Etat de connaissances autour de la phénologie pour la filière forêt

Le hêtre du Ventoux

Int J Biometeorol
DOI 10.1007/s00484-012-0560-8

ORIGINAL PAPER

One man, 73 years, and 25 species. Evaluating phenological responses using a lifelong study of first flowering dates

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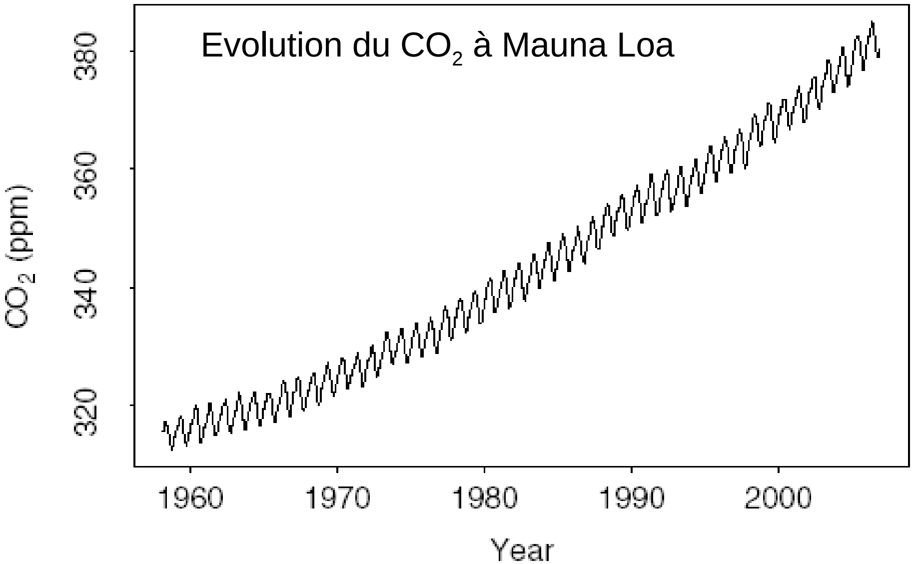
Importance de la phénologie

Indicateur des changements environnementaux

Détermine la saison de croissance et donc la croissance

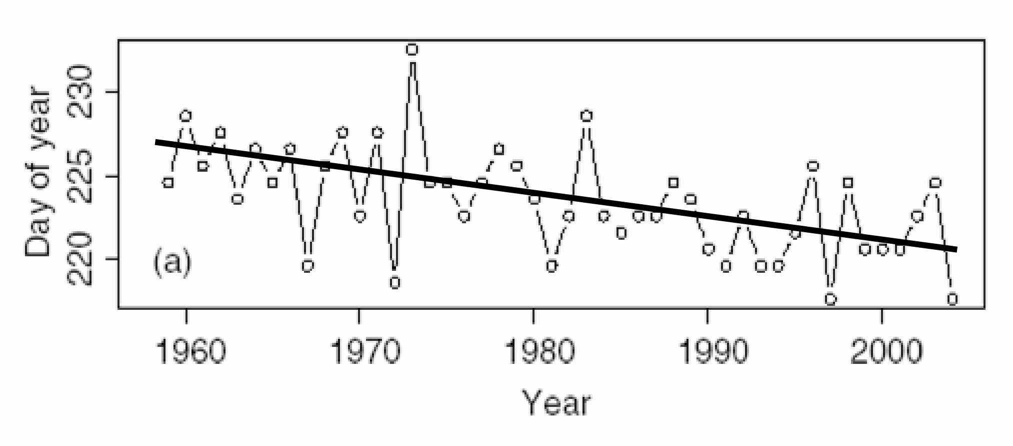
Elément de la valeur reproductive (fitness)

Exemple majeur d'indicateur du changement climatique



Keeling et al. 1996

Evolution du début de la diminution saisonnière du CO_2

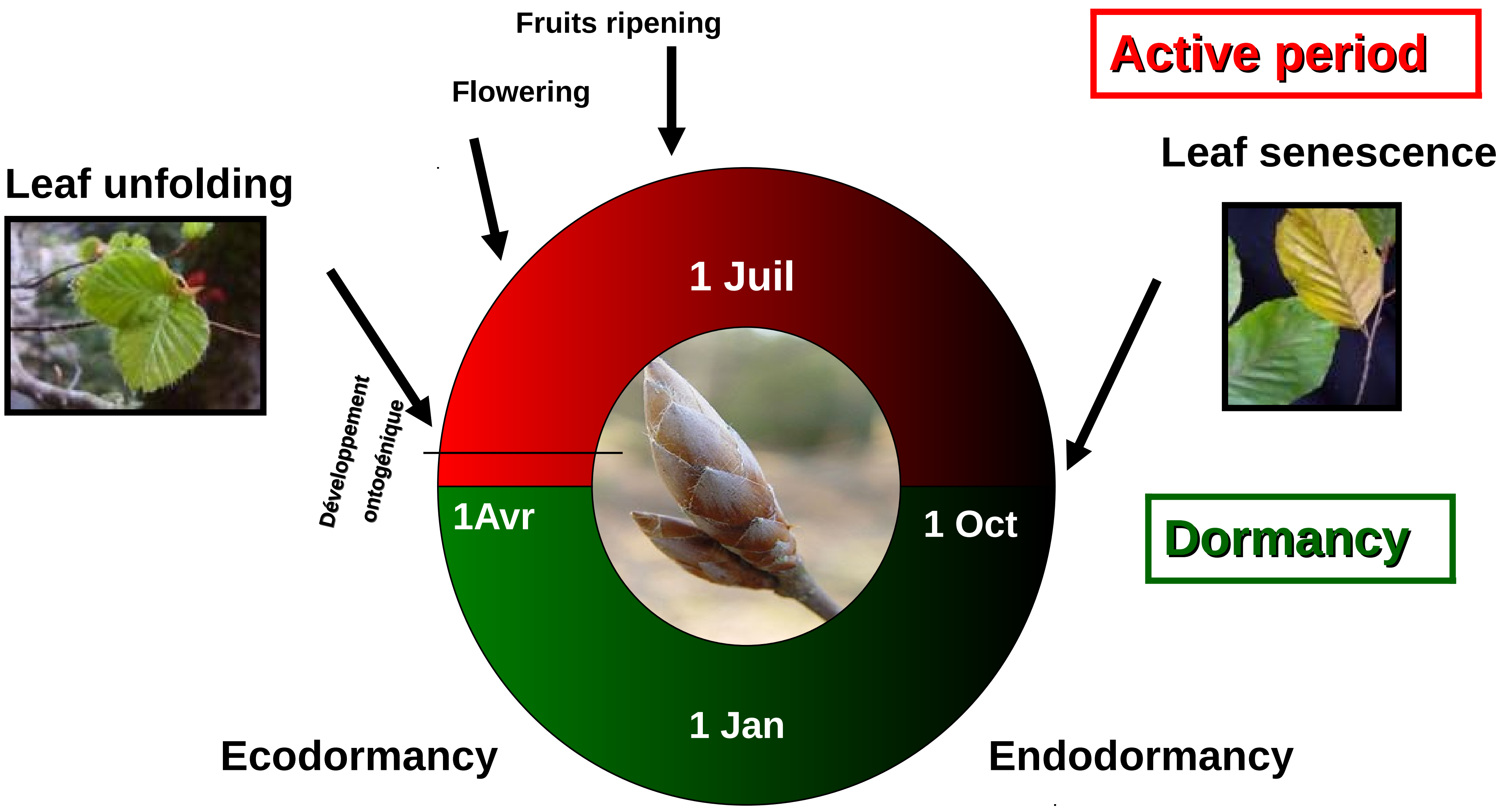


Thompson et al. 2008

Tree phenology ?

