Ecologie et Dynamique
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Contemporary range shifts and late-Quaternary niche stasis of terrestrial plants – inference from vegetation databases

14th meeting of the German Working Group on Vegetation databases – Oldenburg – 4-6/02/2015

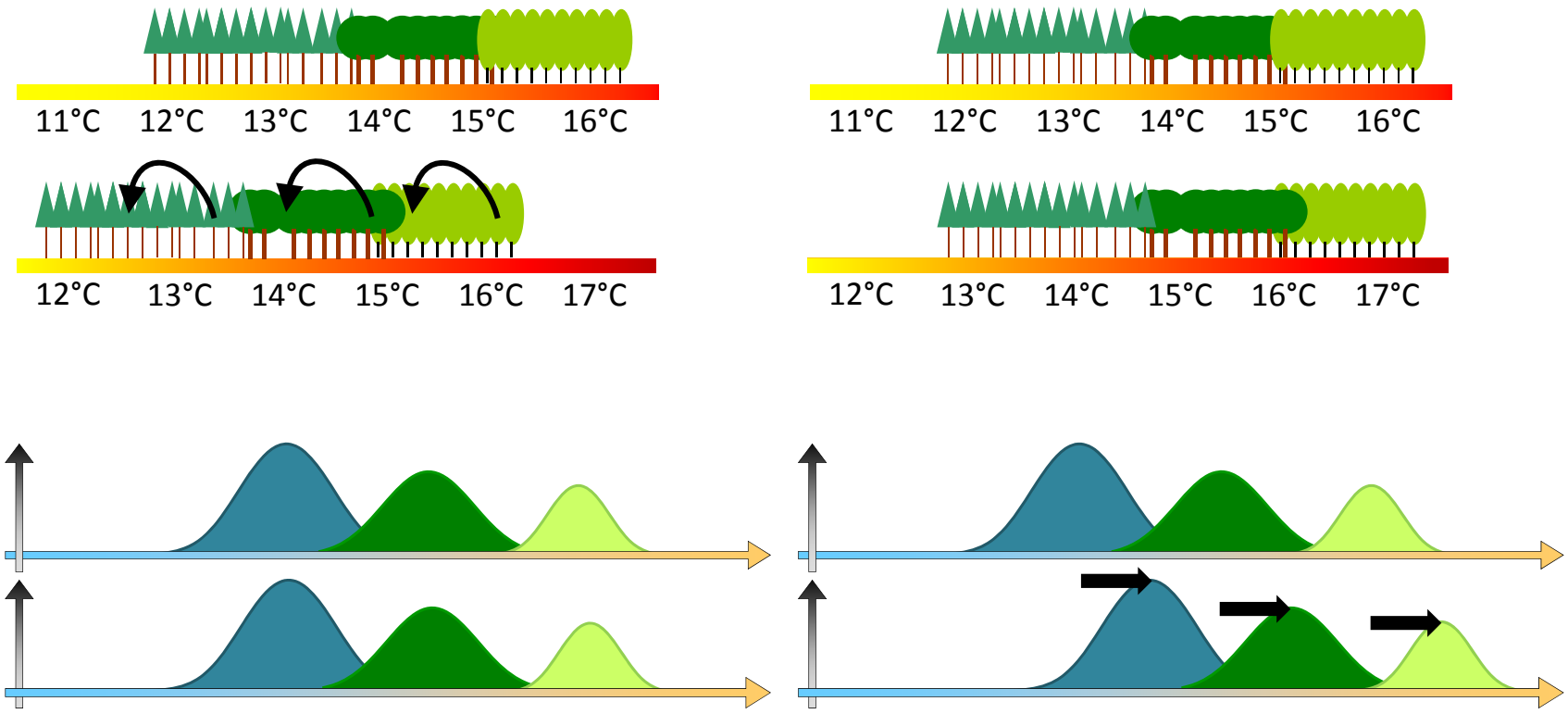
Photo: Jonathan Lenoir

Of niches and distributions

Should I stay or should I go for not to die?

Perfect niche conservatism

Perfect niche adaptation



Two recent meta-analyses on species range shits

One for terrestrial organisms (Chen *et al.*, 2011)

19 AUGUST 2011 VOL 333 SCIENCE www.sciencemag.org

Rapid Range Shifts of Species Associated with High Levels of Climate Warming

I-Ching Chen,[1,2] Jane K. Hill,[1] Ralf Ohlemüller,[3] David B. Roy,[4] Chris D. Thomas[1]*

One for marine organisms (Poloczanska *et al.*, 2013)

nature climate change

LETTERS

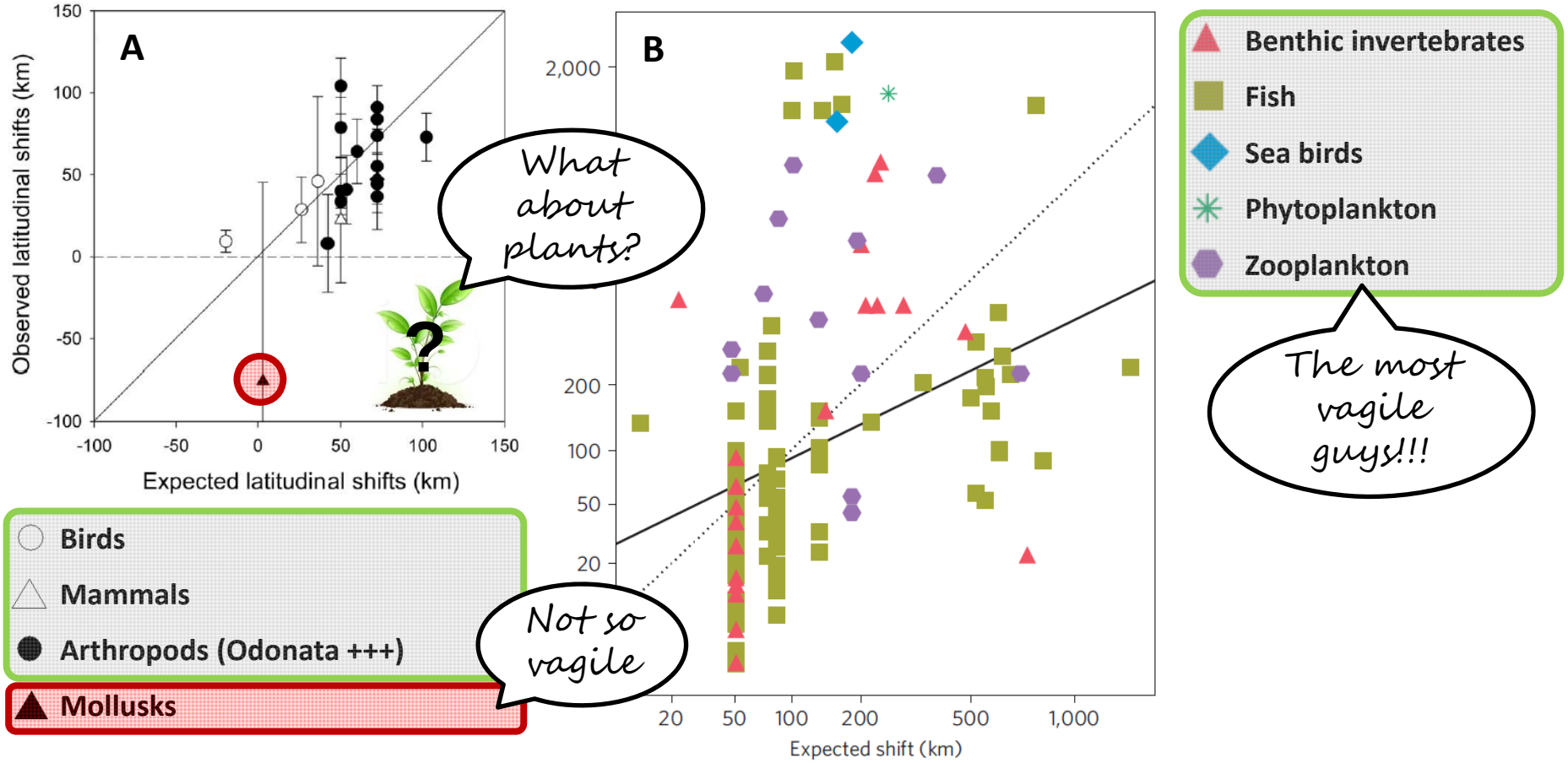
PUBLISHED ONLINE: 4 AUGUST 2013 | DOI: 10.1038/NCLIMATE1958

Global imprint of climate change on marine life

Elvira S. Poloczanska *et al.*†

Are plants shifting poleward?

Living terrestrial & marine organisms are shifting toward the poles as climate warms (Chen *et al.*, 2011; Poloczanska *et al.*, 2013)



Beyond meta-analyses: review & synthesis

How much do we know about range shifts for terrestrial plants compare to marine plants or animals (Lenoir & Svenning, 2015)?

Ecography 38: 15–28, 2015
doi: 10.1111/ecog.00967

Subject Editor: Robert Colwell. Accepted 30 April 2014

Climate-related range shifts – a global multidimensional synthesis and new research directions

J. Lenoir and J.-C. Svenning

An important new review and synthesis of species movements in response to climate change is presented. This study is unusually broad in that it covers terrestrial and marine environments for plants and animals, and not only poleward or downward movement of terrestrial species or marine species, respectively, but also other movements that can occur due to complex interactions of climate, environment and species traits, such as equatorward and longitudinal movements in response to a warming climate. Different types of range responses to climate change are put in perspective - it is commonly assumed that species will colonize new areas in a poleward direction, accompanied by local extinctions along the trailing edge - however, poleward colonization without losses along the trailing edge, trailing-edge losses without poleward expansion, shifts in the region of optimum abundance without changes in range limits, and losses throughout species ranges are also possibilities. The study examines imbalances in the existing published literature, for example, there are a lot more published case studies of terrestrial animals than plants, and there are regions of the world and taxonomic groups for which there is a deficit of knowledge. A useful framework for future research is included that does a better job of linking potential range shifts to extinction risk than previous publications.

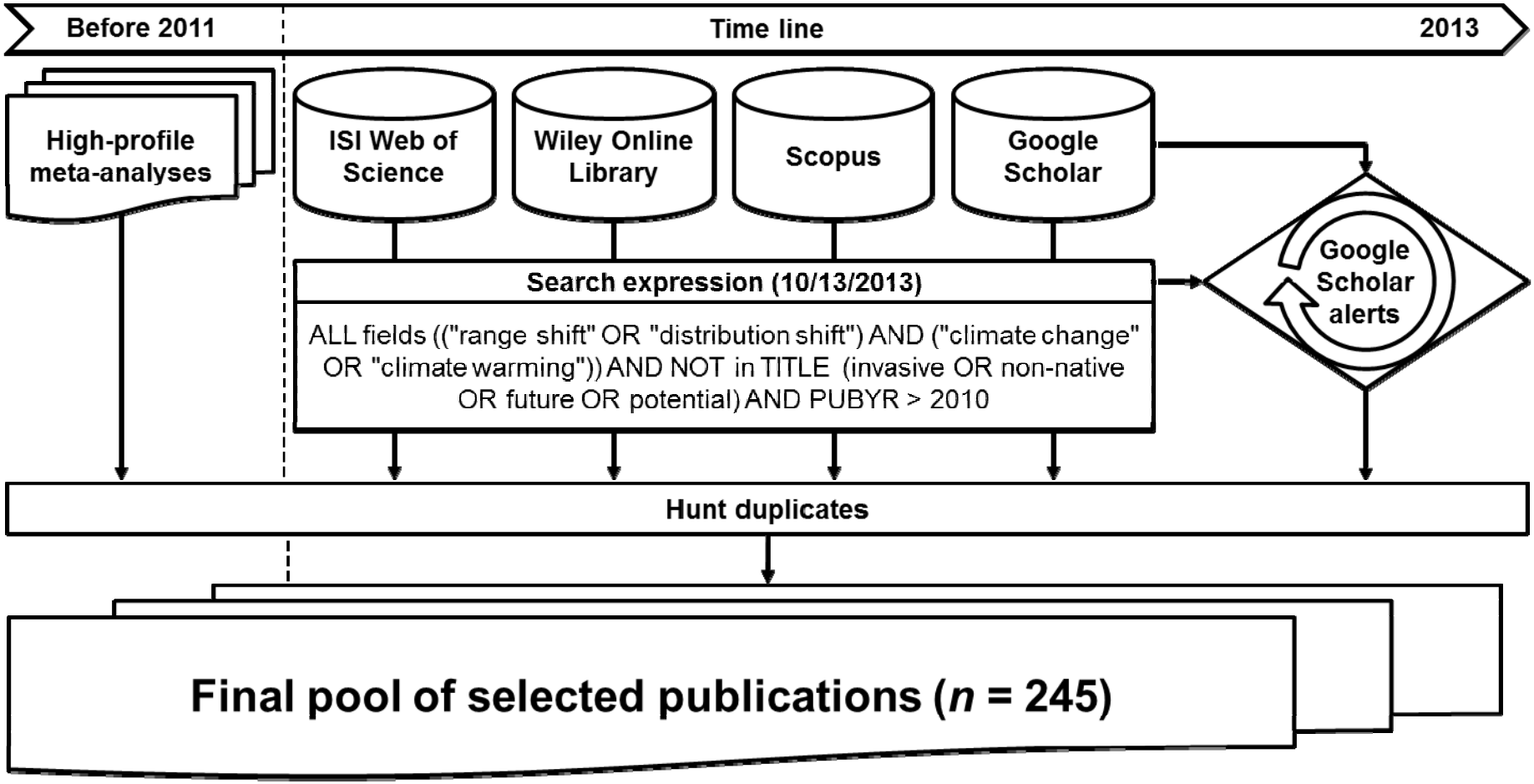
★★ Very Good

FM Lee Frelich
F1000 Ecology
University of Minnesota Center for Forest Ecology, St Paul, MN, USA.

