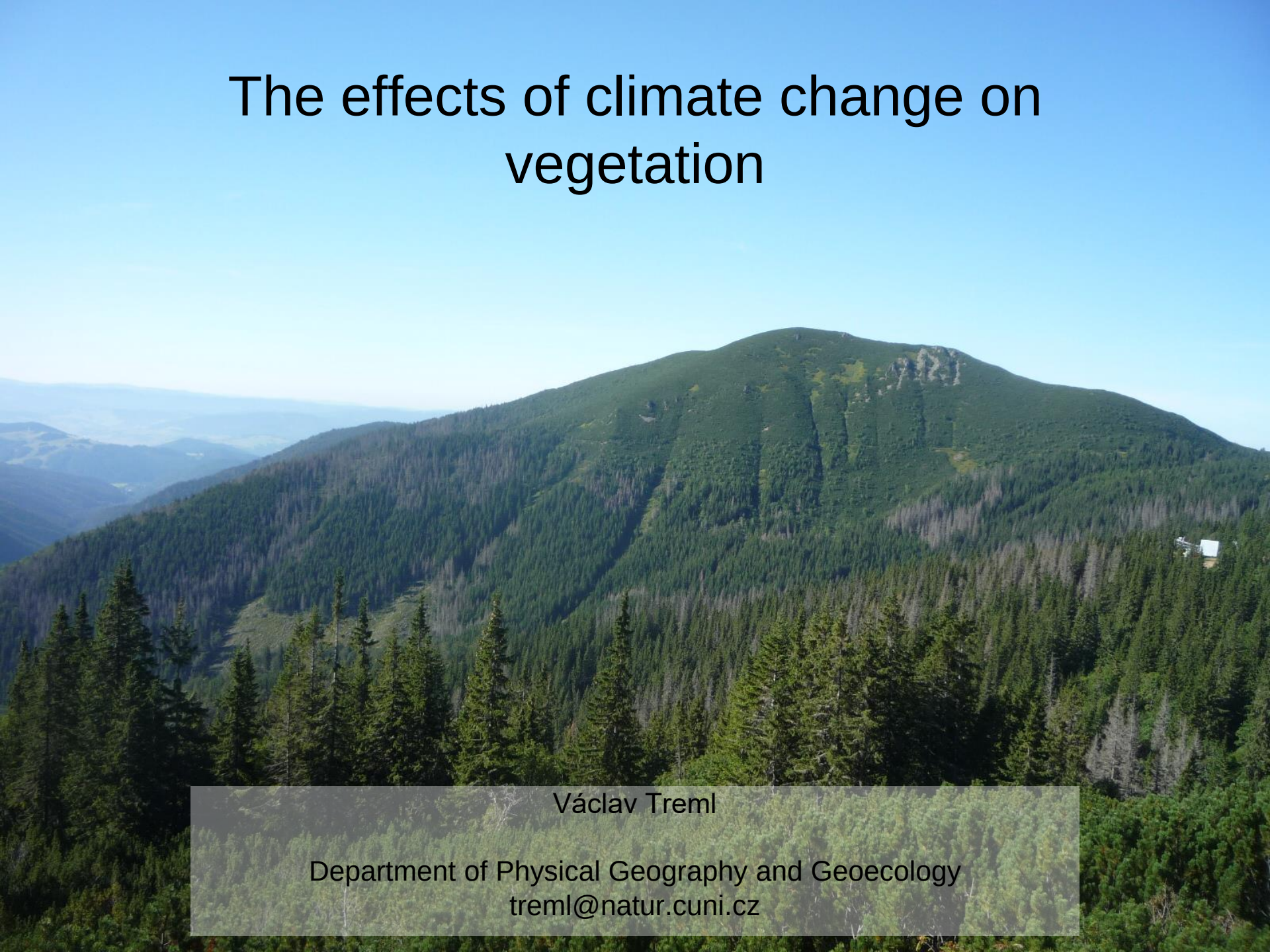
The effects of climate change on vegetation



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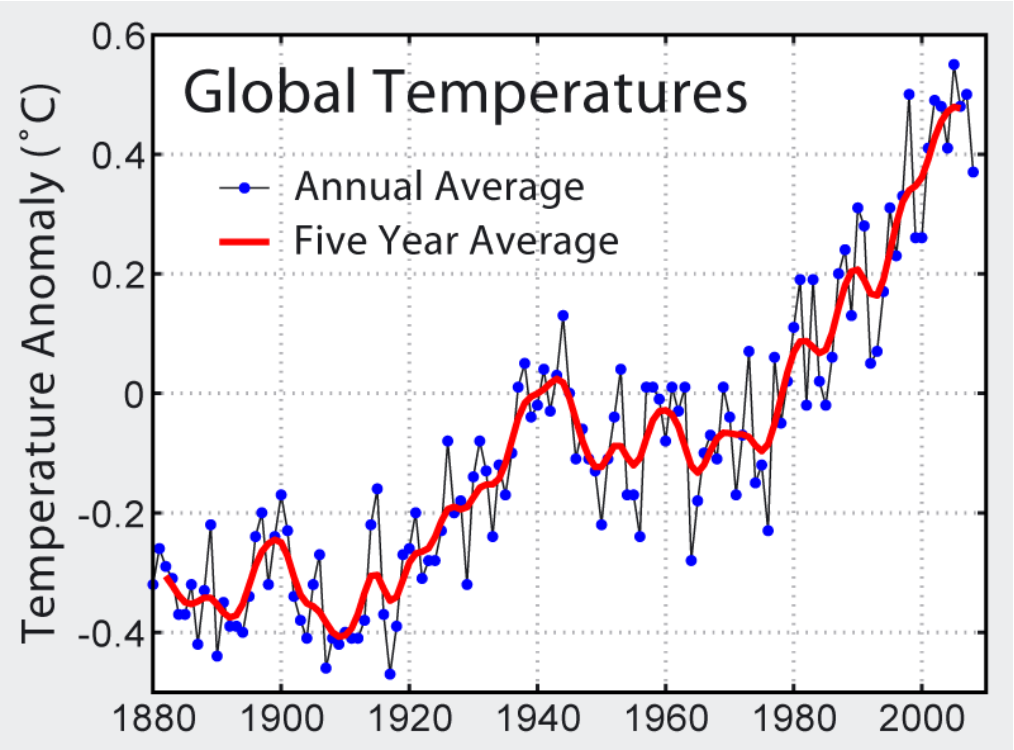
Outline

- Introduction
- Plant productivity
- Plant phenology
- Species ranges
- Disturbances
- Examples



Readings

nature climate change

REVIEW ARTICLE

PUBLISHED ONLINE: 25 FEBRUARY 2015 | DOI: 10.1038/NCLIMATE2448

Assessing species vulnerability to climate change

Michela Pacifici *et al.*†

***Nat Clim Chang*. Author manuscript; available in PMC 2015 March 01.**

Published in final edited form as:

Nat Clim Chang. 2014 September 1; 4(9): 806–810. doi:10.1038/nclimate2318.