Annual cycle of trees from temperate climate

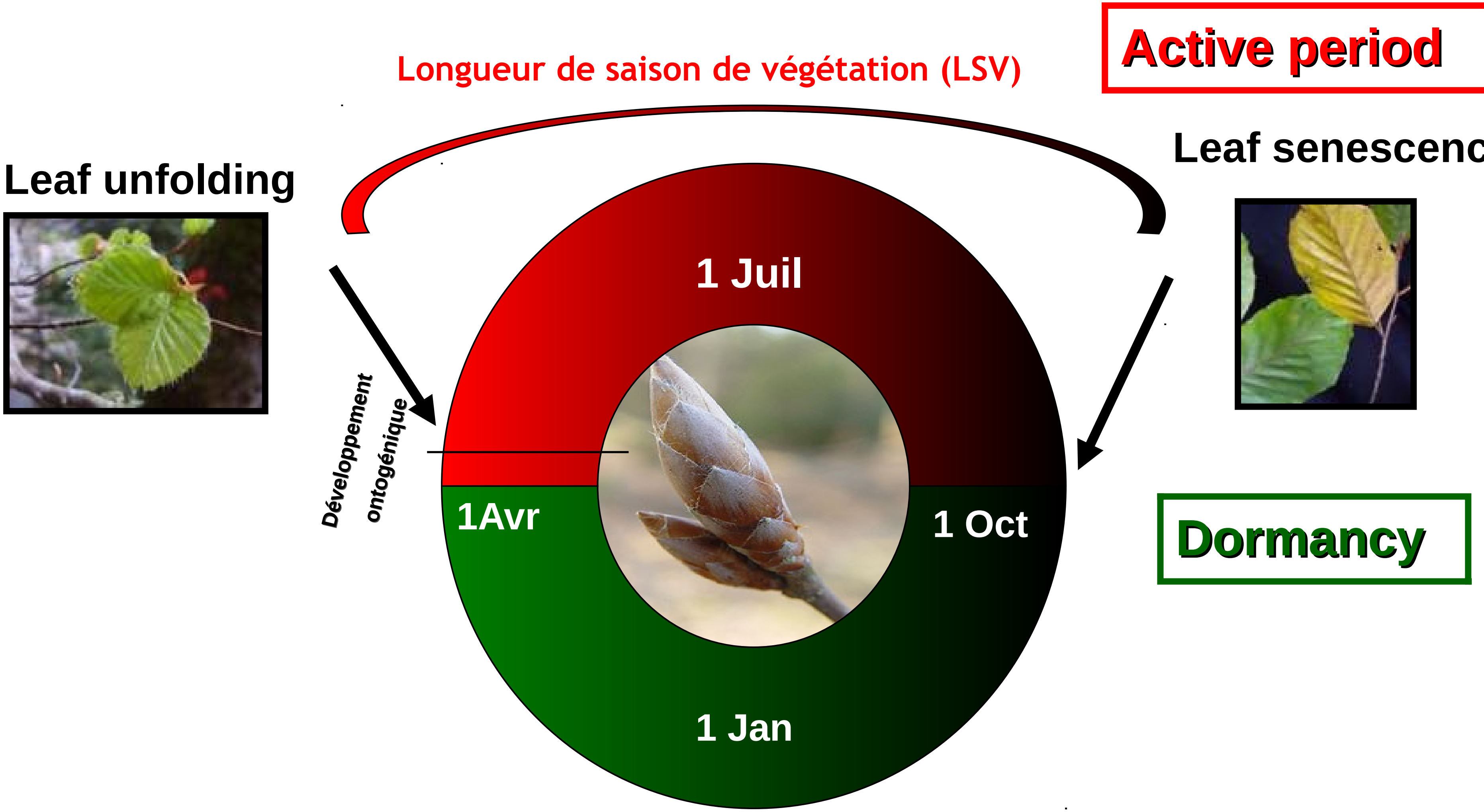
Example of beech



1. La phénologie ?

Annual cycle of trees from temperate climate

Example of beech



→ Un allongement de la LSV augmente la GPP

DESIGNS

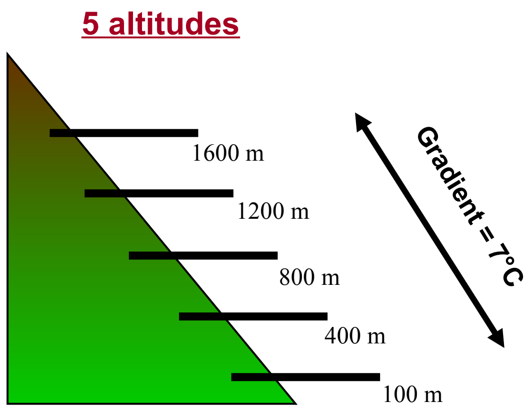
Phenotypic variability

Altitudinal gradient

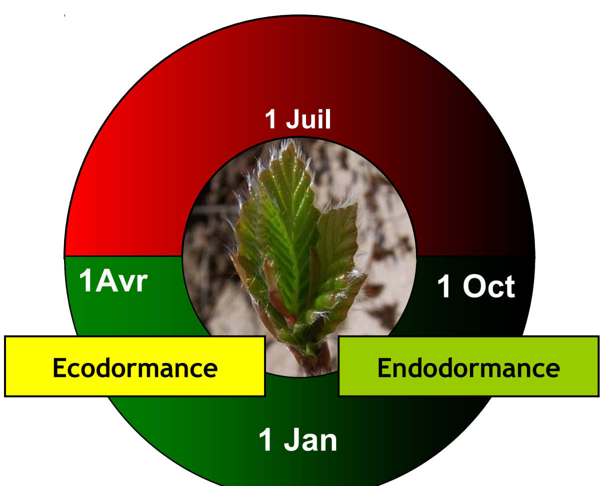
Determinism

Common gardens

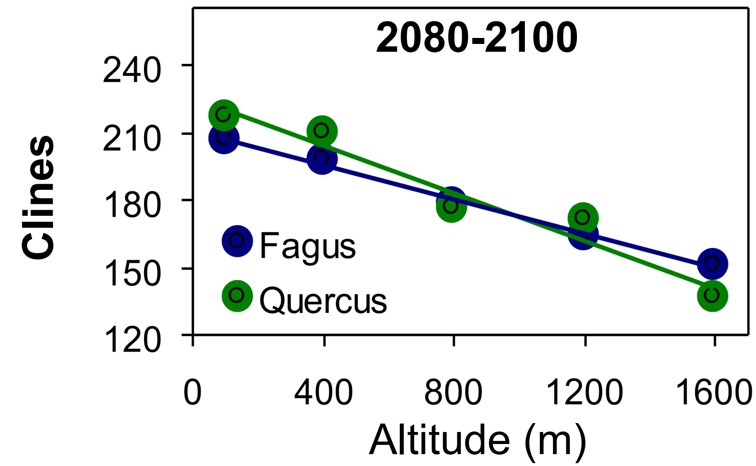
1. Altitudinal and latitudinal gradients



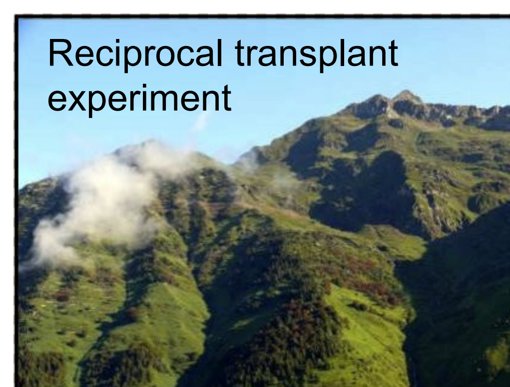
2. Dormancy release



3. Genetic diversity



4. Phenotypic plasticity



DESIGNS

Phenotypic variability

Altitudinal gradient

1. Altitudinal and latitudinal gradients

Leaf unfolding (or bud burst)
Leaf senescence
Growing season length
Growth

Mildew: Timing of spore release
Reproduction: acorn production

Ventoux – Pyrénées – Alpes
Renecofor – réseau européen

2. Dormancy release

Chilling requirement
Transfer experiment
Avoidance of late frost

Determinism

Common gardens

3. Genetic diversity

Leaf unfolding (or bud burst)
Leaf senescence
Growing season length
Growth

Differentiation between pop
Genetic variation within pop
Heritability

4. Phenotypic plasticity

Leaf unfolding (or bud burst)
Leaf senescence
Growing season length
Growth

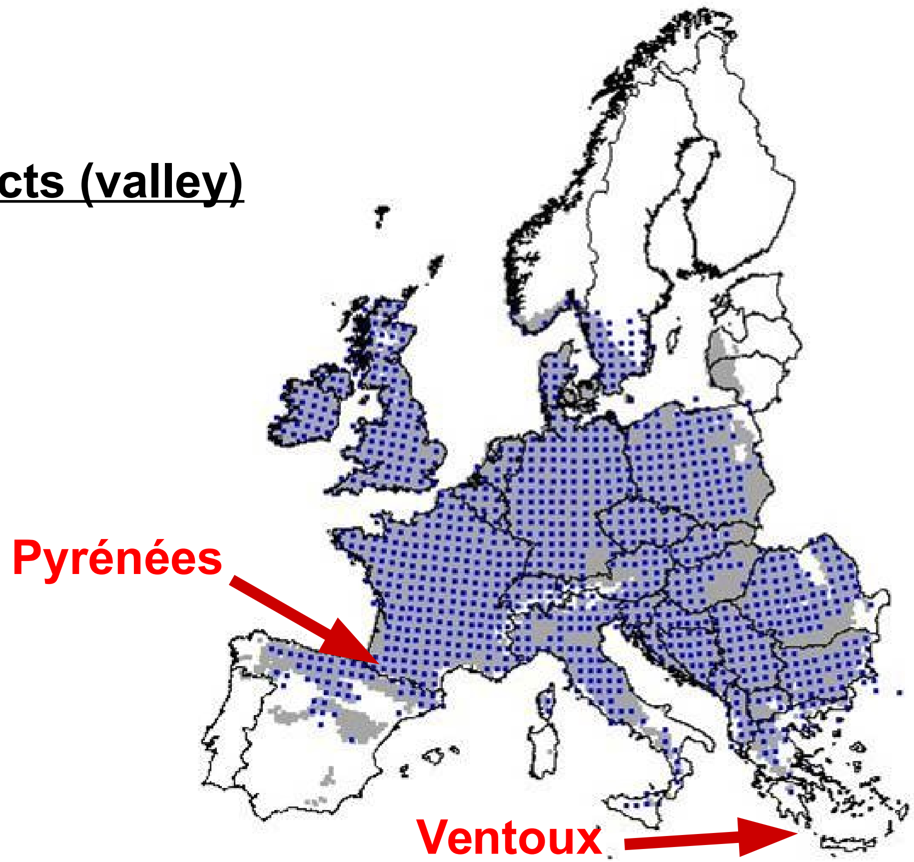
Long-term monitoring

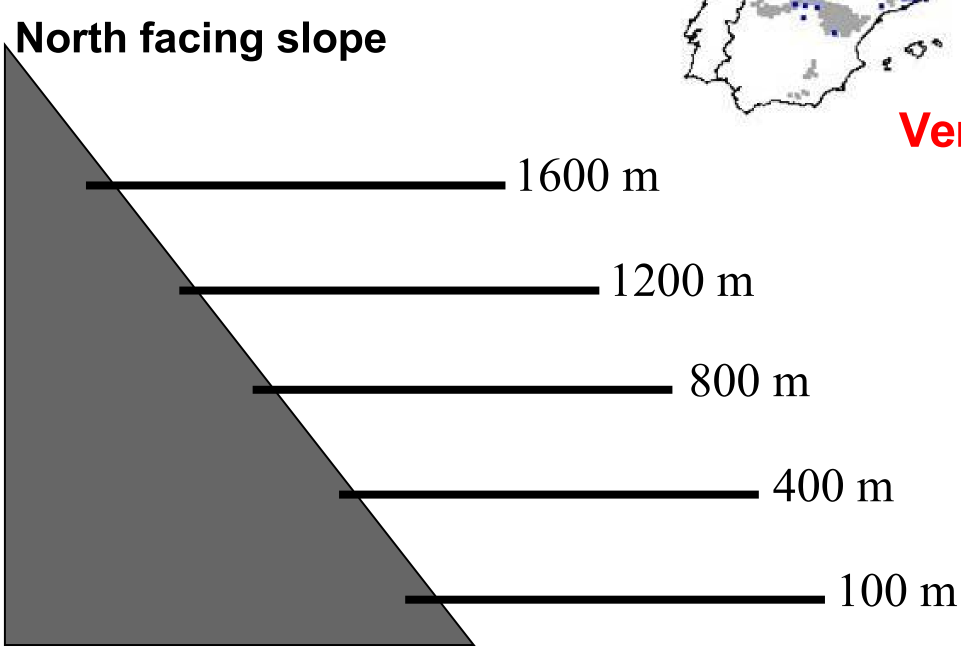
Fagus, Quercus, Abies, Acer, Fraxinus, Larix, Populus, Cornus, Liriodrendron, Picea, Pinus

