



SAPIENZA
UNIVERSITA' DI ROMA



Italian national agency for new technologies,
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The impacts of climate change and air pollution on forest health condition

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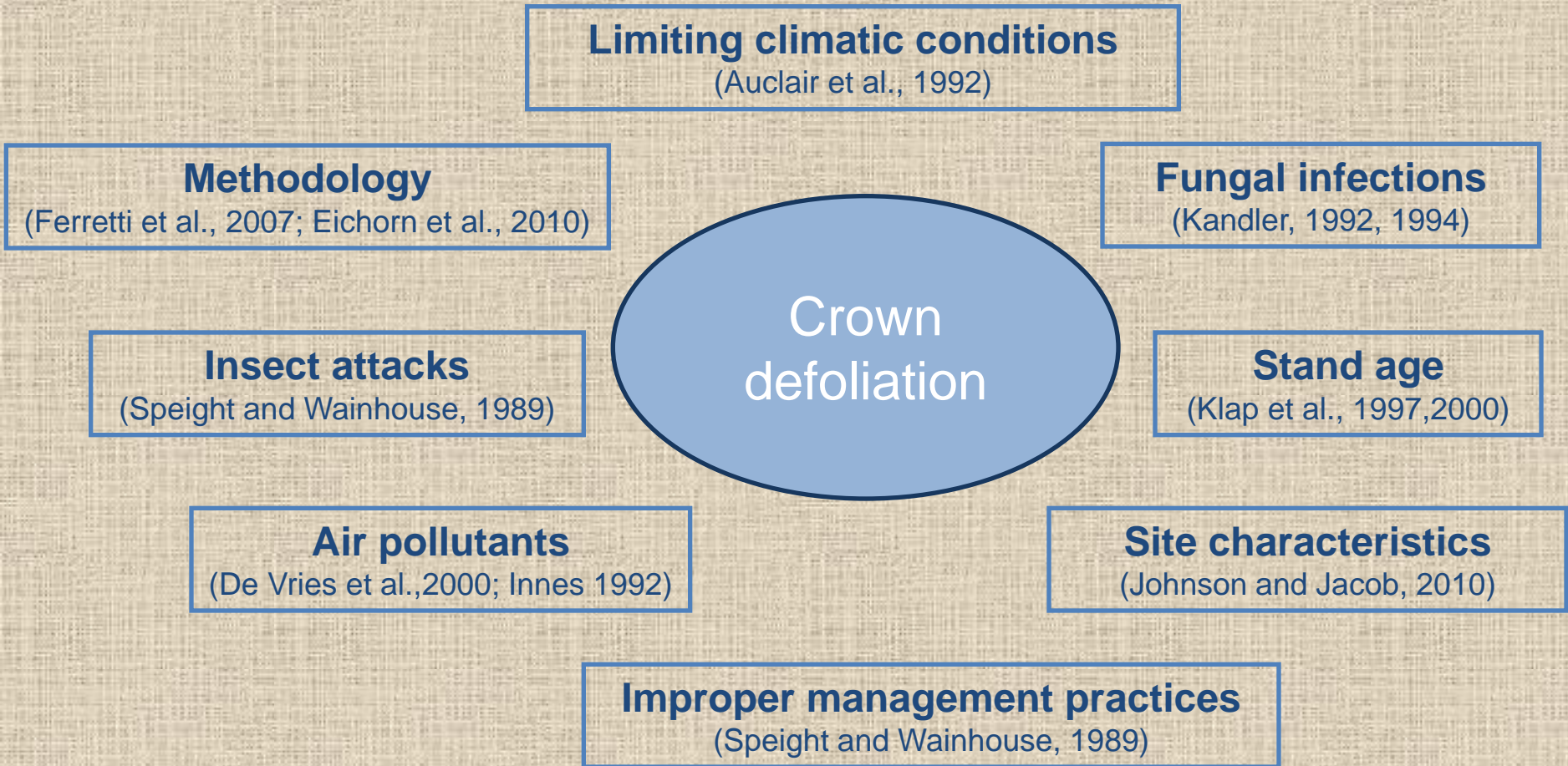
chiara.proietti@uniroma1.it

3rd ICP Forests Scientific Conference, Athens 26-28 May, 2014

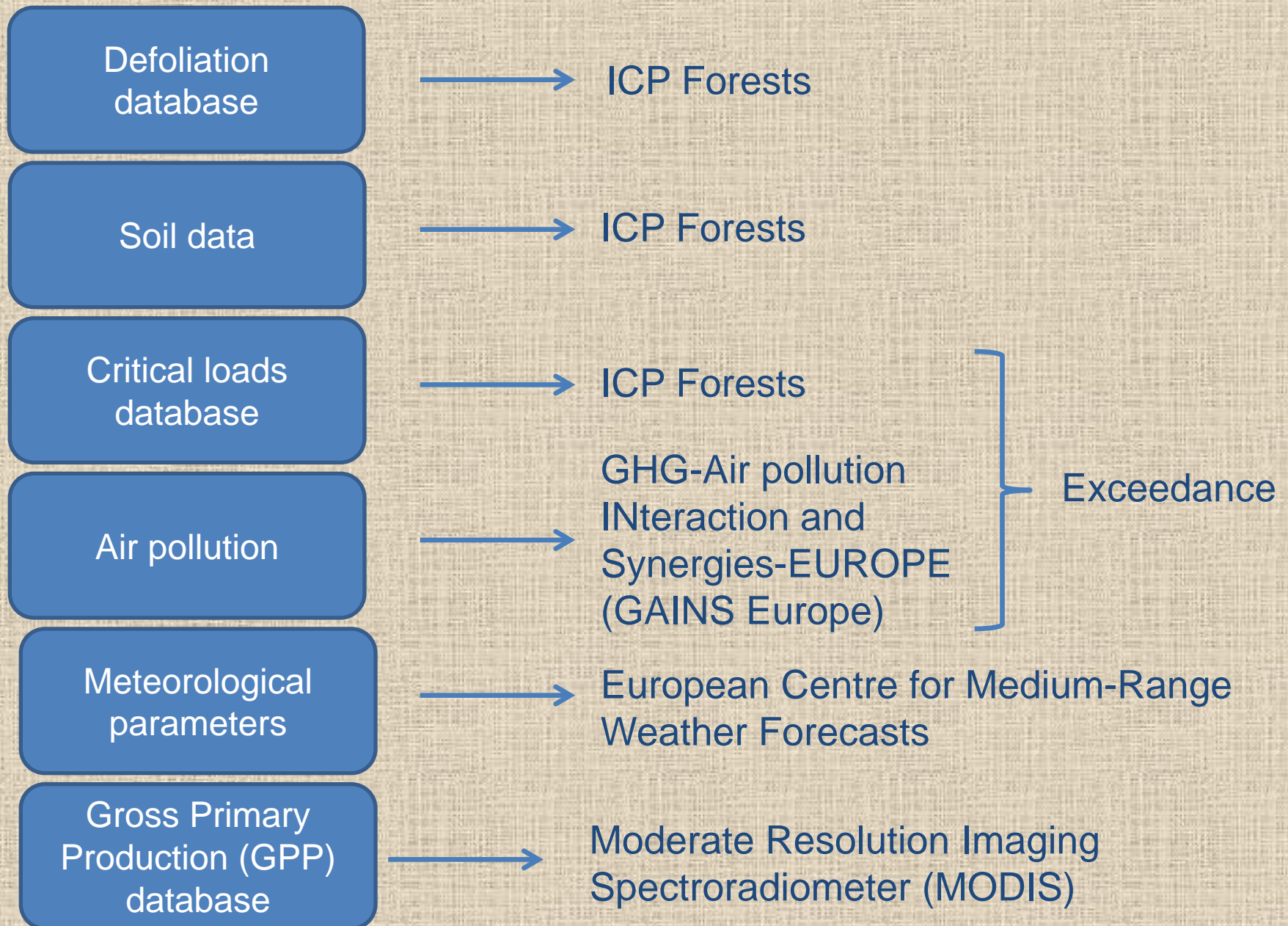
Aims

1. What are the most relevant factors affecting crown defoliation at a European scale?
2. Is it possible to accurately modelling tree crown defoliation through general regression models?
3. How does crown defoliation respond to future nitrogen deposition and climate change scenarios?
4. What are the most relevant factors affecting Gross Primary Production (GPP) at a European scale?

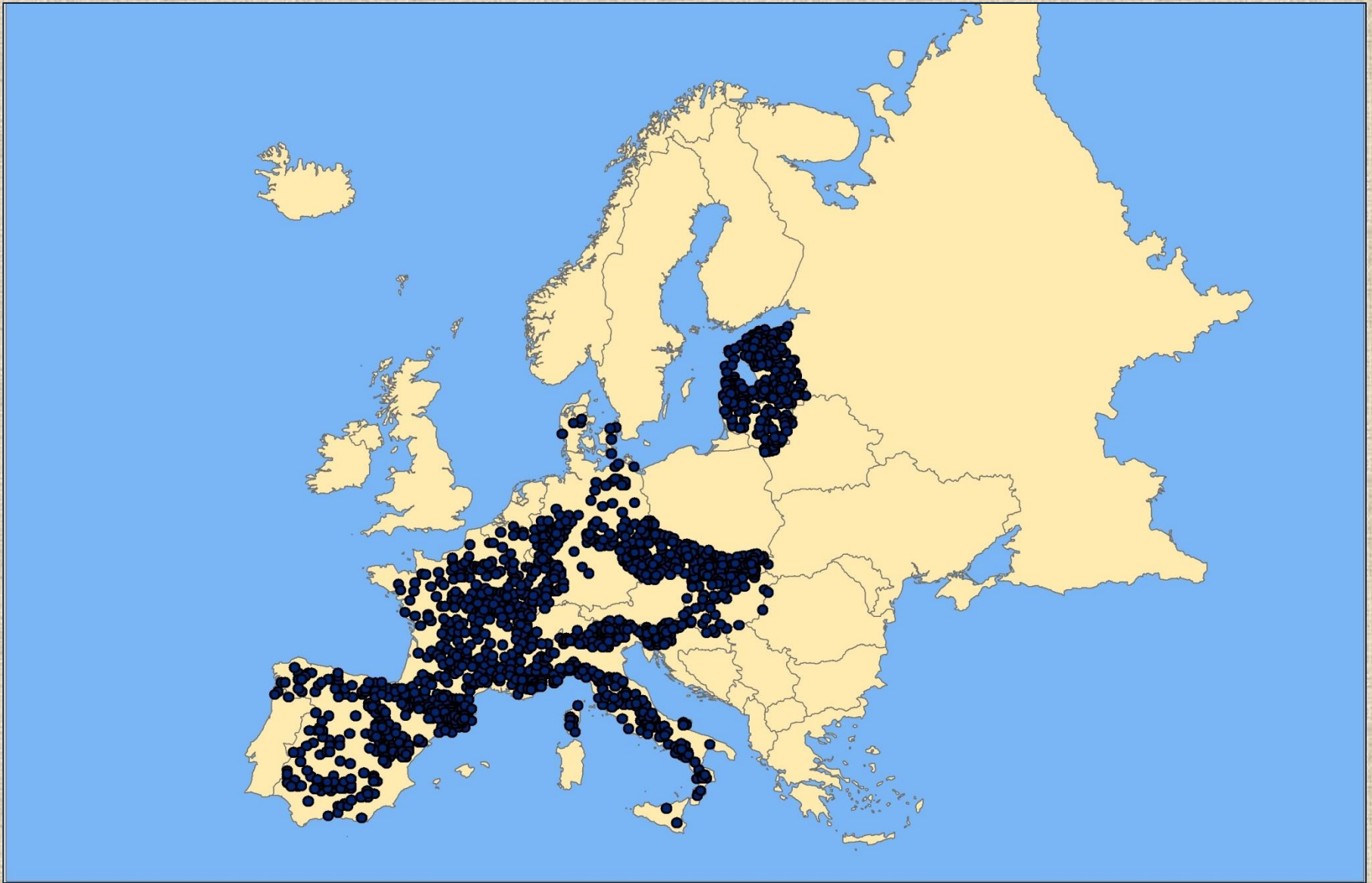
What are the most relevant factors affecting crown defoliation at a European scale?



Methodology: building of the starting database (2001, 2006, 2011)



Methodology: selection of representative species



Total number of plots= 2403

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What are the most relevant factors affecting crown defoliation at a European scale?

Random Forests Analysis (RFA)

(Breiman et al. 1984, 2001)

RFA is a collection of simple tree predictors, each able to generate a response when evaluated in relation to a set of predictor values.

Random Forests Analysis has been performed for selecting the most important (>0.5) species-specific predictors affecting crown defoliation (Vitale et al., (2014) Water, Air, & Soil Pollution, in press).

The final importance ranking is computed in order to assign 1 to the most important predictor and relative magnitudes to the others (Svetnik et al., 2003).

Methodological approach

Adjustement of defoliation values on the basis of latitude and longitude has been performed in order to reduce the high variability of defoliation
(Coordinates-Based Defoliation, CBD)



**Random Forests Analysis: selection of the most important predictors
(values >0.5)**



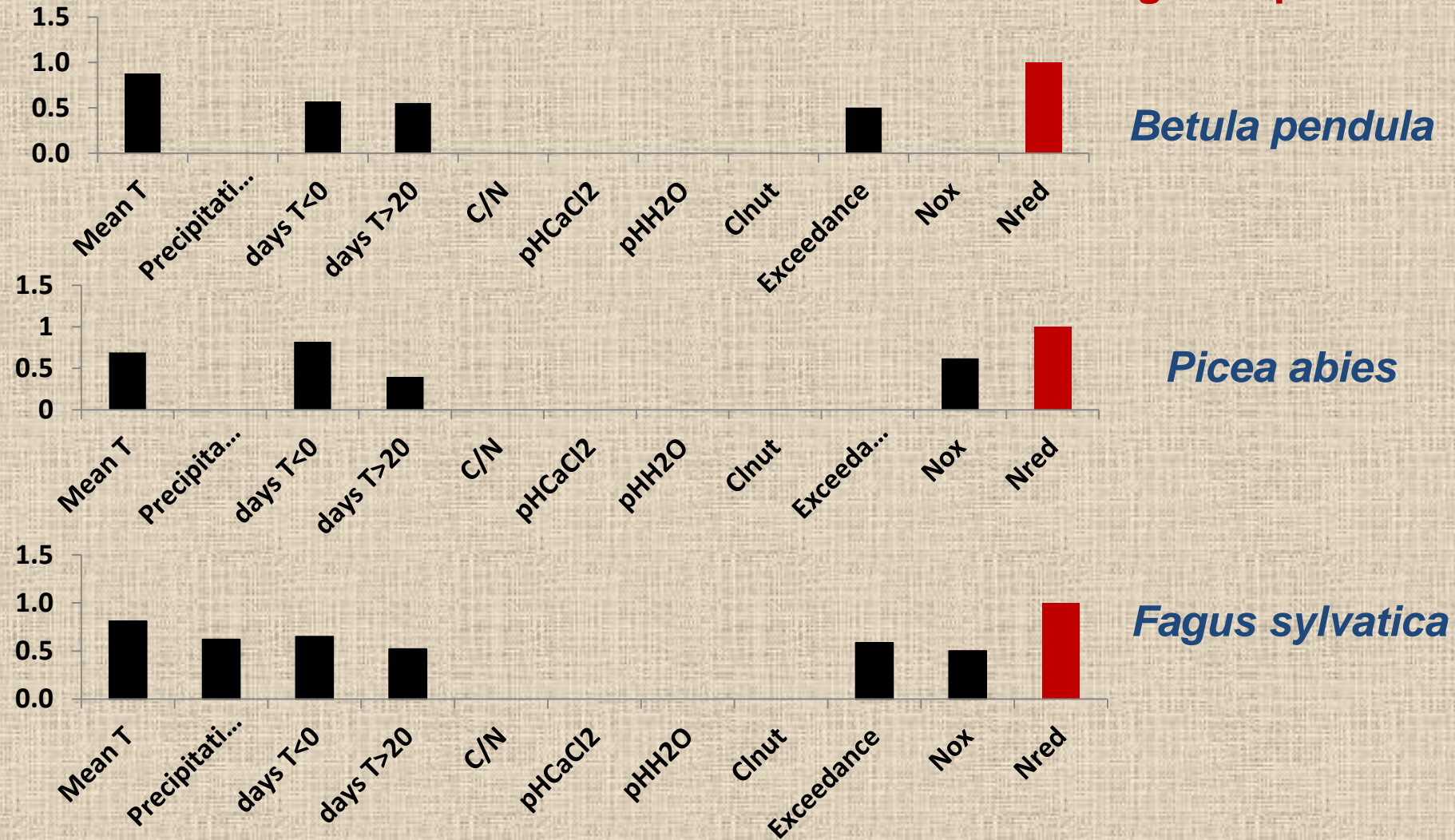
Building of a General Regression Model (non-linear model)