Increasing forest disturbances in Europe and their impact on carbon storage

Rupert Seidl[1,*], **Mart-Jan Schelhaas**[2], **Werner Rammer**[1], and **Pieter Johannes Verkerk**[3]

Global Change Biology (2006) **12,** 1969–1976, doi: 10.1111/j.1365-2486.2006.01193.x

European phenological response to climate change matches the warming pattern

ANNETTE MENZEL*, TIM H. SPARKS†, NICOLE ESTRELLA*, ELISABETH KOCH‡,

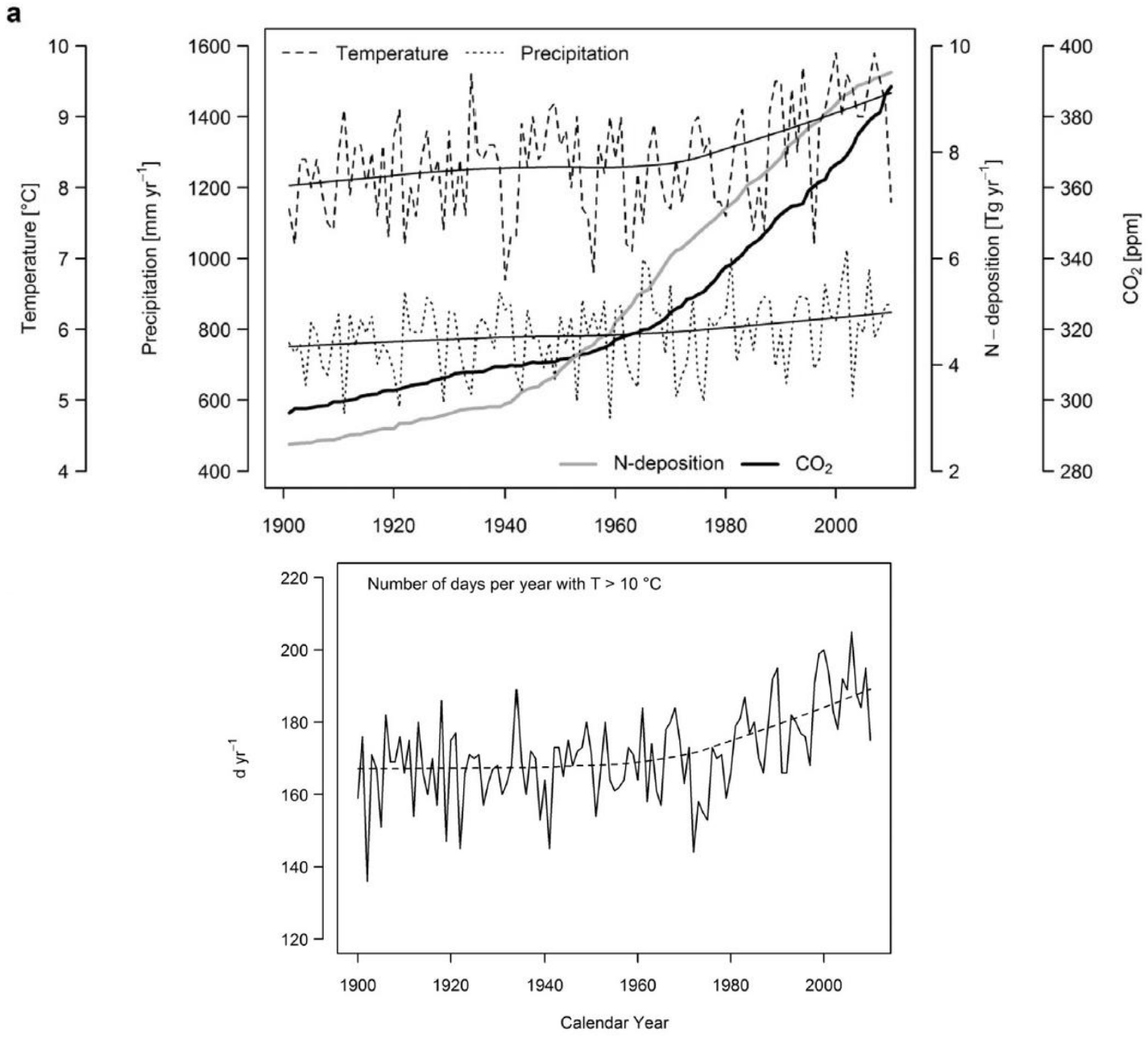
LETTER

doi:10.1038/nature15402

Declining global warming effects on the phenology of spring leaf unfolding

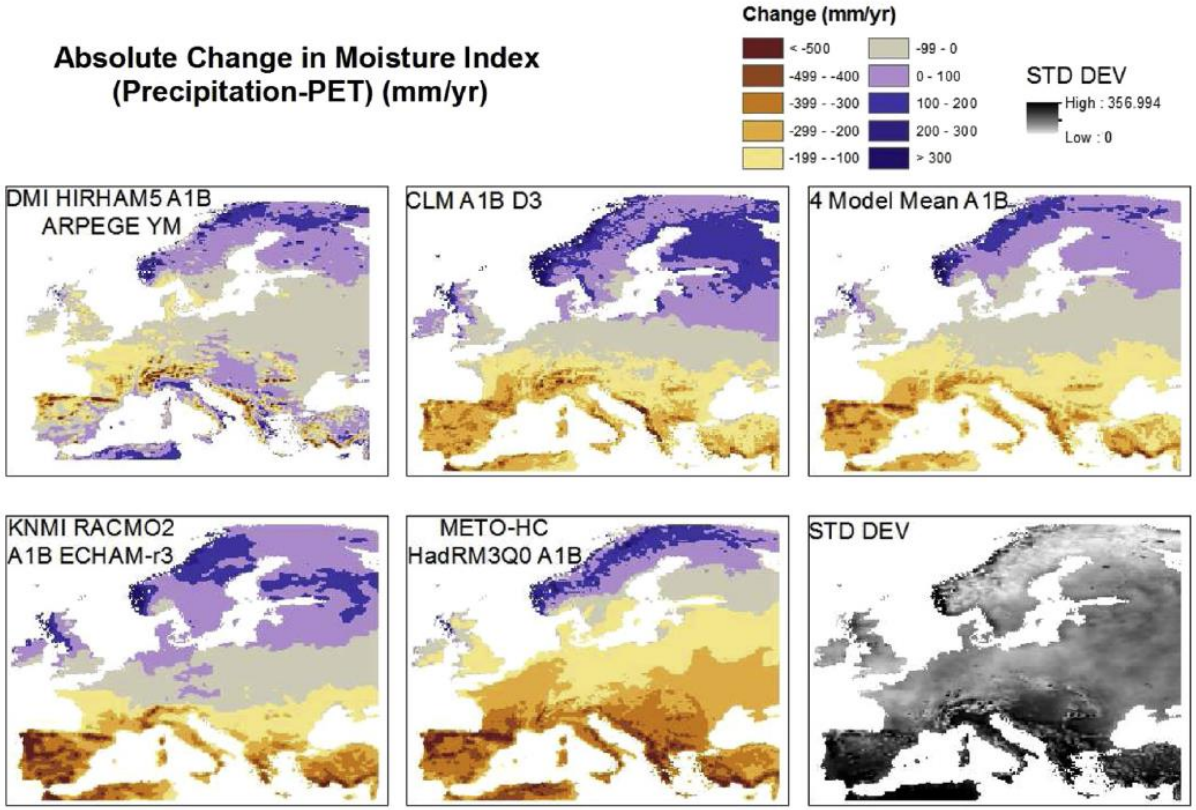
Yongshuo H. Fu[1,2], Hongfang Zhao[1], Shilong Piao[1,3,4], Marc Peaucelle[5], Shushi Peng[1,5], Guiyun Zhou[6], Philippe Ciais[1,5], Mengtian Huang[1], Annette Menzel[7,8], Josep Peñuelas[9,10], Yang Song[11], Yann Vitasse[12,13,14], Zhenzhong Zeng[1] & Ivan A. Janssens[2]

Recent climatic trends (Central Europe)