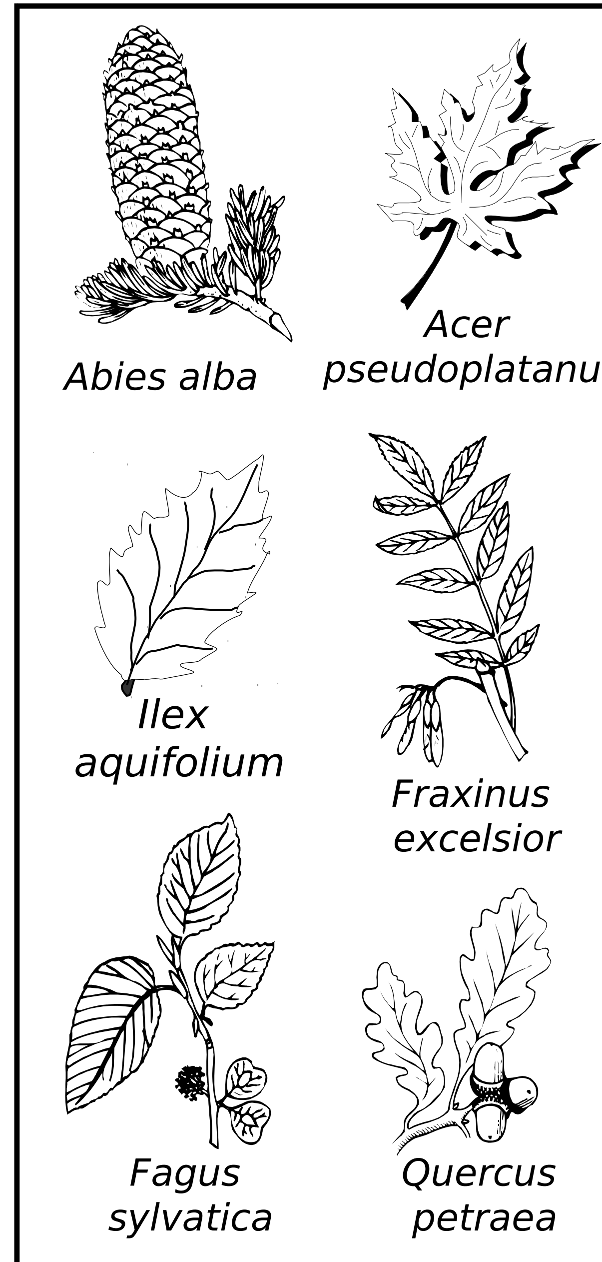
Altitudinal gradient

Tree Species

2 altitudinal transects (valley)
5 altitudes
6 species
41 populations

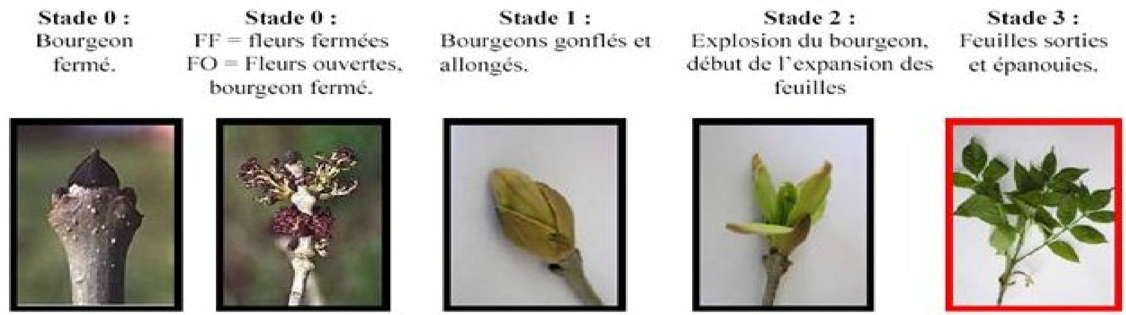






Monitoring of leaf phenology during 7 years in the Pyrénées and Ventoux

Leaf unfolding



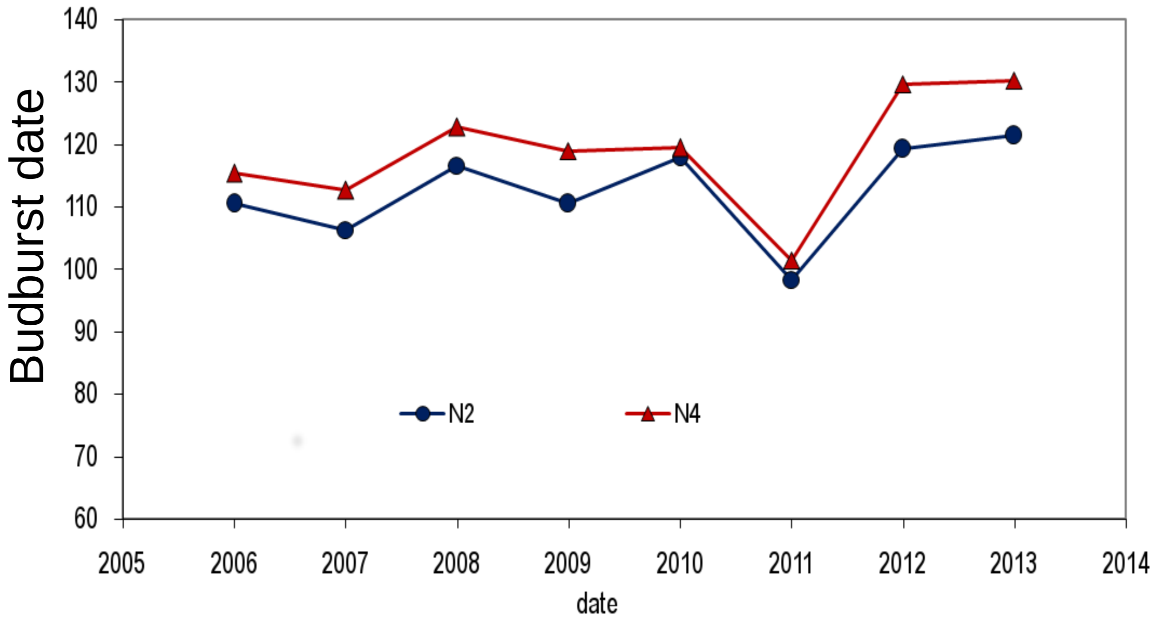
Leaf senescence

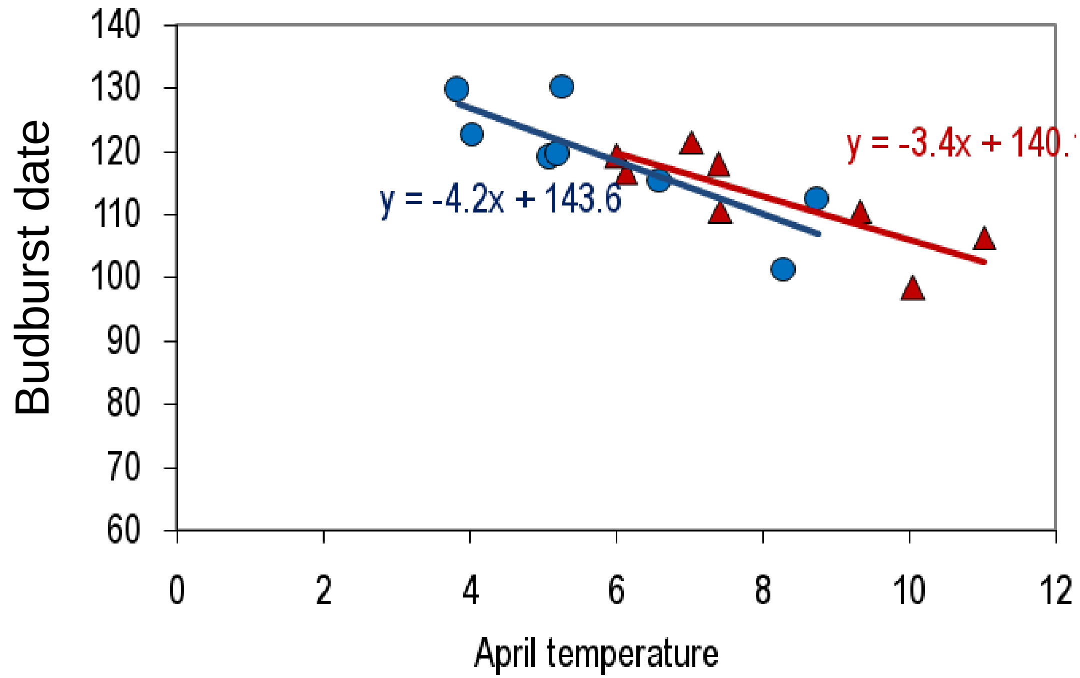
Leaf colouring

Leaf fall

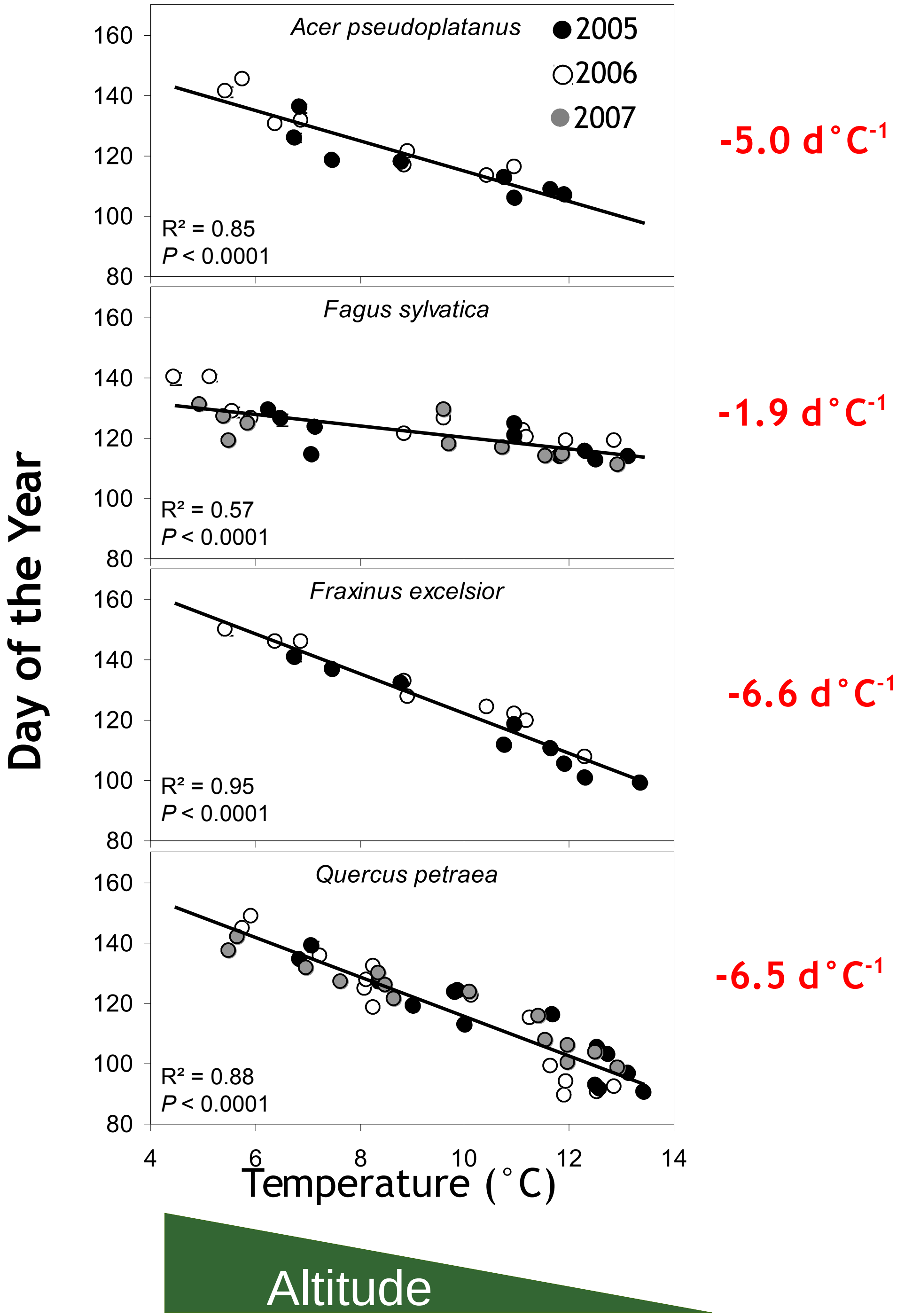
Growing season length

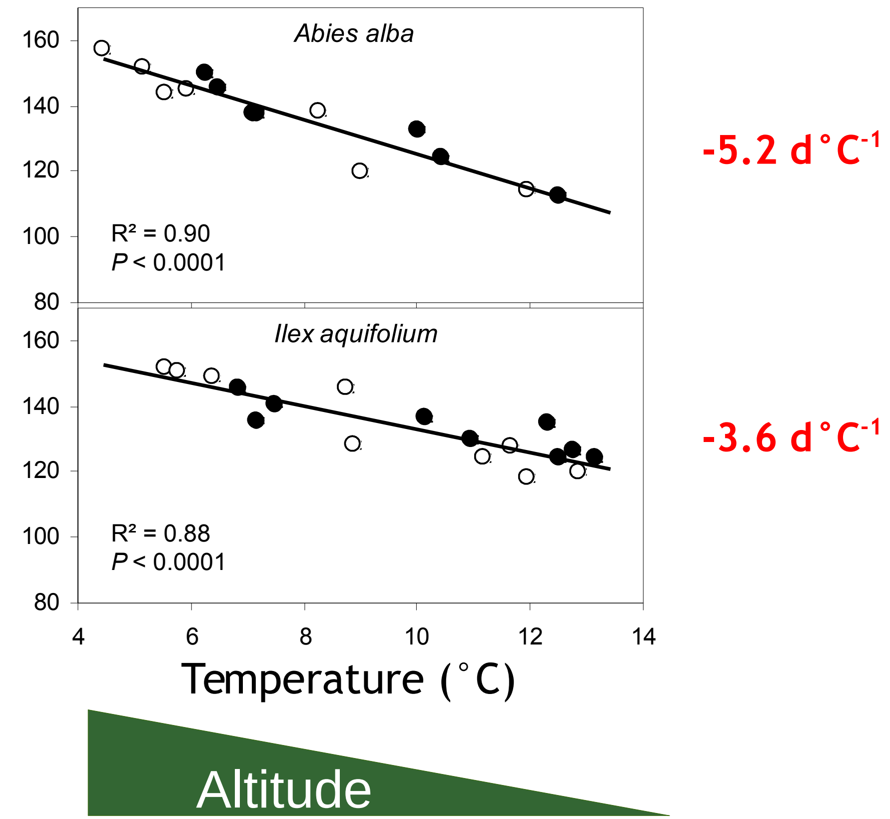
Phenology of beech in the Ventoux





Phenological sensitivity to temperature

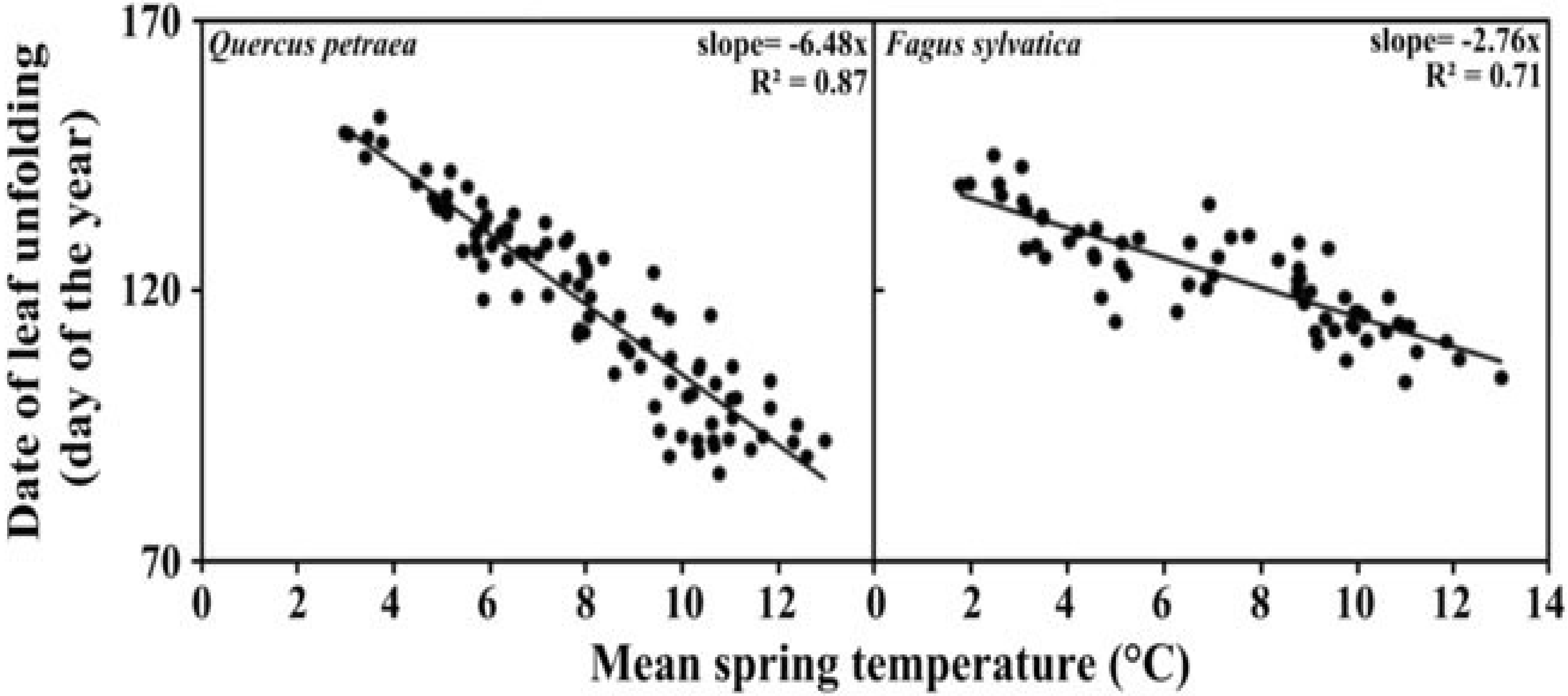




Vitasse et al. 2009 AFM

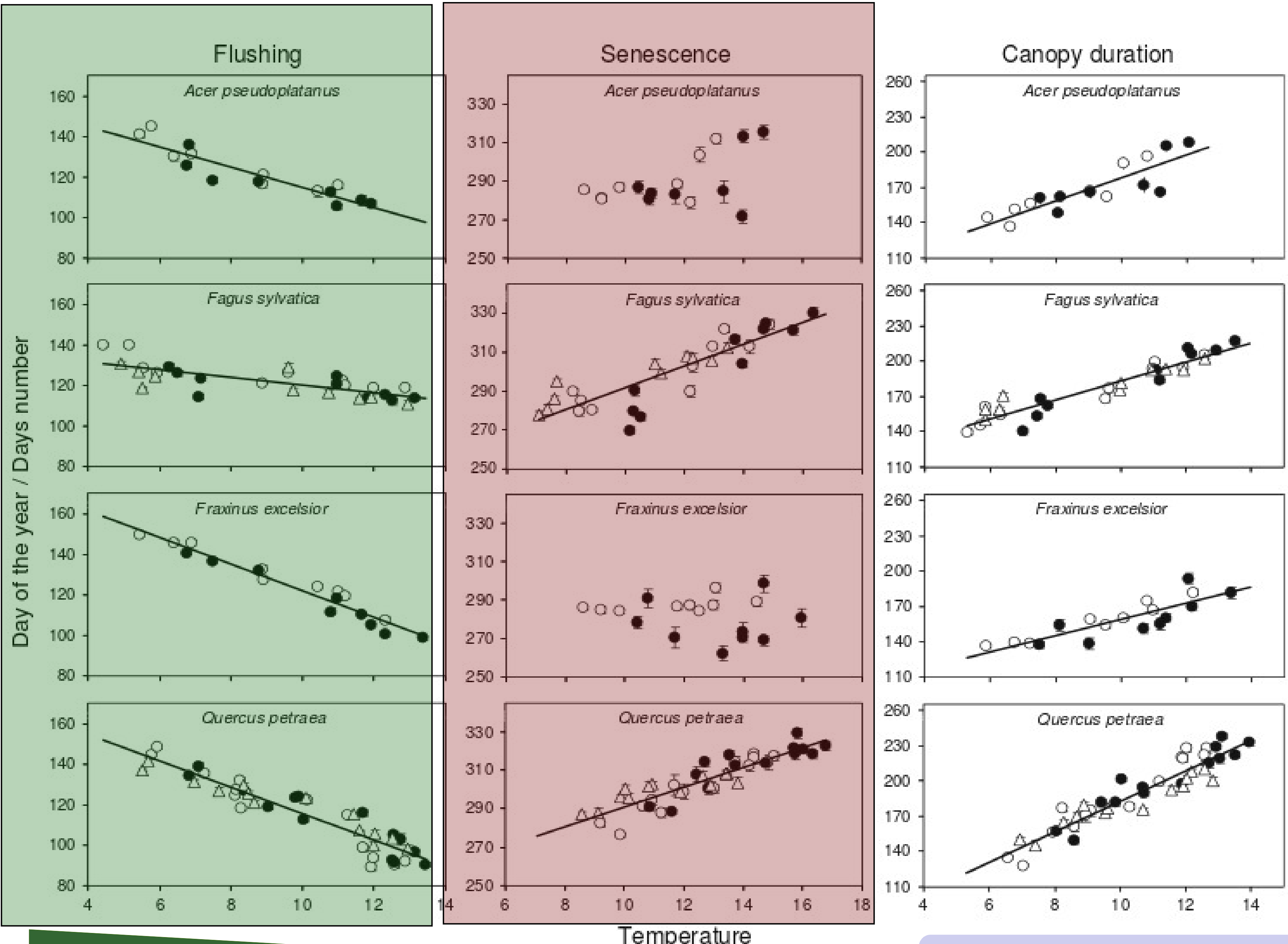
