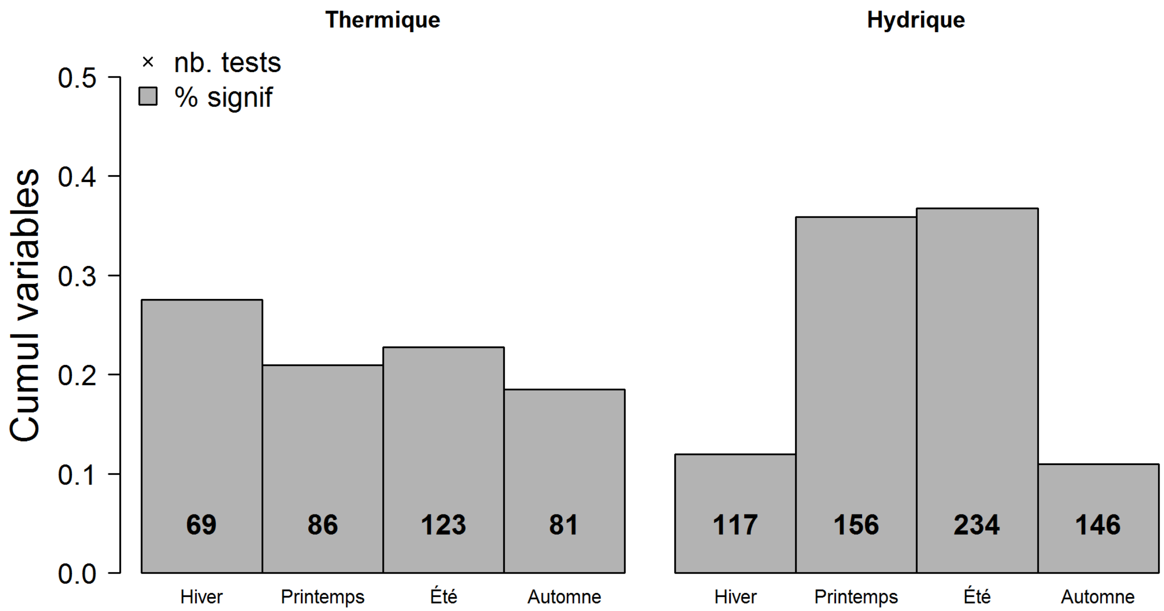
References studied: ~ 280

- 50 integrated to the bibliographic database
- 23 with quantitative relationships: 19 radial growth; 2 distribution; 2 height growth



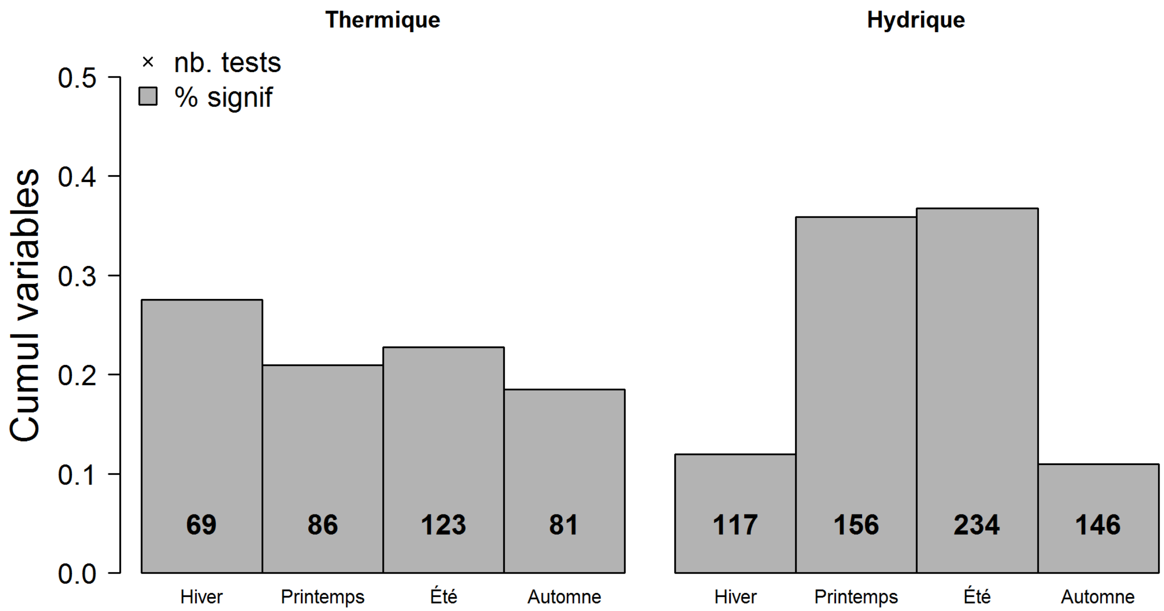
- 1097 variables tested
- 288 variables significant or integrated in models
  → classified by season and climatic factor (hydric/thermic)