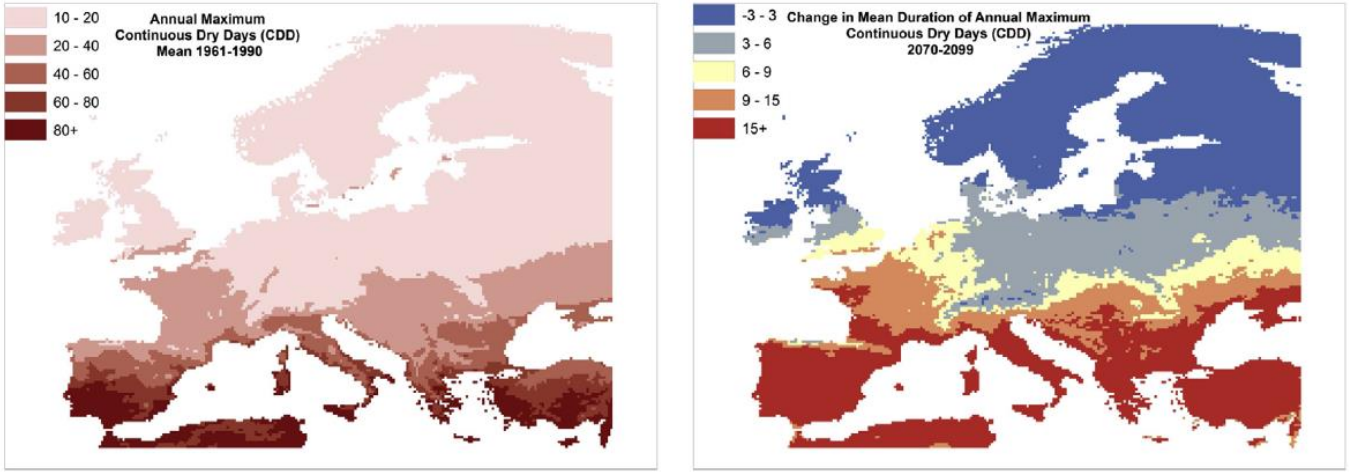


Climatic projections

Precipitation-PET



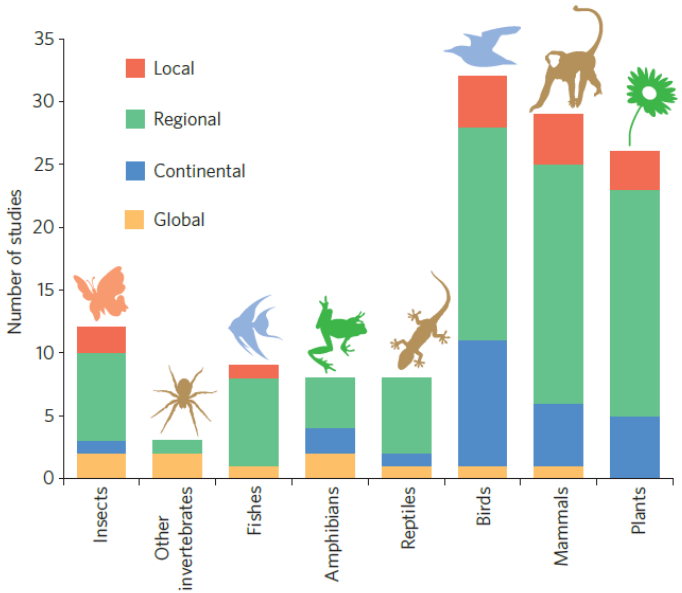
Duration of drought days



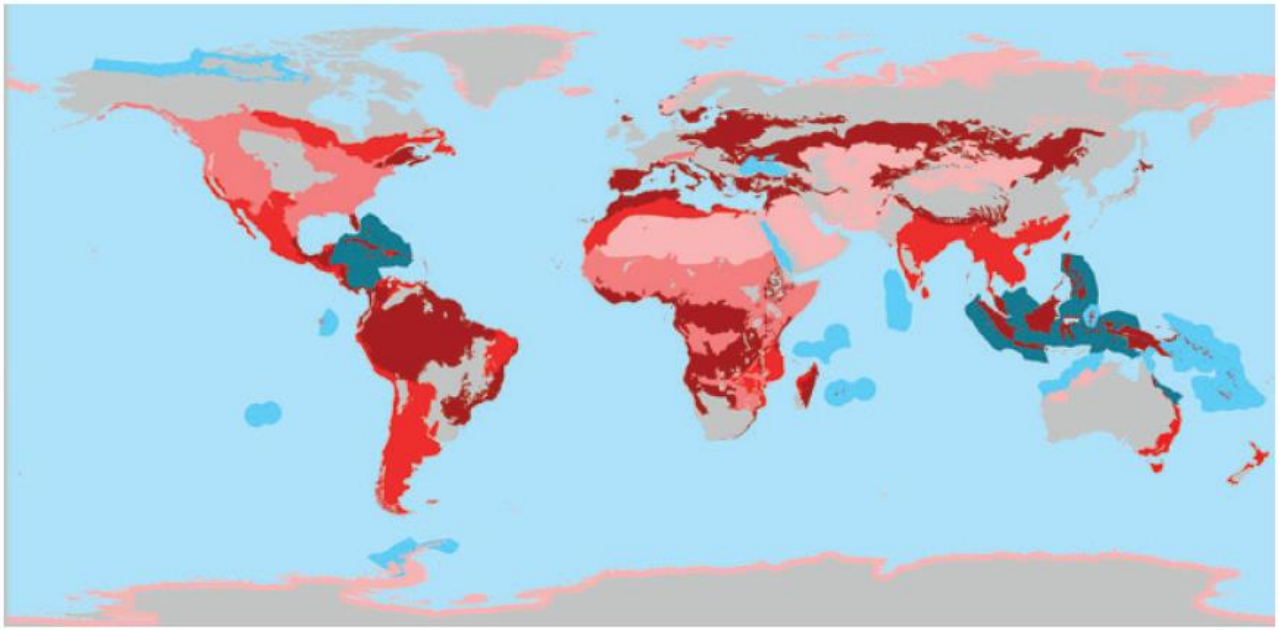
Species vulnerability to climate change

Exposure – degree of climatic variation

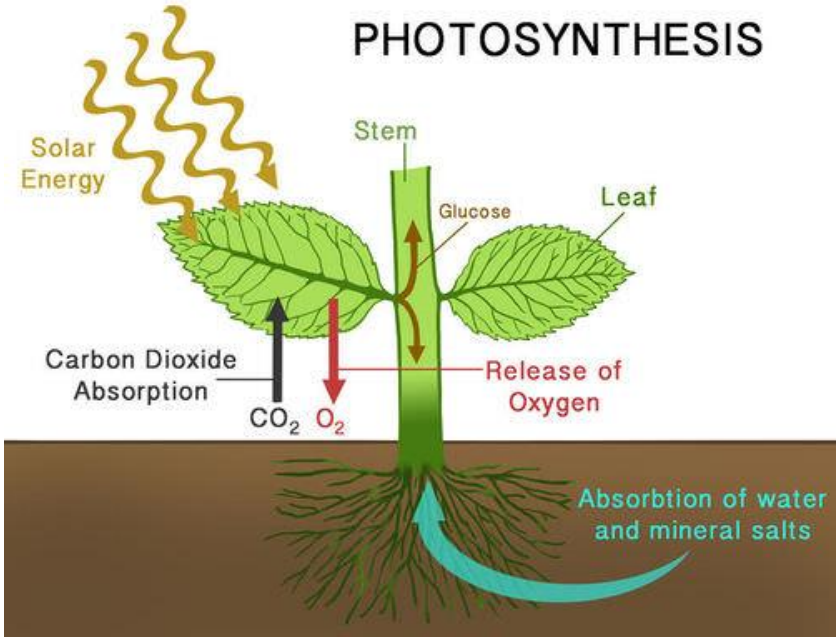
Sensitivity – Changes in species range, population change, change in probability of extinction