Phenological sensitivity to temperature

7 years of phenological monitoring in 10 populations per species



Dantec et al. 2014 IJB

Phenological sensitivity: Canopy duration



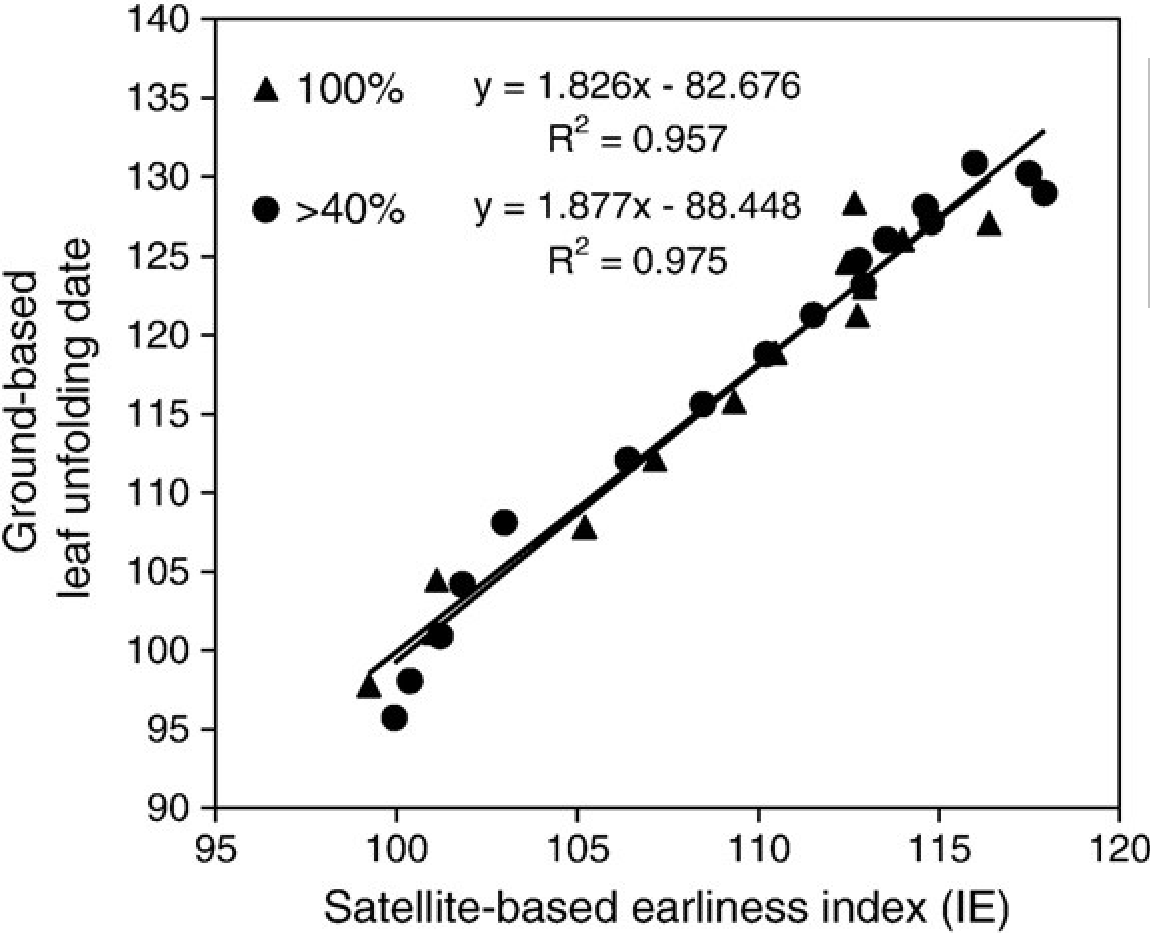
$+9.7\ d\,^{\circ}C^{-1}$

$+8.0\ d\,^{\circ}C^{-1}$

$6.9\ d\,^{\circ}C^{-1}$

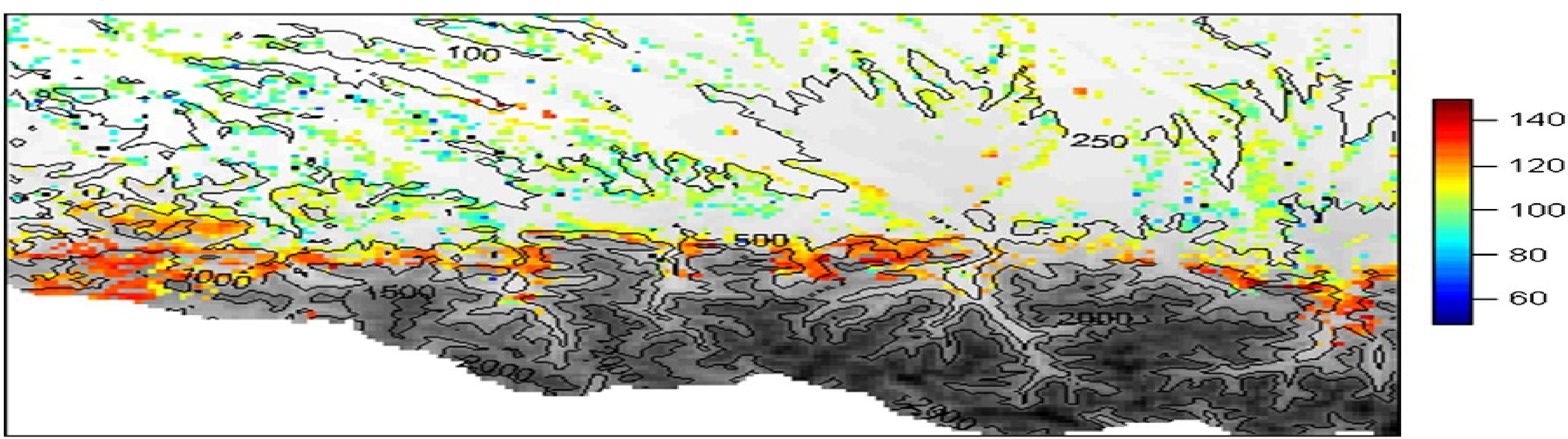
$3.0\ d\,^{\circ}C^{-1}$

Vitasse et al. 2009 Oecologia



Satellite-based observations

Guyon et al. 2011 RSE



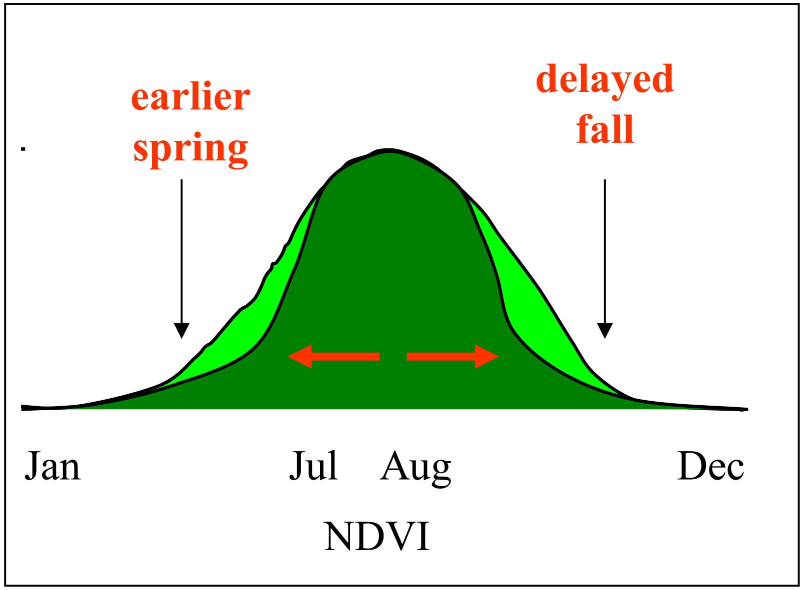
Satellite-based observations

- **Changes in vegetation activity can be characterized through**

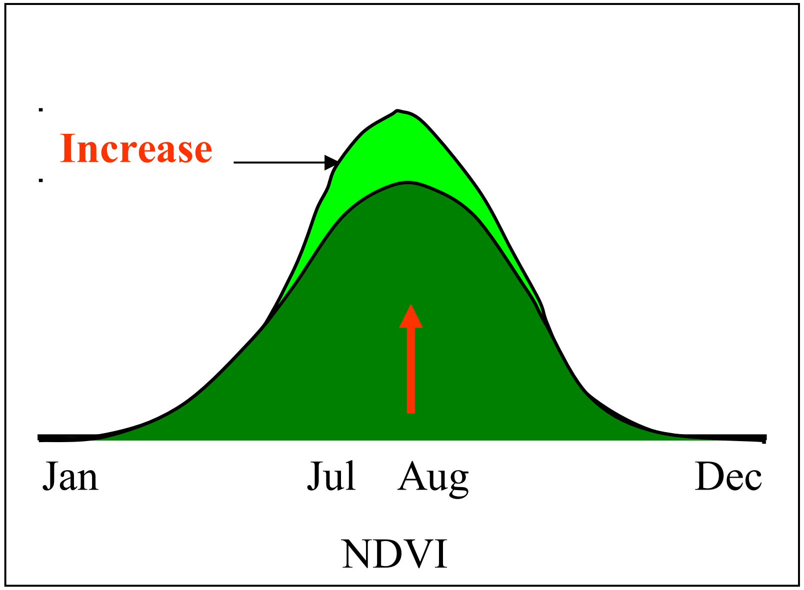
  1. Changes in growing season

