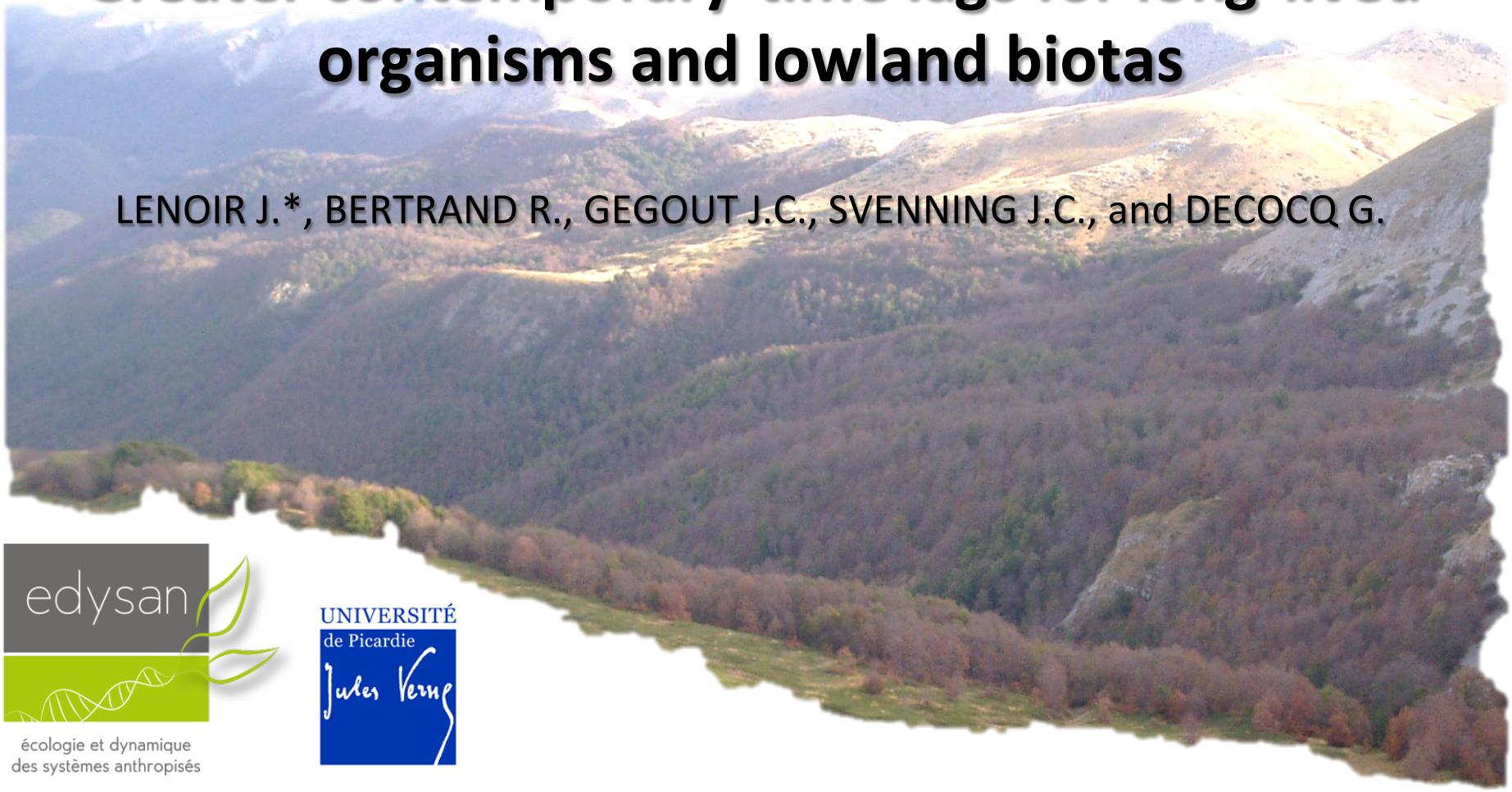
The 55th Symposium of the IAVS
(Mokpo, Korea, 23-28 July 2012)

*jonathan.lenoir@u-picardie.fr

Impact of climate change on vegetation in Europe: Greater contemporary-time lags for long-lived organisms and lowland biotas

LENOIR J.*, BERTRAND R., GEGOUT J.C., SVENNING J.C., and DECOCQ G.



edysan
écologie et dynamique des systèmes anthropisés

UNIVERSITÉ de Picardie Jules Verne

What do we mean by contemporary-time lags?

Differences between:

- What are the **observed changes** in species distribution or community composition under contemporary climate change

And…

- What would be the **expected changes** in species distribution or community composition to perfectly match climatic changes

Implied: the niche conservatism assumption

ECOLOGY LETTERS

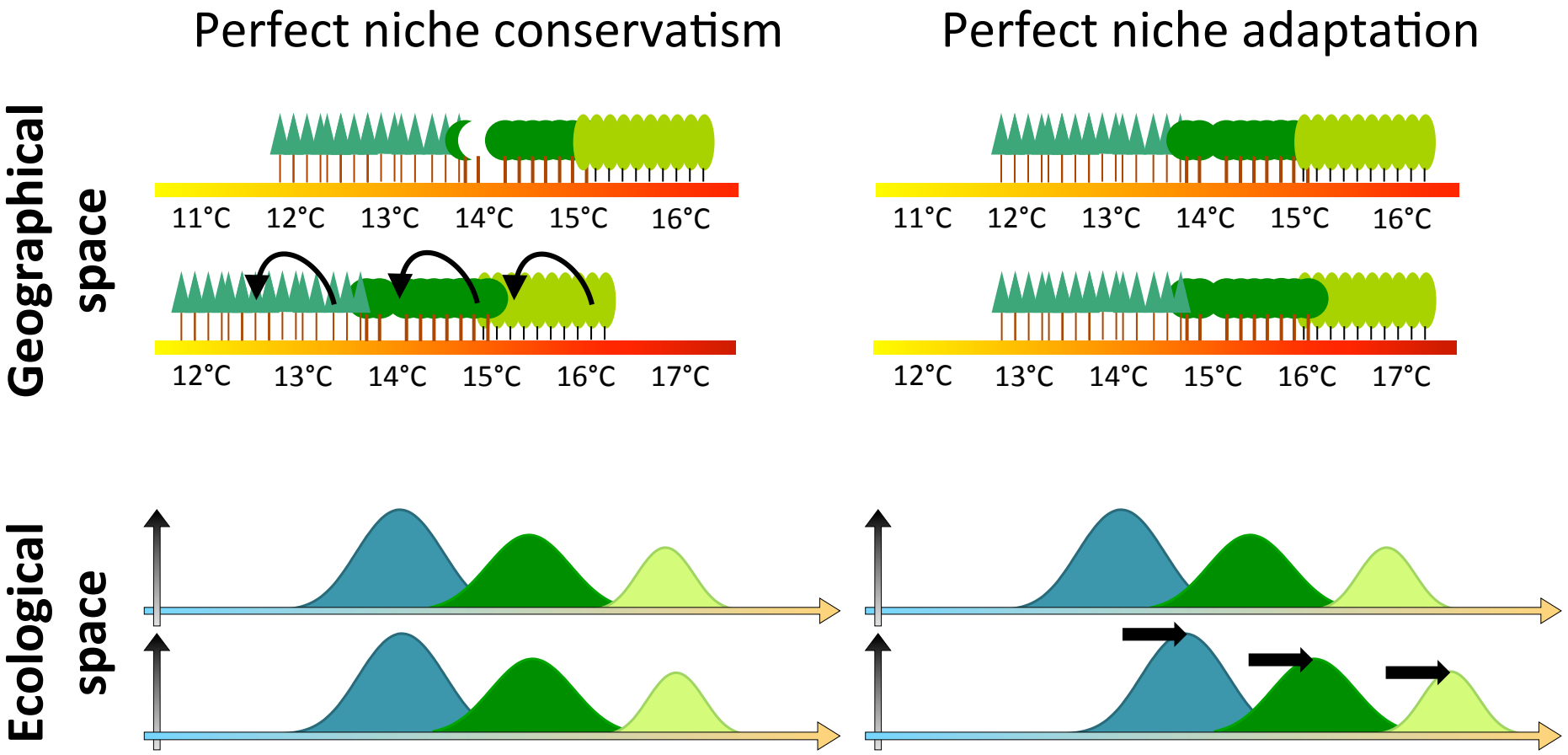
Ecology Letters, (2010) **13**: 1310–1324 doi: 10.1111/j.1461-0248.2010.01515.x