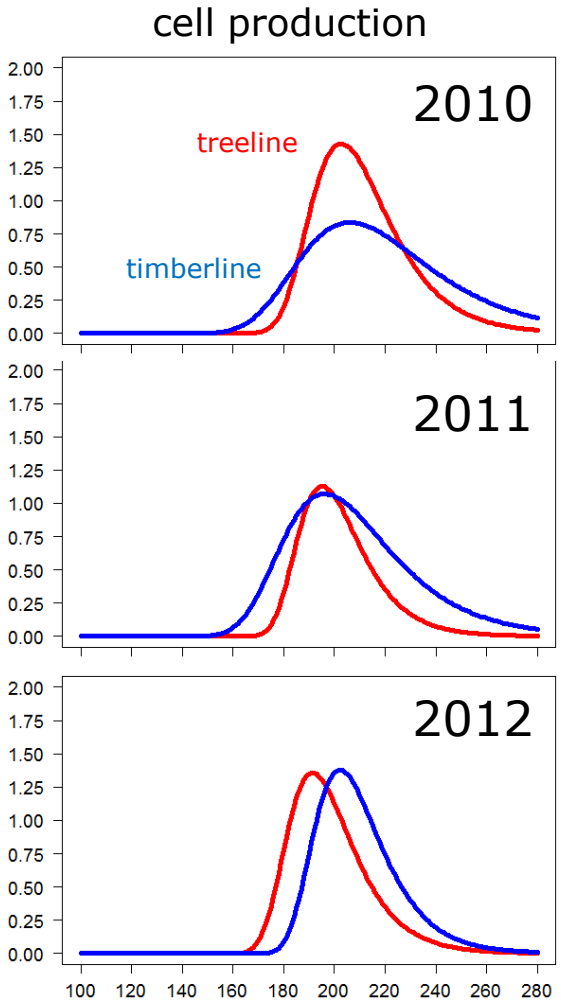


Concentration of vulnerable species



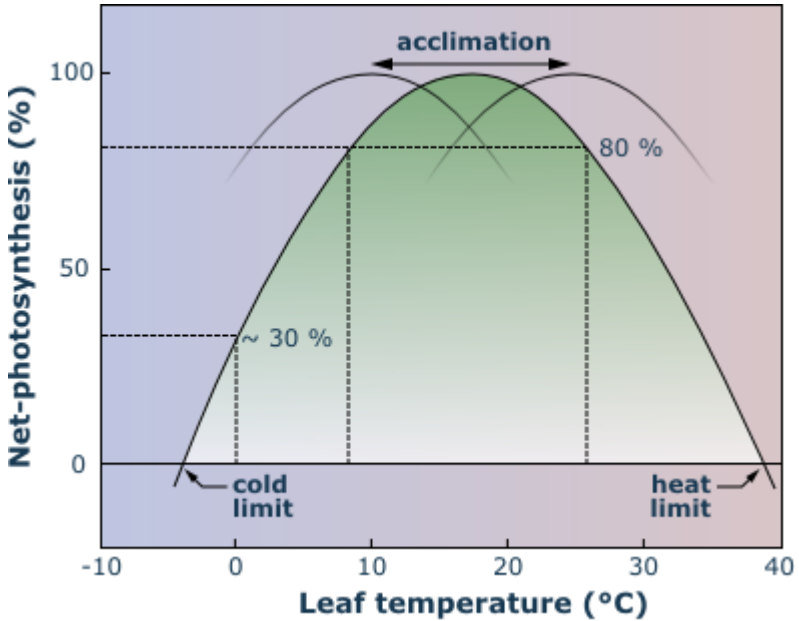
Climate influence on plants
1) Photosynthesis and 2) growth