**Cross-validation of the models
(70% training set; 30% validation set)**

Random Forests Analysis

More sensitive to nitrogen deposition



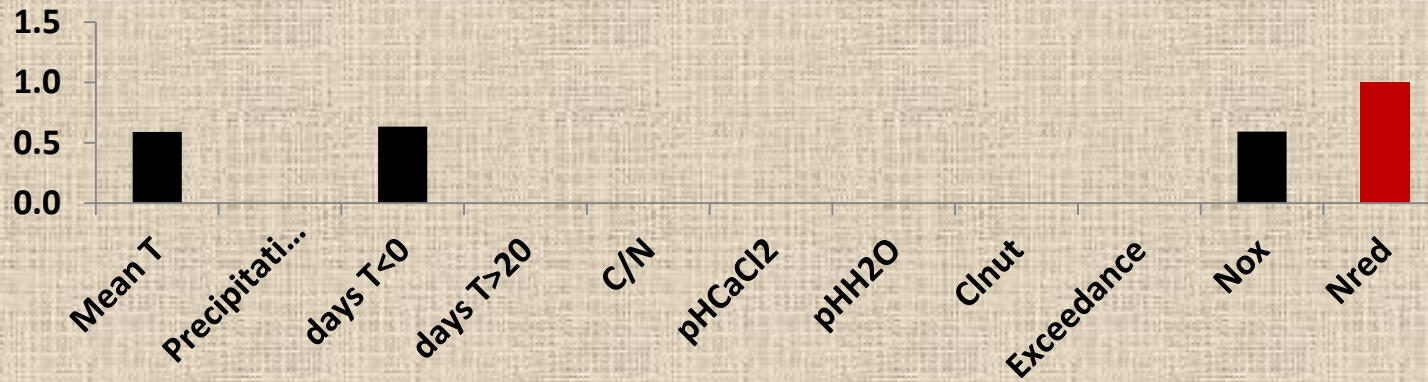
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Random Forests Analysis

More sensitive to nitrogen deposition



Pinus nigra

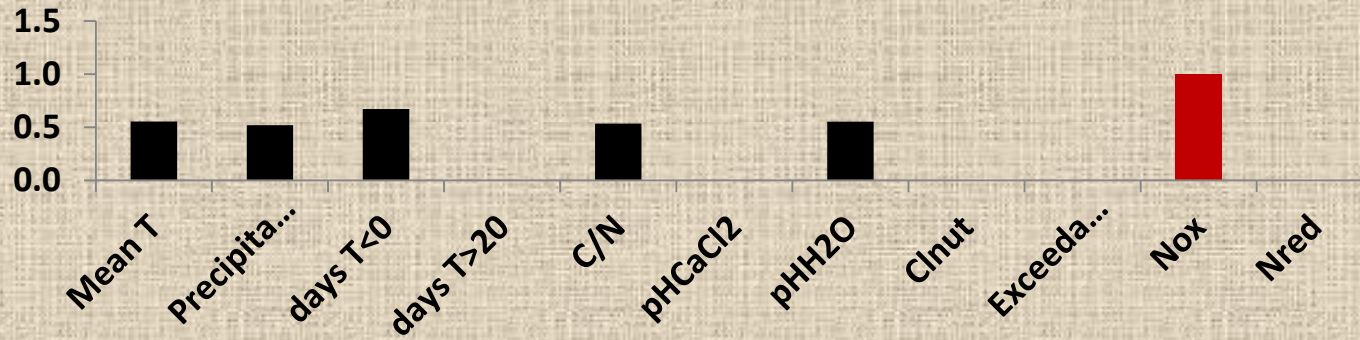


Pinus sylvestris

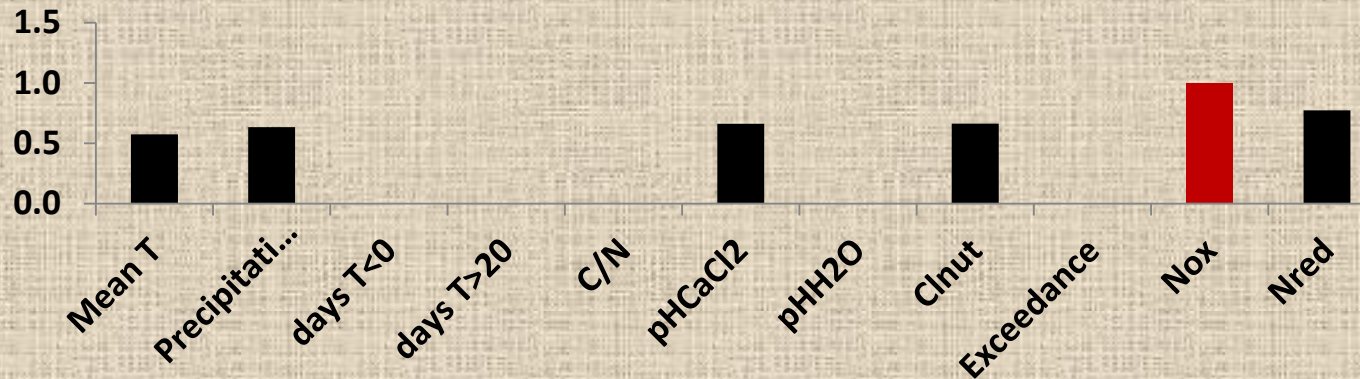
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Random Forests Analysis

More sensitive to nitrogen deposition



*Carpinus
betulus*



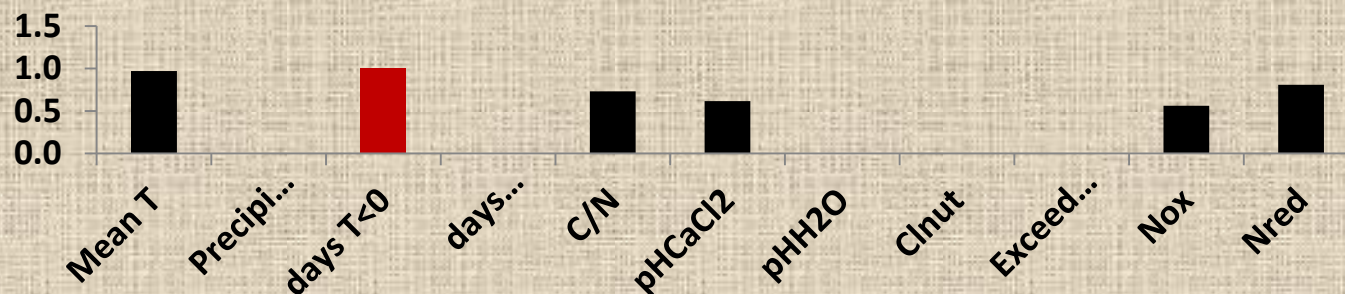
Quercus ilex

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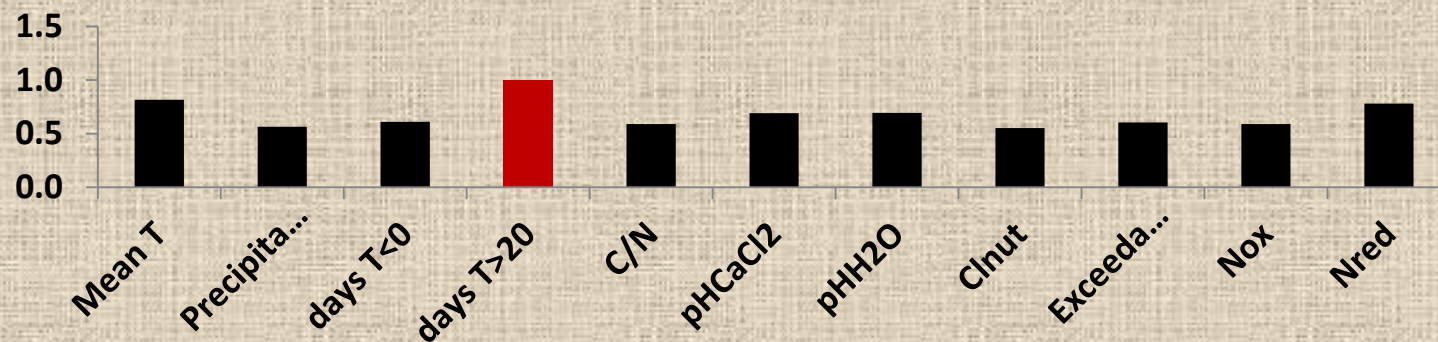
Random Forests Analysis

More sensitive to climatic predictors

*Fraxinus
excelsior*



*Castanea
sativa*



*Quercus
petraea*

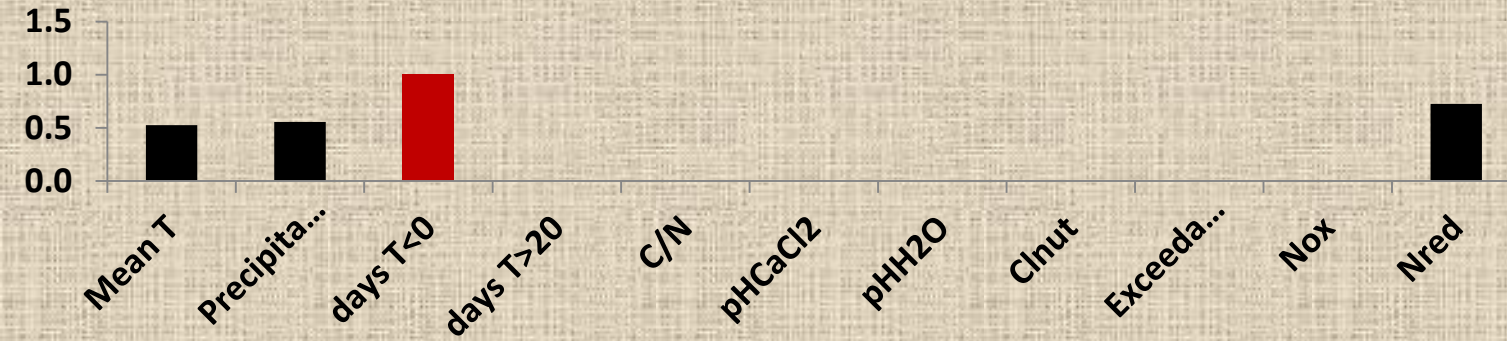


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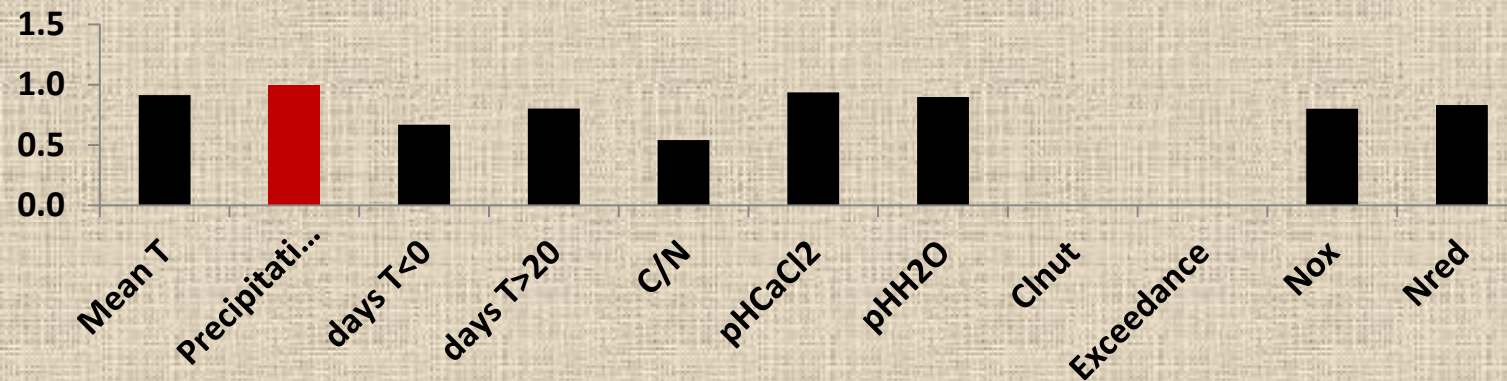
Random Forests Analysis