F FOLLOW

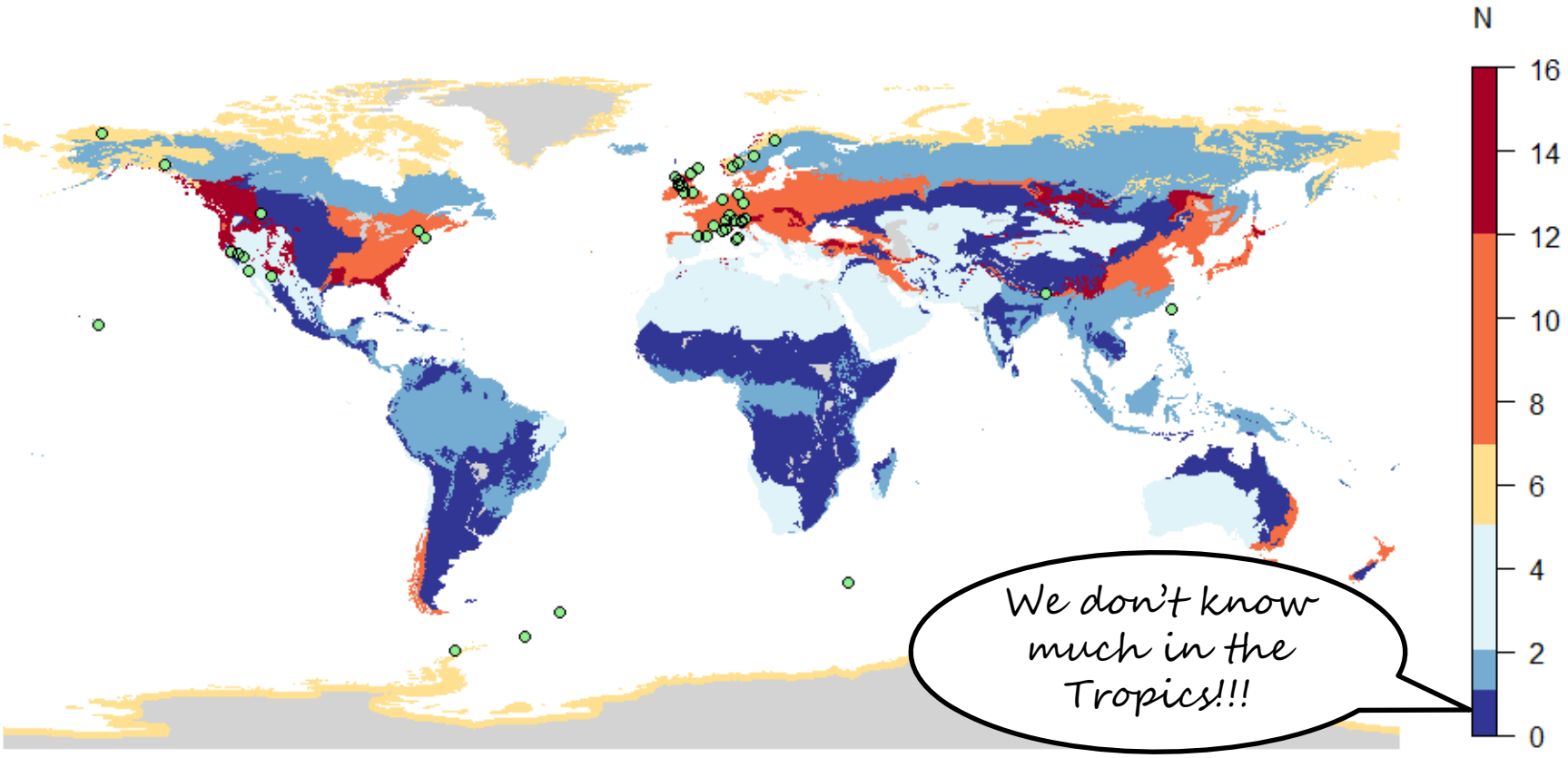
How to capture a fast-moving field of research?

Extensive review on geographical patterns of species range shifts under contemporary climate change (Lenoir & Svenning, 2015)



Geographic shortfalls

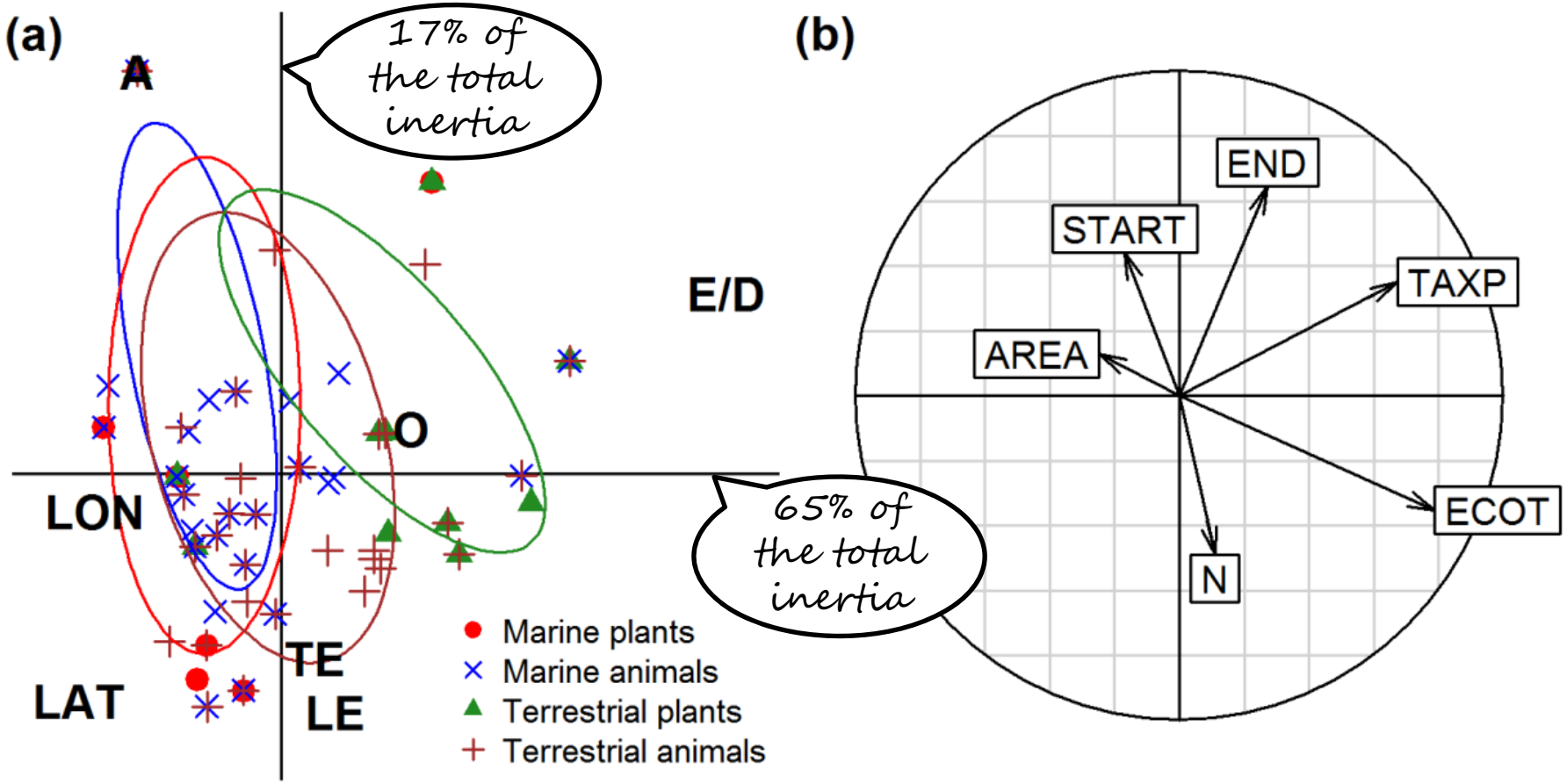
For terrestrial plants, publication effort (n = 34) peaks in the temperate conifer forests' and temperate broadleaf & mixed forests' biomes (Lenoir & Svenning, 2015)



Terrestrial biomes of the World: World Wildlife Fund's (WWF)

Taxonomic and methodological shortfalls

Most studies reporting distribution changes for terrestrial plants focused on species optimum elevation (Lenoir & Svenning, 2015)



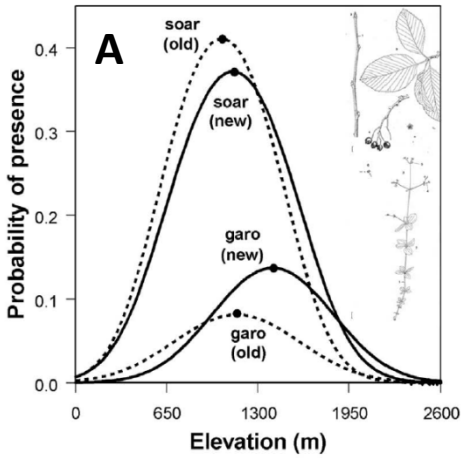
A case study using national vegetation databases