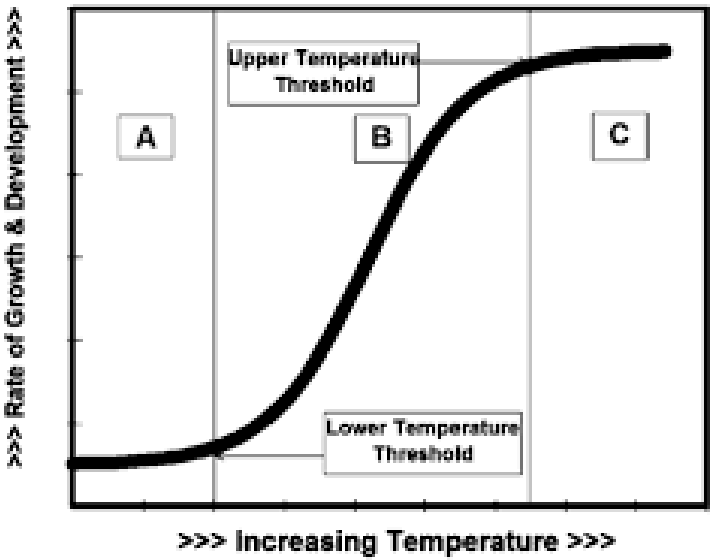




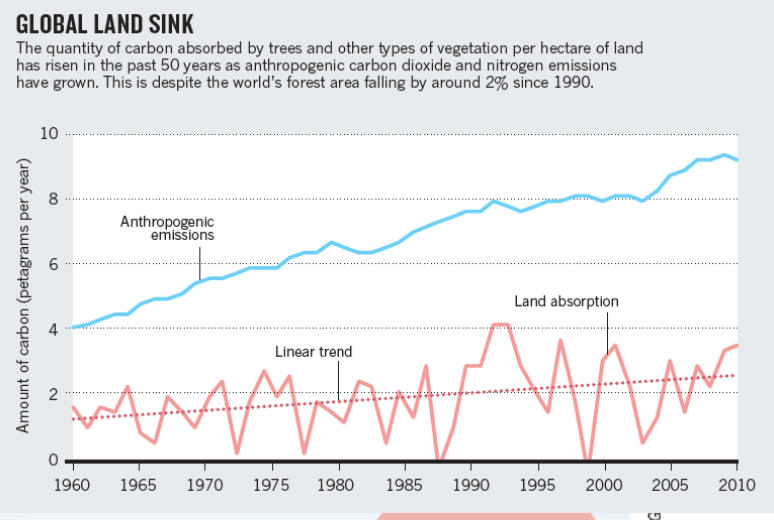
Climate change and vegetation

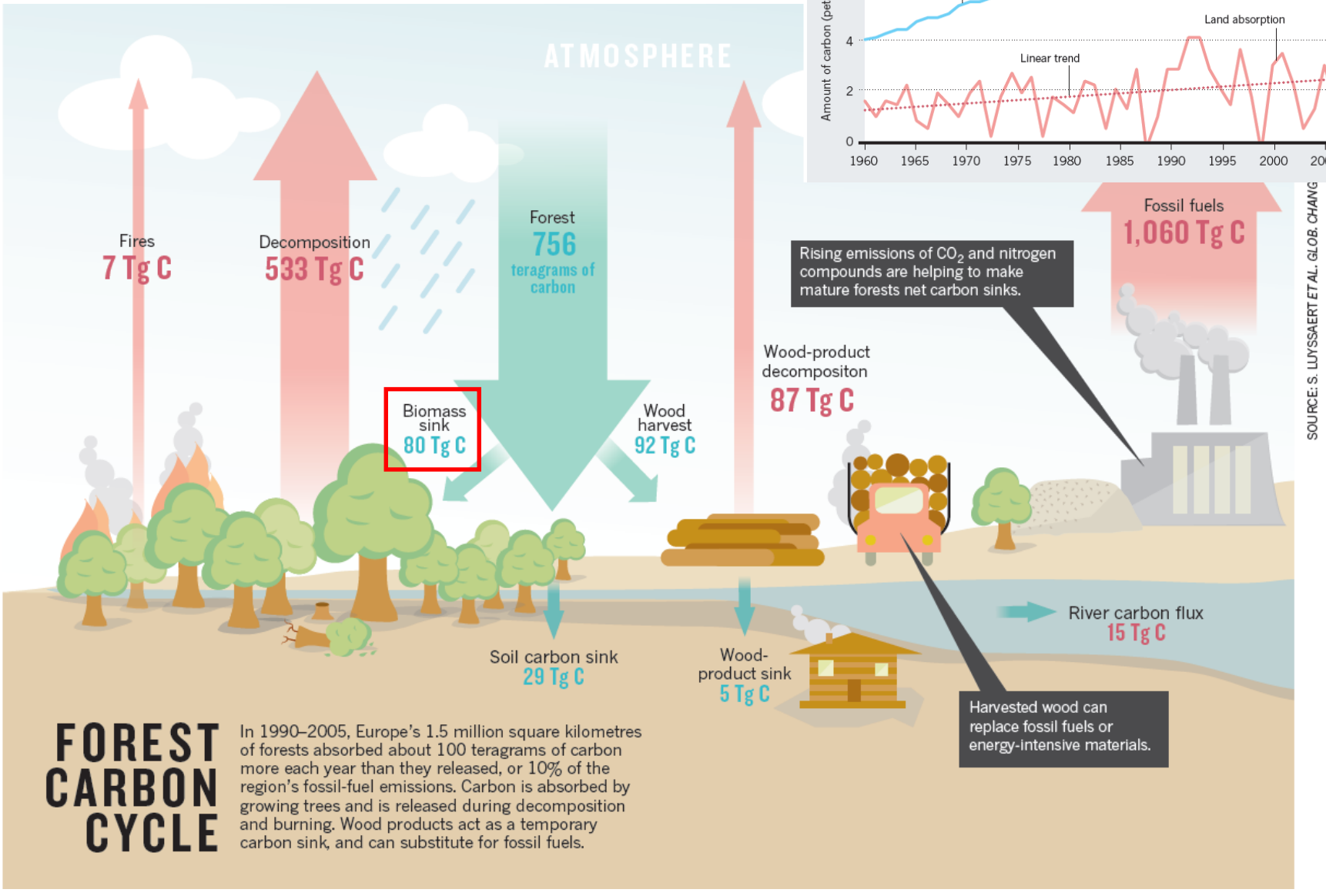
- Increasing temperature (growth, photosynthesis)
- Increasing drought stress (growth, photosynthesis)
- Increasing CO_2 concentration (photosynthesis)
- (increasing nitrogen deposition) (growth)





CO_2 and forests





FOREST CARBON CYCLE

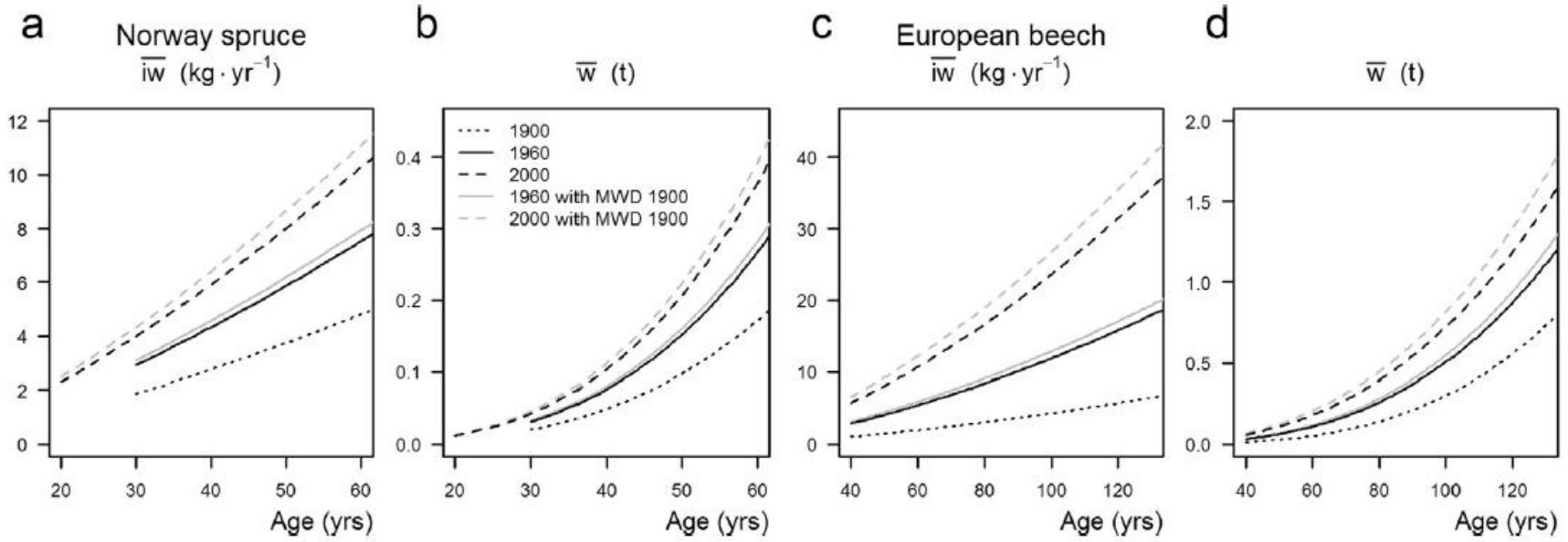
In 1990–2005, Europe's 1.5 million square kilometres of forests absorbed about 100 teragrams of carbon more each year than they released, or 10% of the region's fossil-fuel emissions. Carbon is absorbed by growing trees and is released during decomposition and burning. Wood products act as a temporary carbon sink, and can substitute for fossil fuels.