3. Bibliographic analysis: global results



Proportion of significant variables

3. Bibliographic analysis: global results



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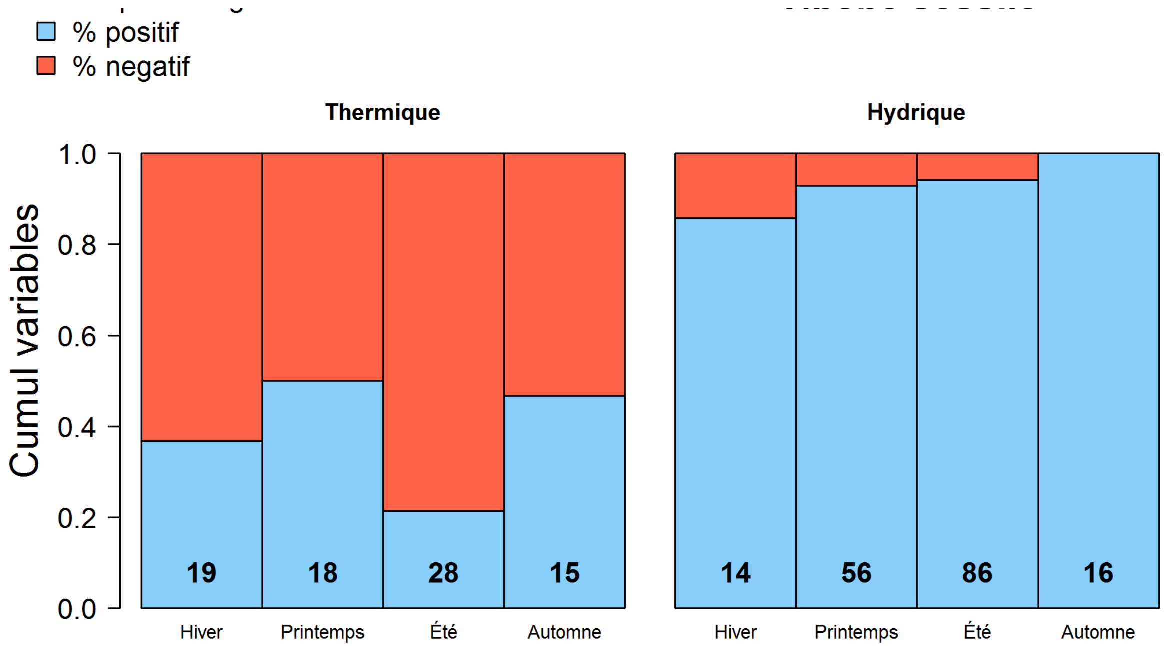