More sensitive to climatic predictors

*Quercus
robur*



*Quercus
pubescens*



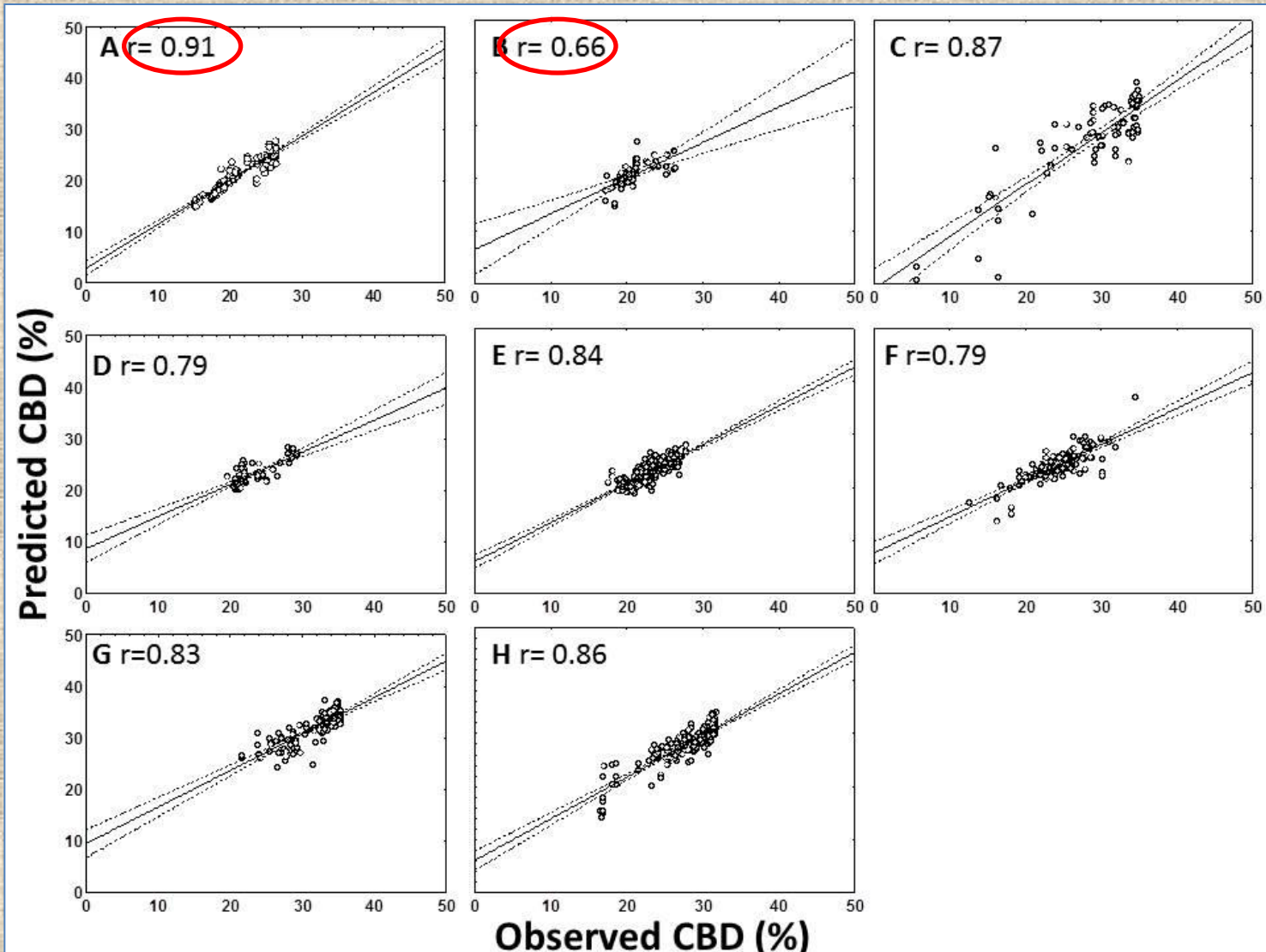
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12 statistical models: GRM models based on Response Surface Regression

<i>Quercus pubescens</i>							
Predictors	Parameter coeff.	S.E	p	Predictors	Parameter coeff.	S.E	p
Intercept	-2.89E+02	1.18E+02	0.015	Mean T*days T>20	5.41E-02	4.52E-02	0.233
Nred	-1.16E-02	2.35E-02	0.623	Nred*days T<0	-8.25E-05	1.16E-04	0.476
Nred^2	1.78E-06	1.51E-06	0.239	Nox*days T<0	-4.79E-04	2.13E-04	0.026
Nox	8.39E-02	4.31E-02	0.053	pHCaCl2*Days T<0	7.90E-02	1.97E-01	0.689
Nox^2	-7.88E-06	5.62E-06	0.162	pHH2O*Days T<0	-2.70E-02	2.09E-01	0.897
pHCaCl2	-7.10E+01	4.14E+01	0.088	C/N*Days T<0	-1.32E-02	7.67E-03	0.087
pHCaCl2^2	1.05E+01	4.10E+00	0.011	Precipitation*days T<0	-3.29E-01	1.50E-01	0.030
pHH2O	7.11E+01	4.50E+01	0.115	Mean T*days T<0	-1.63E-01	6.98E-02	0.021
pHH2O^2	1.07E+01	4.42E+00	0.016	days T>20*days T<0	4.60E-03	2.93E-03	0.118
C/N	9.96E-01	1.86E+00	0.594	Nox*Mean T	-2.22E-03	2.99E-03	0.459
C/N^2	8.36E-03	1.19E-02	0.484	pHCaCl2*Mean T	4.30E+00	2.78E+00	0.123
Precipitation	1.73E+02	3.99E+01	0.000	pHH2O*Mean T	-3.96E+00	2.98E+00	0.185
Precipitation^2	-1.64E+01	5.12E+00	0.002	C/N*Mean T	-2.85E-03	1.11E-01	0.980
Mean T	3.53E+01	1.48E+01	0.018	Precipitation*Mean T	-9.43E+00	2.73E+00	0.001
Mean T^2	-1.17E+00	5.21E-01	0.026	Nred*days T>20	-2.87E-05	6.42E-05	0.655
days T>20	-1.06E+00	6.80E-01	0.121	Nox*days T>20	1.44E-04	1.22E-04	0.240
days T>20^2	-7.34E-04	1.05E-03	0.484	pHCaCl2*days T>20	-1.60E-01	1.00E-01	0.112
days T<0	2.15E+00	9.20E-01	0.020	pHH2O*days T>20	1.51E-01	1.08E-01	0.165
days T<0^2	-2.15E-03	2.33E-03	0.357	C/N*days T>20	-7.79E-04	5.60E-03	0.889
Nred*Nox	8.59E-06	5.06E-06	0.091	<i>Quercus robur</i>			
Nred*pHCaCl2	-1.31E-03	3.69E-03	0.722	Predictors	Parameter coeff.	S.E	p
Nox*pHCaCl2	1.80E-02	6.26E-03	0.005	Intercept	-5.31E+01	2.79E+01	0.057
Nred*pHH2O	1.31E-03	3.89E-03	0.737	Nred	2.99E-03	5.71E-03	0.601
Nox*pHH2O	-1.99E-02	6.87E-03	0.004	Nred^2	-1.95E-06	3.68E-07	0.000
pHCaCl2*pHH2O	-2.12E+01	8.44E+00	0.013	Precipitation	3.02E+01	9.53E+00	0.002
Nred*C/N	1.37E-04	2.35E-04	0.560	Precipitation^2	-3.82E+00	1.34E+00	0.005
Nox*C/N	-5.75E-04	4.16E-04	0.168	Mean T	1.00E+01	3.63E+00	0.006
pHCaCl2*C/N	4.05E-01	4.90E-01	0.410	Mean T^2	-2.96E-01	1.22E-01	0.015
pHH2O*C/N	-4.15E-01	5.36E-01	0.439	days T<0	9.83E-01	2.73E-01	0.000
Nred*Precipitation	6.41E-03	5.69E-03	0.261	days T<0^2	-5.65E-03	7.42E-04	0.000
Nox*Precipitation	-2.42E-02	9.16E-03	0.009	Nred*Precipitation	2.89E-03	1.44E-03	0.046
pHCaCl2*Precipitation	2.27E+01	6.94E+00	0.001	Nred*Mean T	-5.42E-06	3.55E-04	0.988
pHH2O*Precipitation	-2.56E+01	7.38E+00	0.001	Precipitation*Mean T	-2.46E+00	5.74E-01	0.000
C/N*Precipitation	-3.20E-01	3.10E-01	0.303	Nred*days T<0	2.49E-05	2.70E-05	0.358
Nred*Mean T	-4.05E-04	1.75E-03	0.817	Precipitation*days T<0	1.87E-02	4.11E-02	0.649
Precipitation*days T>20	4.96E-01	1.40E-01	0.000	Mean T*days T<0	-5.84E-02	1.80E-02	0.001

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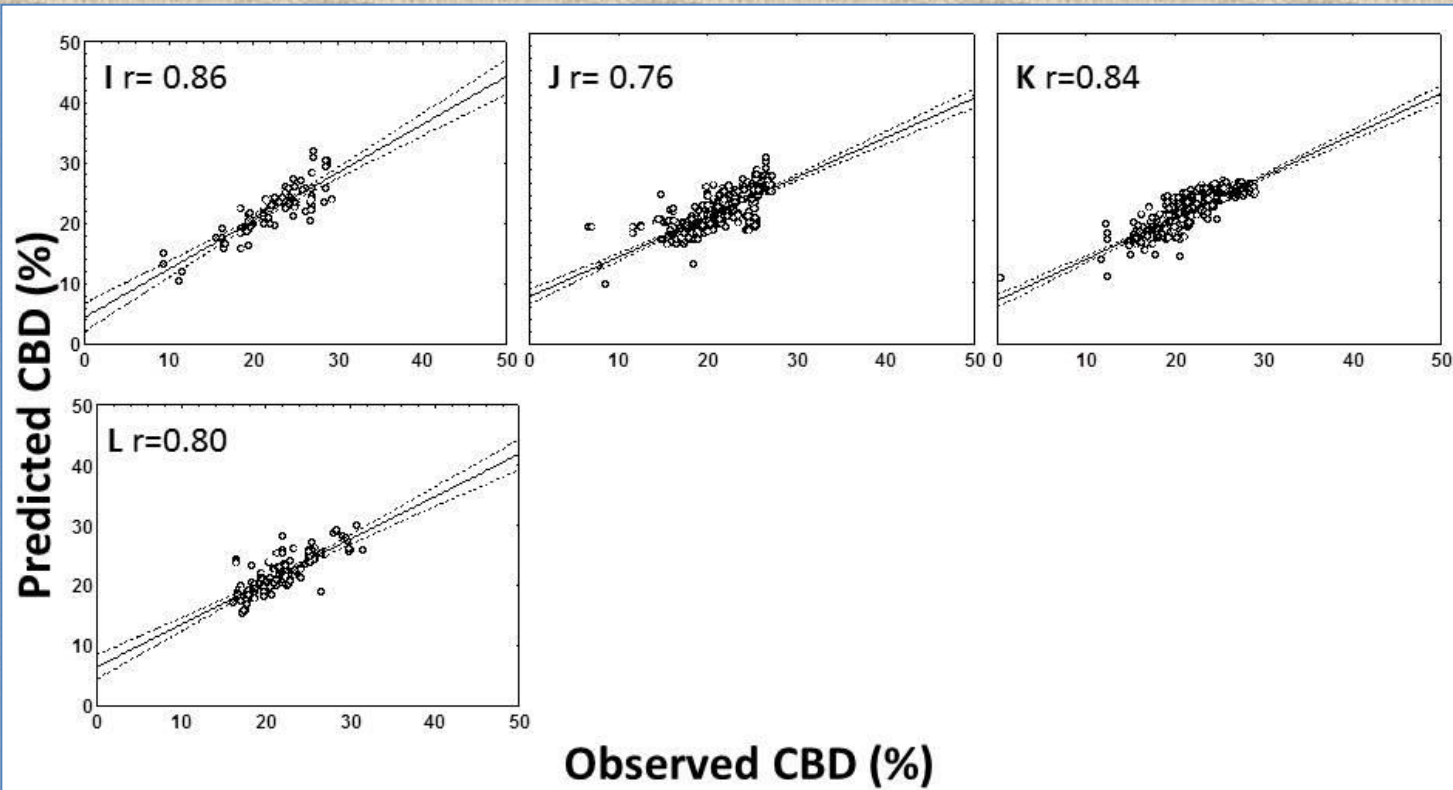
Cross Validation



A: *B. pendula*
B: *C. betulus*
C: *C. sativa*
D: *F. excelsior*
E: *F. sylvatica*
F: *Q. petraea*
G: *Q. pubescens*
H: *Q. robur*

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Cross Validation



I: *P. nigra*
J: *P. sylvestris*
K: *P. abies*
L: *Q. ilex*

Representative Concentration Pathways (RCP) scenarios

The RCPs are named according to their 2100 radiative forcing level

(Representative
Concentration Pathway)

2.6



(3W/m², 2100)

(Representative
Concentration Pathway)

4.5



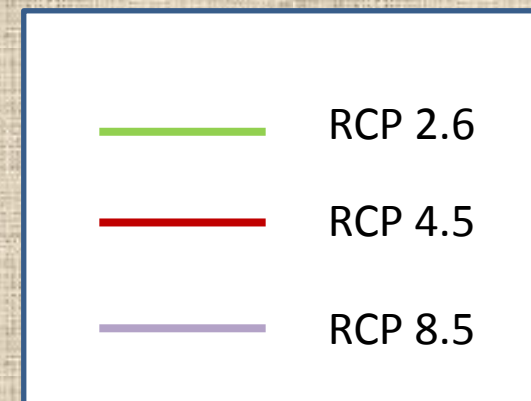
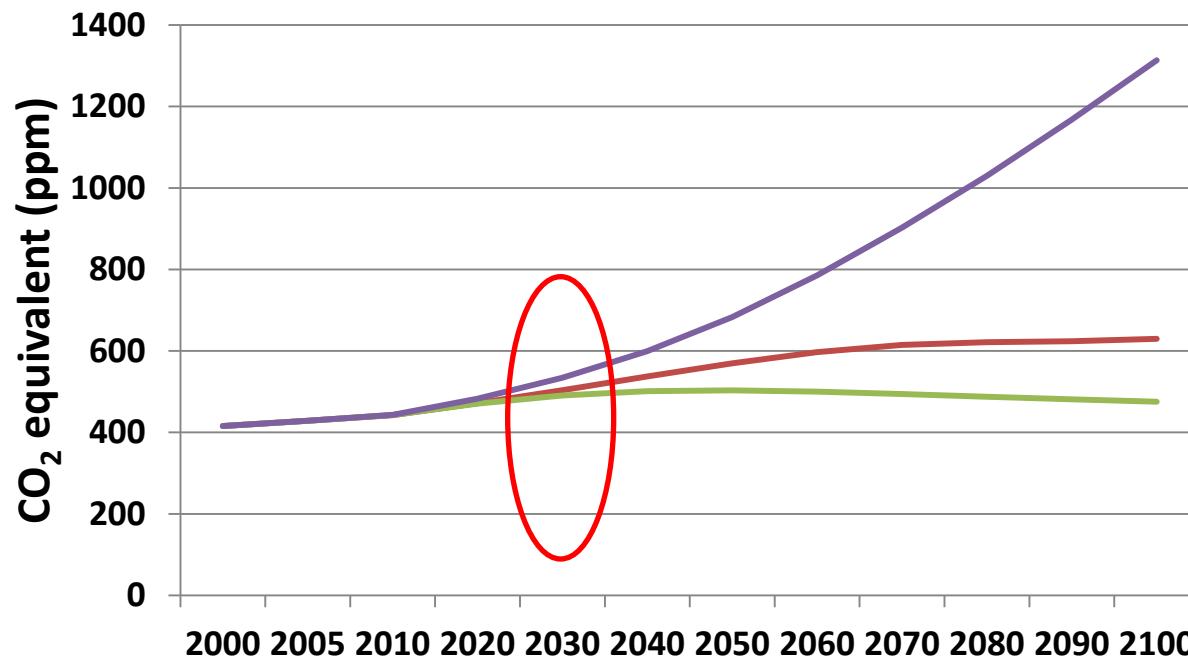
(4.5W/m², 2100)

(Representative
Concentration Pathway)