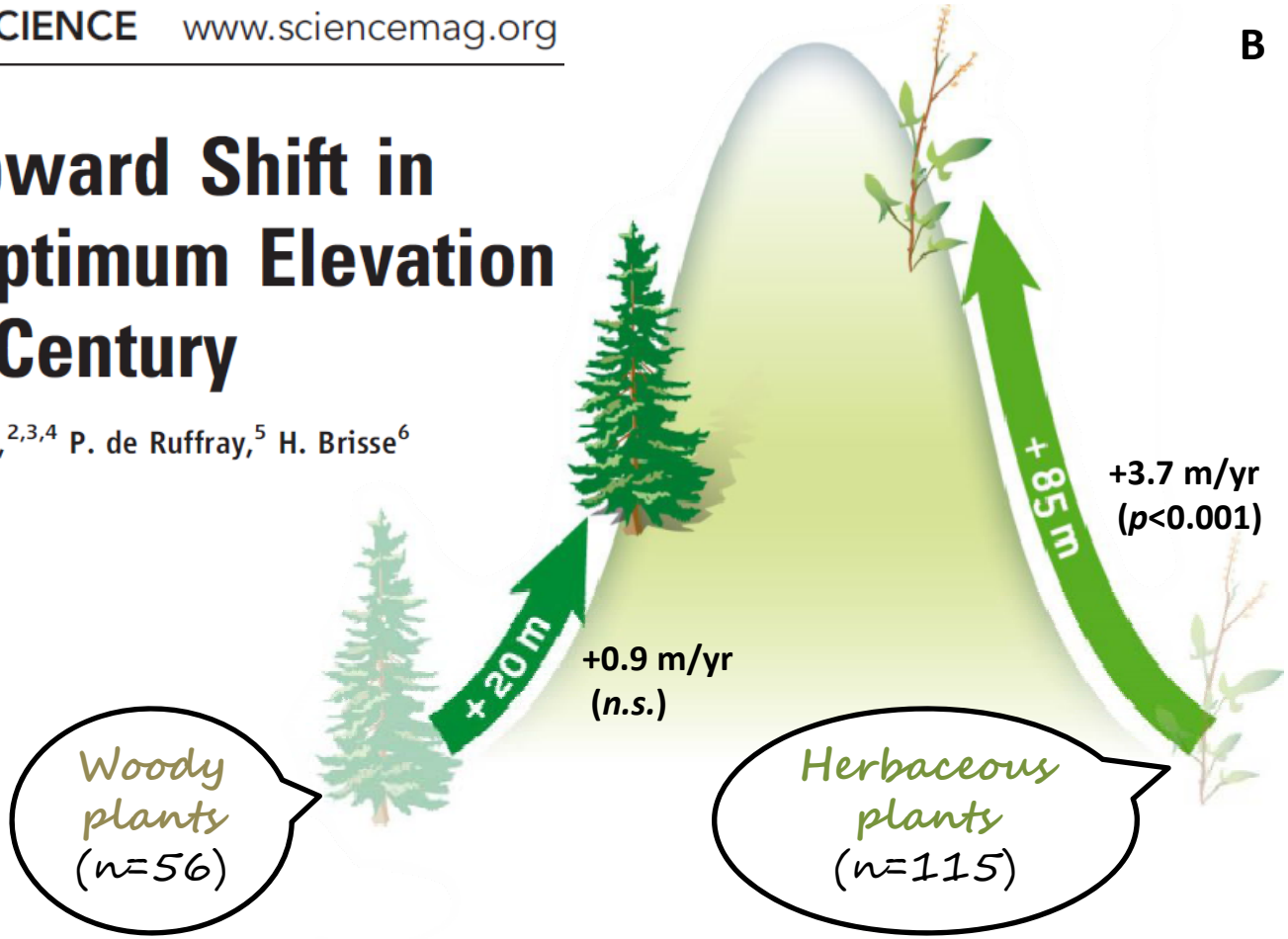
Inference from two French vegetation databases (Sophy & EcoPlant) storing historical relevés (from 1905 onwards) (Lenoir *et al.*, 2008)

27 JUNE 2008 VOL 320 **SCIENCE** www.sciencemag.org

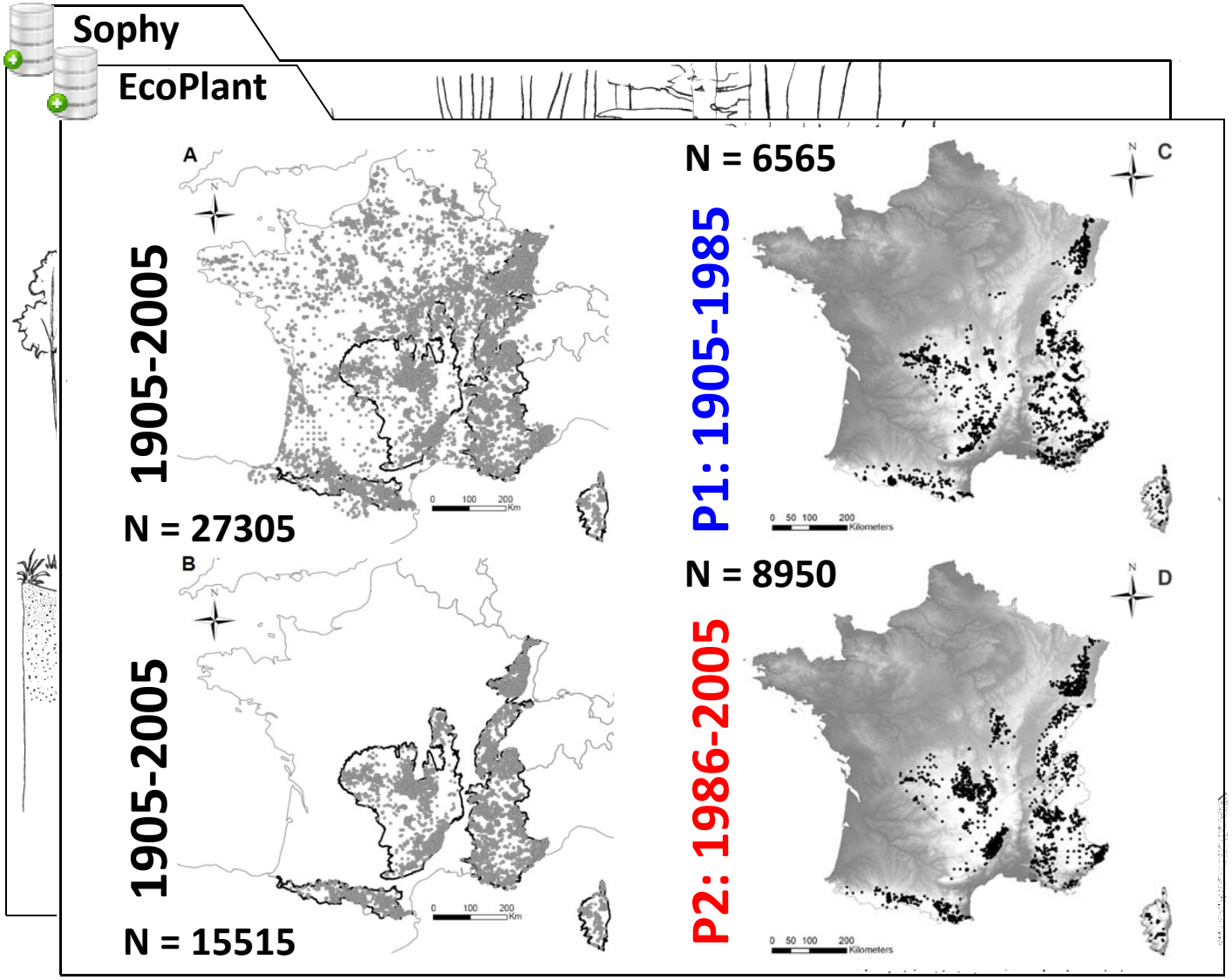
A Significant Upward Shift in Plant Species Optimum Elevation During the 20th Century

J. Lenoir,[1]* J. C. Gégout,[1] P. A. Marquet,[2,3,4] P. de Ruffray,[5] H. Brisse[6]





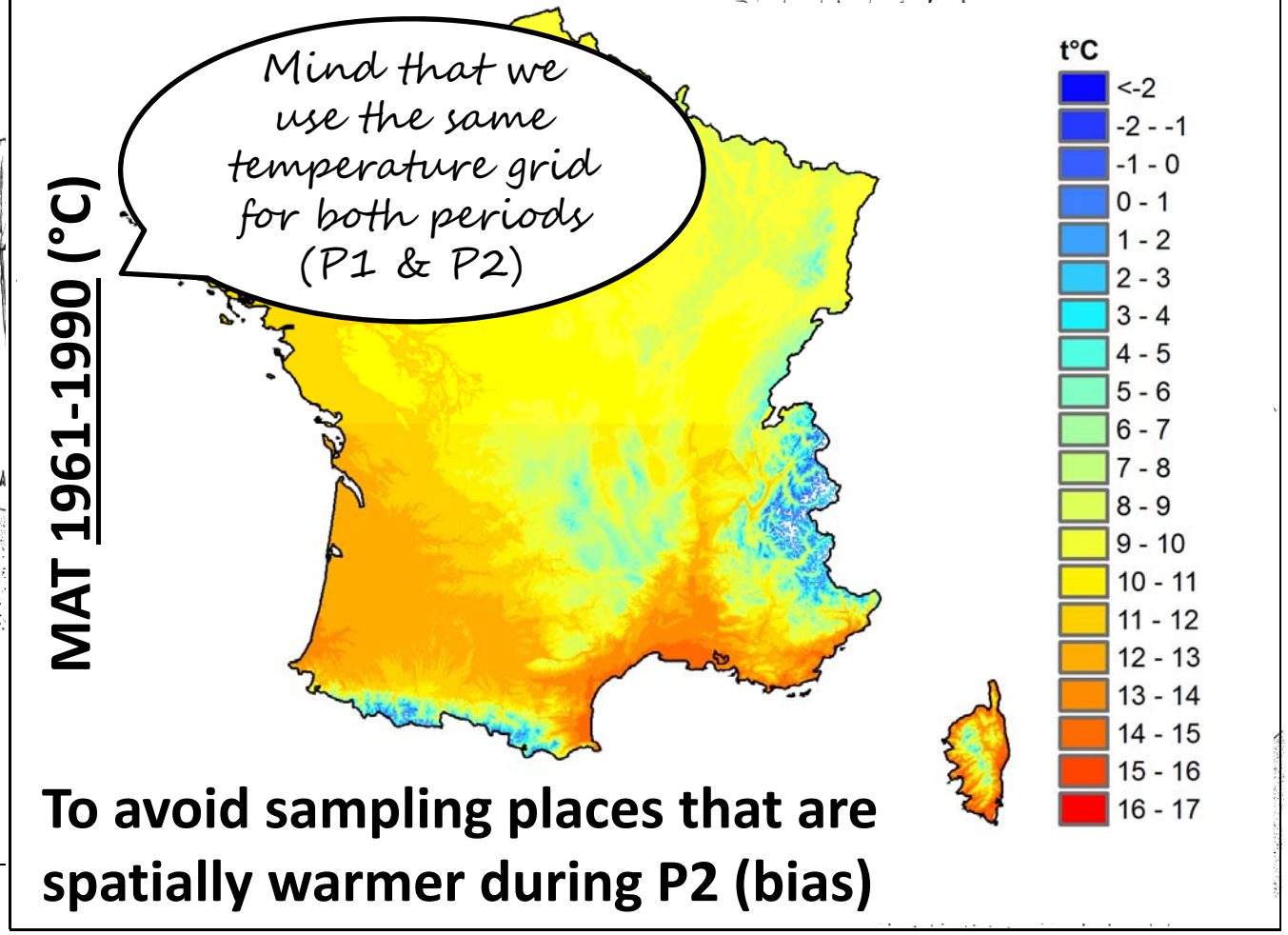
Large databases are powerful but also messy