Signs of the relationships

3. Bibliographic analysis: spatial differenciation

Atlantic
United Kingdom
West of France
North of Spain

'Central' zone
East of France
Germany

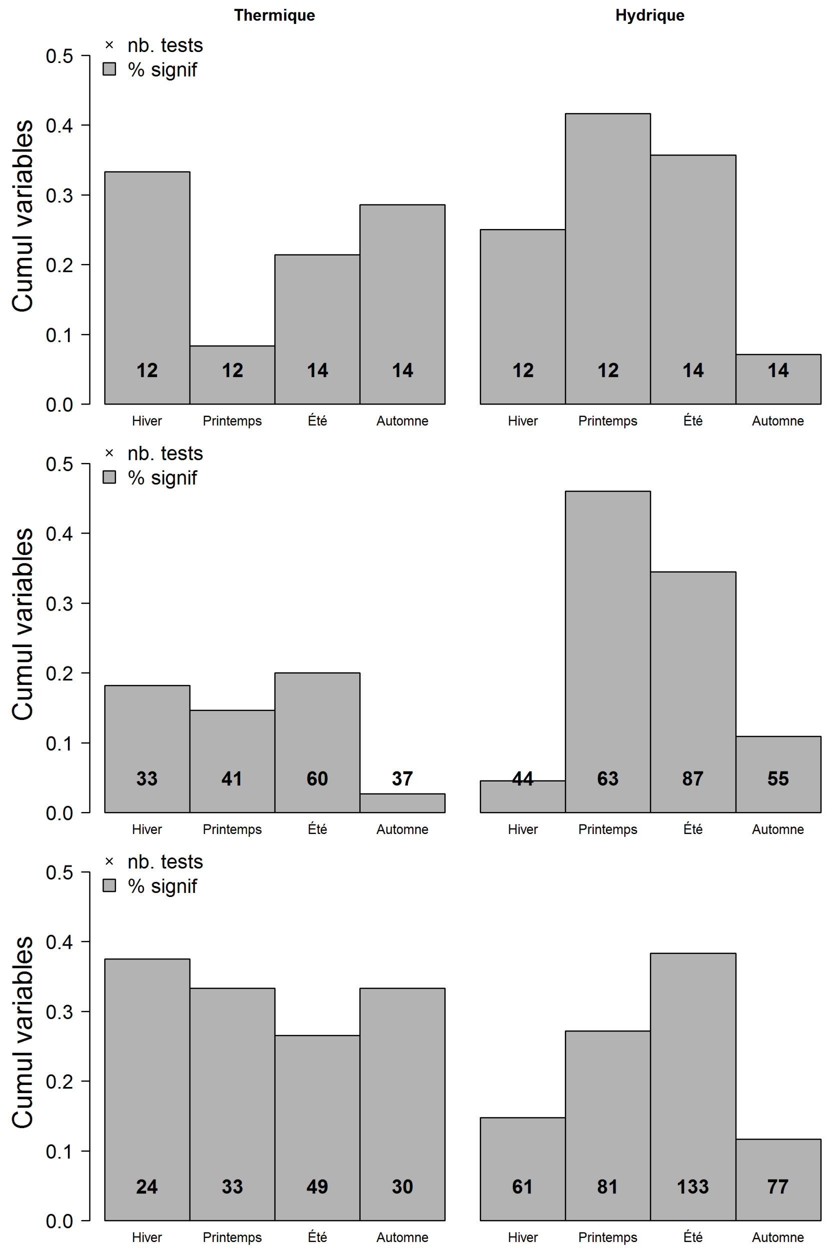
Continental
Czech Republic
Romania
Poland