  2. Changes in seasonal NDVI or PVI magnitude (Guyon et al 2011)

Increases in growing season



Increases in NDVI magnitude



Zhou et al. 2000

Genetic variations

VP = VG + VE + VGxE

Low altitude common garden

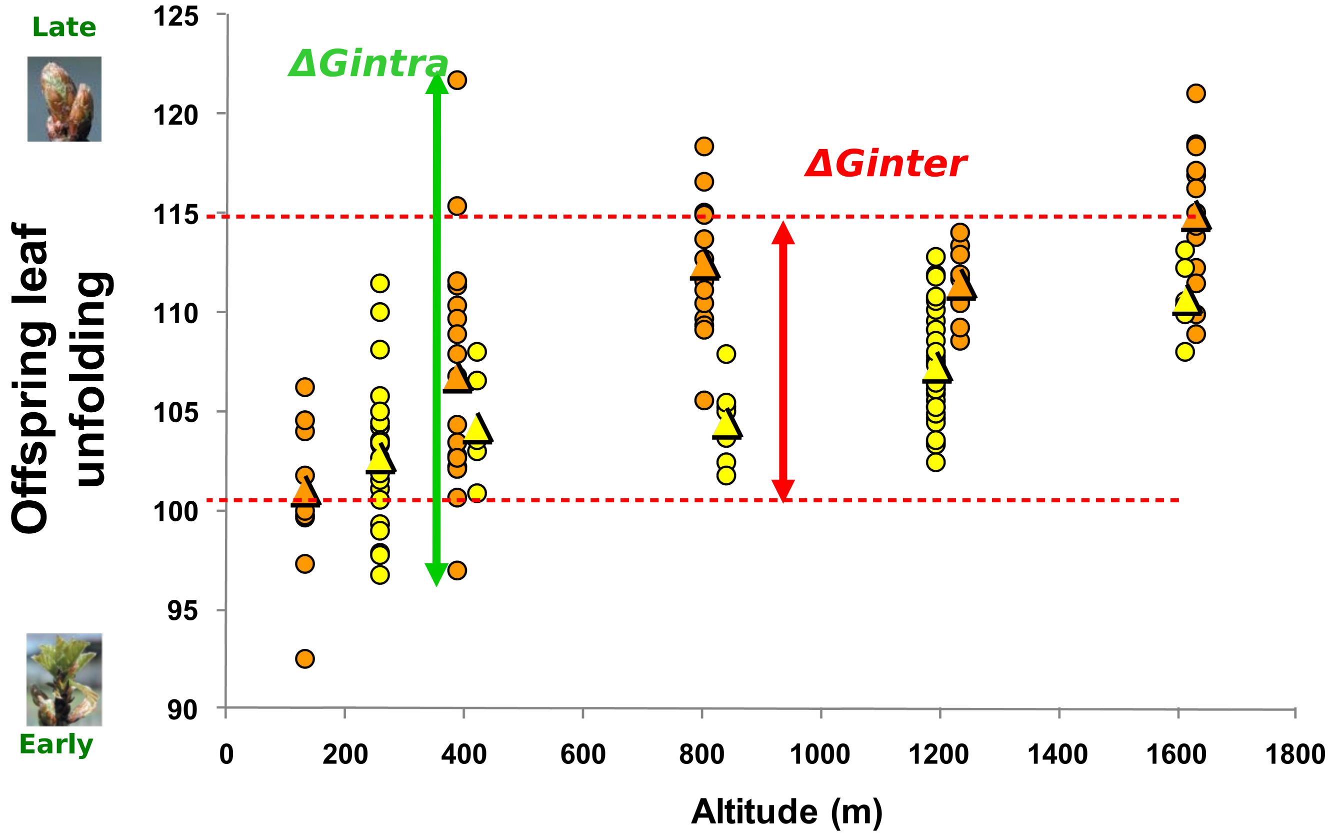
Total ≈ **1500** plants (1 ha)

Measurements

1. Growth
2. Leaf unfolding
3. Senescence

High within-population genetic differentiation

Leaf unfolding of sessile oak populations



Vitasse et al. 2009 CJFR

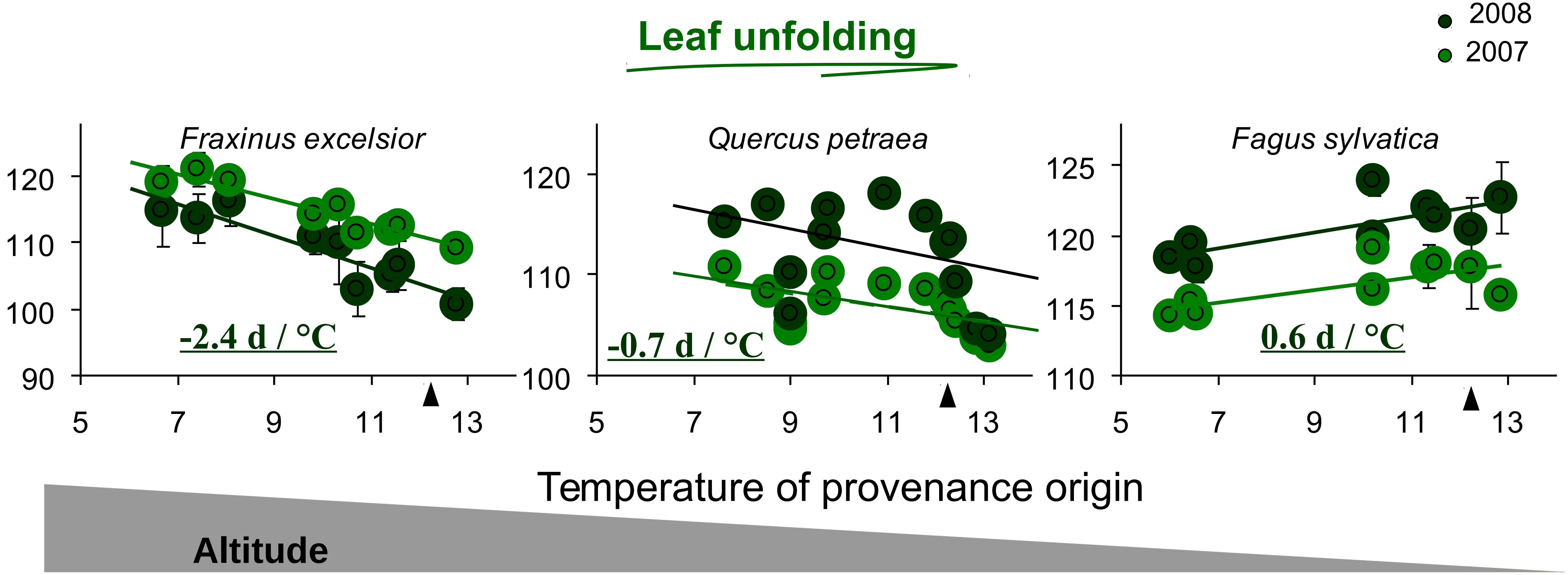
Alberto et al. 2011 JEB

- Within-population variations are as large as the between-population variations, that is be a valuable resource for future adaptation of sessile oak populations