CO_2 fertilization

50yr oak 1940s

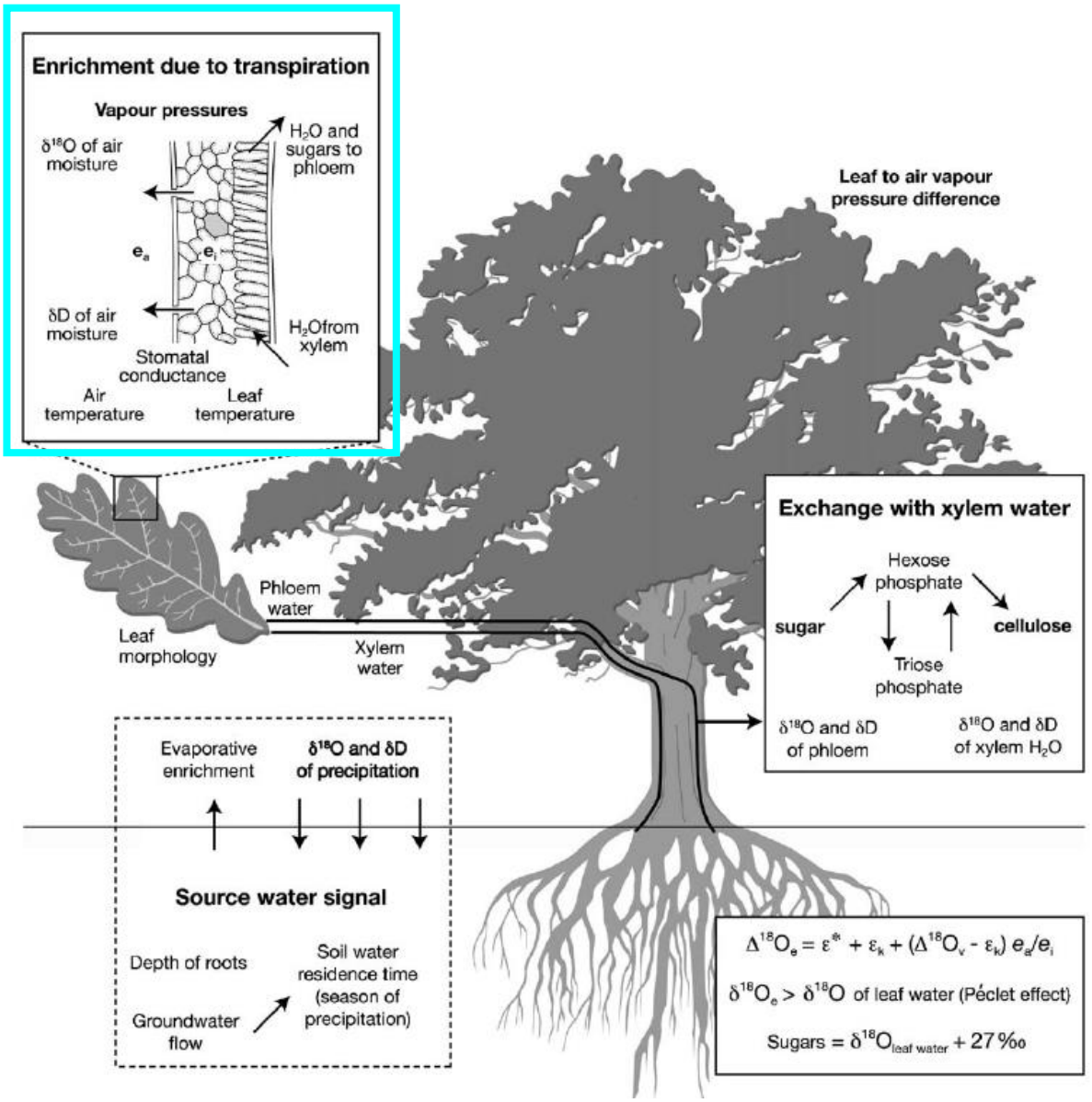
50yr oak 2010s

Trends in tree biomass (Central Europe)

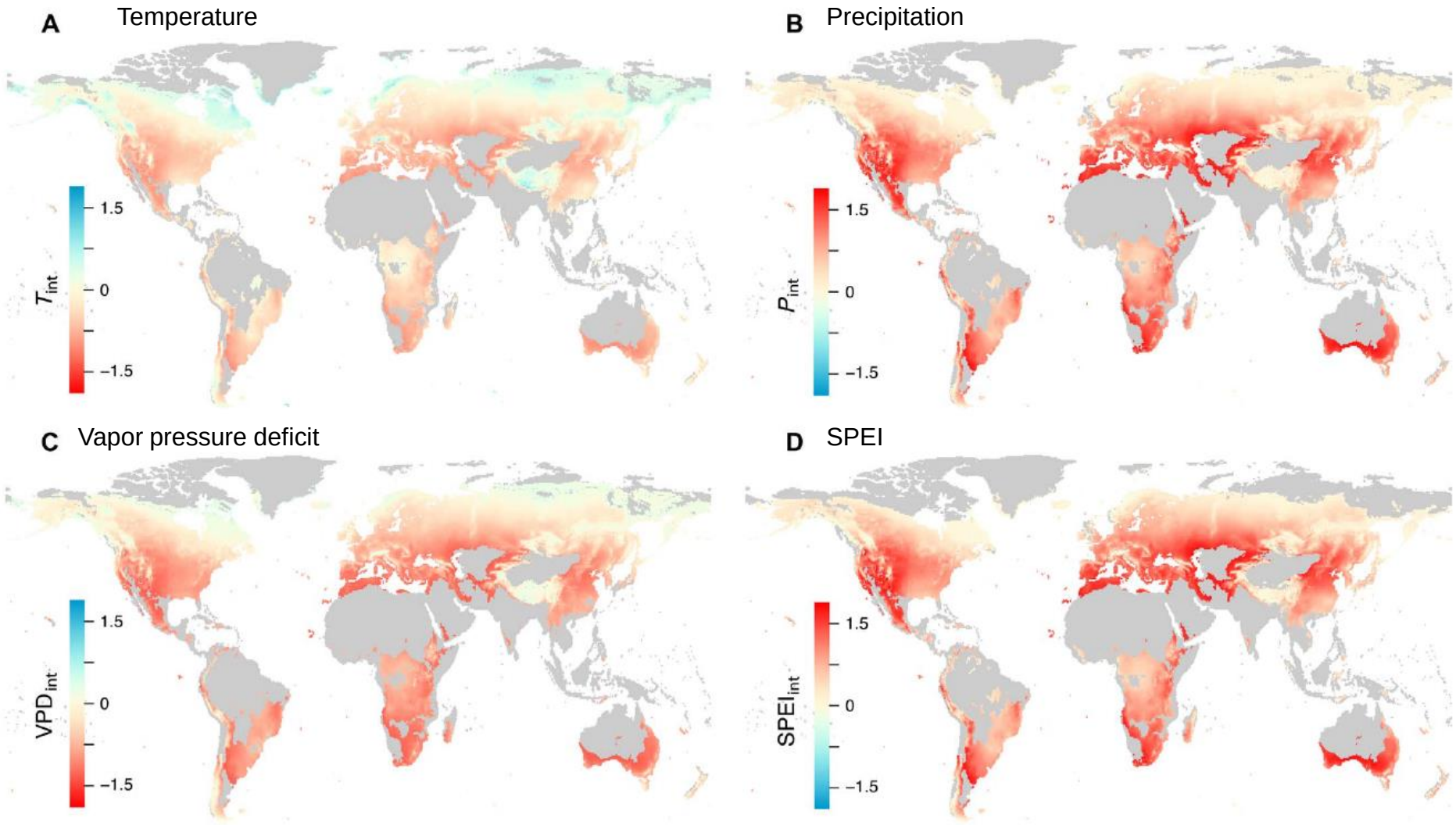


Overall increase in tree size

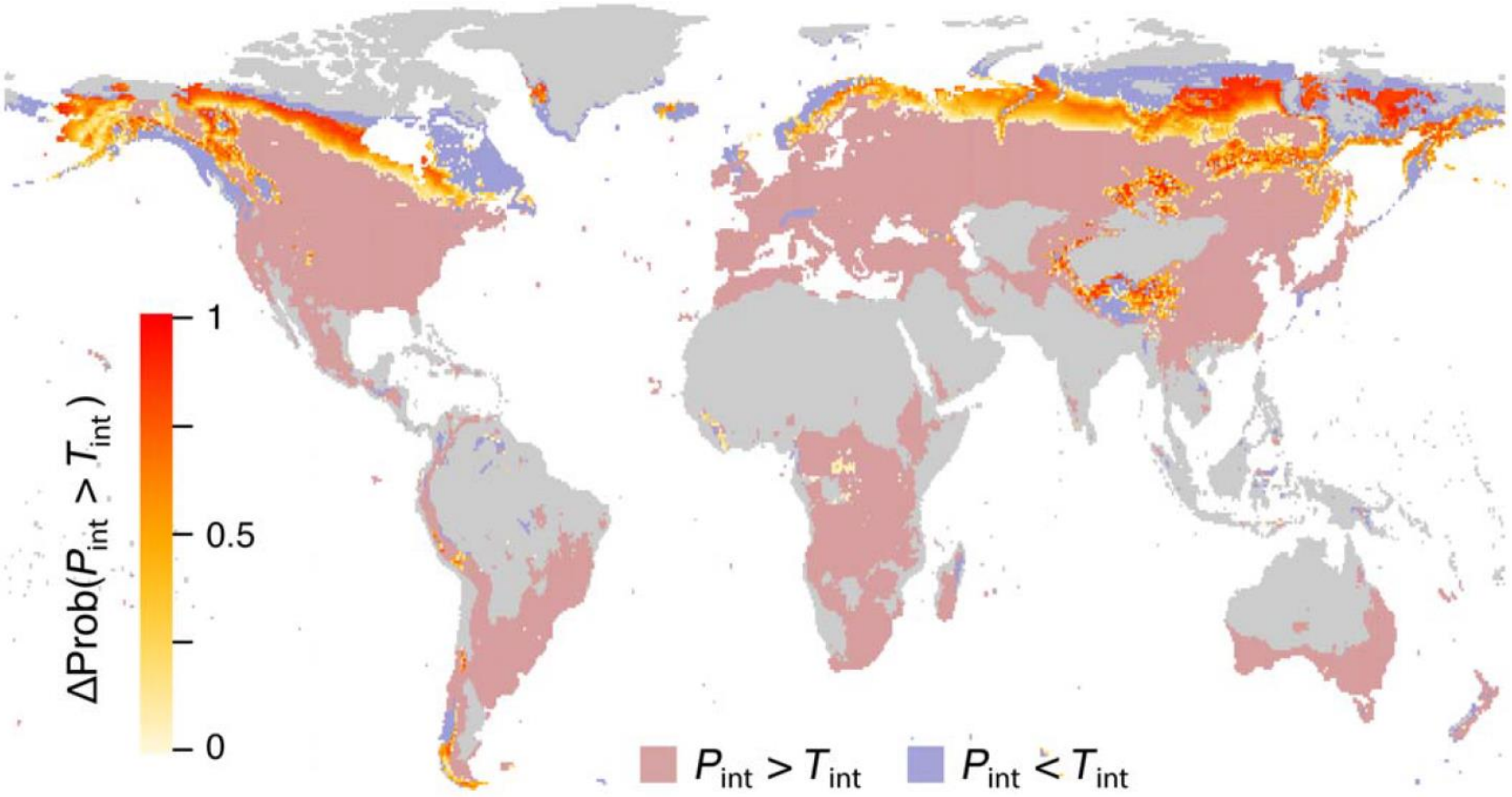
Increasing water-use efficiency due to CO_2