3. Bibliographic analysis: spatial differenciation

Atlantic

'Central' zone

Continental



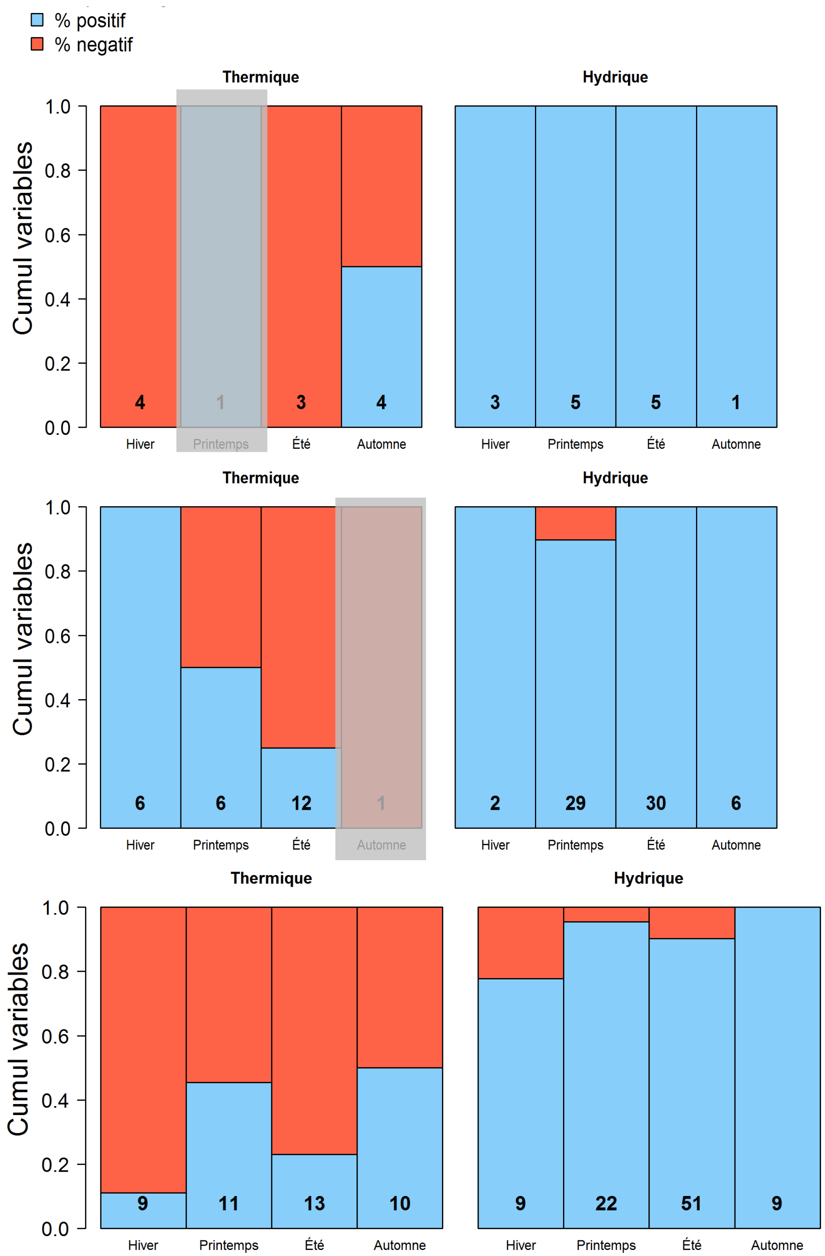
- Spring and summer hydric factors are the most importants
- Thermic factors are more variables:
  - Important in the continental zone
  - Weak in the central zone
  - Depending on seasons in the atlantic zone

3. Bibliographic analysis: spatial differenciation

Atlantic

‘Central’ zone

Continental



- Positive role of hydric factors
- Mostly negative role of summer thermic factors (how to explain positive ones)
- Signs of spring and autumn thermic factors unstables
- **Difference in the sign of winter thermic factors between the central and the other zones**

3. Bibliographic analysis: synthesis

Precipitation and temperature are the most tested variables: dendrochronological approach

Global scale:

- Spring and summer hydric factors are the most important
- No clear differences between seasons for thermic factors

From atlantic to continental conditions:

- Hydric factors more important in the ‘central’ area
- Inversion of the sign of relationship with the winter thermic factors
- Thermic factors more important for atlantic and continental than central areas

4. Discussion

Agreement between approaches:

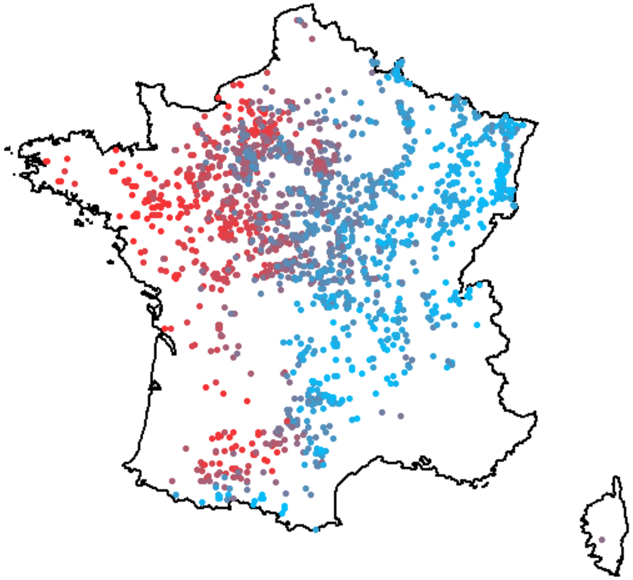
- Importance of hydric factors during spring
- Importance of winter thermic factors (GAM models)

Disagreements:

- **Importance of soil factors**
- Importance of thermic factors during summer and autumn
- Importance of summer hydric conditions

4. Discussion

Are the two approaches comparable?



Winter temperature
Site index analysis

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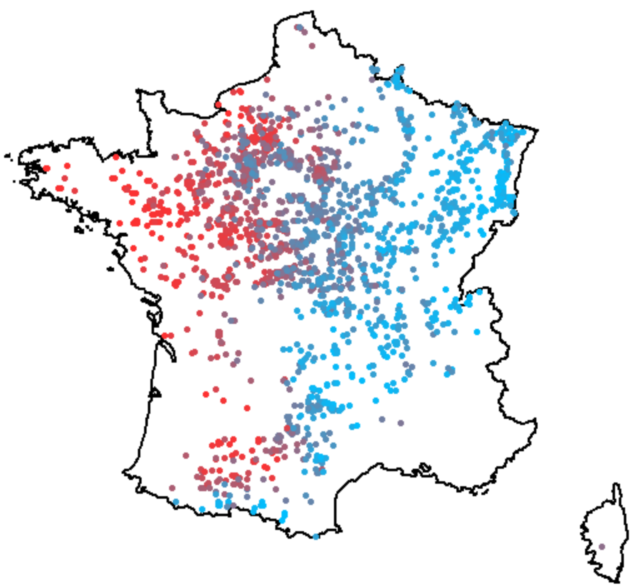
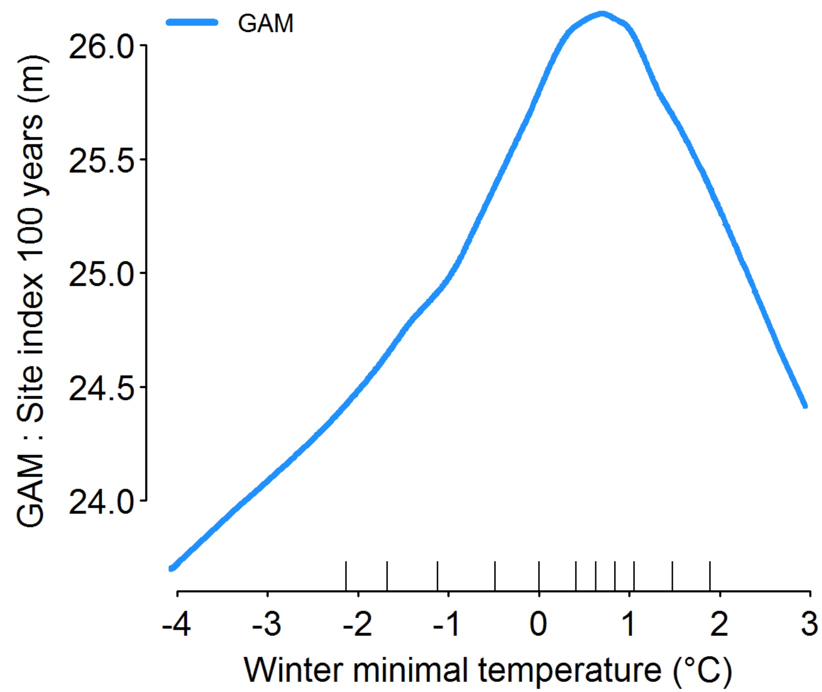