A stratified sampling strategy is generally needed

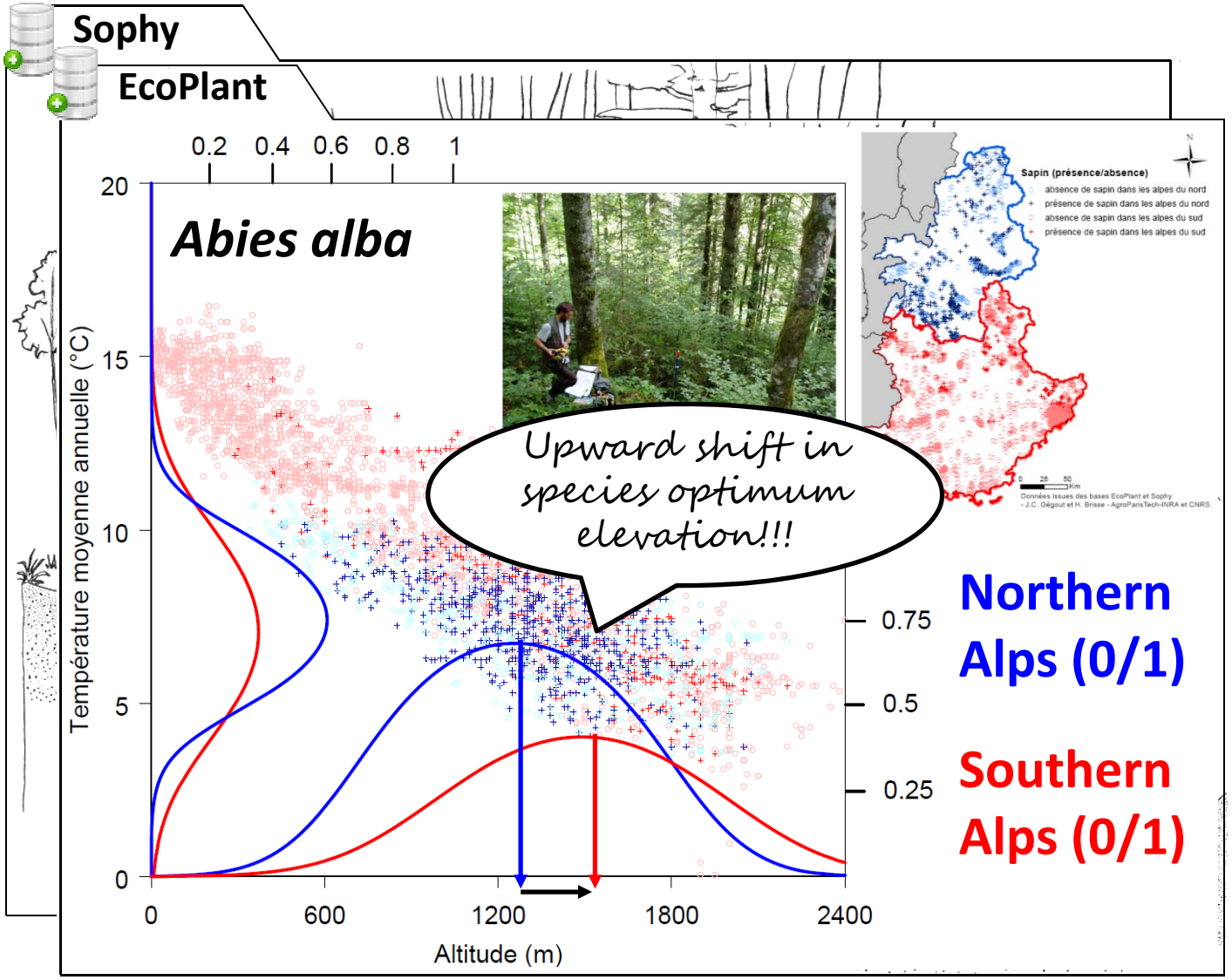
Sophy

EcoPlant



To avoid sampling places that are spatially warmer during P2 (bias)

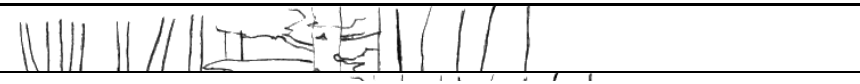
Why does it matter so much?



Randomization to balance sampling effort

Sophy

EcoPlant

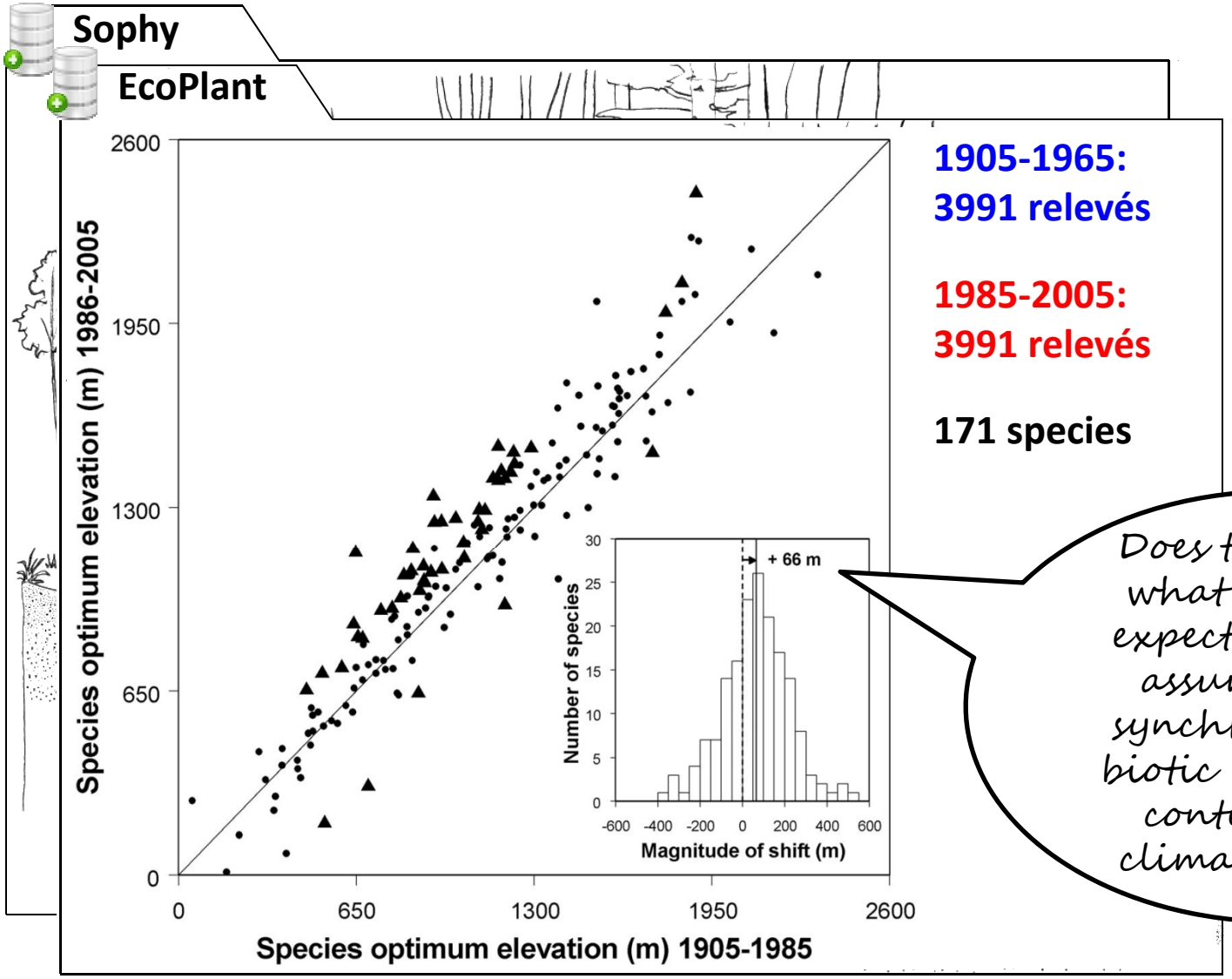


T (°C)	Alpes		Corse		Jura		Massif Central		Pyrénées		Vosges	
	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
< 0	**2**	2										
1,1-2	**0**	0										
2,1-3	11	**1**										
3,1-4	59	**23**			1	**0**	3	**0**	7	**3**		
4,1-5	163	**45**			35	**15**	**15**	20	18	**2**		
5,1-6	202	**151**			26	**16**	**50**	102	29	**8**		
6,1-7	317	**168**			46	**32**	**83**	192	45	**40**		
7,1-8	280	**212**	5	**0**	**16**	78	**101**	237	99			
8,1-9	221	**187**	12	**5**	102	**93**	**281**	351	89			
9,1-10	247	**185**	21	**8**	**67**	109	**287**	382	**74**			
10,1-11	158	**48**	51	**14**	**2**	5	**148**	428	**35**			
11,1-12	173	**135**	37	**14**			**143**	316	**44**			
12,1-13	**87**	200	20	**11**			**44**	214	**11**			
13,1-14	**138**	210	13	**5**			**4**	6	**16**			
14,1-15	**162**	188	**11**	48					28			
15,1-16	**38**	114	10	**5**					10			
16,1-17	**1**	19										
> 17	**0**	19										

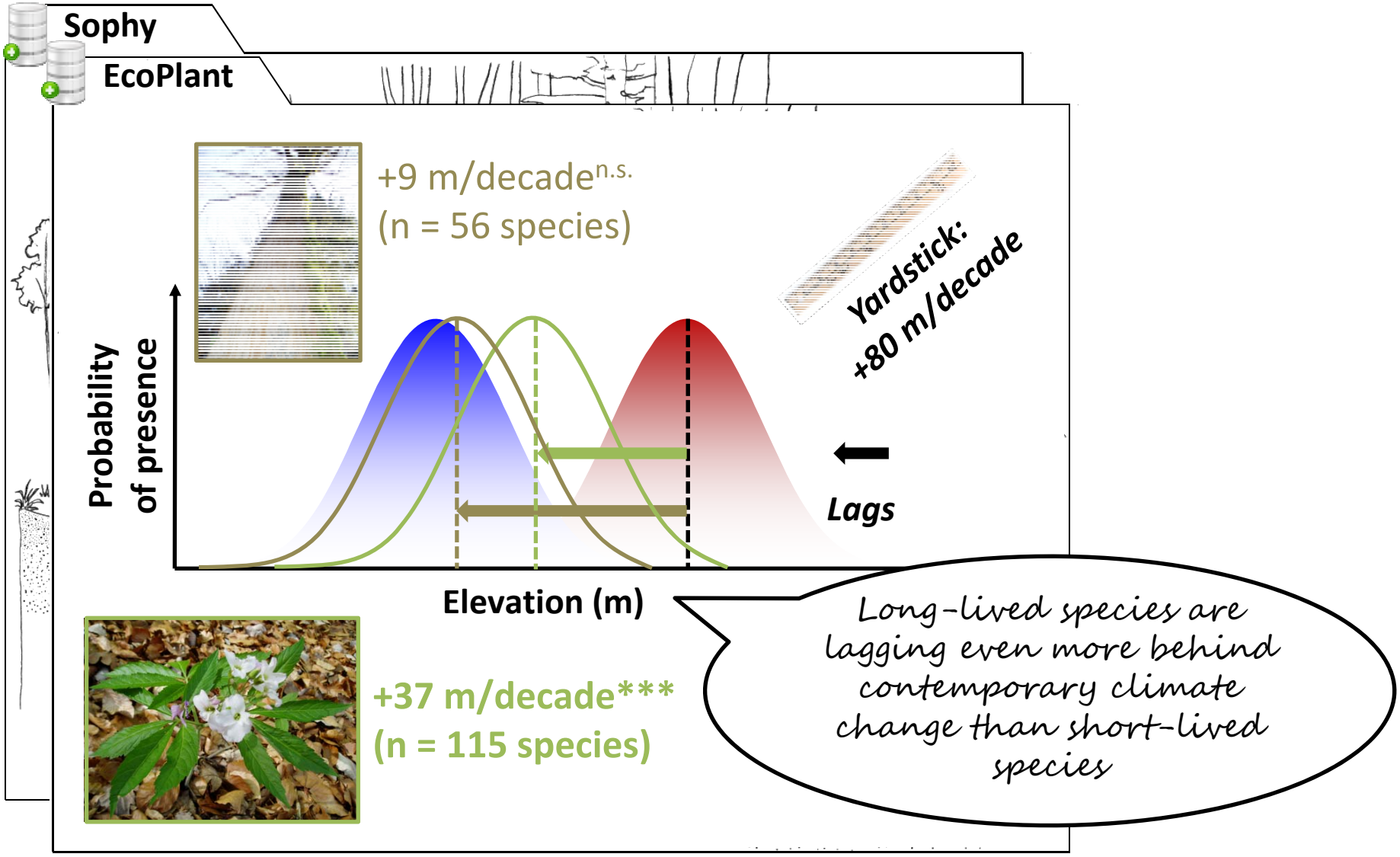
Temperature conditions (without considering the effect of climate warming) are the same between the two samples and thus any range shifts cannot be attributed to spatial sampling bias over time

Extract the random solution minimizing the residual sum of squares (RSS) in MAT between P1 & P2 to sample similar places given MAT

A general trend to shift upward over time



Lagging effect?