Genetic variations: clines in common garden

VP = **VG** + VE + V(GxE)

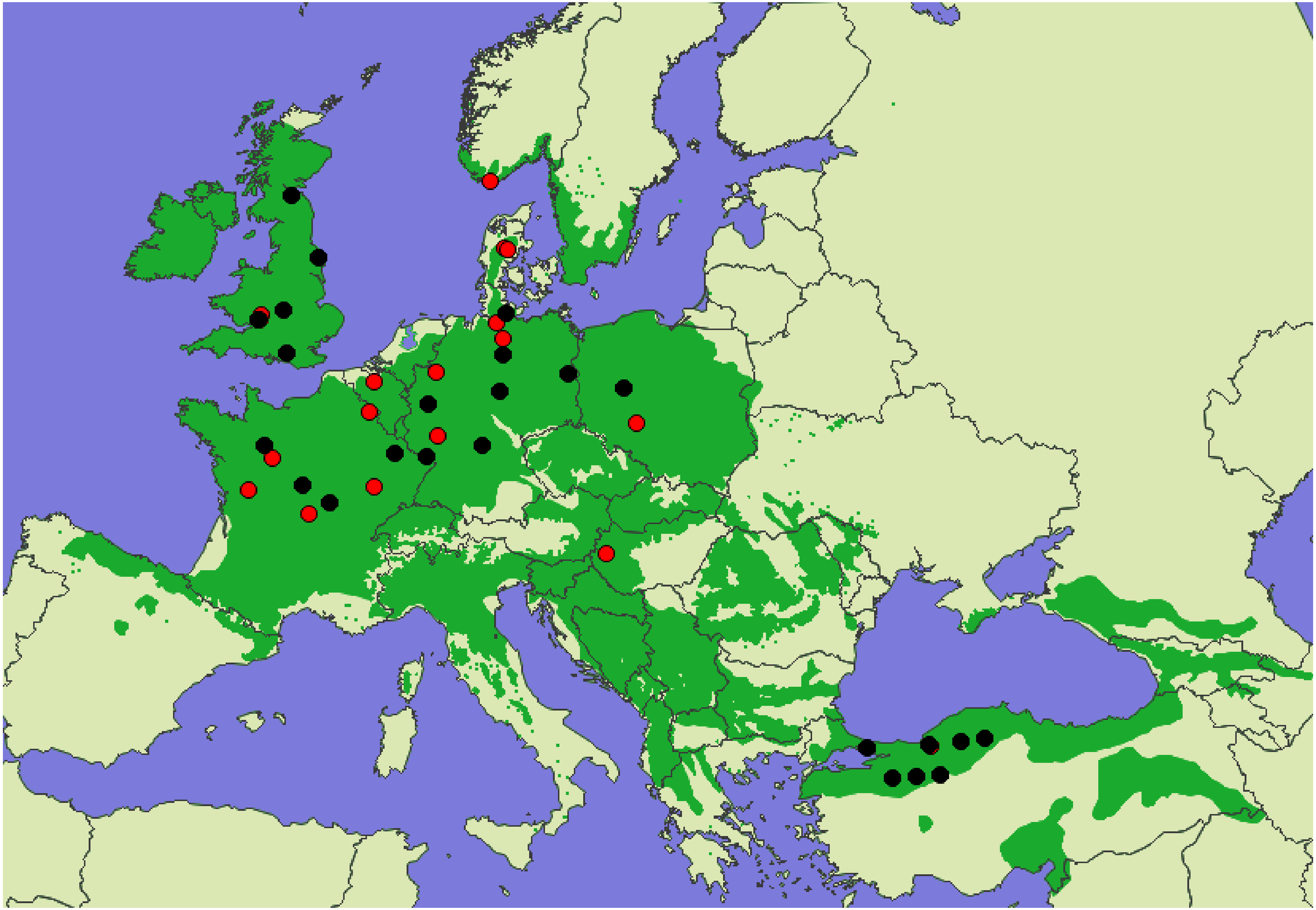
between-population differentiations



Opposite clines between oak/beech

Co- and counter-gradients

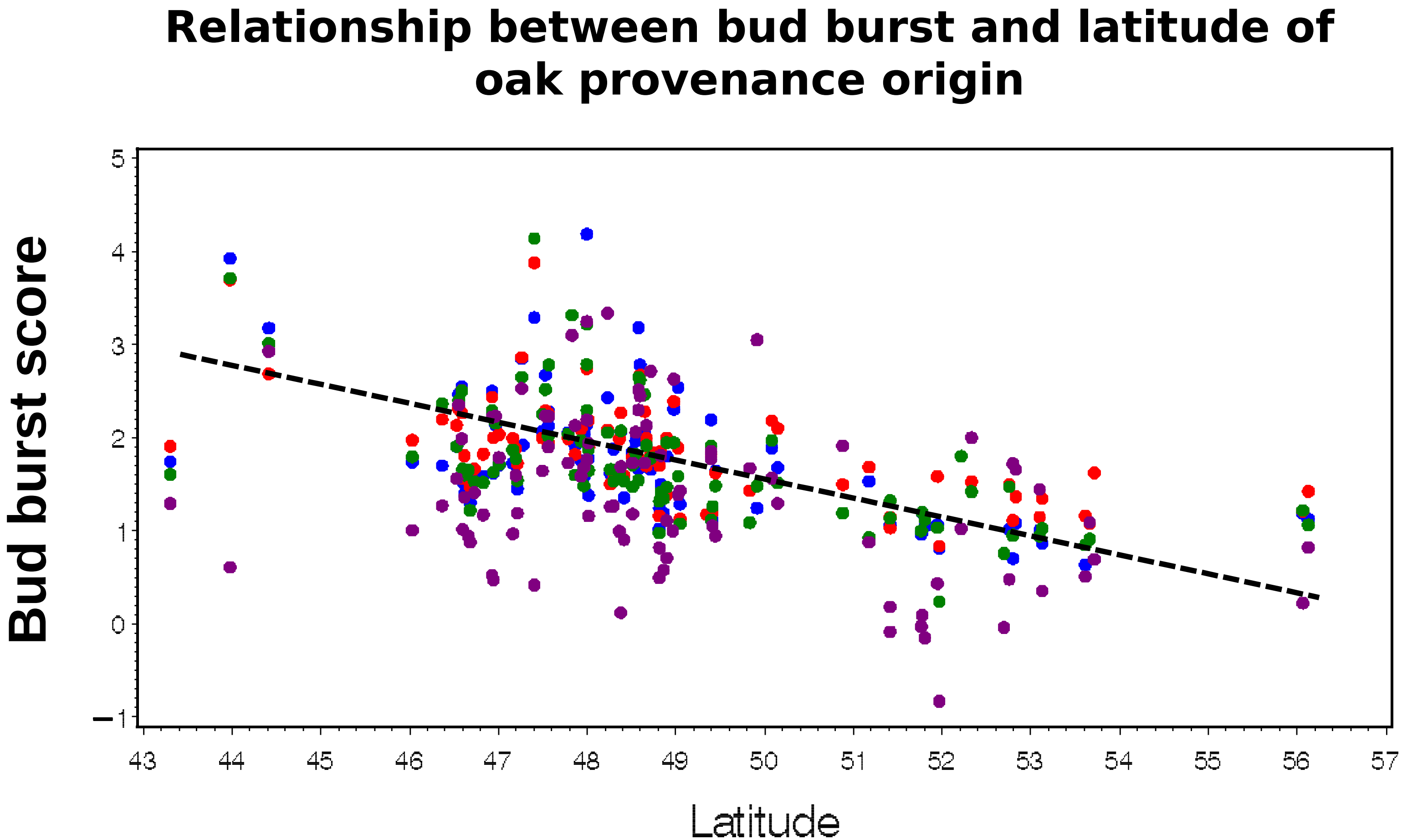
Vitasse et al. 2009 CJFR



Population tested

Testing sites

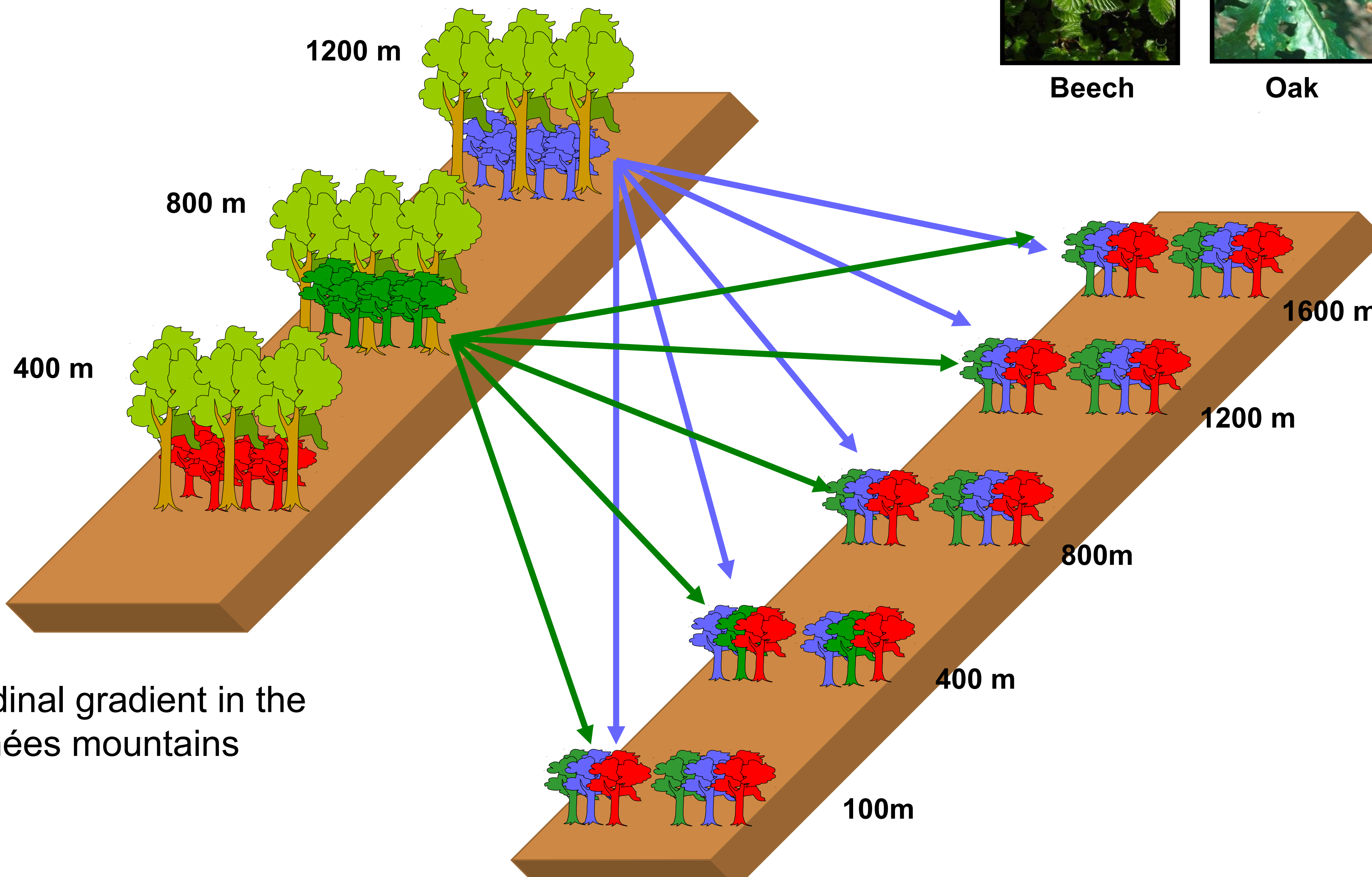
DIACHRONIC APPROACHES: Clines along latitudinal gradients