8.5



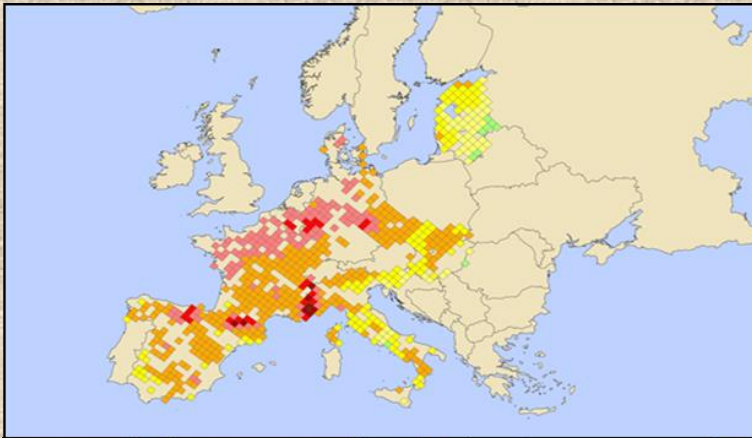
(8.5W/m², 2100)



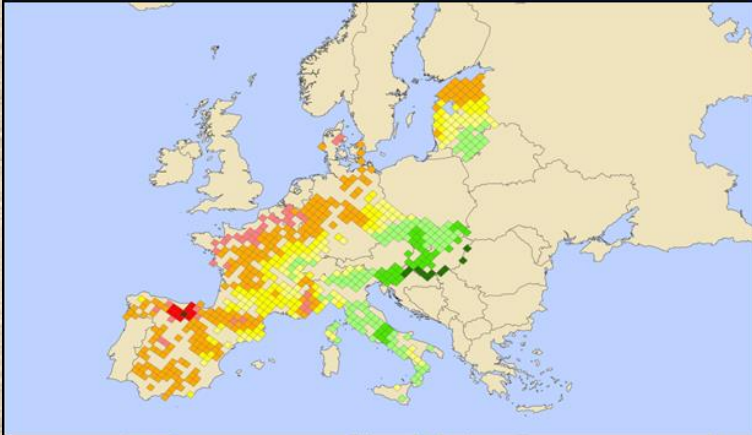
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Three climate change scenarios,
2030
(mean annual temperature)

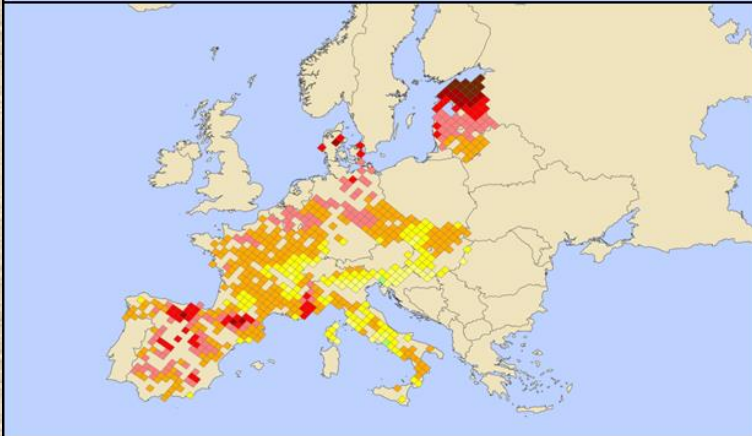
T mean Rcp 2.6



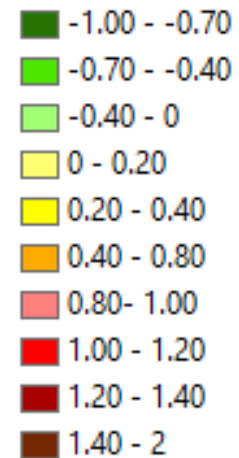
T mean Rcp 4.5



T mean Rcp 8.5

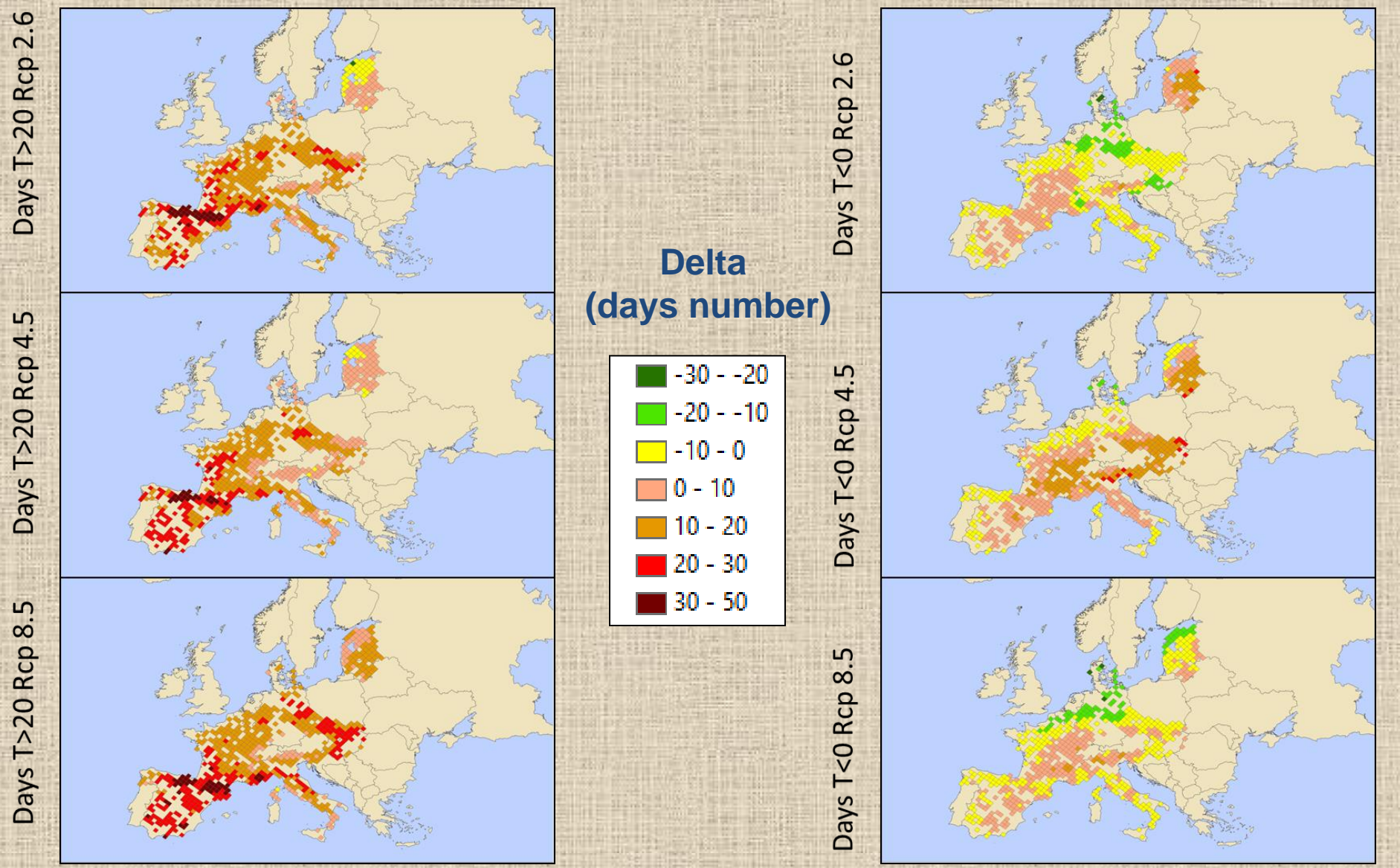


Delta (°C)



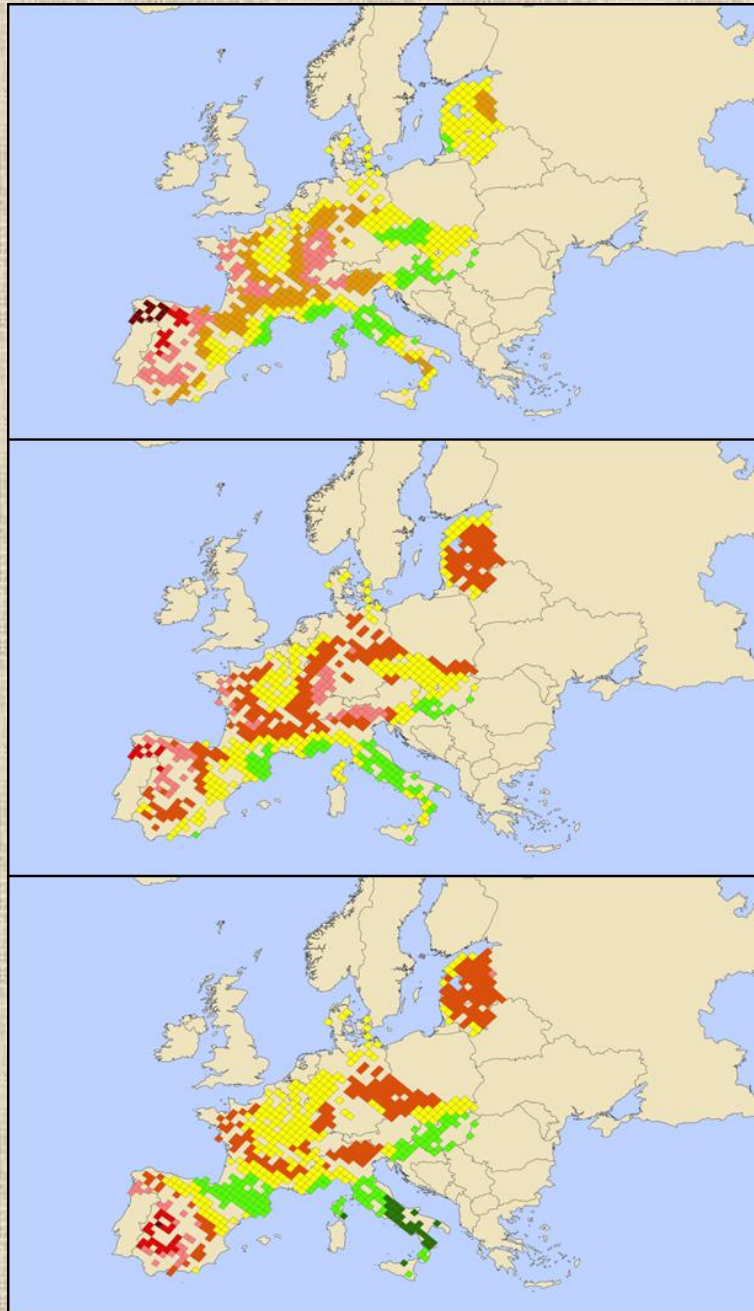
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Three climate change scenarios, 2030 (number days $T > 20$; number days $T < 0$)



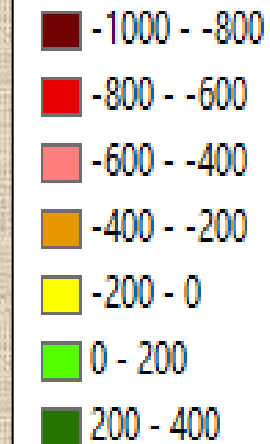
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Precipitation Rcp 8.5 Precipitation Rcp 4.5 Precipitation Rcp 2.6



Three climate change scenarios,
2030 (total annual precipitation)

Delta (mm)

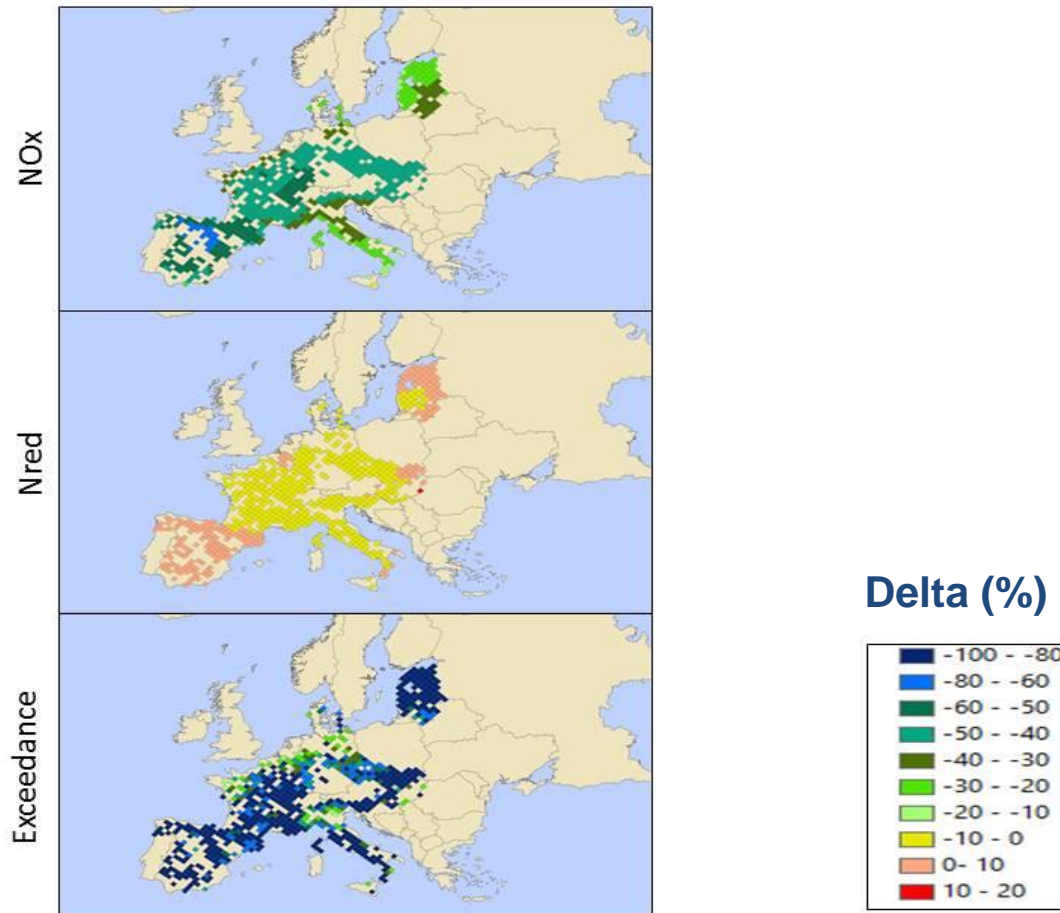


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Air pollution scenario

GAINS Europe model (http://gains.iiasa.ac.at/Goth_data)

Pollution data was derived by the PRIMES Model. This model determines parameters like emission factors and rates of abatement technologies based on market economics, industry structure, energy/environmental policies as implemented in the European community by April 2009.