Biotic responses are not synchronous

A quantification of lags in biotic responses (Bertrand *et al.*, 2011)

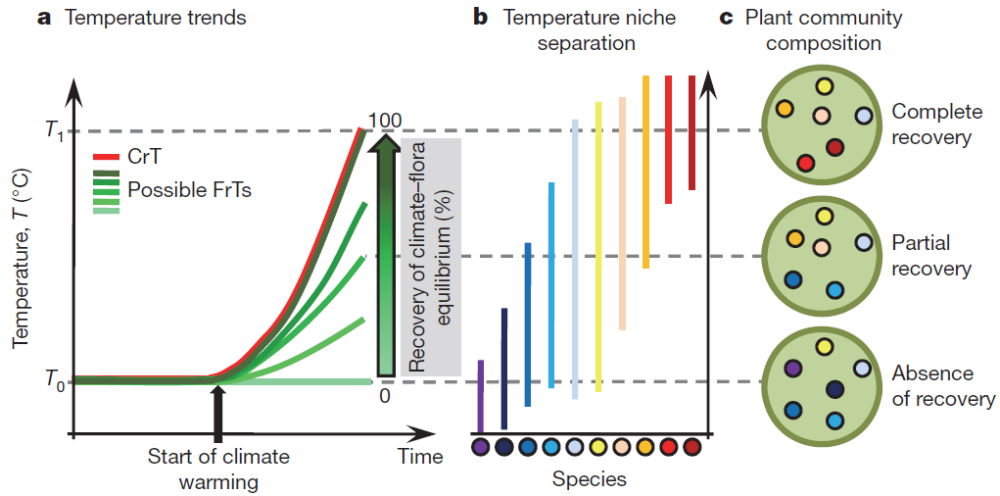
LETTER

24 NOVEMBER 2011 | VOL 479 | NATURE | 517

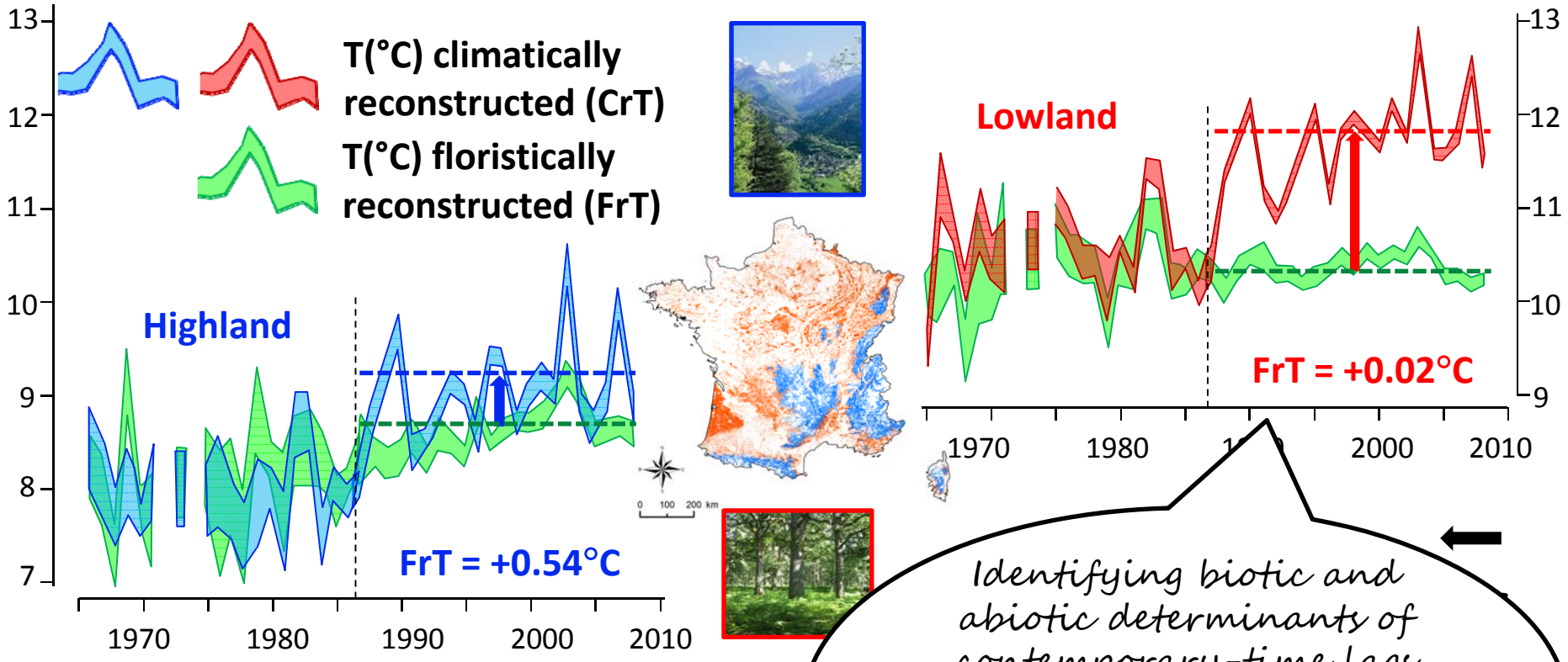
doi:10.1038/nature10548

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

Romain Bertrand[1,2], Jonathan Lenoir[3], Christian Piedallu[1,2], Gabriela Riofrío-Dillon[1,2], Patrice de Ruffray[4], Claude Vidal[5], Jean-Claude Pierrat[1,2] & Jean-Claude Gégout[1,2]



Greater lags in the lowlands than in the highlands

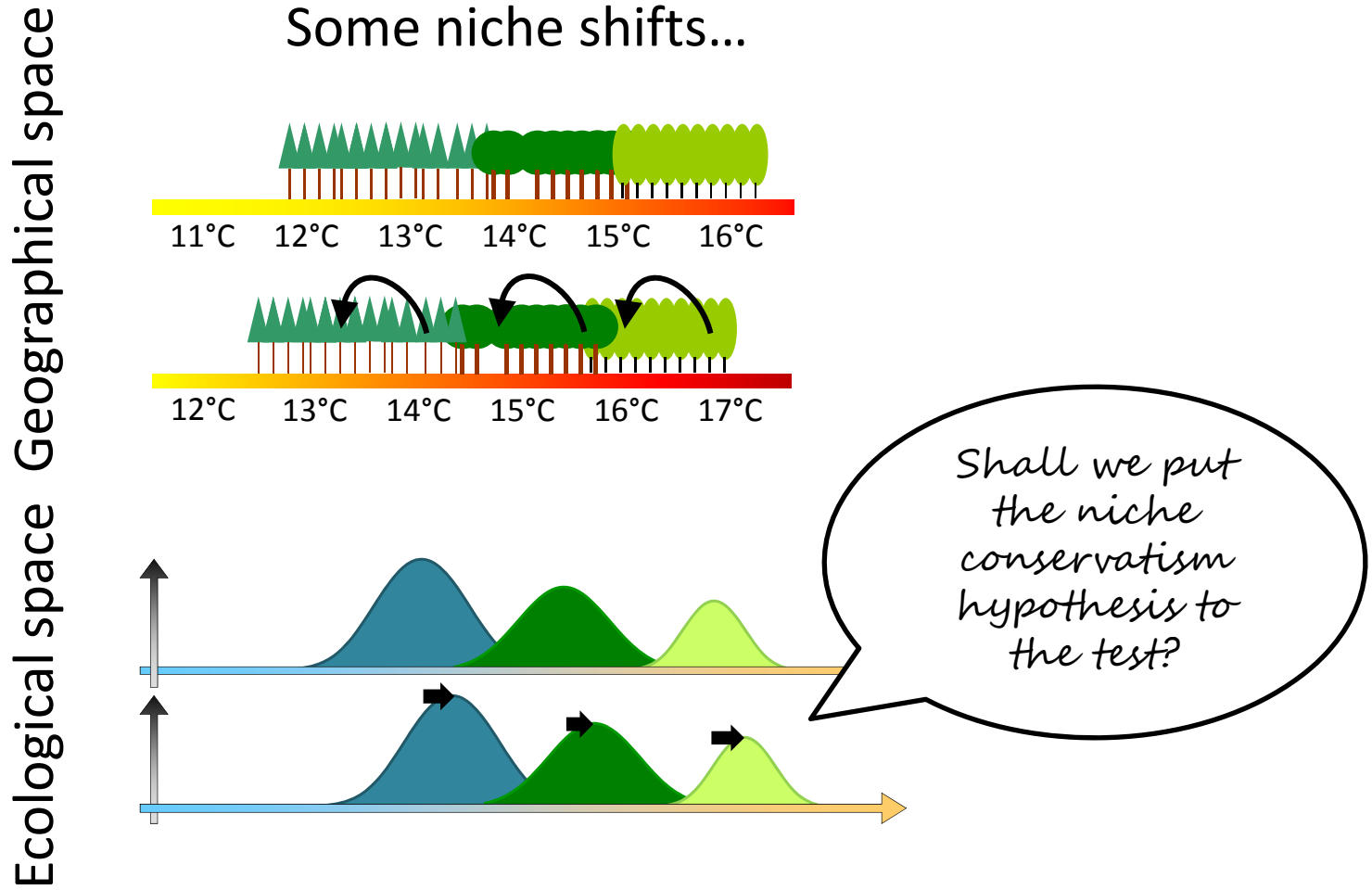


Identifying biotic and abiotic determinants of contemporary-time lags in the biotic responses of terrestrial plants to climate change is a timely issue...

Is niche adaptation/shift one of them?

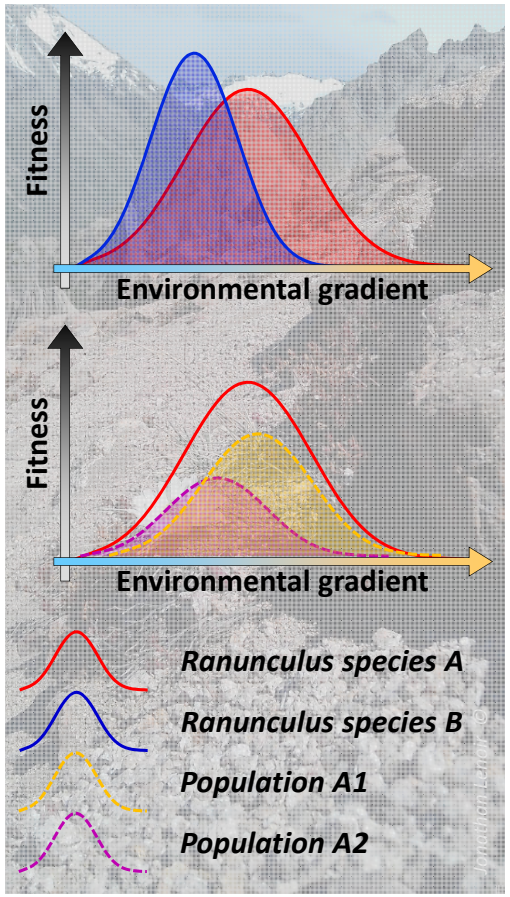
Back to our hypotheses on niches and distributions!!!

Some niche shifts…



Caution!!! Niche conservatism is a catch-all term

The niche conservatism hypothesis has very different meanings & implications depending on the time scale (Wasof *et al*. in revision)



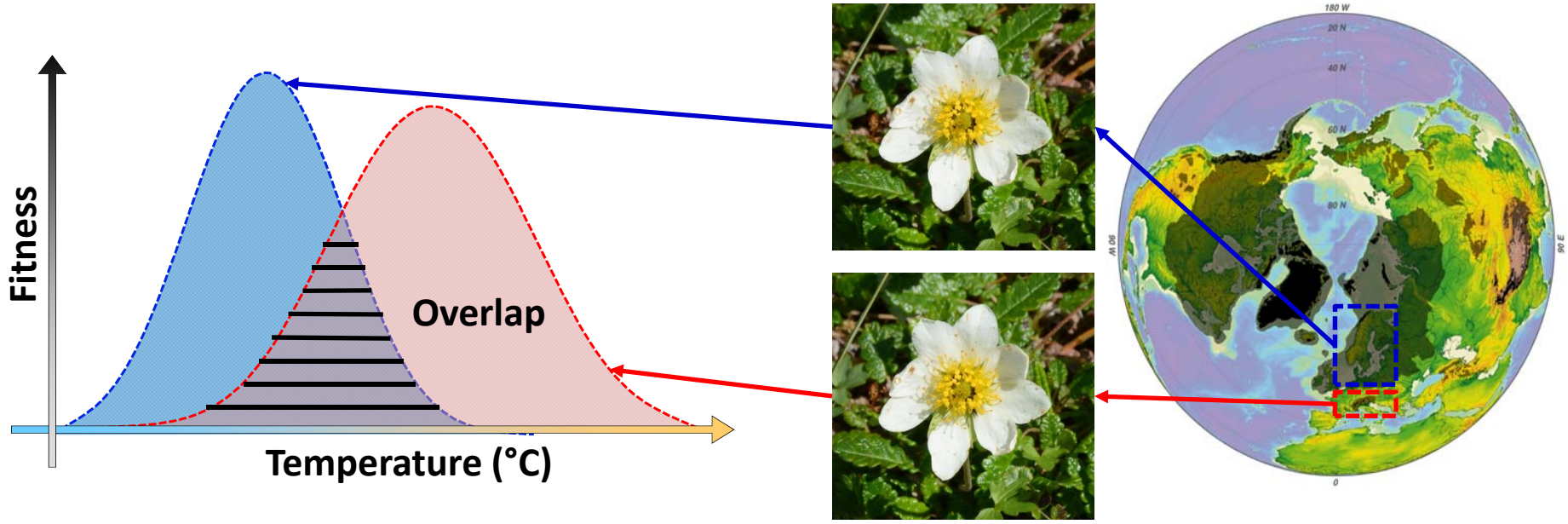
- ❖ **Closely related (or sister) species of the same genera: phylogenetic niche conservatism & evolutionary time scales (Wiens *et al*. 2010; Losos 2008)**
- ❖ **Distant populations of the same species: species' niche conservatism & shorter time scales (Petitpierre *et al*. 2012)**
- ➢ **Focus on distant populations of the same species is needed to test the species' niche conservatism hypothesis which is central to species distribution models (SDMs)**