REVIEW AND SYNTHESIS

Niche conservatism as an emerging principle in ecology and conservation biology

Wiens *et al.* (2010)

What is niche conservatism?



Hutchinson's duality: The once and future niche

PNAS | November 17, 2009 | vol. 106 | suppl. 2 | 19651–19658

Colwell & Rangel (2009)

What do we need to measure potential time lags?

What is needed is some sort of a yardstick: a measure of how much a species should shift to match the change in its environment caused by climate change.

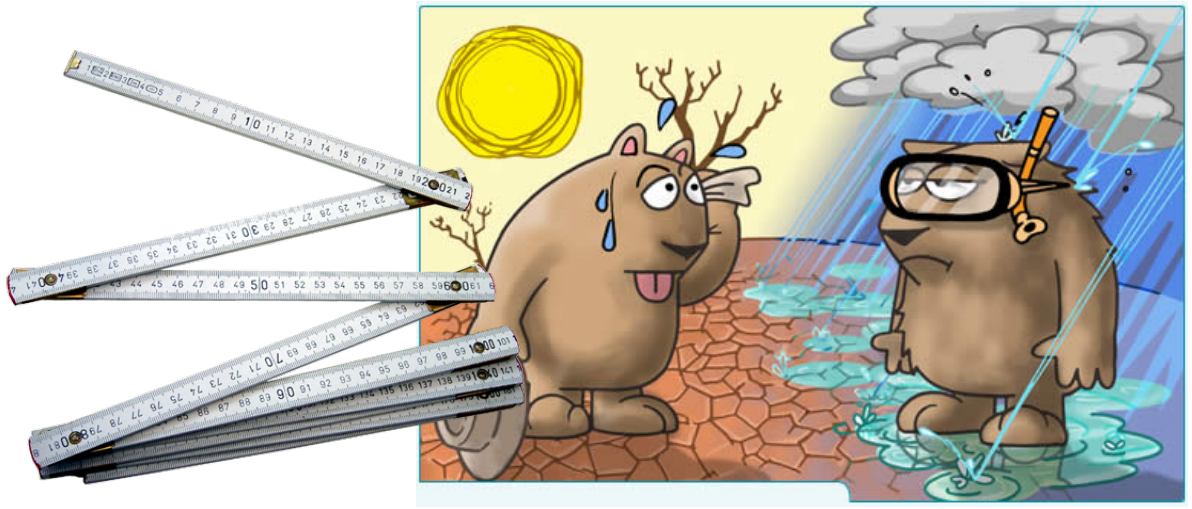
PROCEEDINGS OF THE ROYAL SOCIETY B

Proc. R. Soc. B (2005) **272**, 2561–2569
doi:10.1098/rspb.2005.3356
Published online 1 November 2005

Review

Shifts in phenology due to global climate change: the need for a yardstick

Visser & Both (2005)

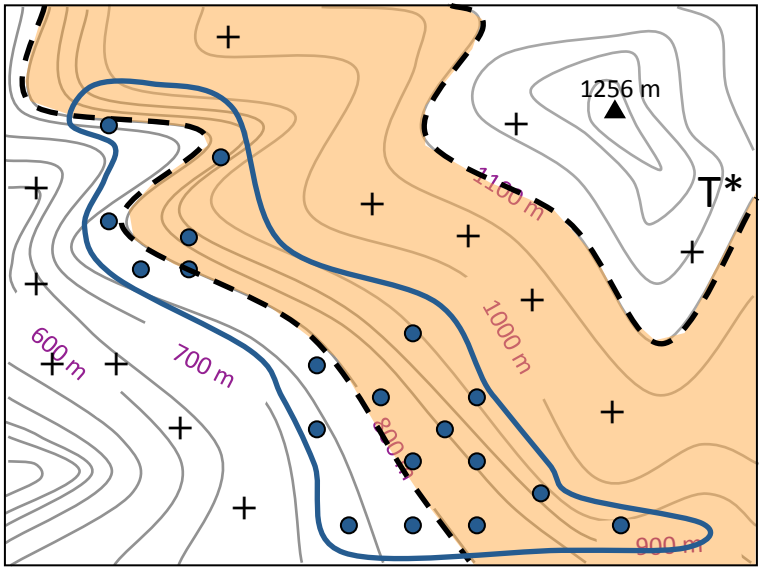


A yardstick for changes in species altitudinal distribution in response to increased temperatures

Let's consider an increase in temperature conditions of 1.05°C in our study region during 1987-2008: **+0.48°C/decade**

Yardstick: +80 m/decade

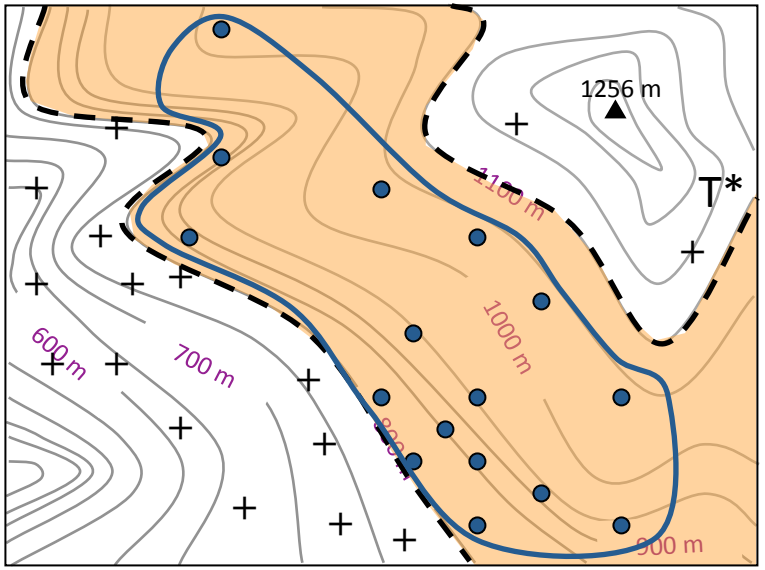
Assuming **perfect niche conservatism** and an adiabatic lapse rate of **+0.6°C/100 m**, species altitudinal distribution will shift about **+80 m/decade**



Species occurrence

Species distribution

Species niche (T)