Changes in growth-climate responses



Projected changes in climatic variable driving growth



Changing growth
Plant phenology

Growing season length

Phenological gardens

Germany +6.6 days (1951-1996)

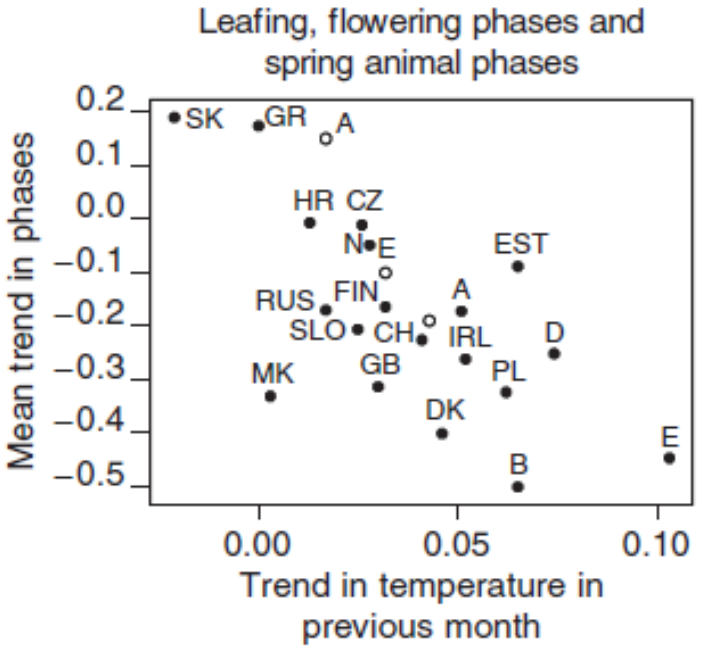
Switzerland +13.3 days (1951-2000)

Japan +12 days (1953-2000)

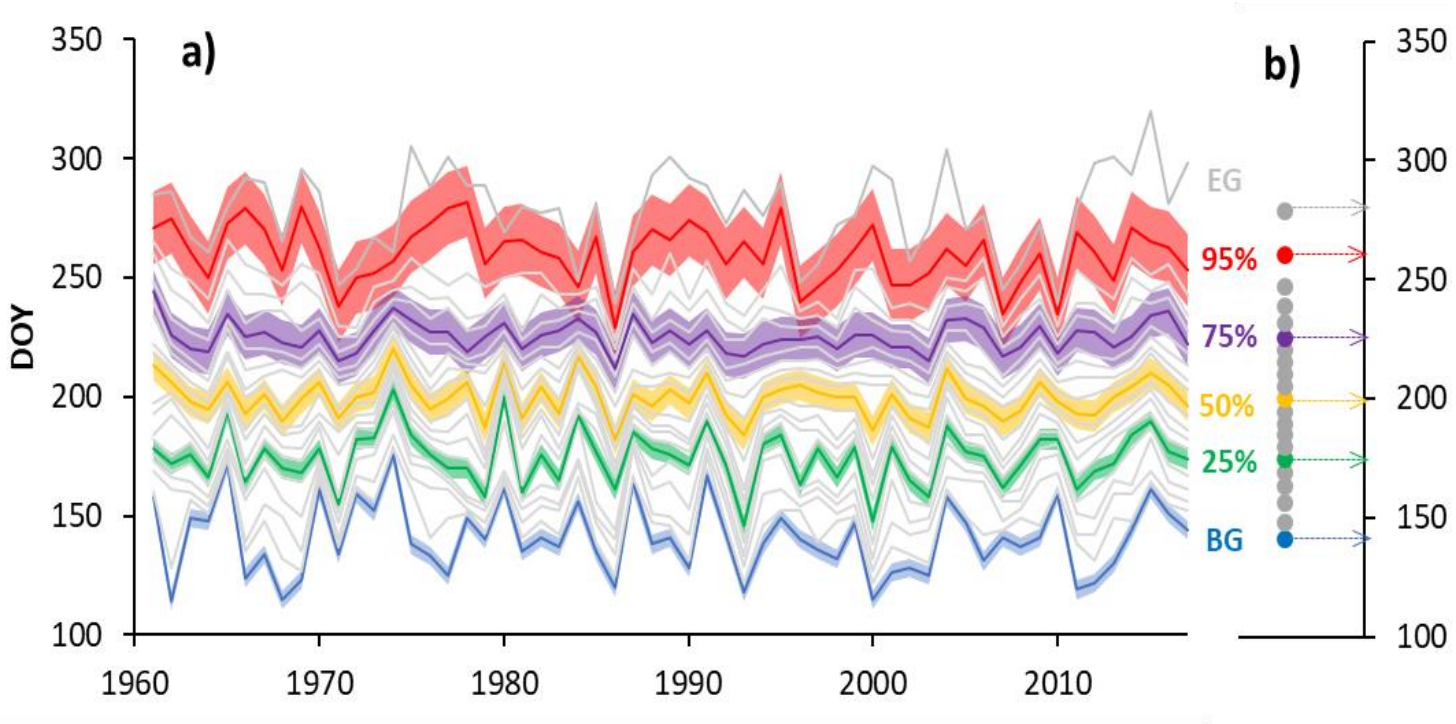
NDVI

Eurasia +18 days (1981-1999)

North America +12 days (1981-1999)