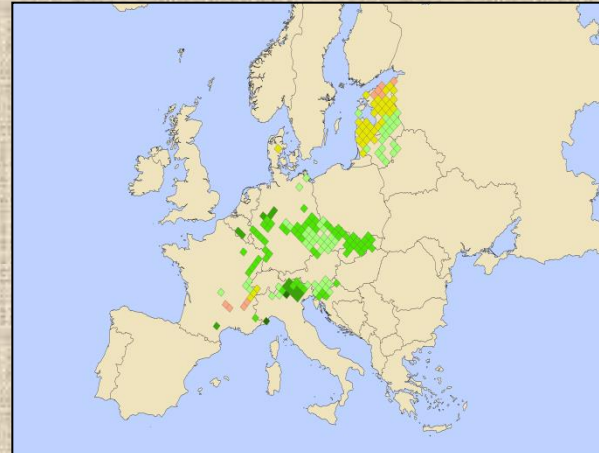
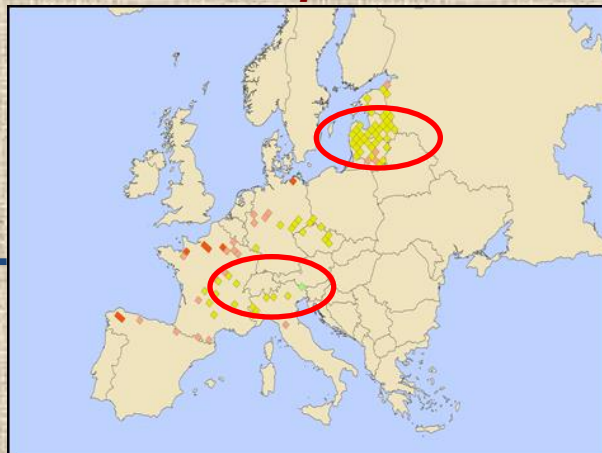
**Change in N
deposition
and
exceedance**

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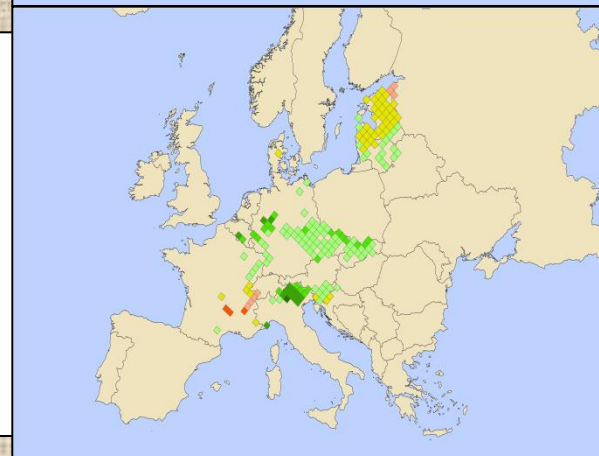
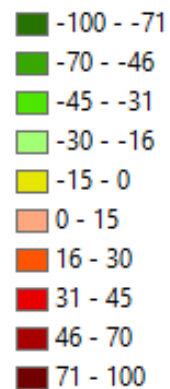
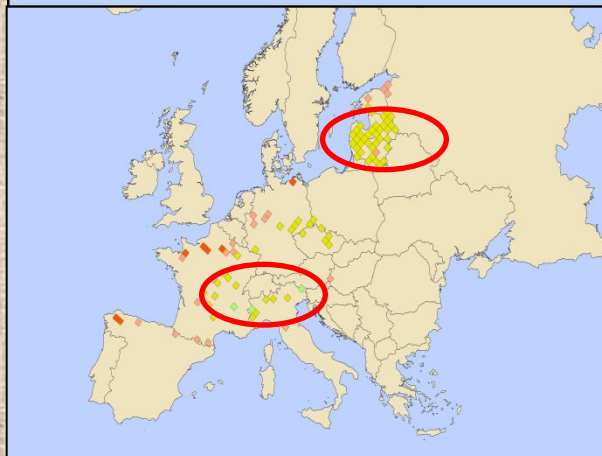
Betula pendula

Picea abies

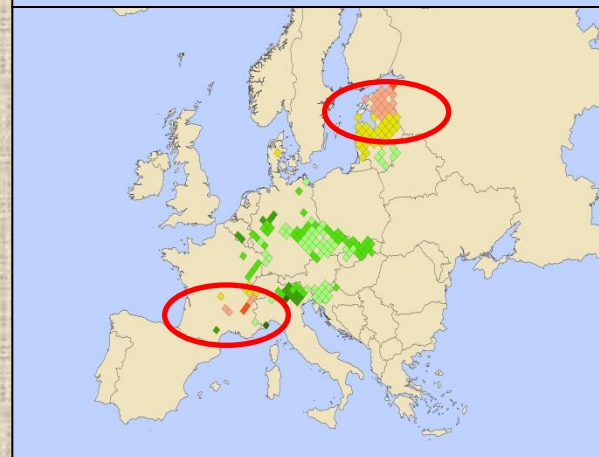
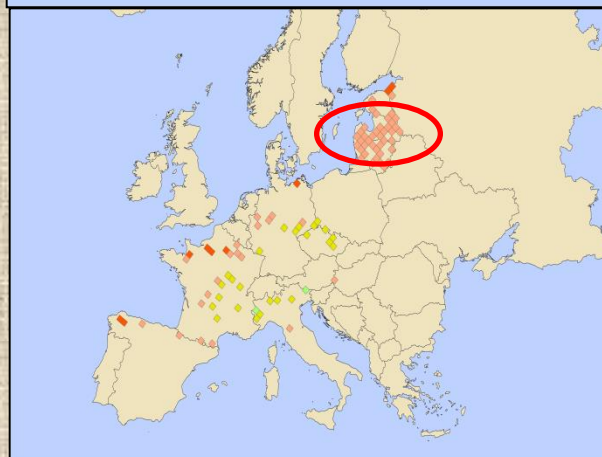
Rcp 2.6



Rcp 4.5



Rcp 8.5

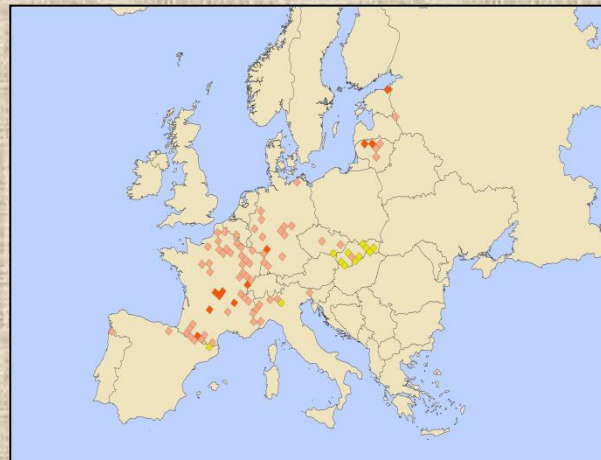


Delta % of
defoliation (2030-
actual defoliation)
considering air
pollution scenario
and three different
climate scenarios

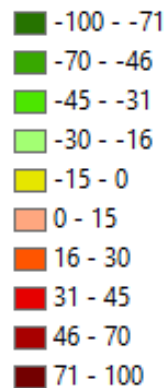
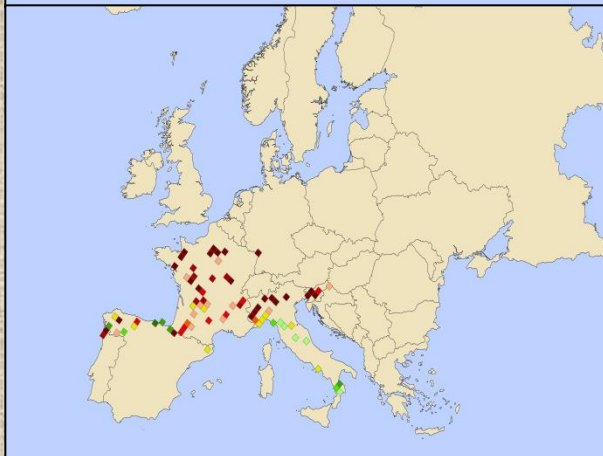
Castanea sativa

Fraxinus excelsior

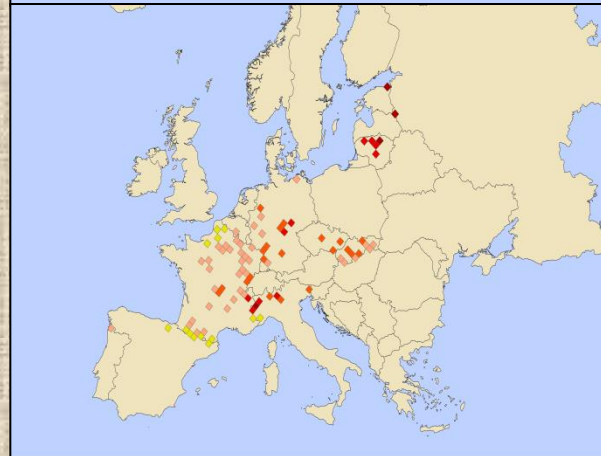
Rcp 2.6



Rcp 4.5



Rcp 8.5

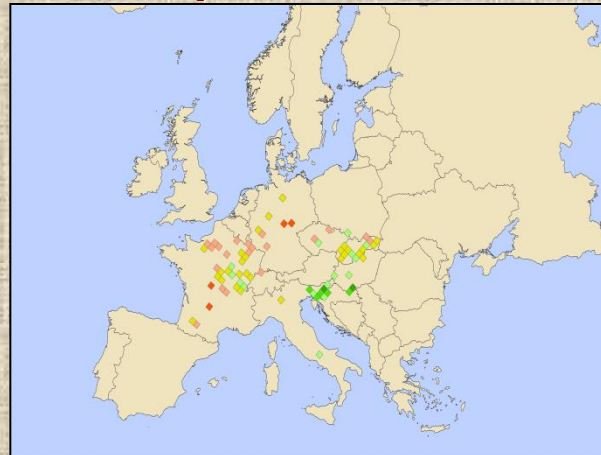
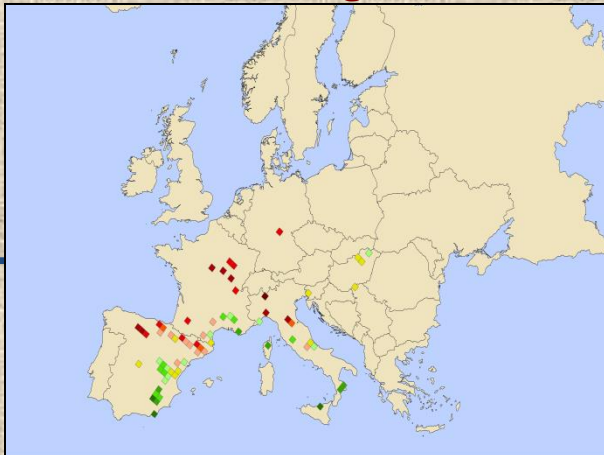


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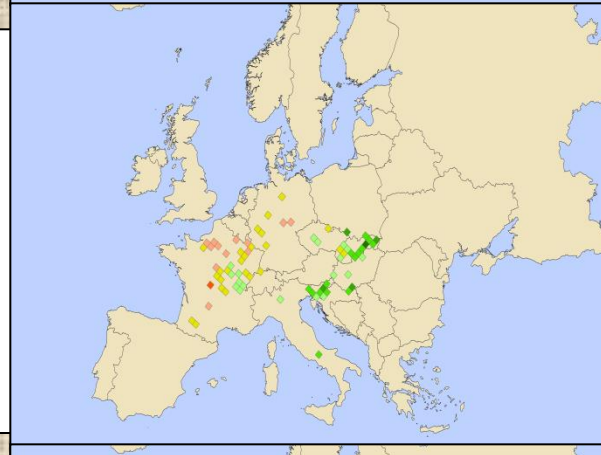
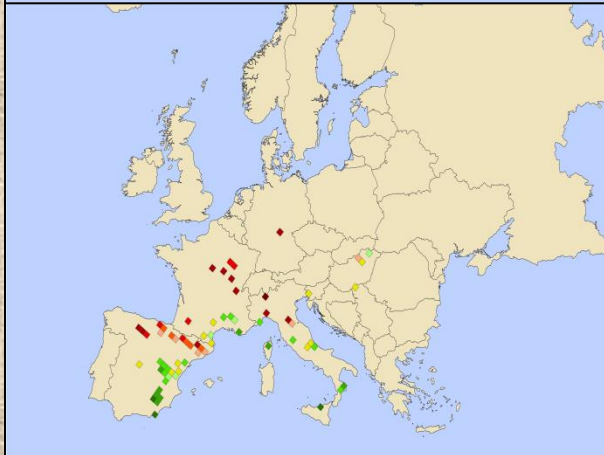
Pinus nigra

Carpinus betulus

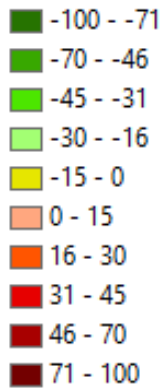
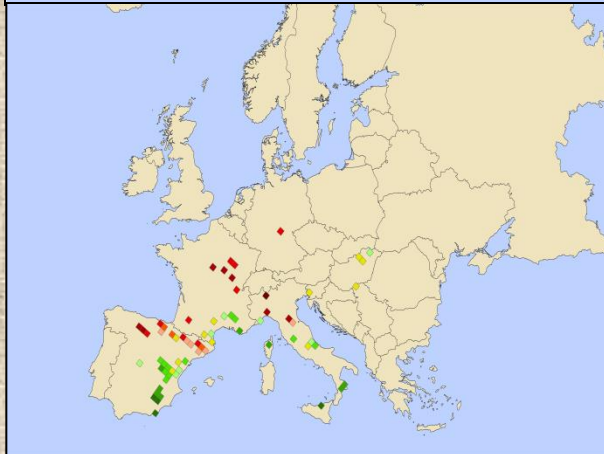
Rcp 2.6



Rcp 4.5



Rcp 8.5

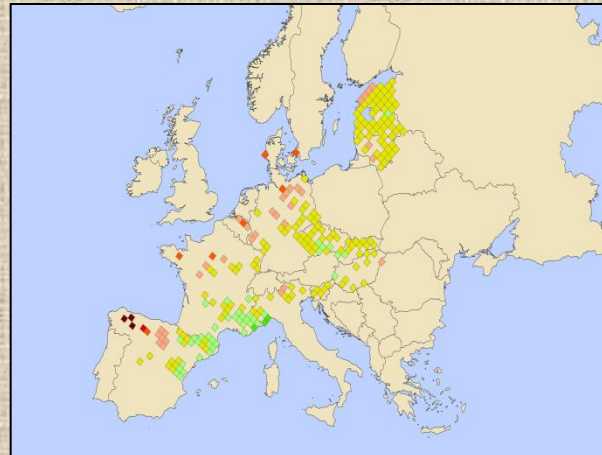
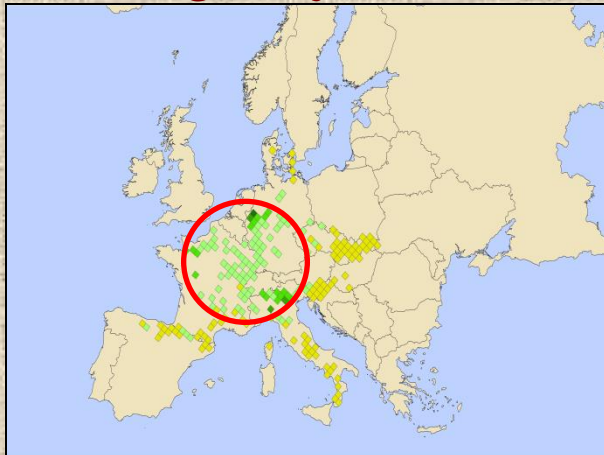