Winter temperature
Site index analysis

East **West**



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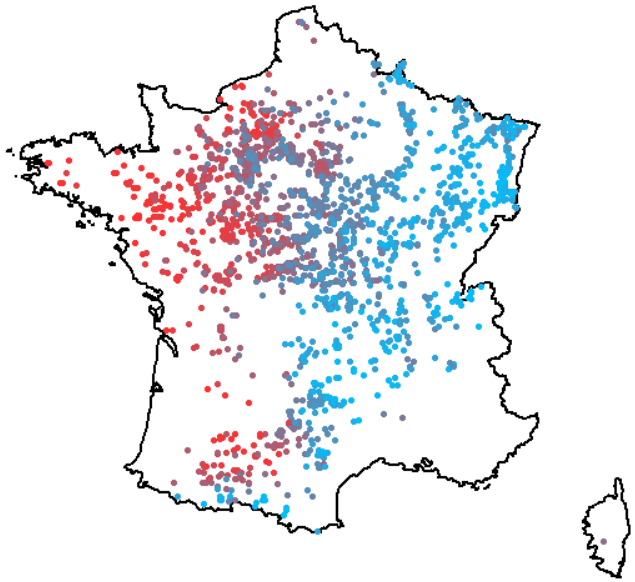
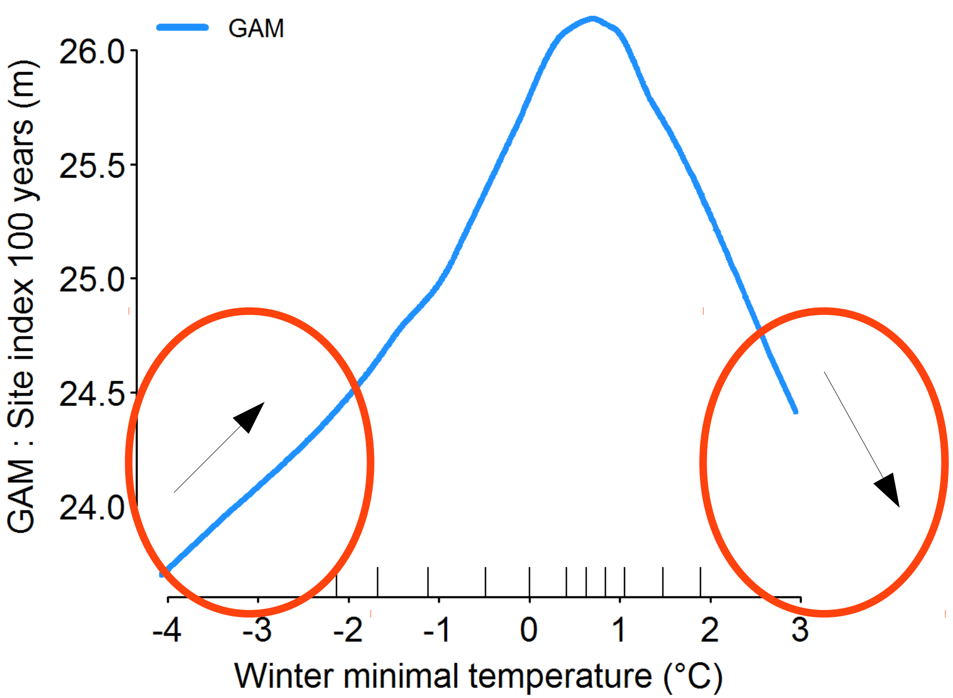