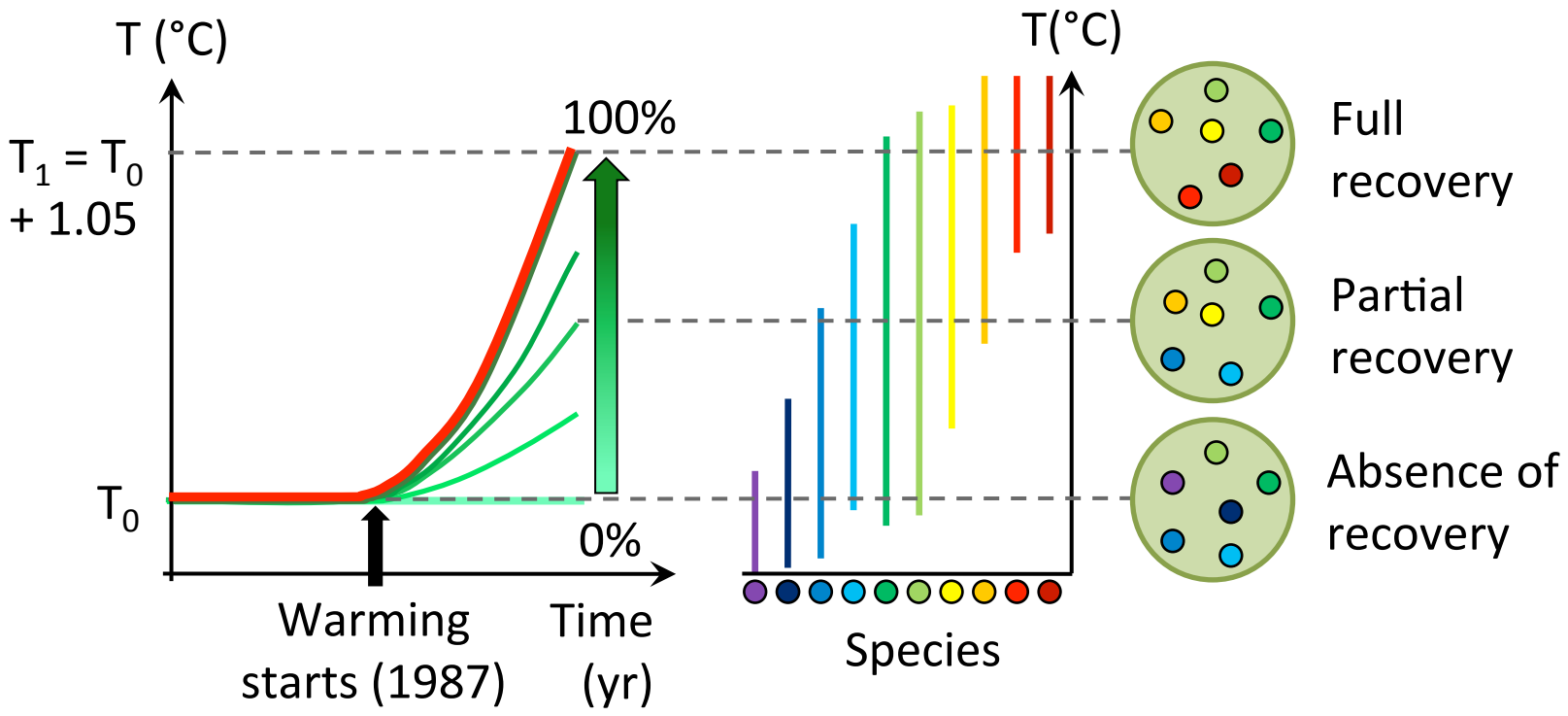
A yardstick for changes in community composition in response to increased temperatures

Let's consider an increase in temperature conditions of 1.05°C in our study region during 1987-2008

Temperature trend over time

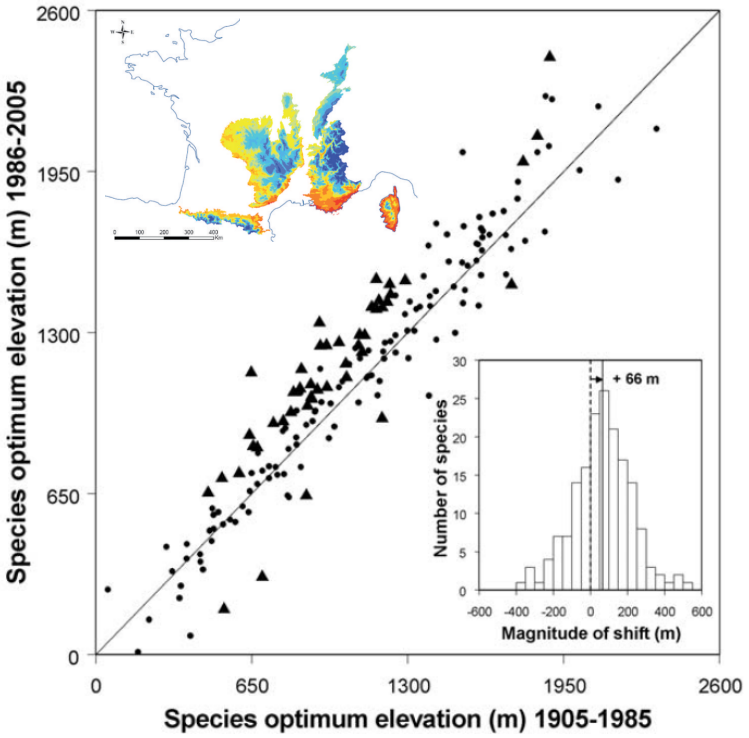
Species niches (T)

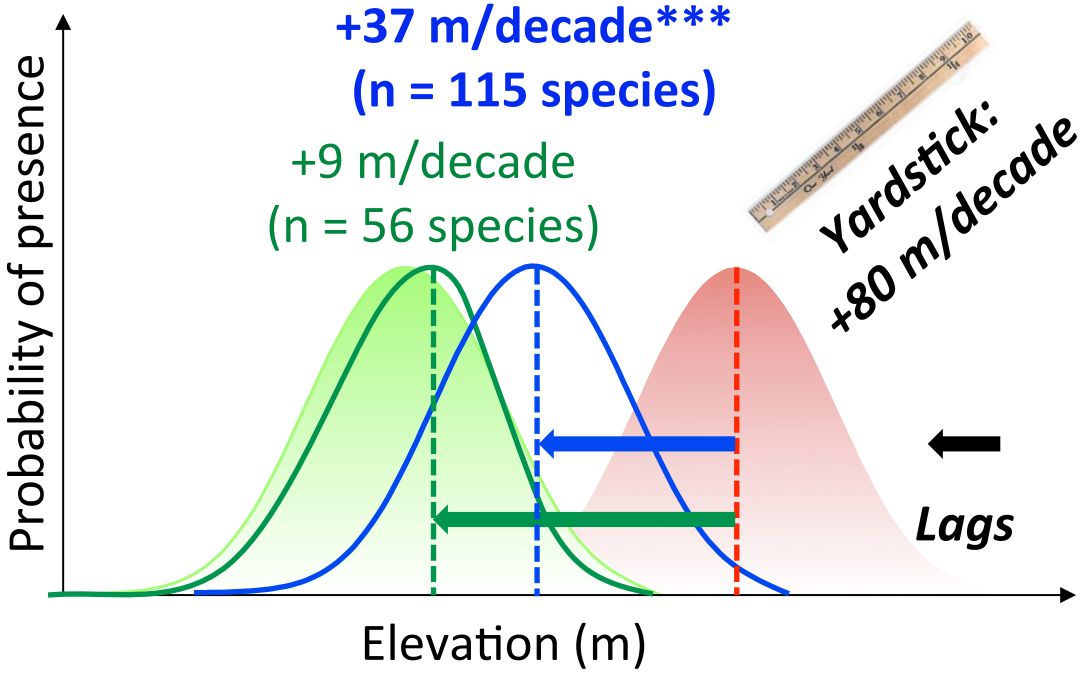
Community composition



Assuming **perfect niche conservatism**

Contemporary shifts in plant species optimum elevation across mountain forests in France