European project FORGER

Phenotypic plasticity

Reciprocal Transplants Experiments (RTE)



Beech

Oak

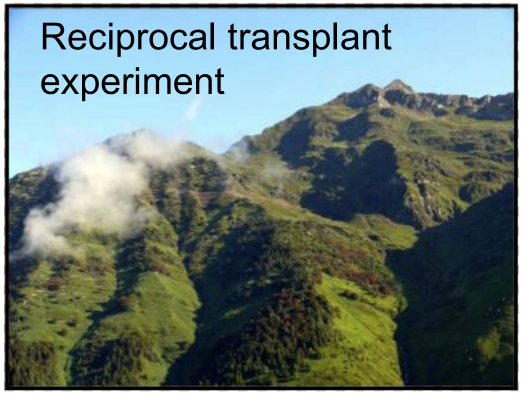
Altitudinal gradient in the Pyrénées mountains

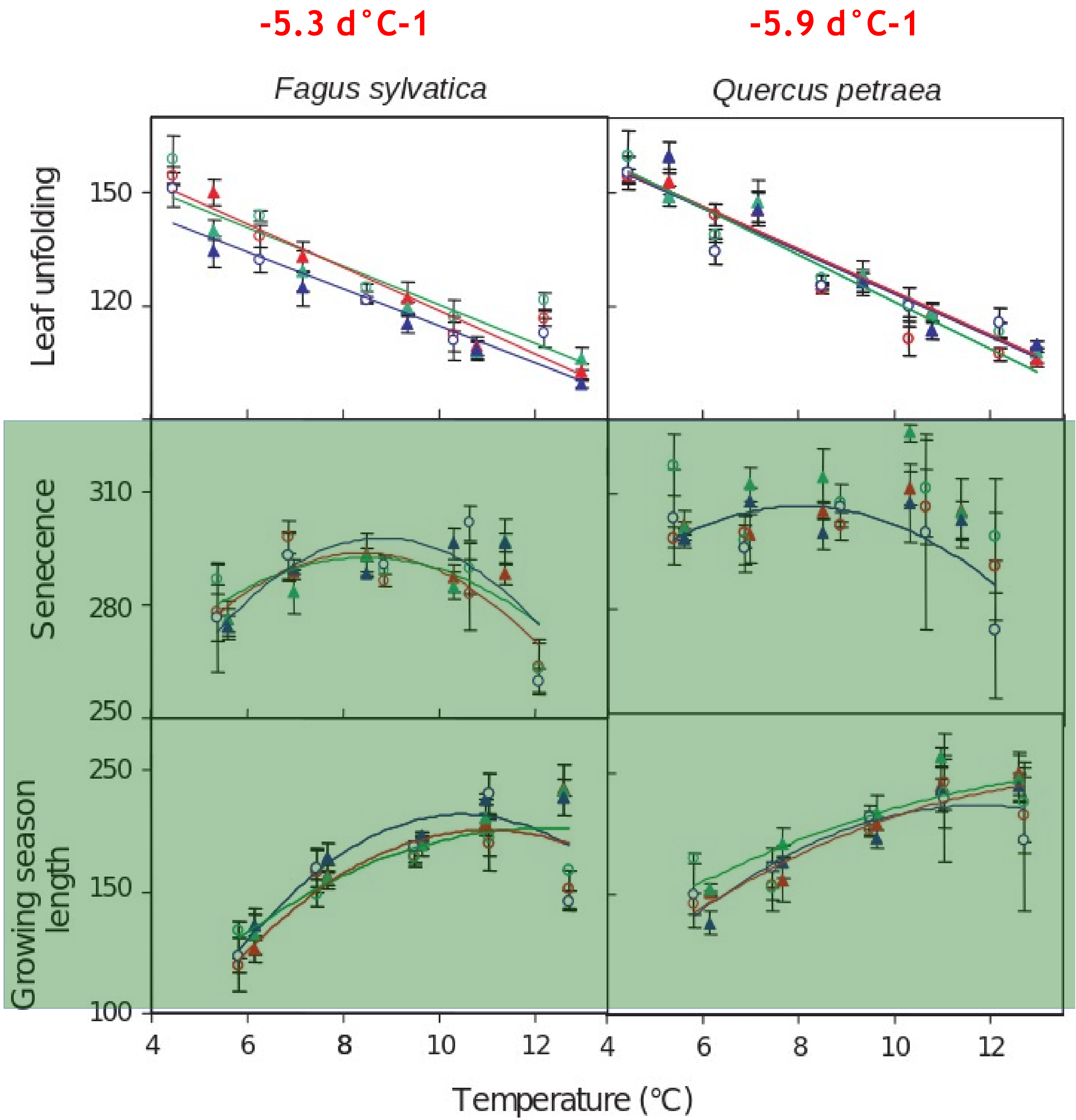
Phenotypic plasticity

Reaction norms

VP = VG + **VE + V(GxE)**

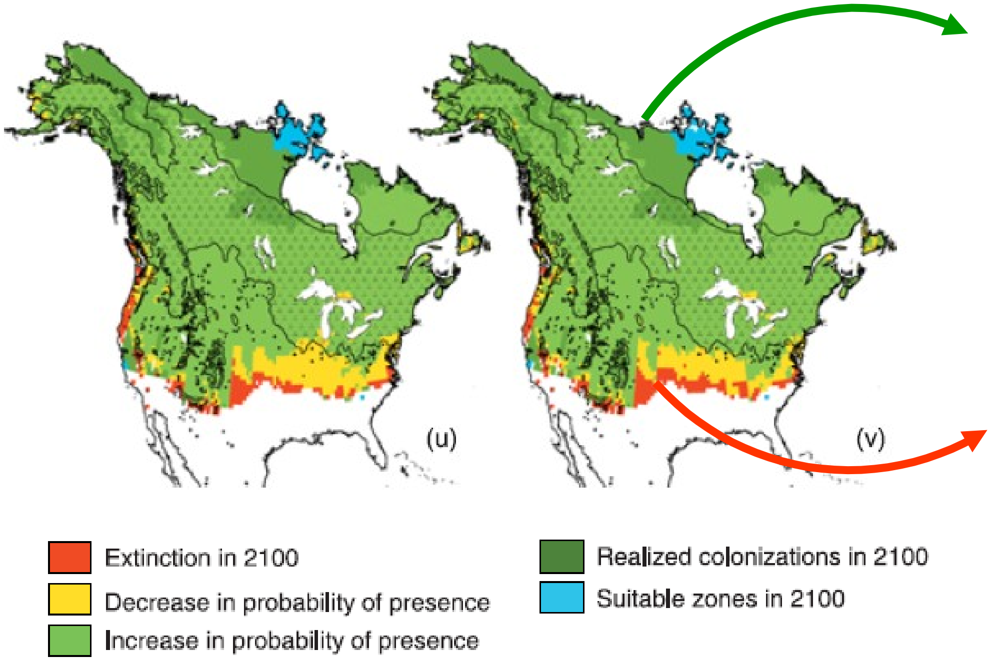
Vitasse et al. 2010 Func. Ecol.





Forecasting phenology and species distribution

- Insight from fitness-based models (Morin et al. 2008)



Northward colonization promoted by fruit, flower and leaf phenology.

Loss of habitat southward due to increase drought mortality and decreased reproductive success

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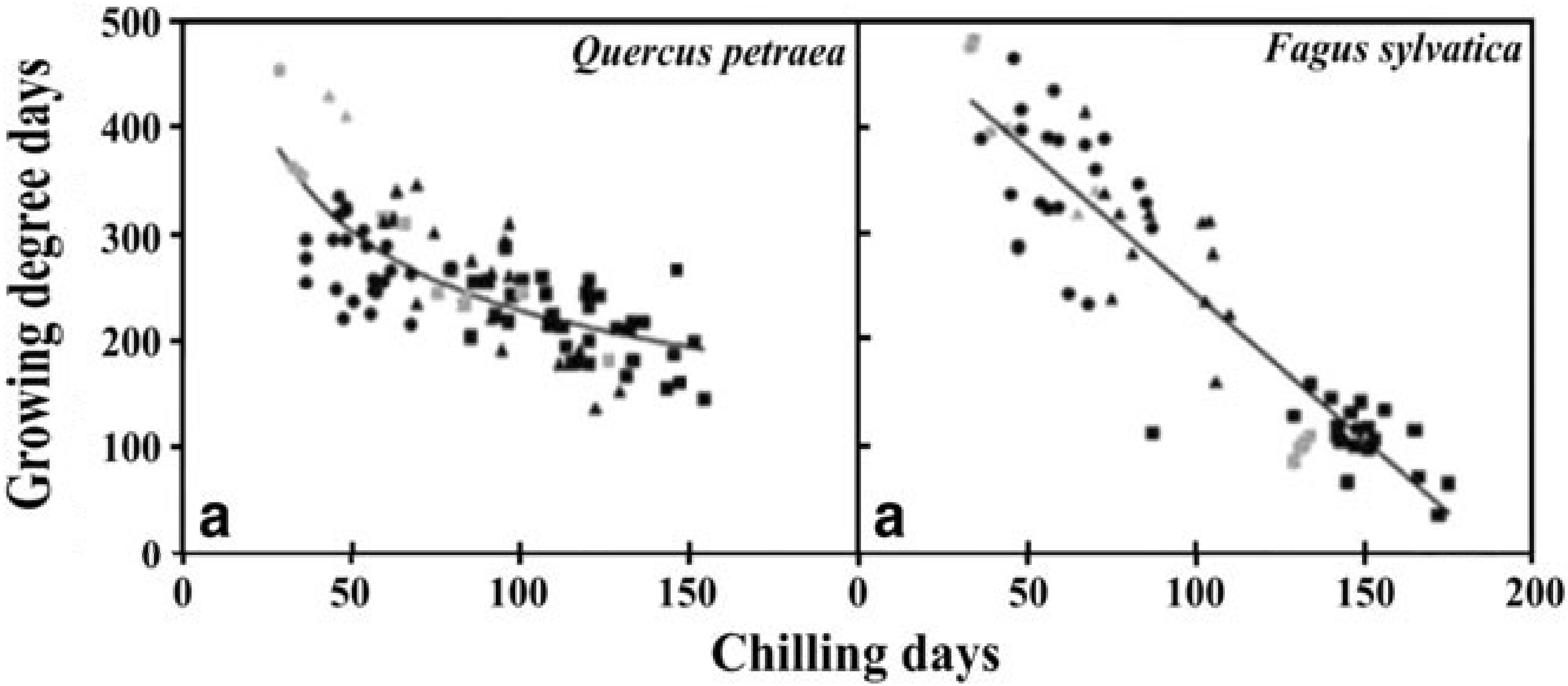
Assessing the effects of climate change on the phenology of European temperate trees