Winter temperature
Site index analysis

	East	West
Model :	+	-



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	East	West
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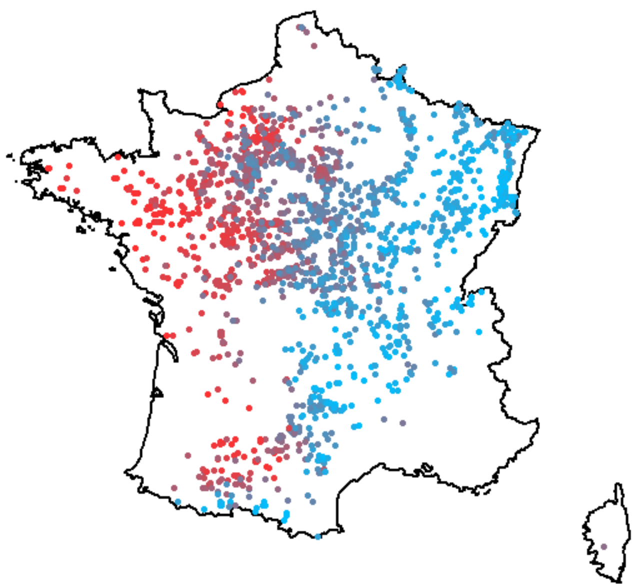

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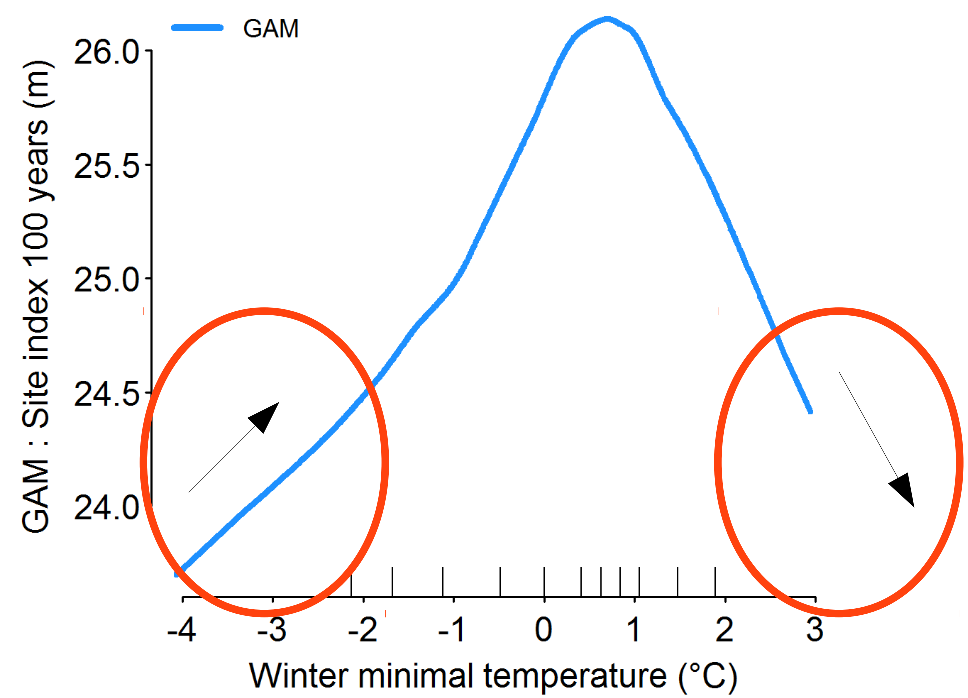

4. Discussion

Comparison of the two approches:

- Models: spatial response of species along environmental gradients
- Dendrochronology: temporal response of species in a given place