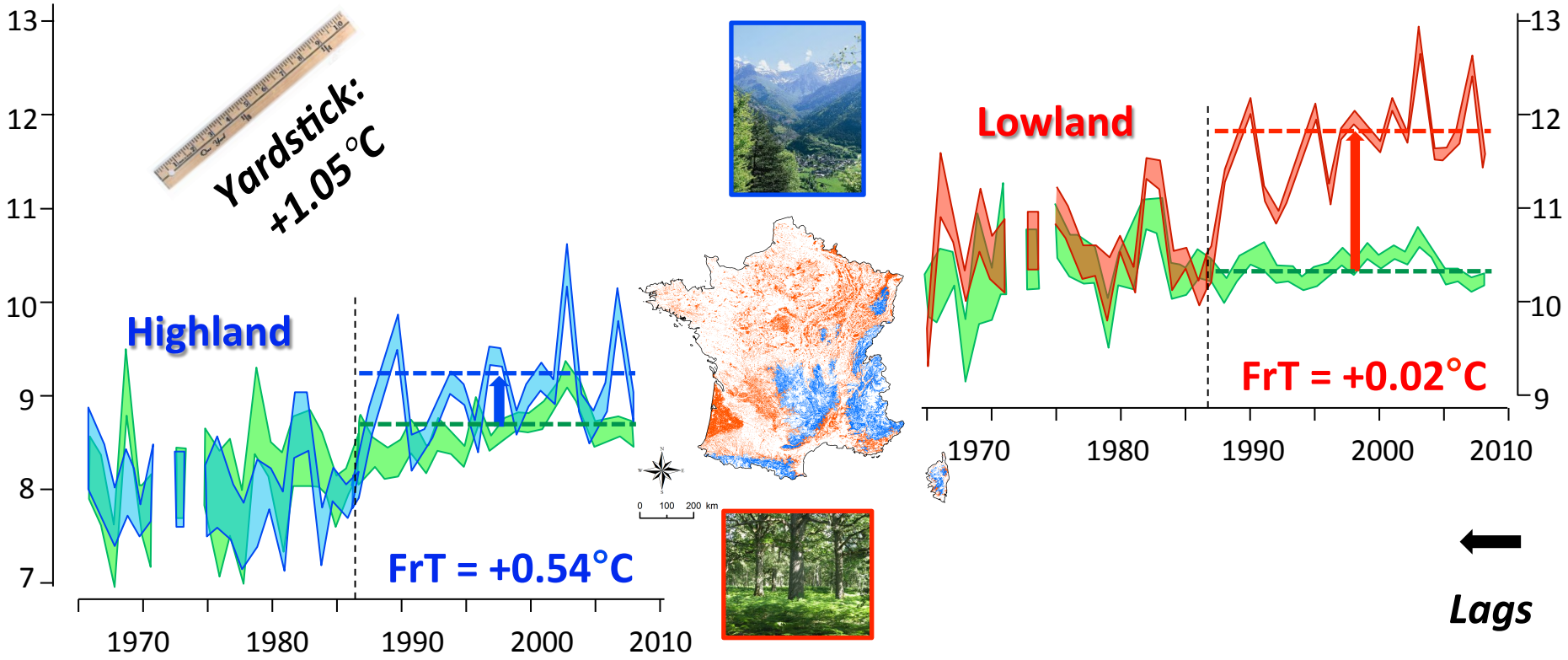


A Significant Upward Shift in Plant Species Optimum Elevation During the 20th Century

27 JUNE 2008 VOL 320 **SCIENCE**

Lenoir *et al.* (2008)

Contemporary changes in plant community composition across the French forests



LETTER
doi:10.1038/nature10548

Changes in plant community composition lag behind climate warming in lowland forests

24 NOVEMBER 2011 | VOL 479 | NATURE | 517

Bertrand *et al.* (2011)

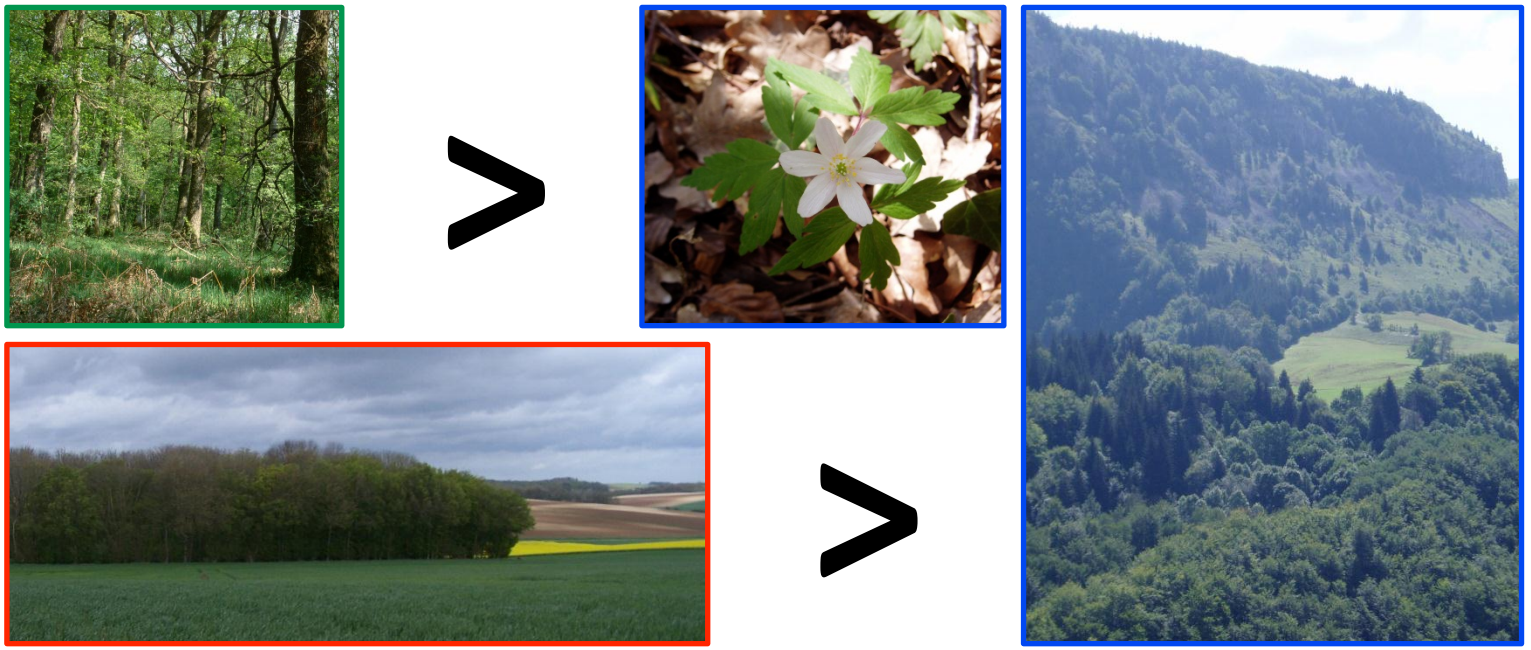
T(°C) climatically reconstructed (CrT)

T(°C) floristically reconstructed (FrT)

Take-home message

Contemporary-time lags are much greater:

- For **trees and shrubs** than for grasses, sedges, forbs, and ferns
- In **lowland forests** than in highland forests

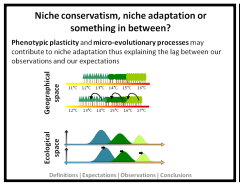


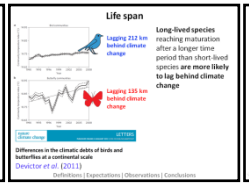
What are the **potential determinants** explaining these lags?