Research questions

1) **Do the climatic niches between distant native populations (e.g., alpine plants occurring in both the Alps & Fennoscandia) differ?**

2) **How big is the climatic niche overlap between the two regions?**

3) **How much of the variation in species' niche overlap can be explained by species' traits?**



Two European vegetation-plot databases (0/1)

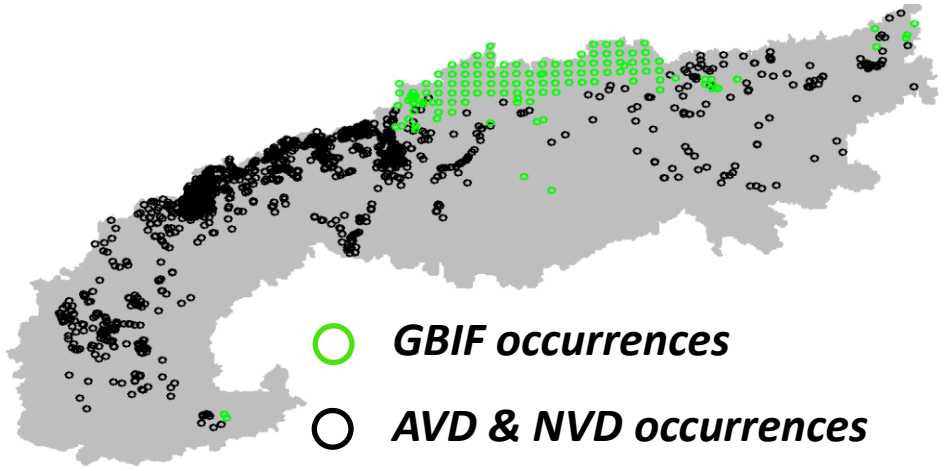
31 524 vegetation plots across the Alps (FR, CH, AU): the Alps Vegetation Database (AVD: EU-00-014) (Lenoir *et al.* 2012)

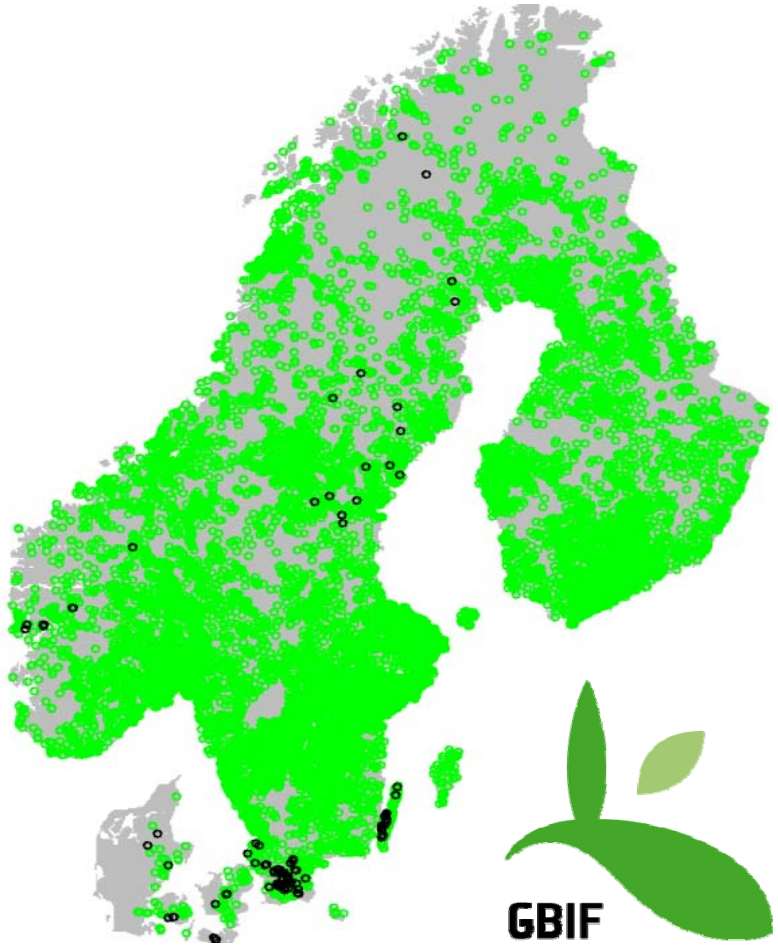
41 785 vegetation plots across Fennoscandia (NO, SE, FI, DK): the Nordic Vegetation Database (NVD: EU-00-018) (Lenoir *et al.* 2013)

888 species common to AVD & NVD

Occurrence records (1-only)

Extraction of occurrence records from the Global Biodiversity Information Facility (@GBIF) for each of the 888 focal species





Climatic grids

Preparation of 3 temperature-related grids at 1-km resolution across the Alps & Fennoscandia (@WordlClim)

- growing degree days above 0°C (**GDD**)
- absolute minimum temperature (**AMT**)
- continentality index (**CI**)

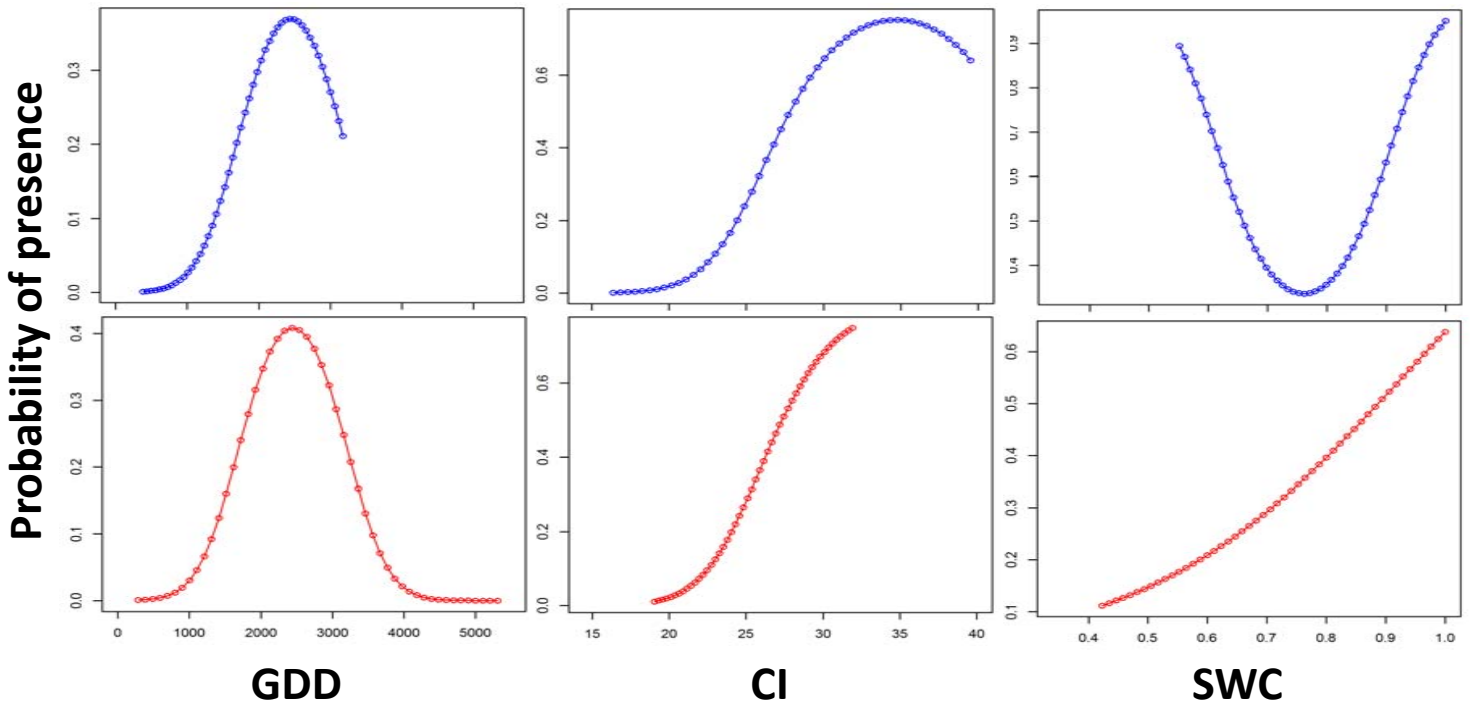
Preparation of 6 water-related grids at 1-km resolution across the Alps & Fennoscandia (@WordlClim, @CGIAR-CSI)

- annual aridity index (**AI**)
- annual potential evapotranspiration (**PET**)
- annual actual evapotranspiration (**AET**)
- Priestley-Taylor alpha coefficient (**APET** = **AET/PET**)
- water balance over the year (**WBAL**)
- soil water content of the most stressful month (**SWC**)

Question 1: testing the region effect

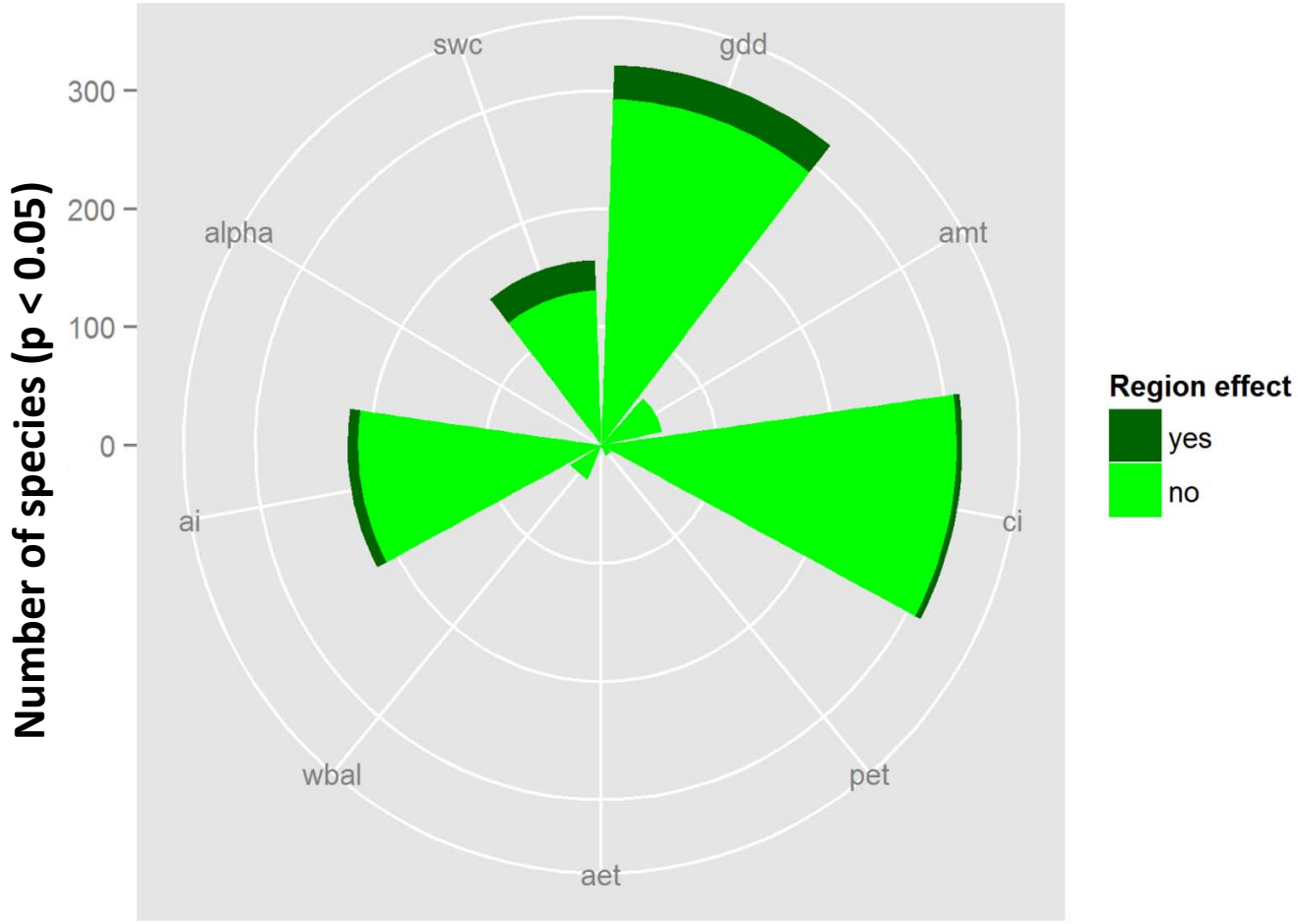
Generalized linear models (GLMs) on proportion data (Y), where Y is the total number of occurrence records divided by the total number of presence and absence records within a given 1-km pixel unit

$$\frac{N_{pres.}}{N_{pres.} + N_{abs.}} \sim (GDD + AMT + CI + AI + PET + AET + APET + WBAL + SWC) \times \text{Reg.}$$