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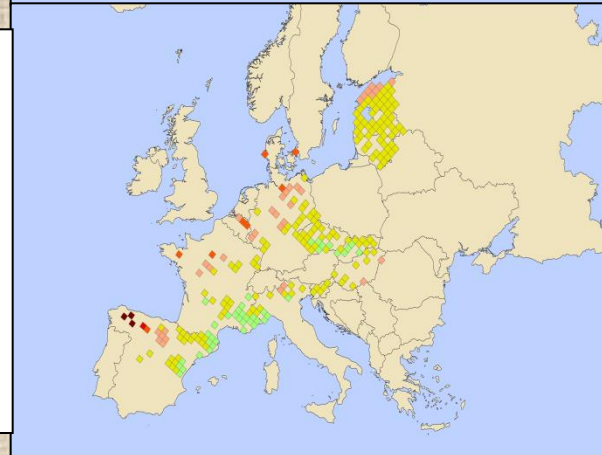
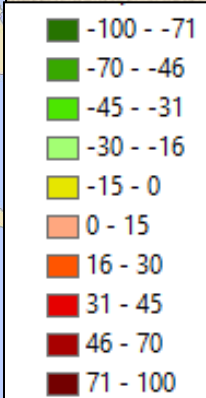
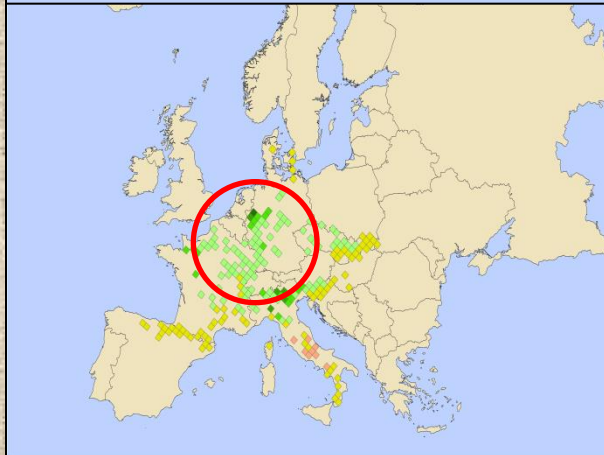
Fagus sylvatica

Pinus sylvestris

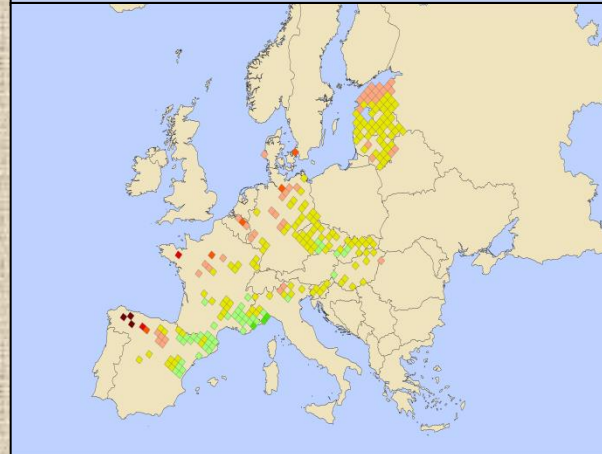
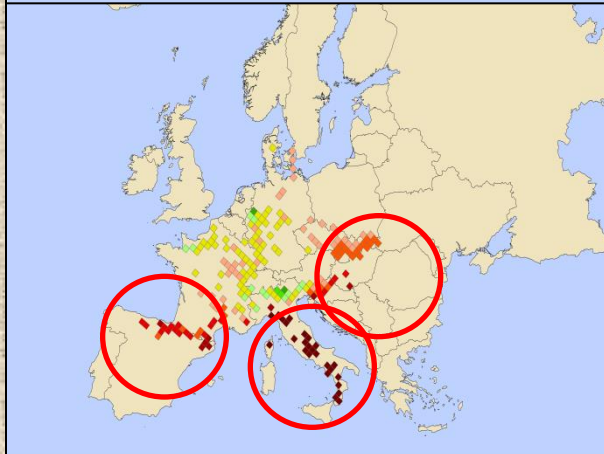
Rcp 2.6



Rcp 4.5



Rcp 8.5

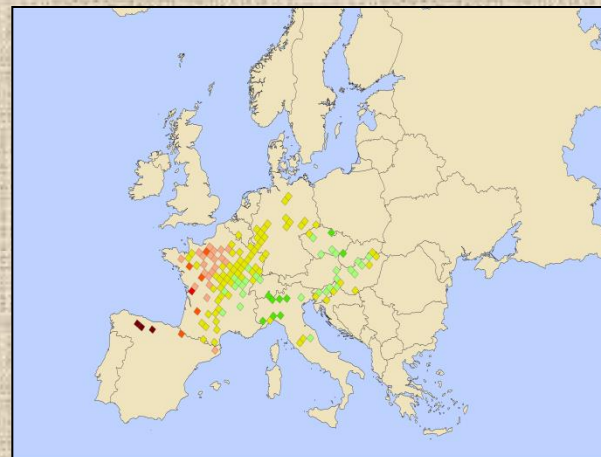
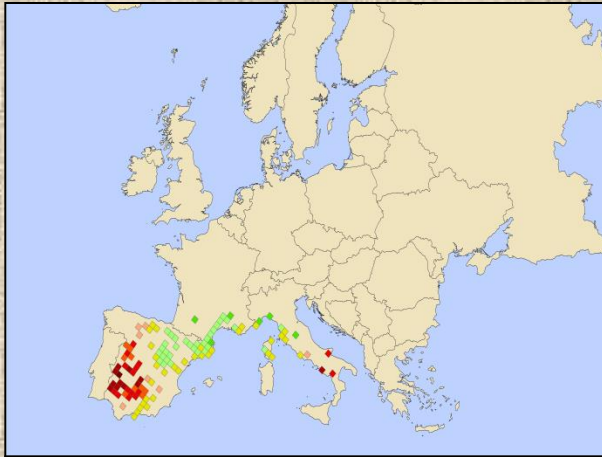


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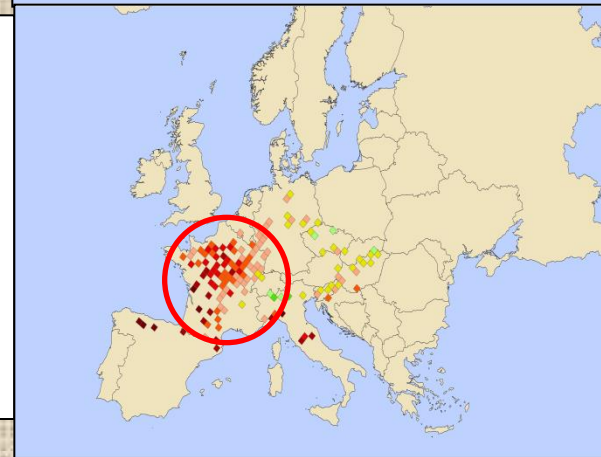
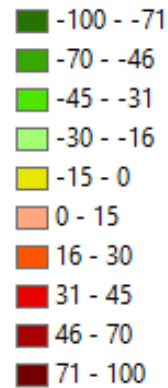
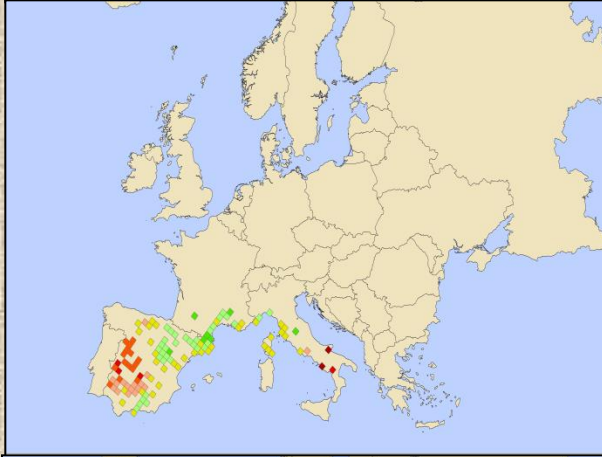
Quercus ilex

Quercus petraea

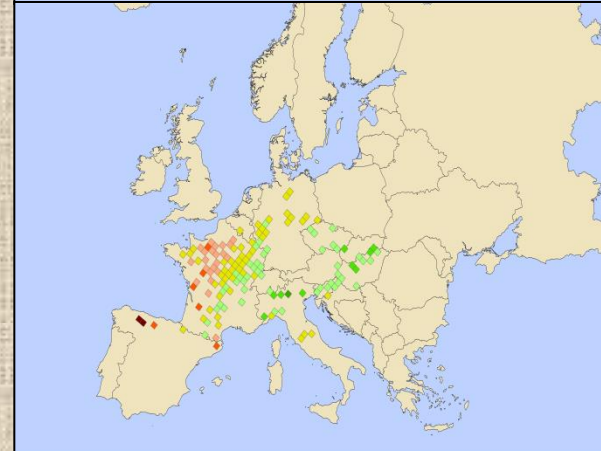
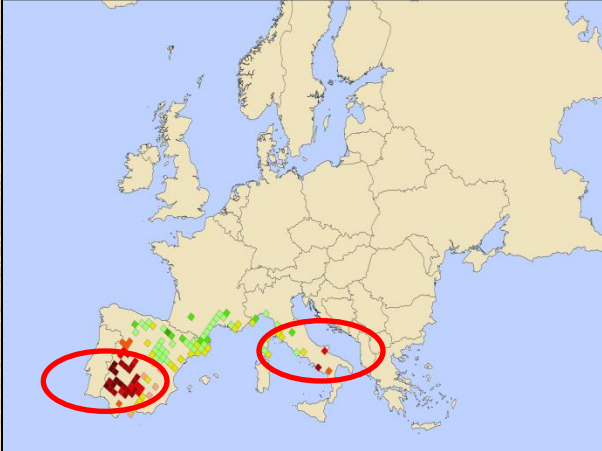
Rcp 2.6



Rcp 4.5



Rcp 8.5

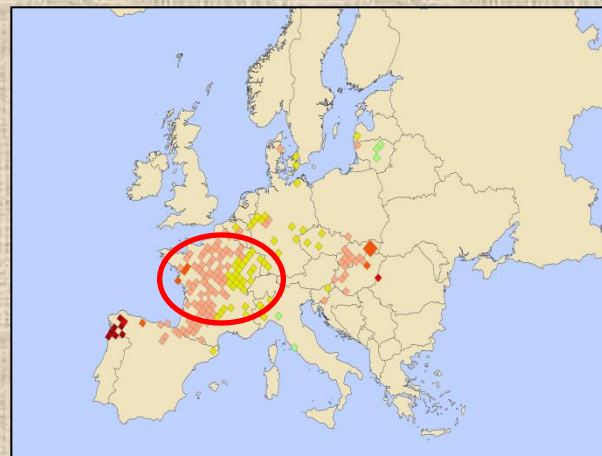
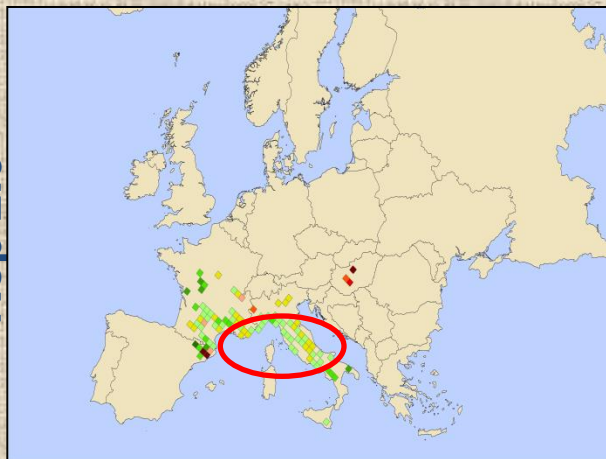


Delta % of
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considering air
pollution scenario
and three different
climate scenarios

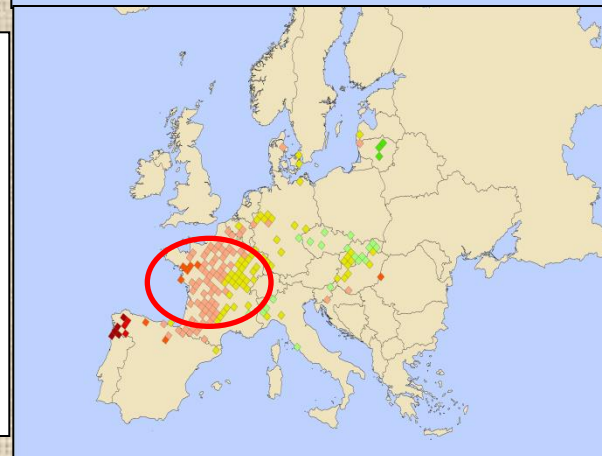
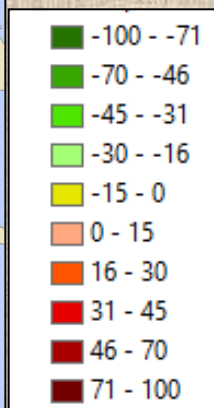
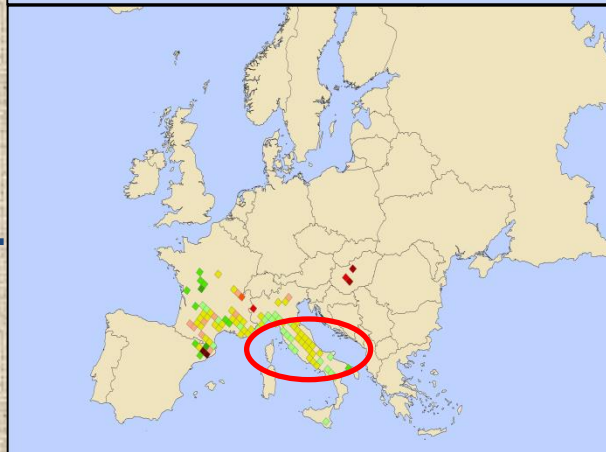
Quercus pubescens

Quercus robur

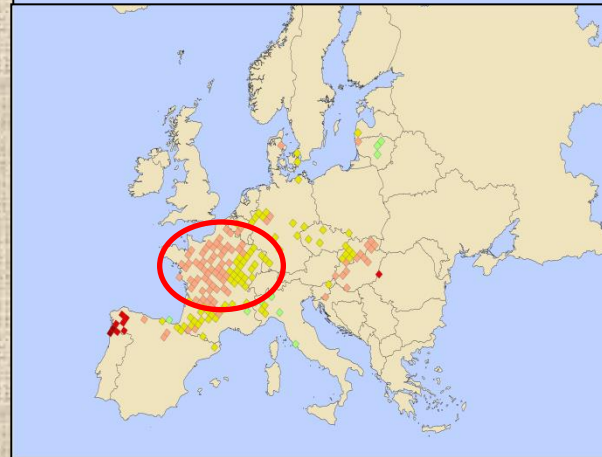
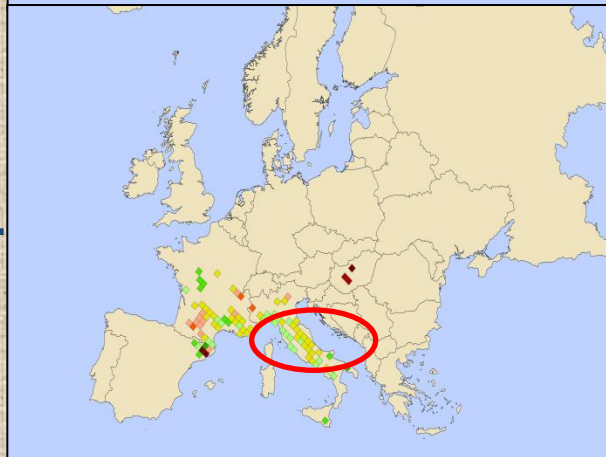
Rcp 2.6