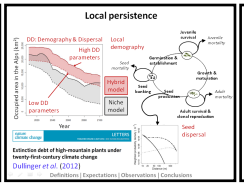
Bullet points for discussion

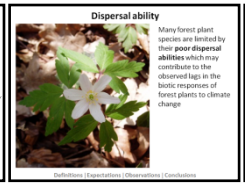
Identifying **biotic** and **abiotic determinants** of contemporary-time lags in the biotic responses of forest plants to climate change in Europe:

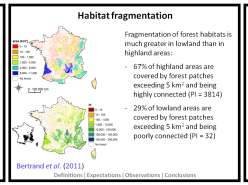
- ❖ Niche adaptation
- ❖ Life span
- ❖ Local persistence
- ❖ Dispersal ability
- ❖ Habitat fragmentation
- ❖ Spatial closeness between isotherms
- ❖ Velocity of temperature changes
- ❖ Mitigating effects due to other changes in abiotic conditions

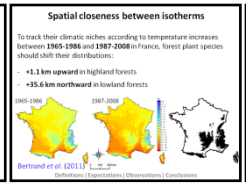


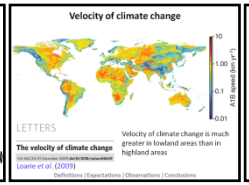


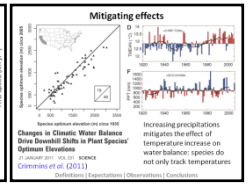












*jonathan.lenoir@u-picardie.fr

Acknowledgements

- **Nobuyuki TANAKA and Ikutaro TSUYAMA** for organizing and inviting me to contribute in this Special Session

- All my co-authors and especially **Romain BERTRAND** for contributing to this talk

- All of you for your kind attention

edysan
écologie et dynamique
des systèmes anthropisés

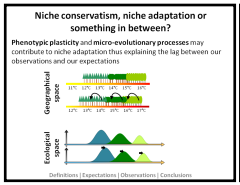
*jonathan.lenoir@u-picardie.fr

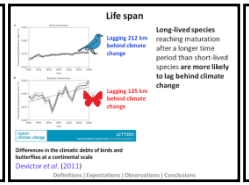
Questions?

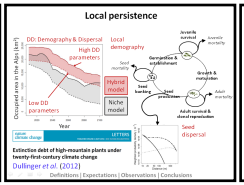
Bullet points for discussion

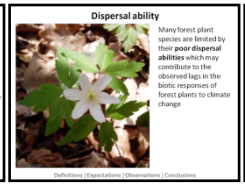
Identifying **biotic** and **abiotic determinants** of contemporary-time lags in the biotic responses of forest plants to climate change in Europe:

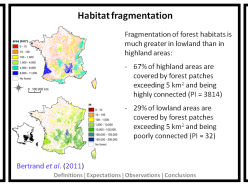
- ❖ Niche adaptation
- ❖ Life span
- ❖ Local persistence
- ❖ Dispersal ability
- ❖ Habitat fragmentation
- ❖ Spatial closeness between isotherms
- ❖ Velocity of temperature changes
- ❖ Mitigating effects due to other changes in abiotic conditions