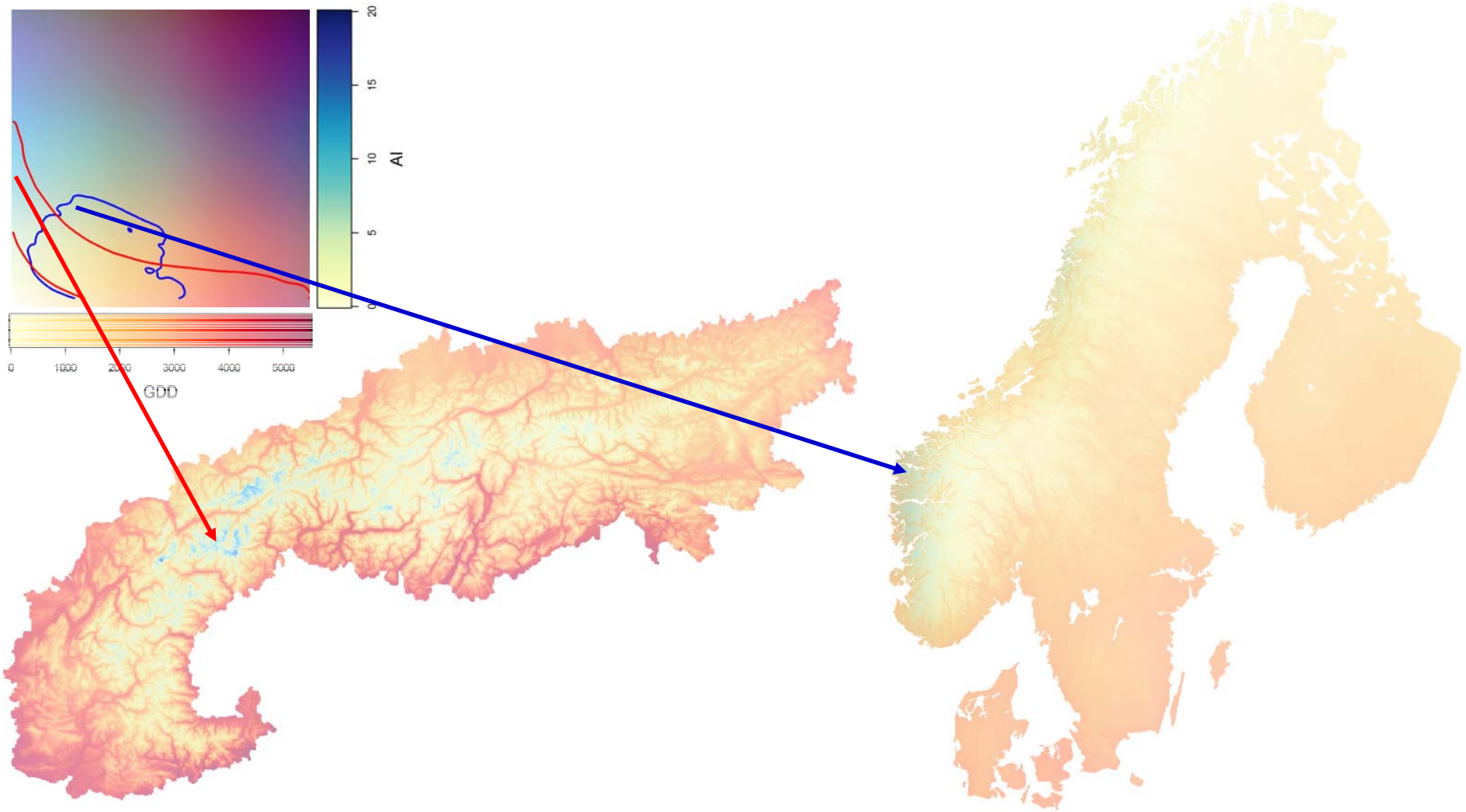
Question 1: testing the region effect

Among the 389 species with sufficient information to be retained to run GLMs, 59 (15%) species showed regional differences



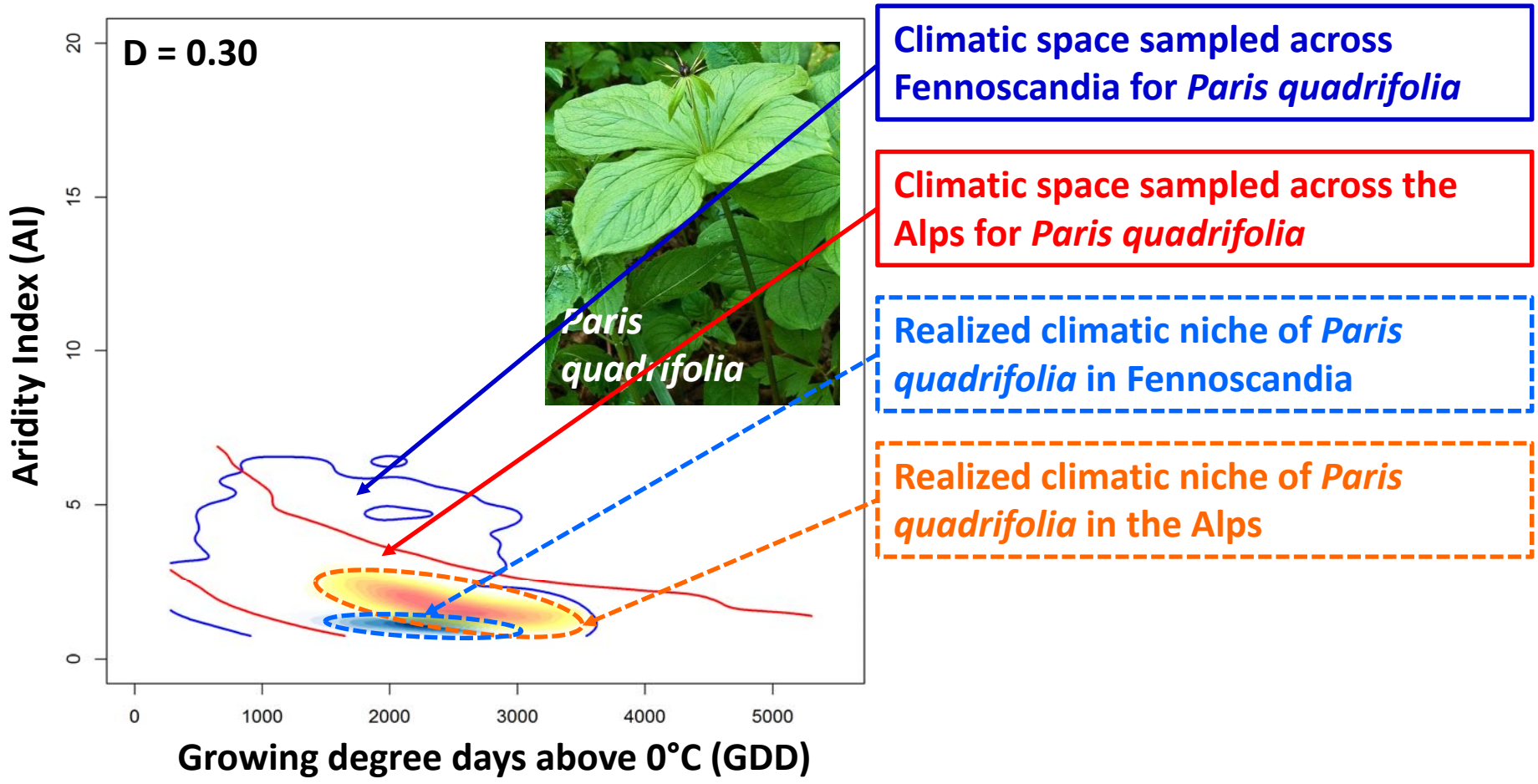
Question 2: assessing niche overlap

Focus on a bi-dimensional climatic space (GDD-AI)



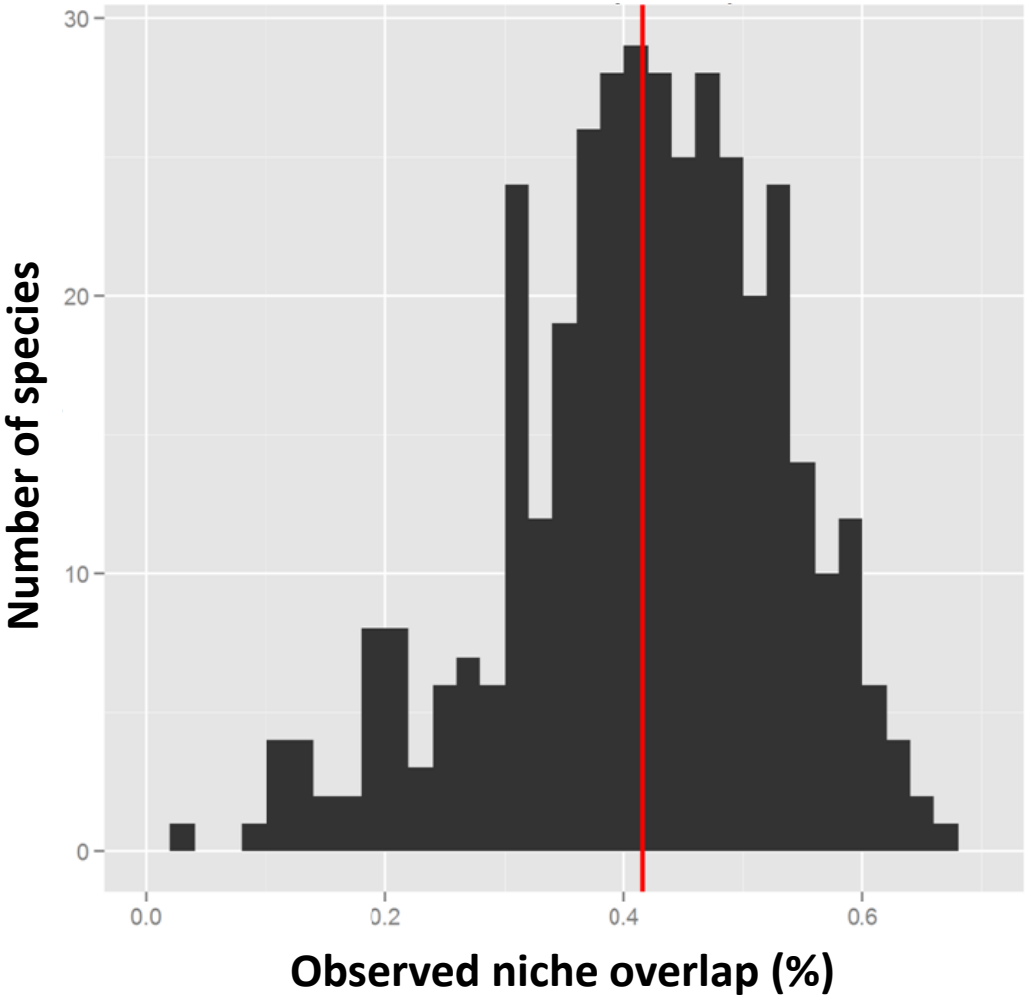
Question 2: assessing niche overlap

Computing, within the GDD-AI climatic space, Schoener's D index which varies from 0 (no overlap) to 1 (complete overlap)