Rcp 4.5

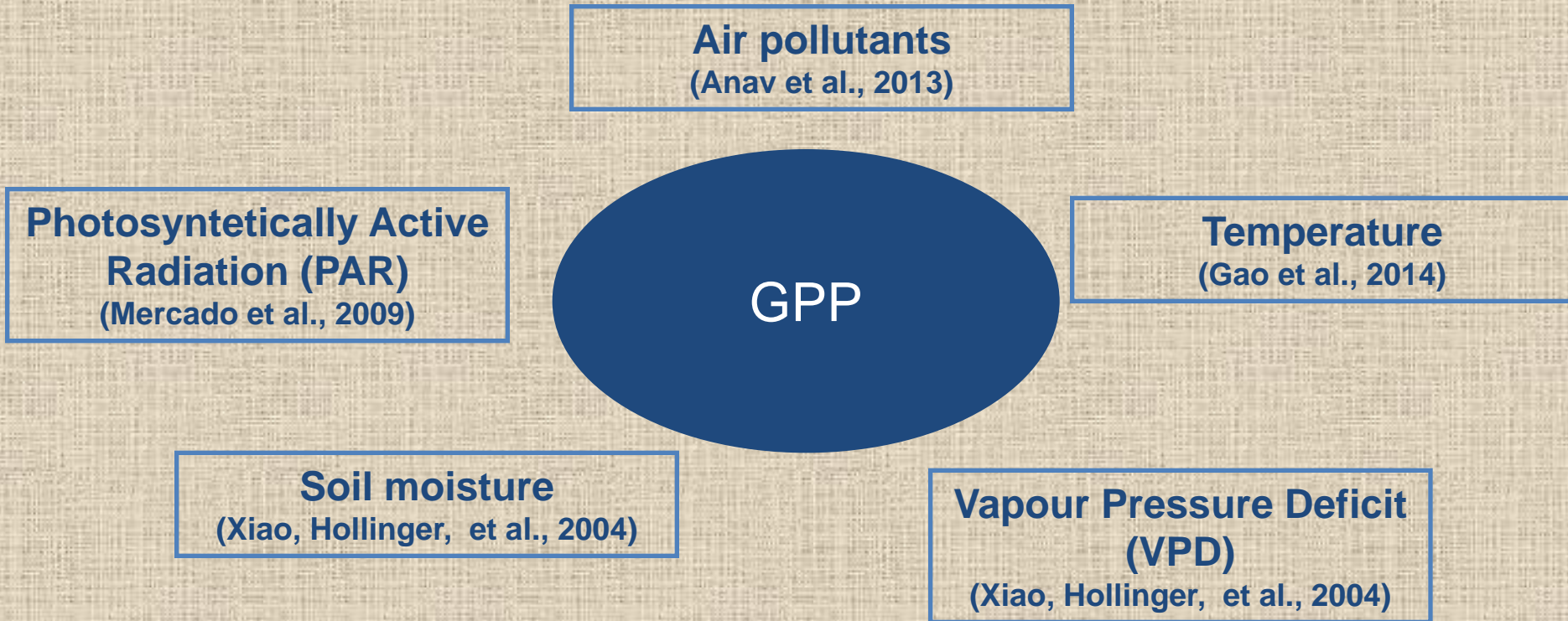


Rcp 8.5



Delta % of
defoliation (2030-
actual defoliation)
considering air
pollution scenario
and three different
climate scenarios

What are the most relevant factors affecting GPP at a European scale?



The impacts of climate change and air pollution on forest health condition

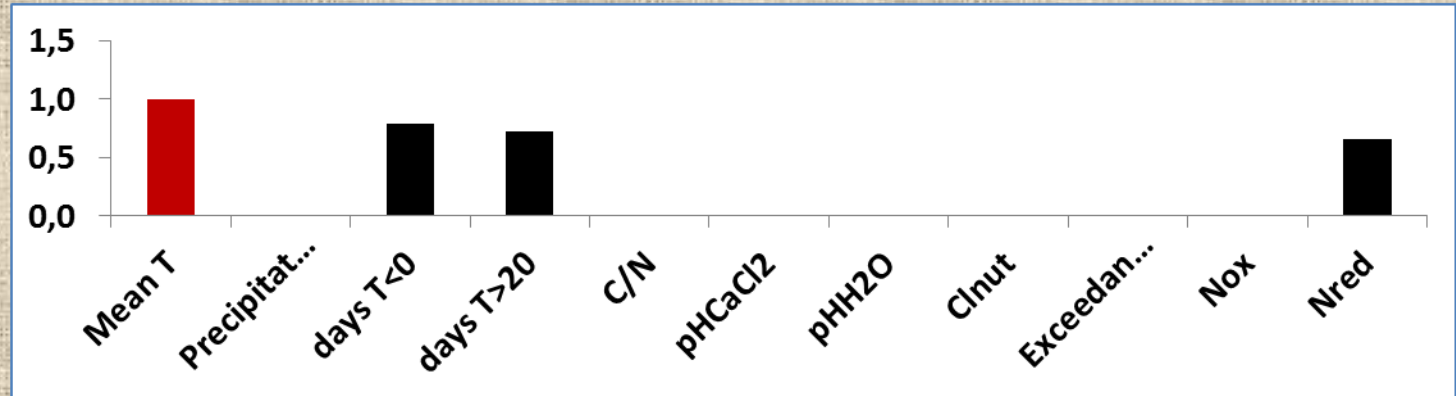
Preliminary results

What are the most relevant factors affecting Gross Primary Production (GPP) at a European scale?

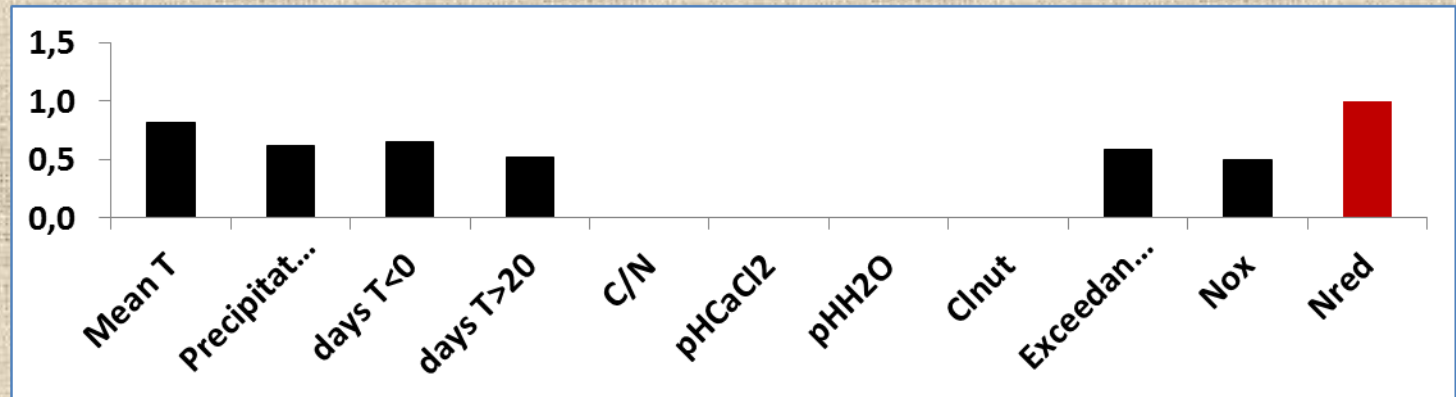
Fagus sylvatica

Random Forests Analysis

GPP



Defoliation



The impacts of climate change and air pollution on forest health condition

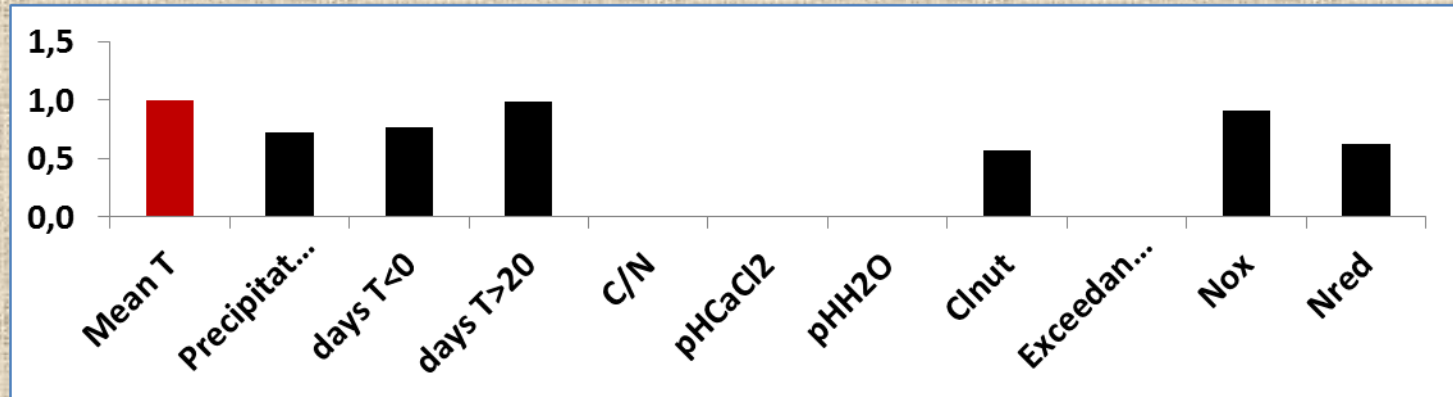
Preliminary results

What are the most relevant factors affecting Gross Primary Production (GPP) at a European scale?

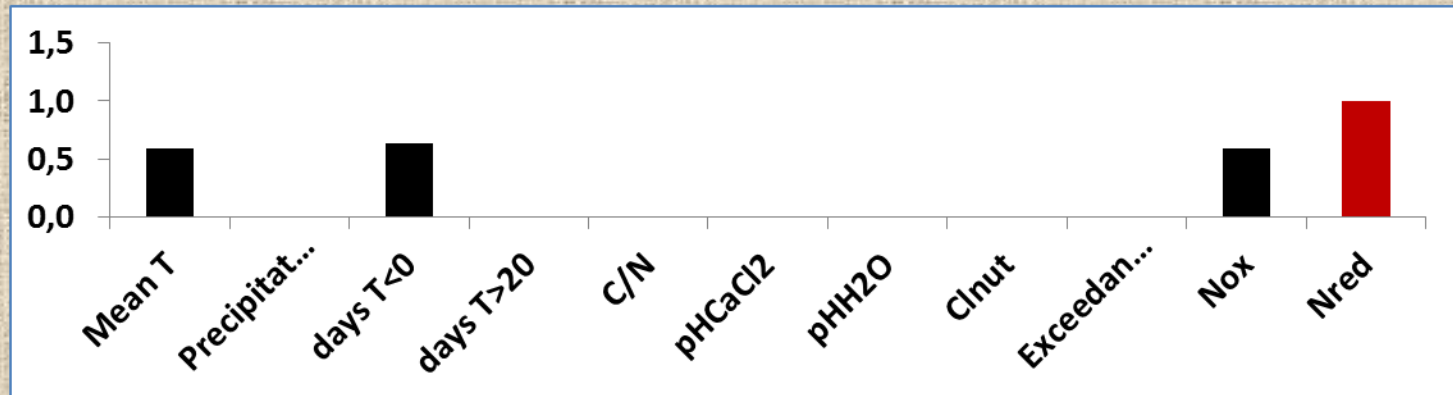
Pinus sylvestris

Random Forests Analysis

GPP



Defoliation



The impacts of climate change and air pollution on forest health condition

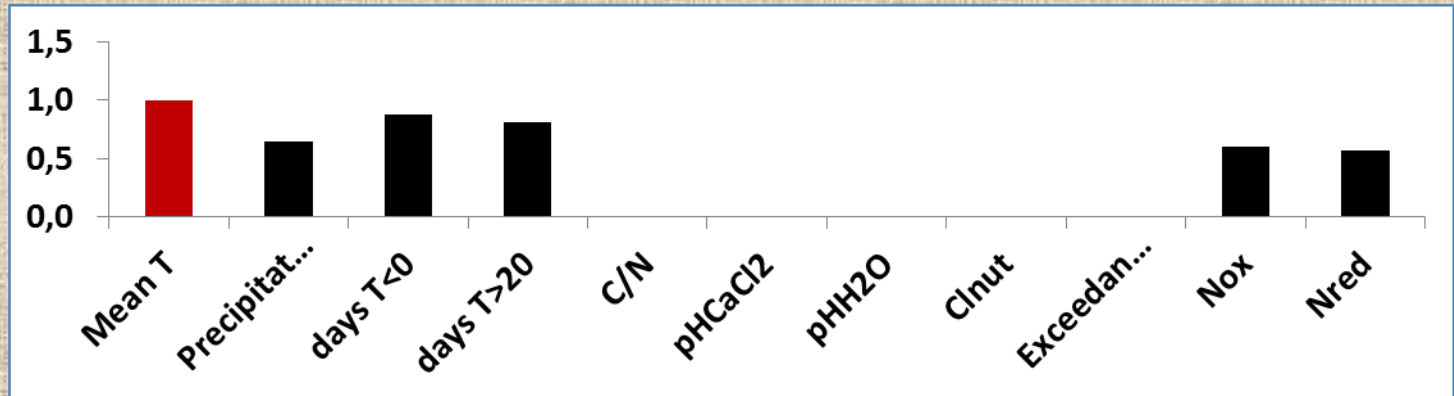
Preliminary results

What are the most relevant factors affecting Gross Primary Production (GPP) at a European scale?