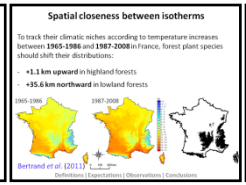


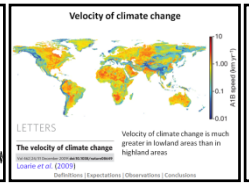


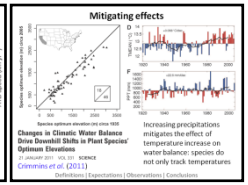






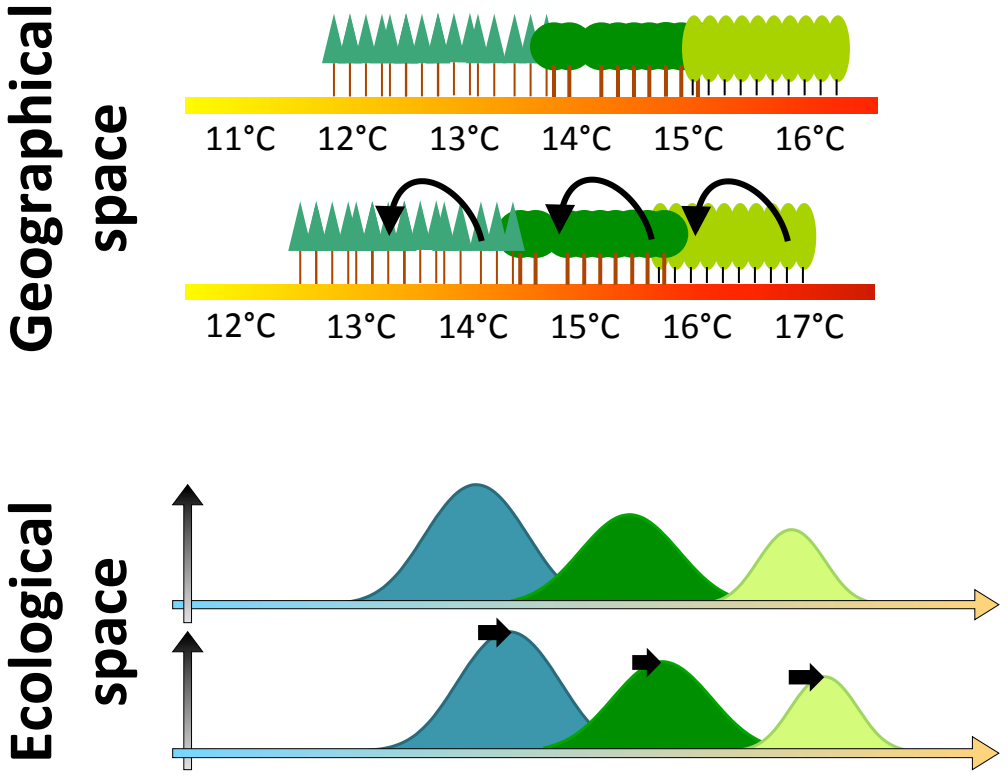




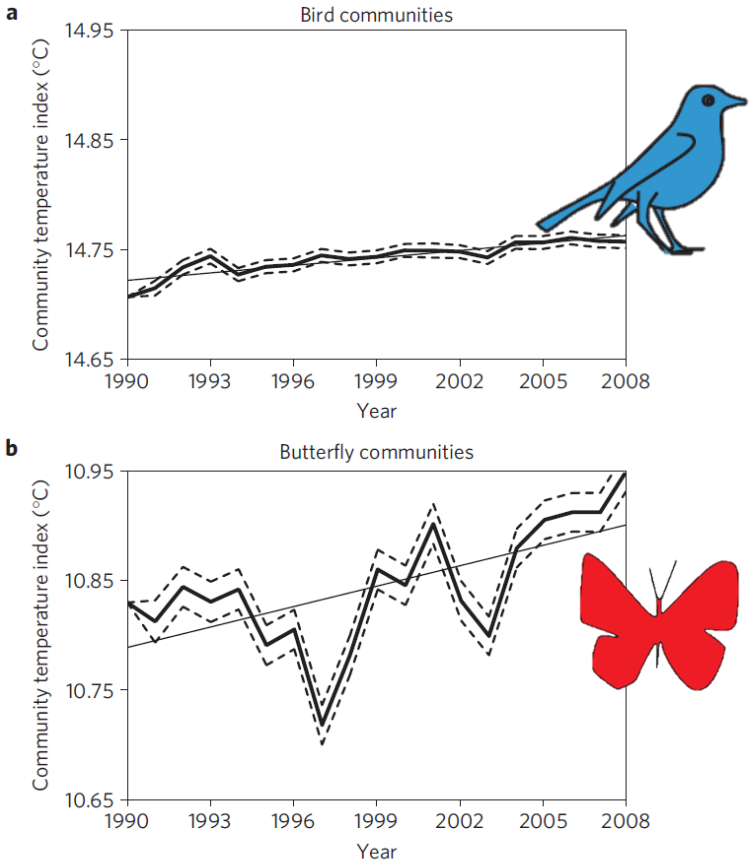


Niche conservatism, niche adaptation or something in between?

Phenotypic plasticity and **micro-evolutionary processes** may contribute to niche adaptation thus explaining the lag between our observations and our expectations



Life span



Lagging 212 km behind climate change

Lagging 135 km behind climate change

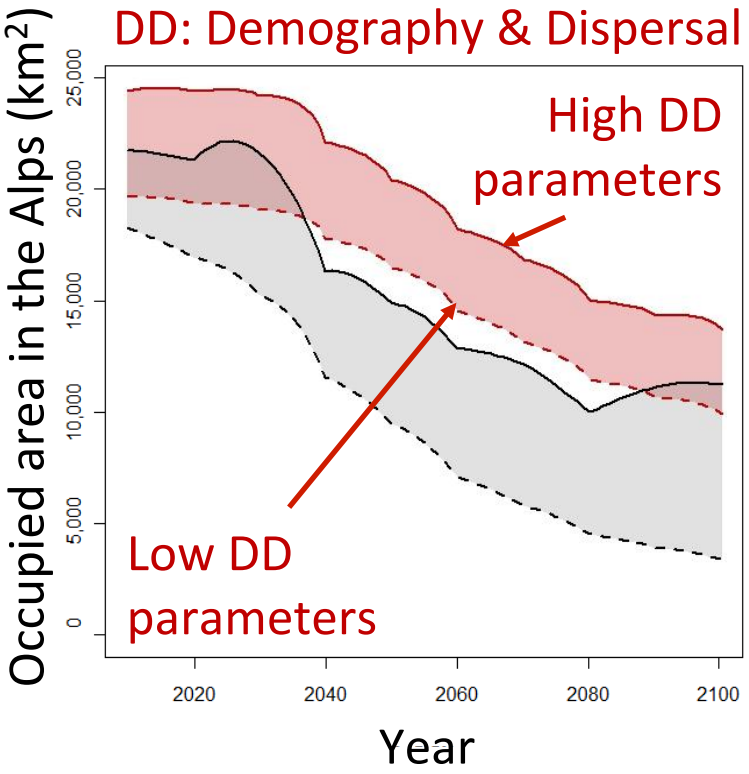
Long-lived species reaching maturation after a longer time period than short-lived species **are more likely to lag behind climate change**

nature climate change
LETTERS
PUBLISHED ONLINE: 8 JANUARY 2012 | DOI: 10.1038/NCLIMATE1347

Differences in the climatic debts of birds and butterflies at a continental scale

Devictor *et al.* (2011)