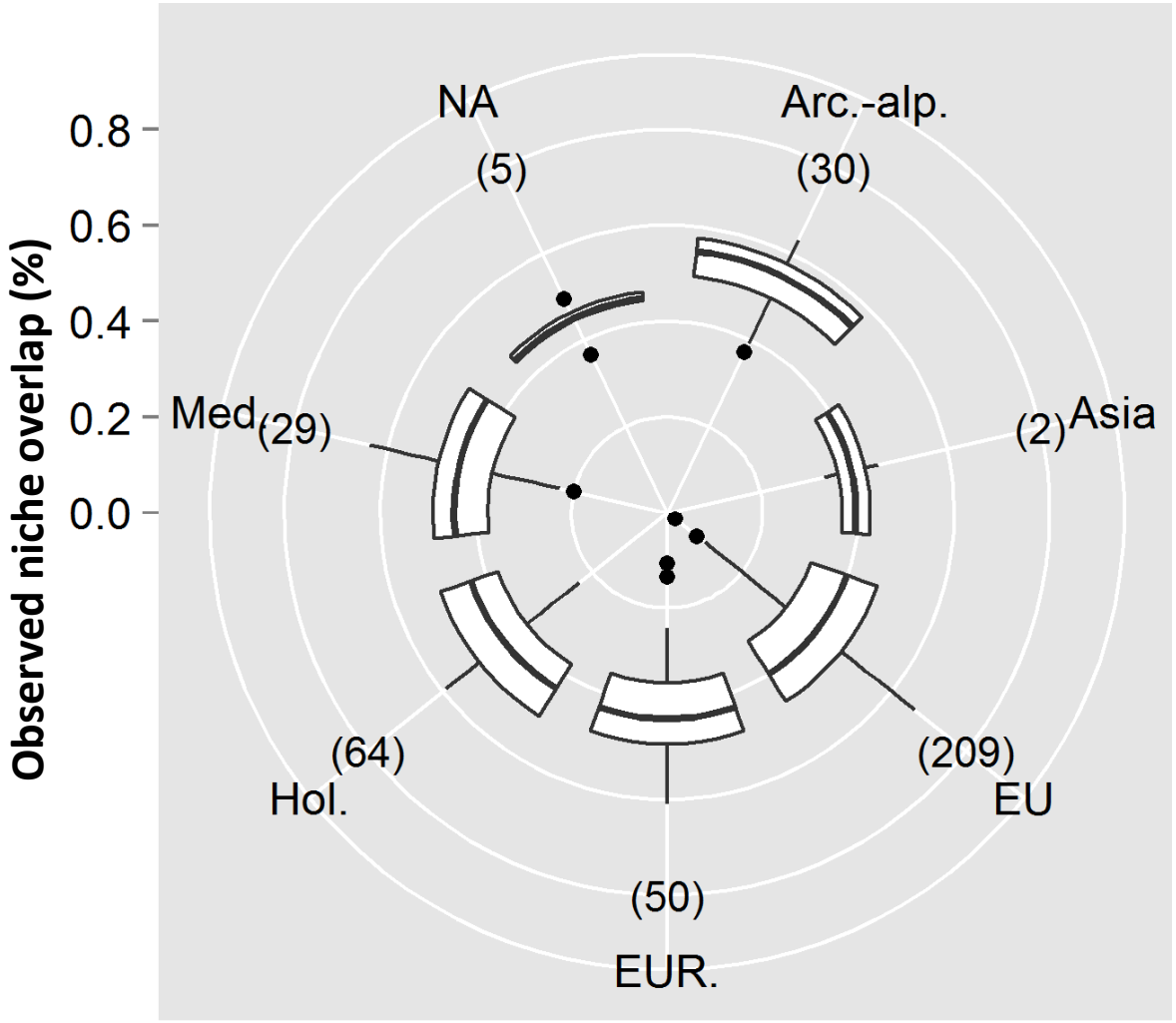
Question 2: assessing niche overlap

Niche overlap ranged from 0.02 to 0.66 (mean = 0.42)



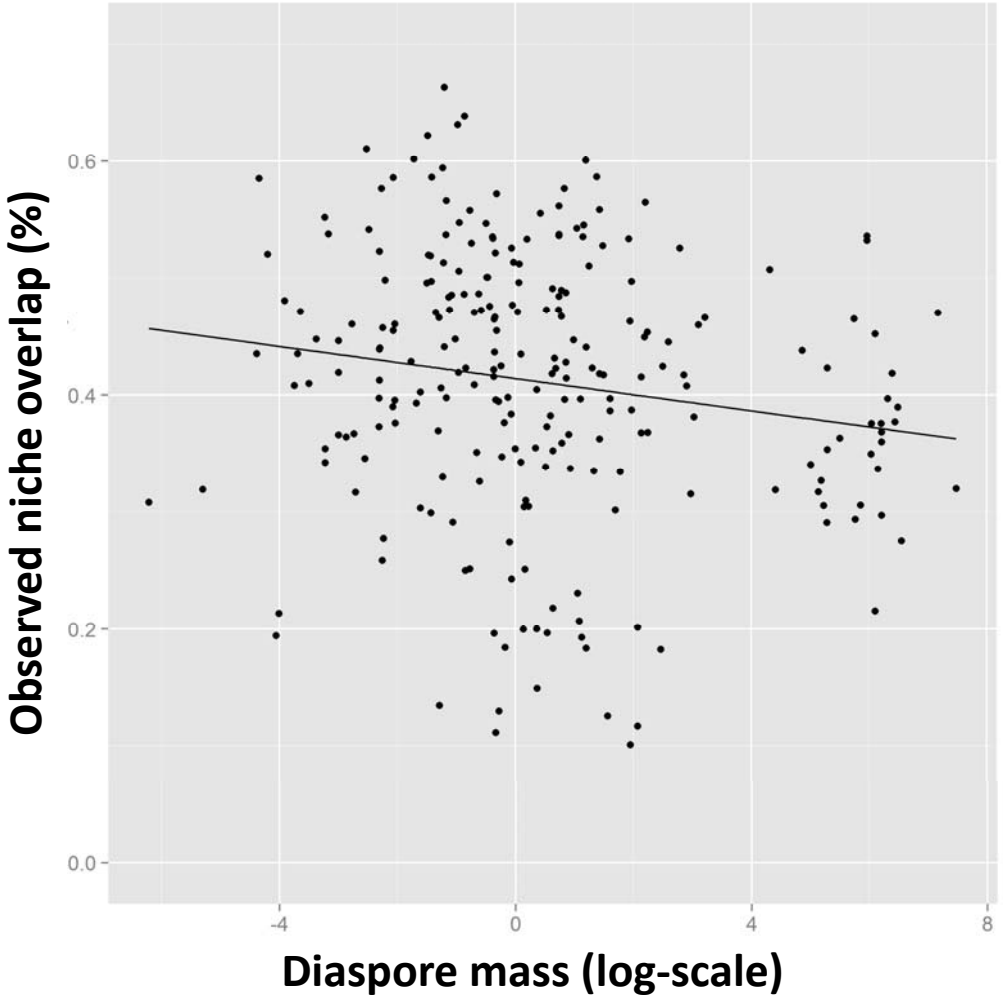
Question 3: explaining niche overlap

Niche overlap was greater for arctic-alpine plants



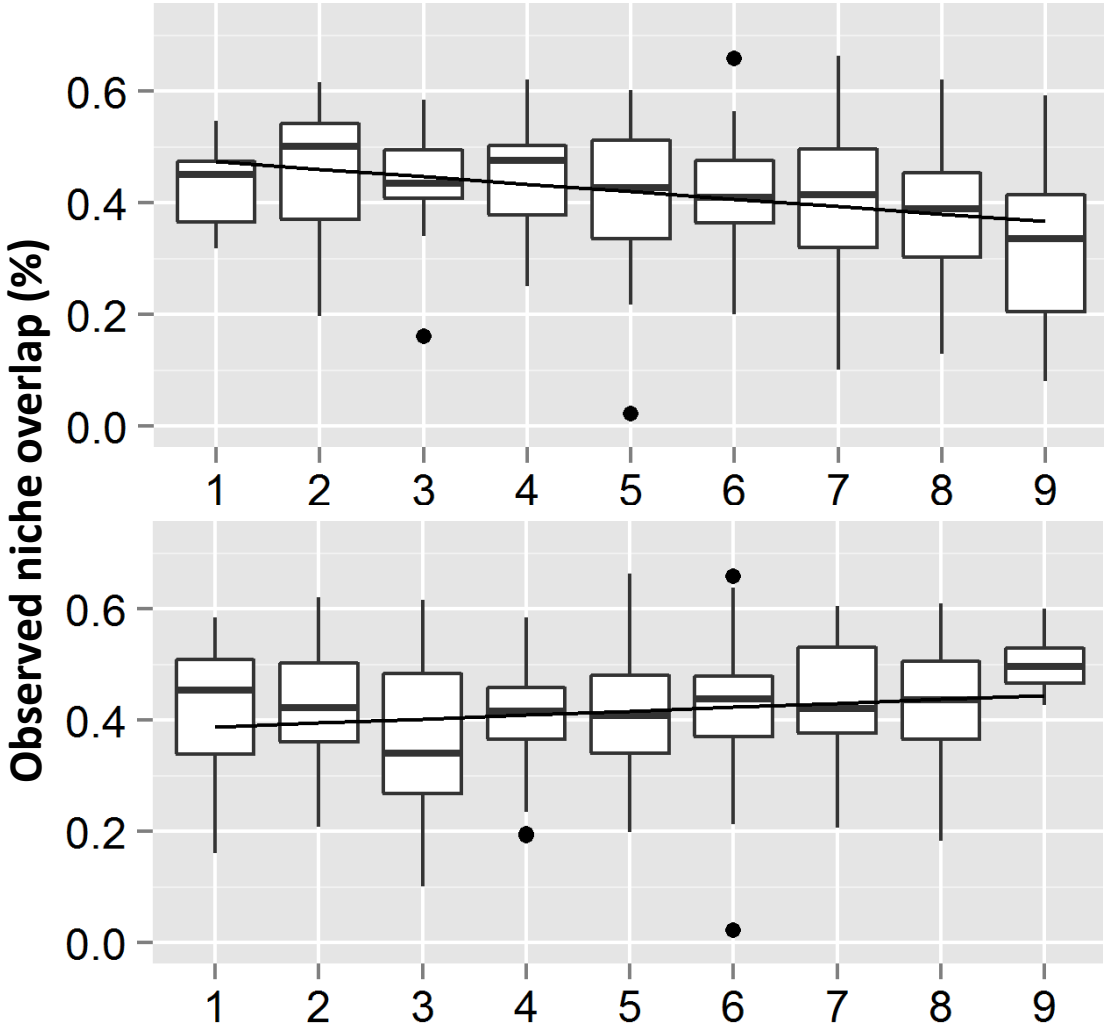
Question 3: explaining niche overlap

Niche overlap was greater for species having light diaspores



Question 3: explaining niche overlap

Niche overlap was greater for acidophilous and eutrophic species



R (from acid to basic)

N (from poor to rich)

Take-home messages

- **Plant climatic niches seem to be generally conserved and the basic assumption of species distribution models that species' climatic niche is constant in space and time (thousands of years) seems to hold for plants**
- **It is thus unlikely that niche adaptation/shift act as a determinant of lags in biotic responses to climate change**
- **Other drivers such as species' intrinsic ability to tolerate changing climate (cf. sensitivity or tolerance) as well as short-distance escapes due to terrain complexity are likely to matter**

@https://jonathanlenoir.wordpress.com/

Jonathan Lenoir

Ecology & Biostatistics

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About

Bio

ecologi

changes, with particular emph

change. My research interests range

term changes in species distribution to finer-scale

community composition.

Thanks Jörg for your kind invitation, thanks Vanessa and Cord for welcoming me in Oldenburg and thanks to all of you for your attention ☺