→ **Is it possible and how to synthetise this information?**

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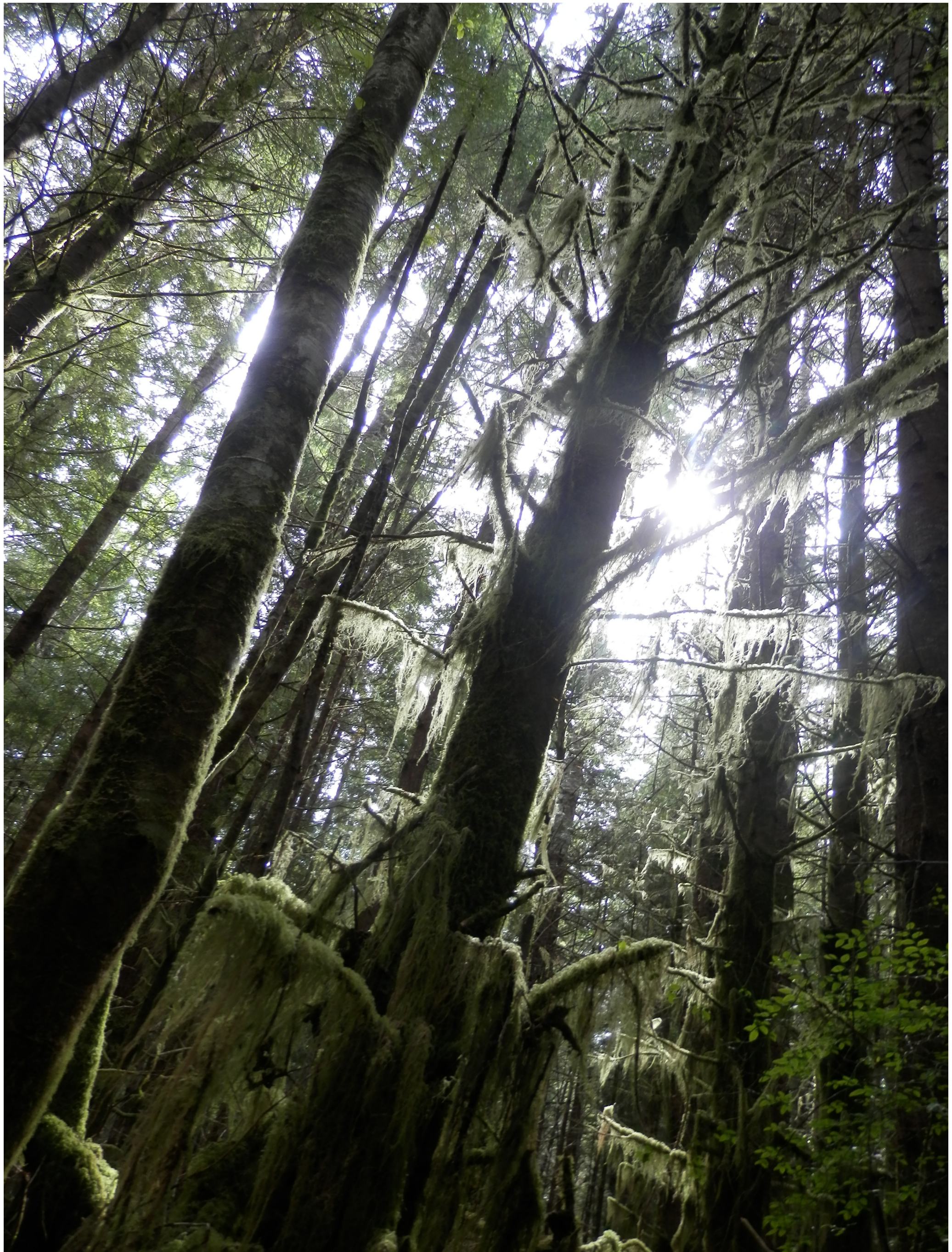
→ **Is it possible and how to synthetise this information?**

Perspectives:

- Finalising analyses for other species: pedunculate oak, maritime and laricio pine, Douglas and silver fir
- Defining the new sampling design: same for all species?
- Monitoring current and future state of networks according to the new sampling design



Thank you!

Questions?