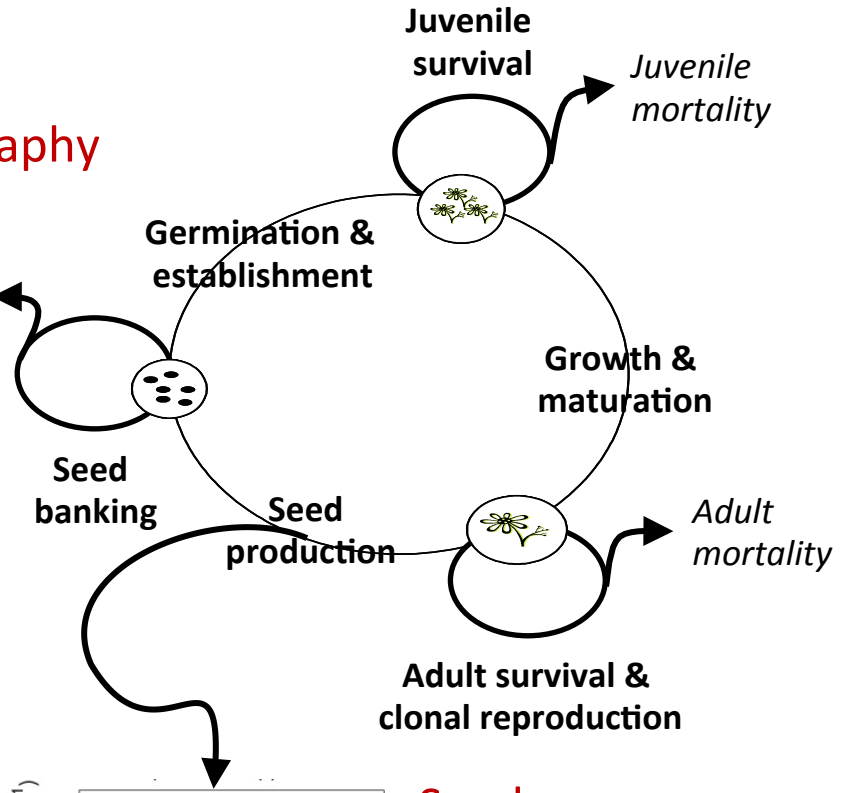
Local persistence

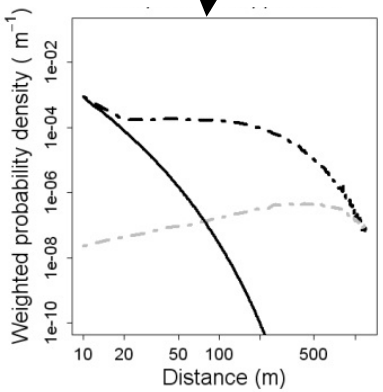


Hybrid model

Niche model

Local demography





Seed dispersal

nature climate change

LETTERS

PUBLISHED ONLINE: 6 MAY 2012 | DOI: 10.1038/NCLIMATE1514

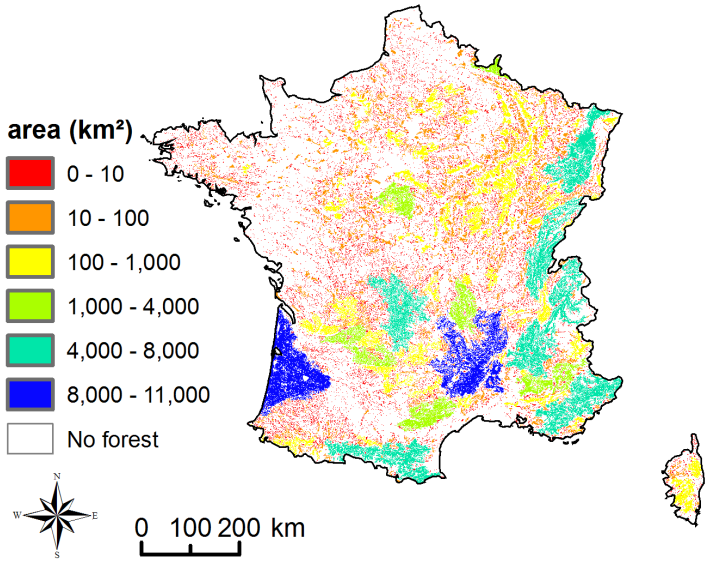
Extinction debt of high-mountain plants under twenty-first-century climate change

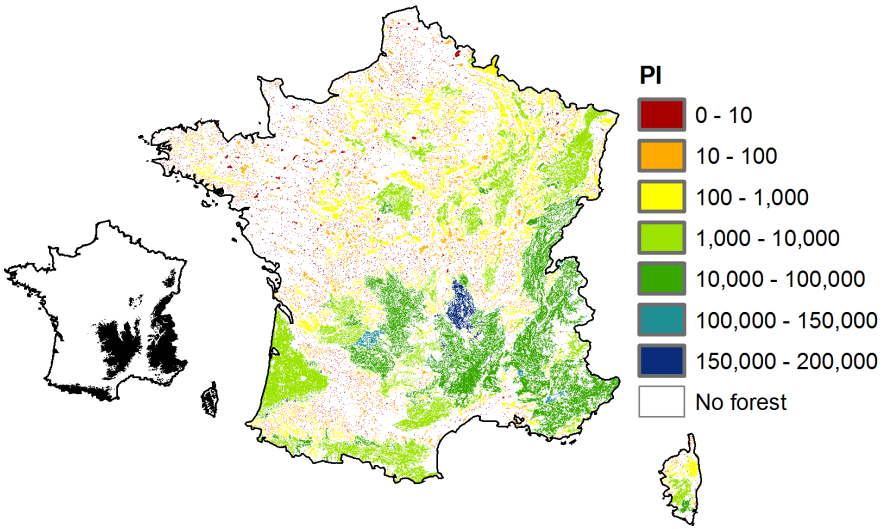
Dullinger *et al.* (2012)

Dispersal ability

Many forest plant species are limited by their **poor dispersal abilities** which may contribute to the observed lags in the biotic responses of forest plants to climate change

Habitat fragmentation





Fragmentation of forest habitats is much greater in lowland than in highland areas:

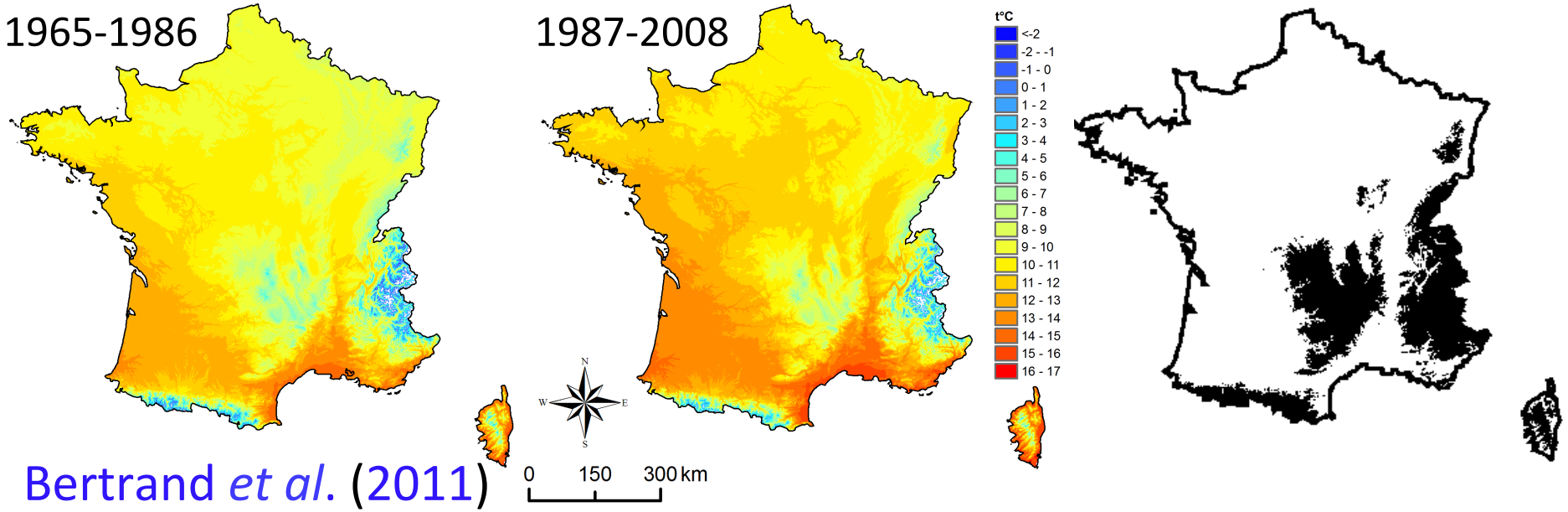
- 67% of highland areas are covered by forest patches exceeding 5 km^2 and being highly connected (PI = 3814)
- 29% of lowland areas are covered by forest patches exceeding 5 km^2 and being poorly connected (PI = 32)

Bertrand *et al.* (2011)