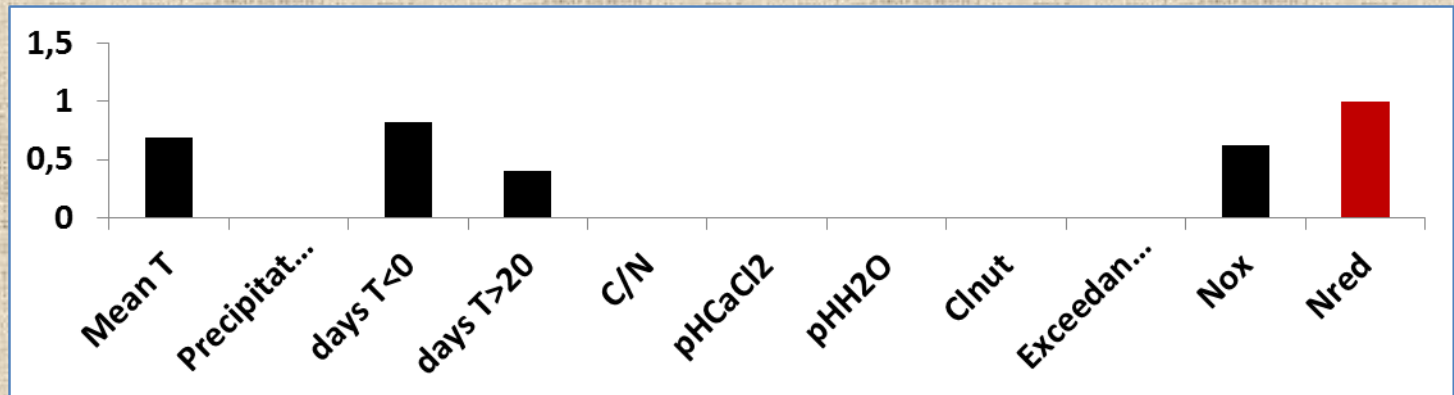
Picea abies

Random Forests Analysis

GPP



Defoliation



The impacts of climate change and air pollution on forest health condition

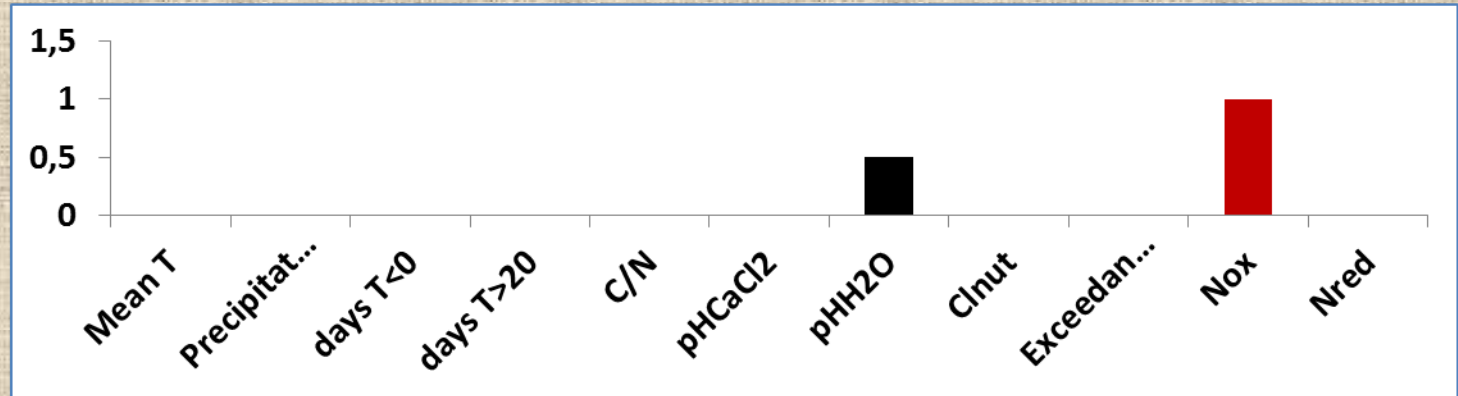
Preliminary results

What are the most relevant factors affecting Gross Primary Production (GPP) at a European scale?

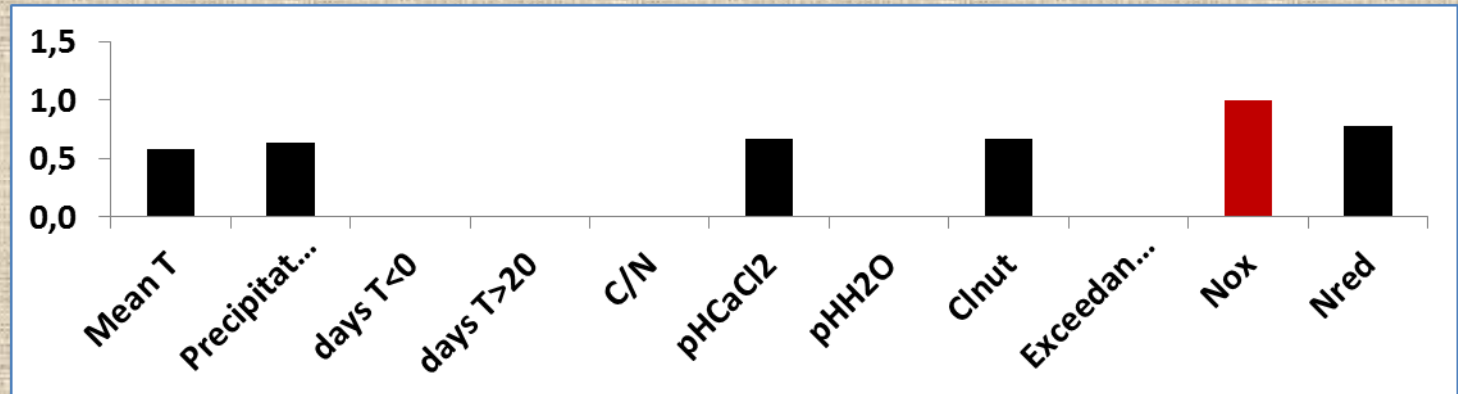
Quercus ilex

Random Forests Analysis

GPP



Defoliation



The impacts of climate change and air pollution on forest health condition

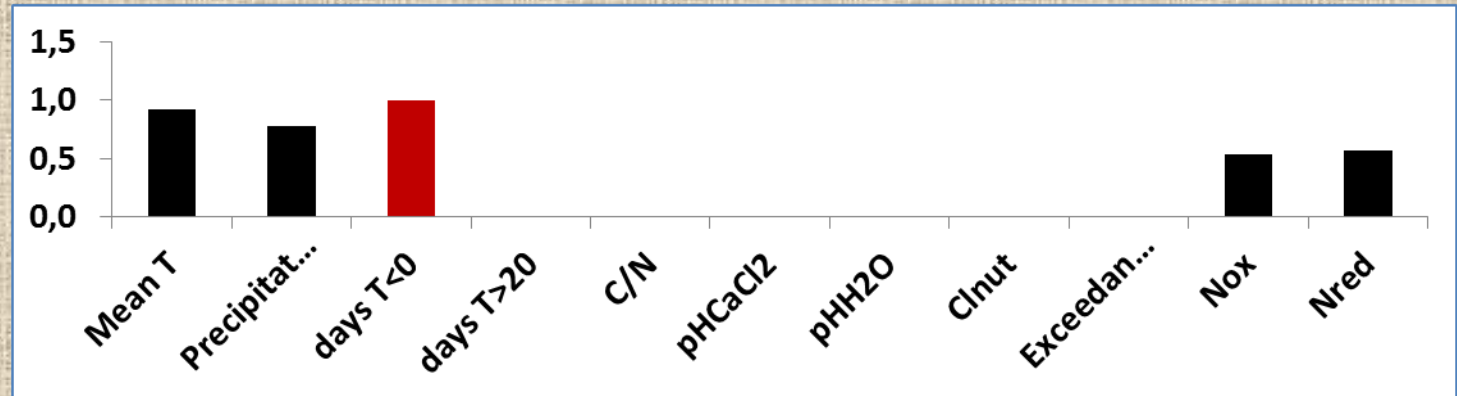
Preliminary results

What are the most relevant factors affecting Gross Primary Production (GPP) at a European scale?

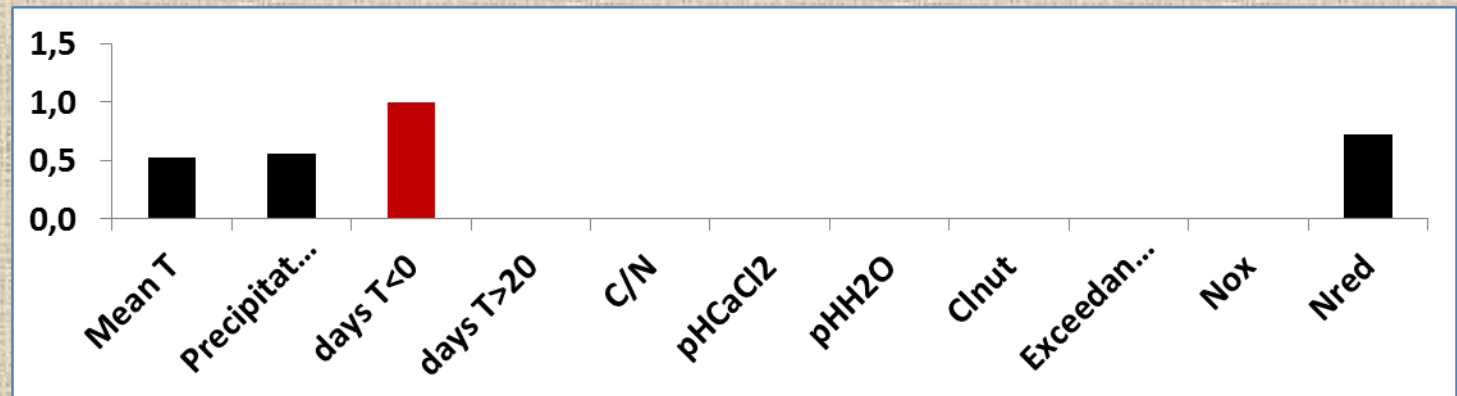
Quercus robur

Random Forests Analysis

GPP



Defoliation



The impacts of climate change and air pollution on forest health condition

Conclusions

Random Forests Analysis and GRM are useful tools to estimate the crown defoliation at European scale.

Nitrogen deposition seems to be generally more important than nutrient nitrogen critical loads exceedances in affecting crown defoliation.

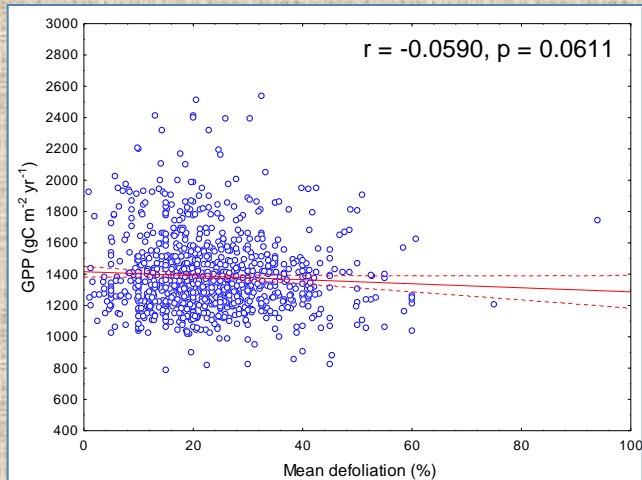
Climate change and air pollution scenarios showed a decrease in defoliation in some areas, and an increase in others and this is species-specific.

Climatic parameters seems to be generally more important than nitrogen depositions in affecting GPP.

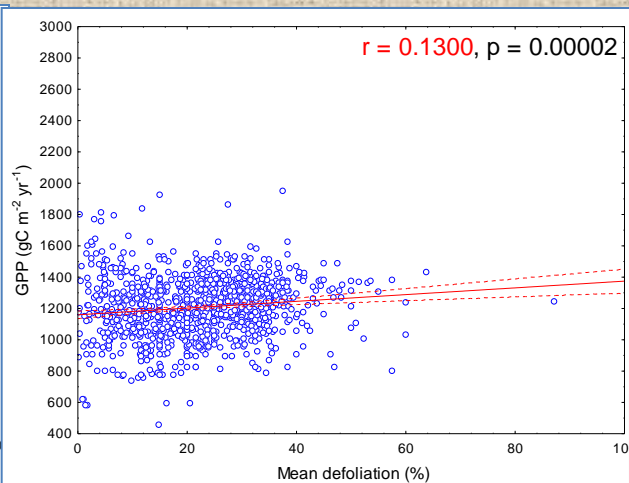
Relationships between crown defoliation and GPP should be further investigated.

Thank you

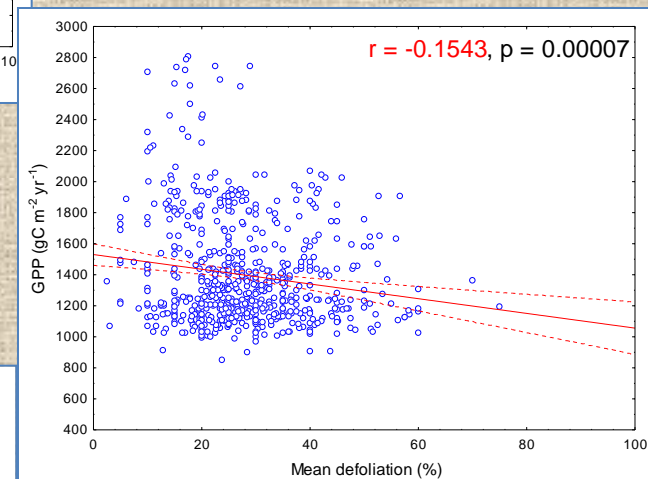
Fagus sylvatica



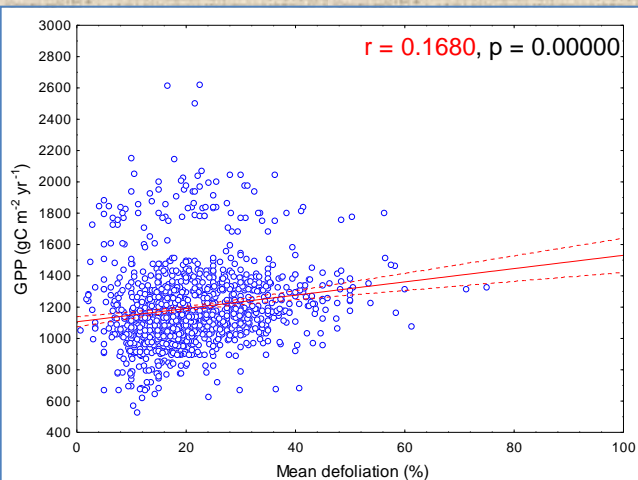
Picea abies



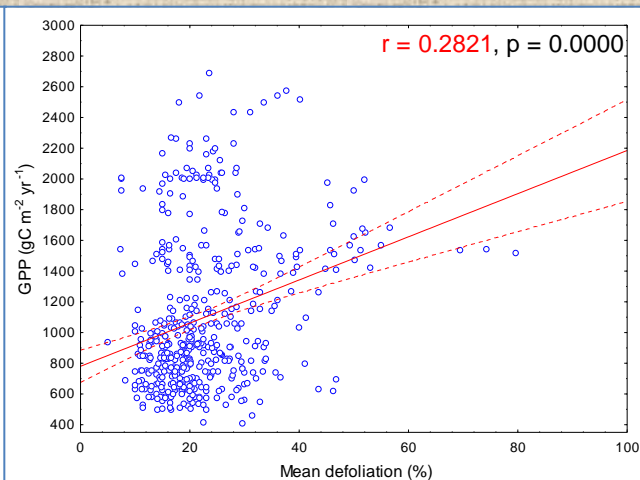
Quercus robur



Pinus sylvestris



Quercus ilex



The impacts of climate change and air pollution on forest health condition