Yann Vitasse[a,*], Christophe François[b,c], Nicolas Delpierre[b], Eric Dufrêne[b,c], Antoine Kremer[d], Isabelle Chuine[e], Sylvain Delzon[a]

Chilling and heat requirements for leaf unfolding



Dantec et al. 2014 IJB

Chilling and heat requirements for leaf unfolding

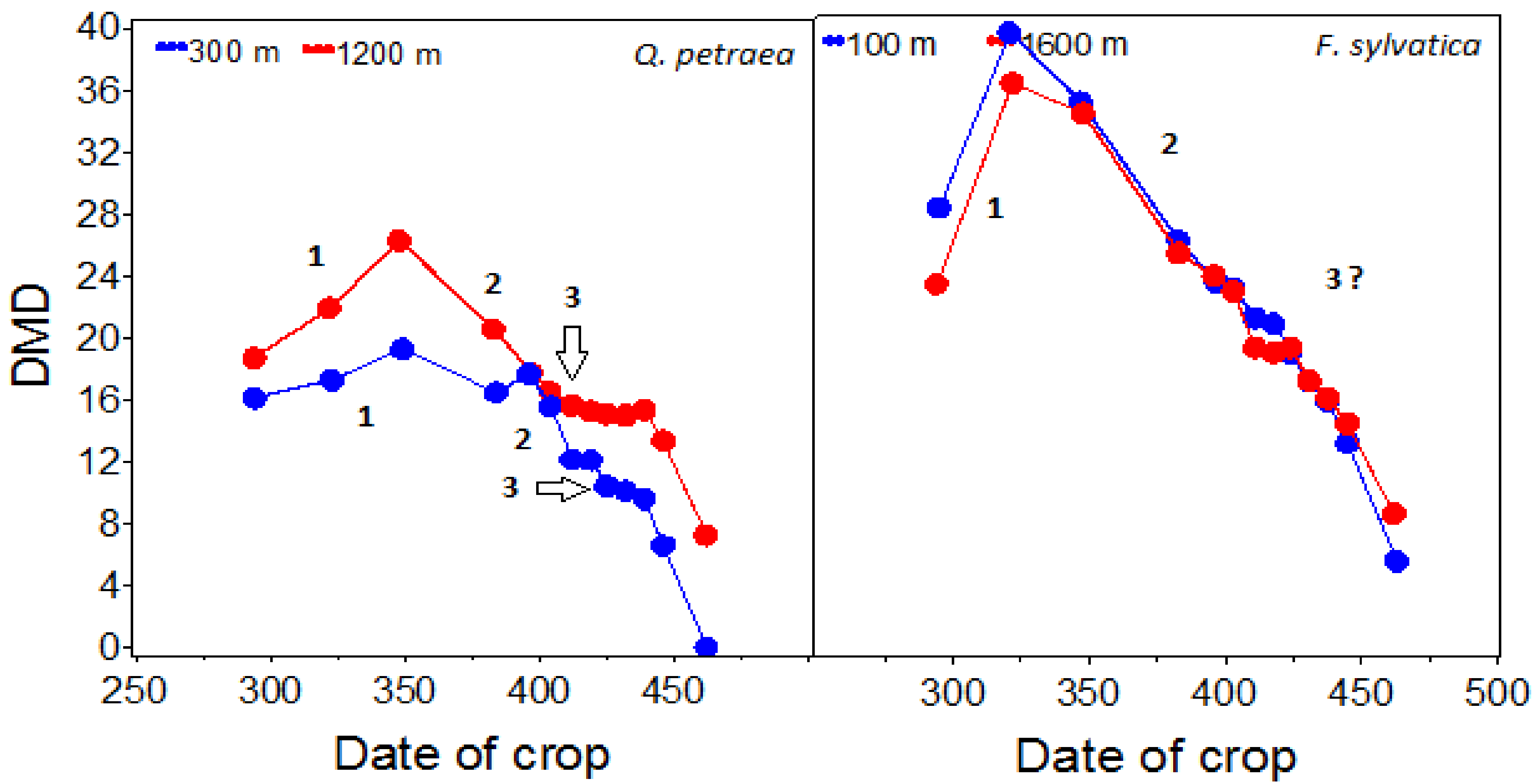
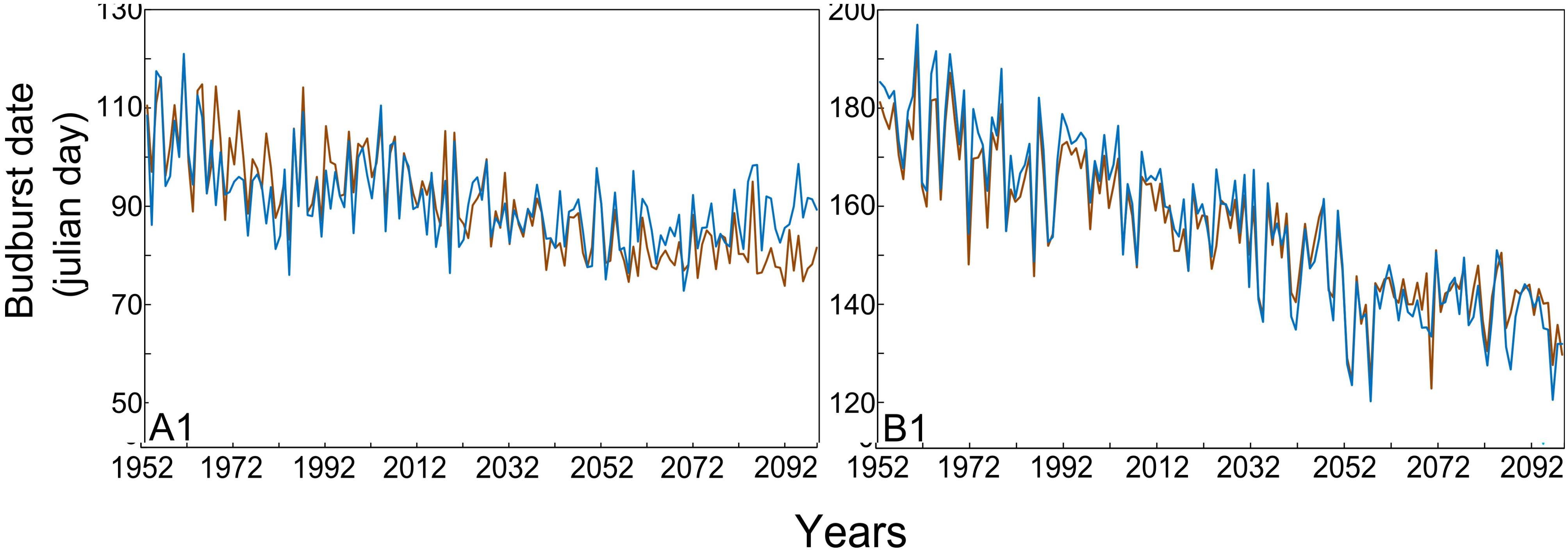


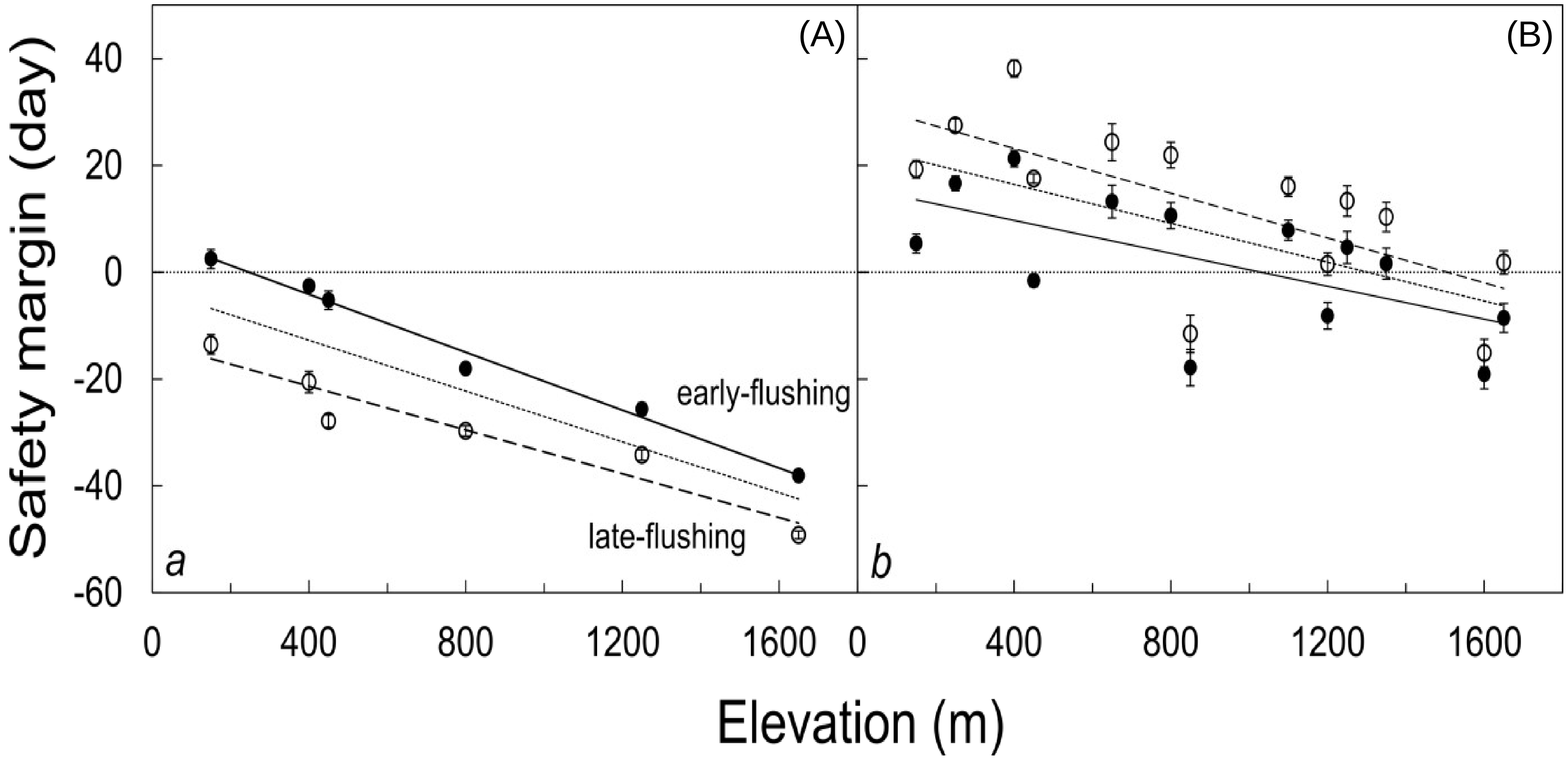
Figure 4 : délai moyen de débourrement (DMD, en nombre de jours) en fonction de la date de récolte des bourgeons, pour *Q.petraea* (300m et 1200m) et *F. sylvatica* (100m et 1600m).

Forecasting phenology and species distribution



Selection pressure on leaf phenology

Variation of powdery mildew (A) and spring frost (B)



- positive safety margin for late frost

- negative safety margin for mildew

Dantec et al. PlosOne in review

Reproductive phenology

- One species only: *Quercus petraea*
- Along a latitudinal gradient (RENECOFOR, ONF); 17 populations
- Along altitudinal gradients (Pyrénées); 10 populations

ERC project TREEPEACE