Spatial closeness between isotherms

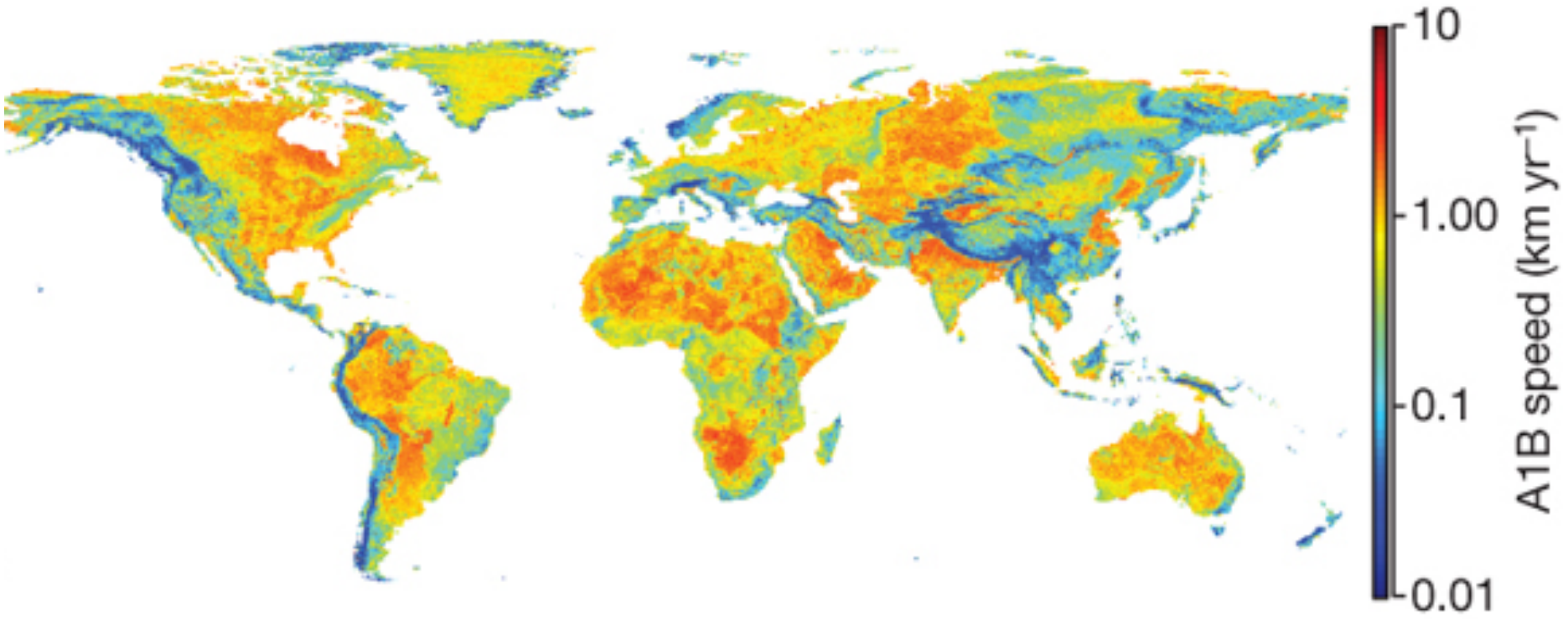
To track their climatic niches according to temperature increases between **1965-1986** and **1987-2008** in France, forest plant species should shift their distributions:

- **+1.1 km upward** in highland forests
- **+35.6 km northward** in lowland forests



Bertrand *et al.* (2011)

Velocity of climate change



LETTERS

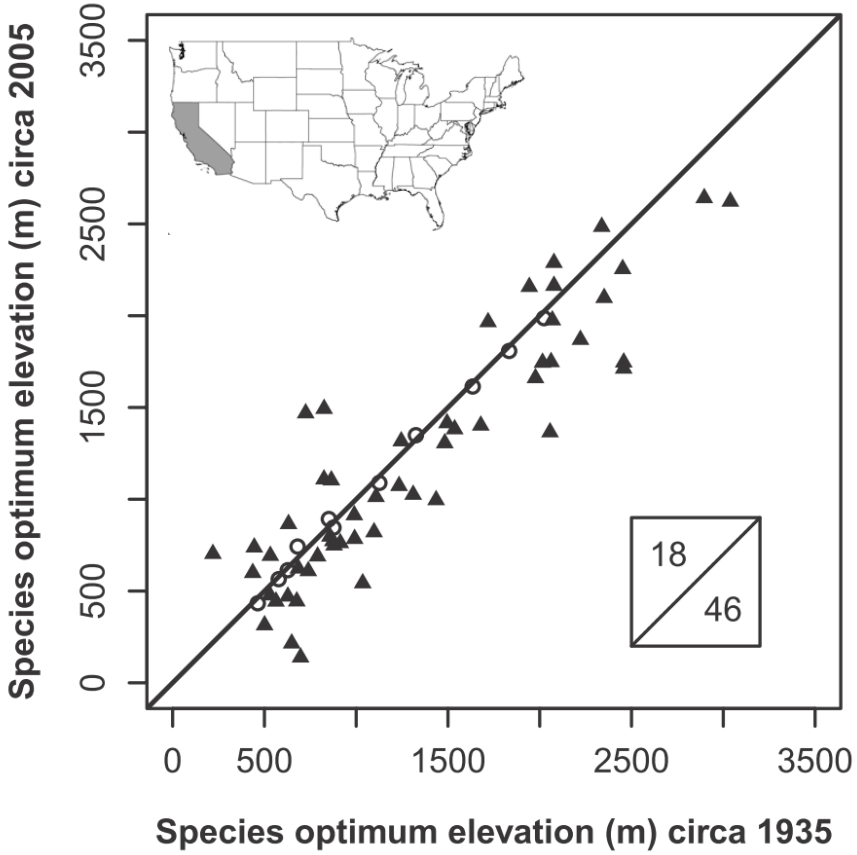
The velocity of climate change

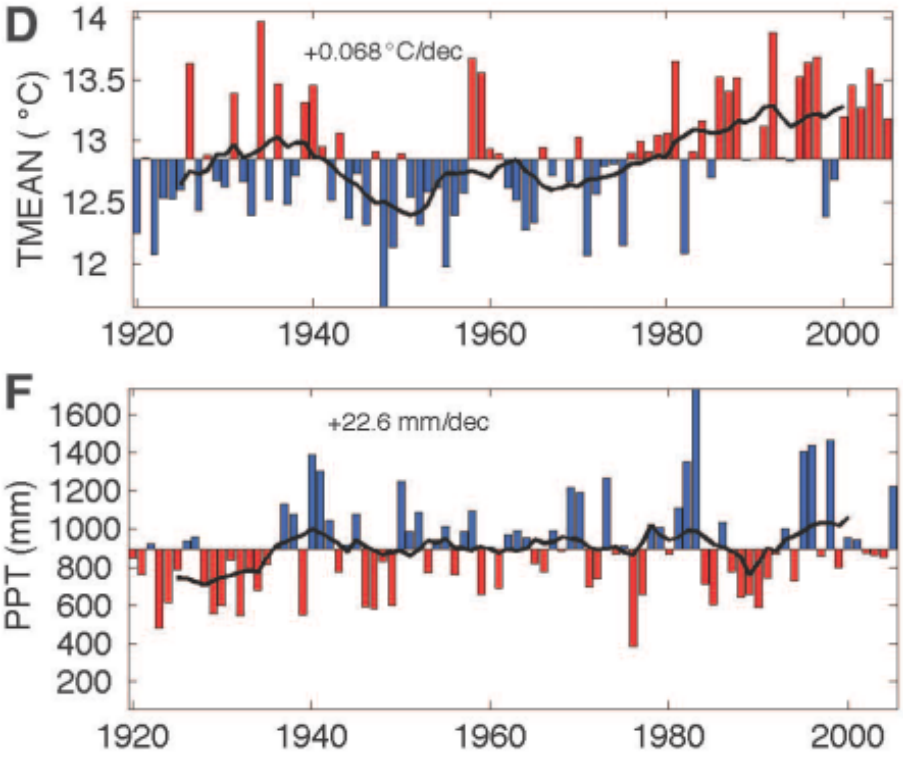
Vol 462|24/31 December 2009|doi:10.1038/nature08649

Loarie *et al.* (2009)

Velocity of climate change is much greater in lowland areas than in highland areas

Mitigating effects





Changes in Climatic Water Balance Drive Downhill Shifts in Plant Species' Optimum Elevations

21 JANUARY 2011 VOL 331 **SCIENCE**

Crimmins *et al*. (2011)

Increasing precipitations mitigates the effect of temperature increase on water balance: species do not only track temperatures