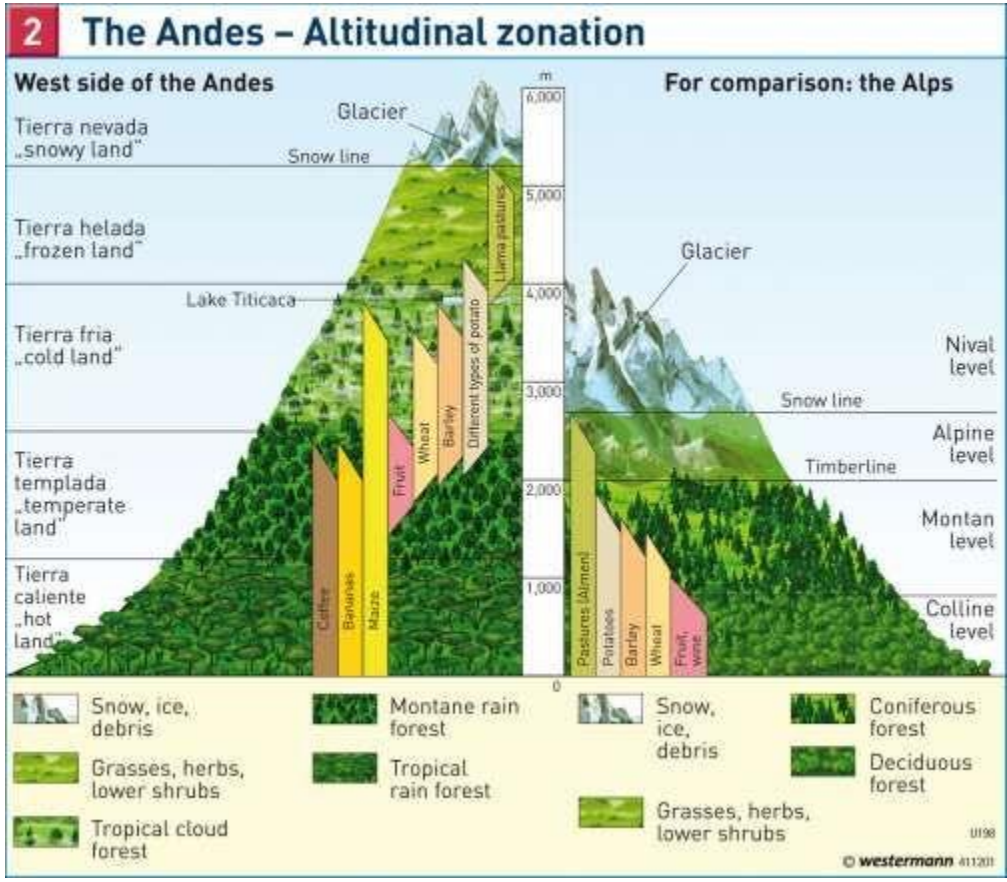
Growing season in treeline Norways spruce



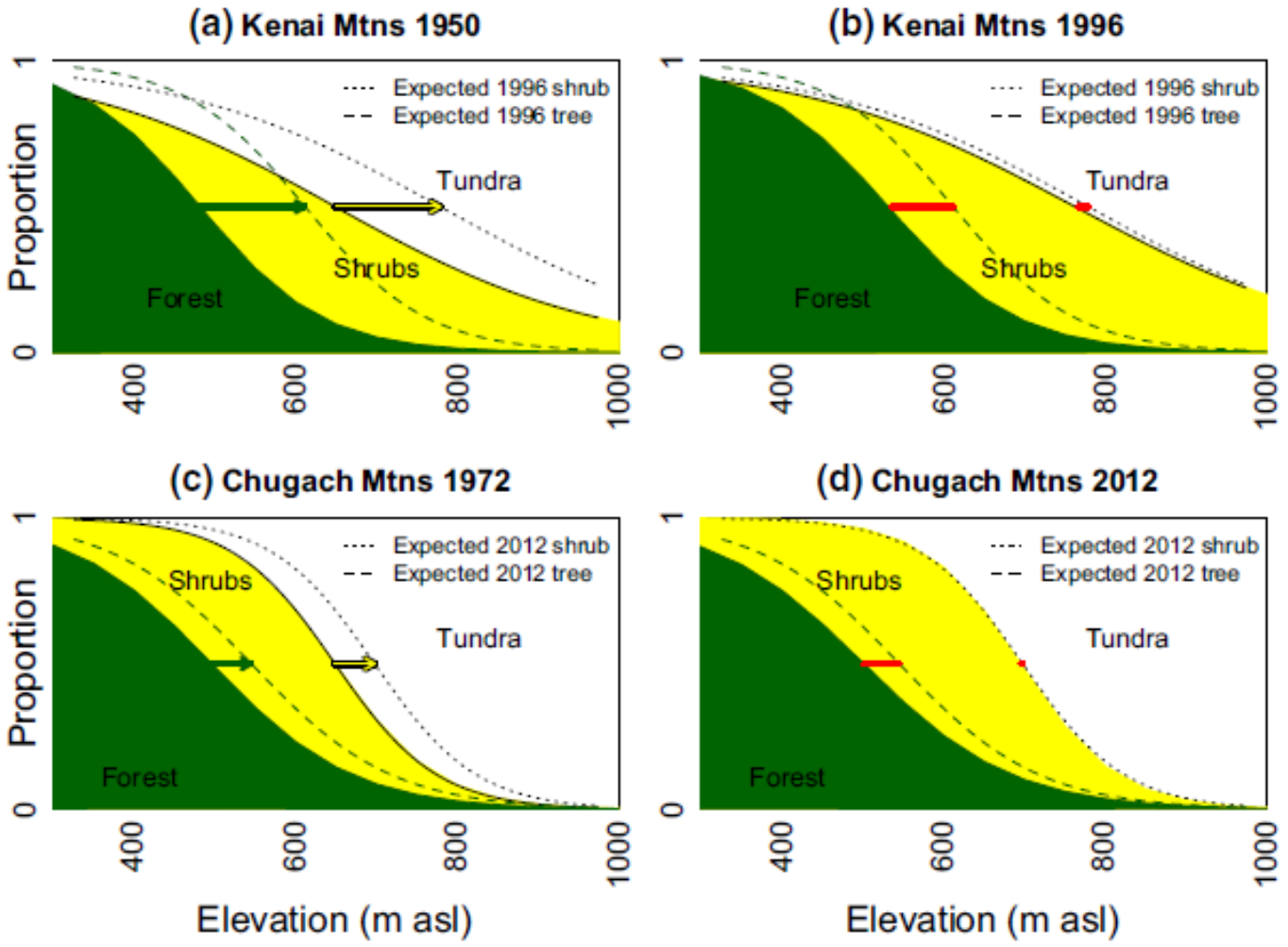
Shifting species ranges

- Expansion of drought-adapted species (*Quercus ilex*) at the expense of *Fagus sylvatica* in NE Spain (trailing edge of *F. sylvatica* distribution);

- Expansion of *F. sylvatica* at the exspense of the heathlands (*Calluna vulgaris*) leading edge of species distribution.

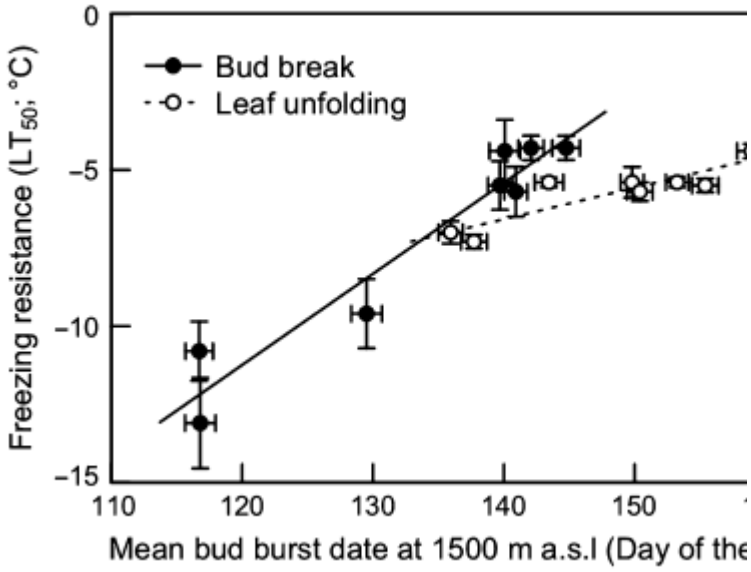


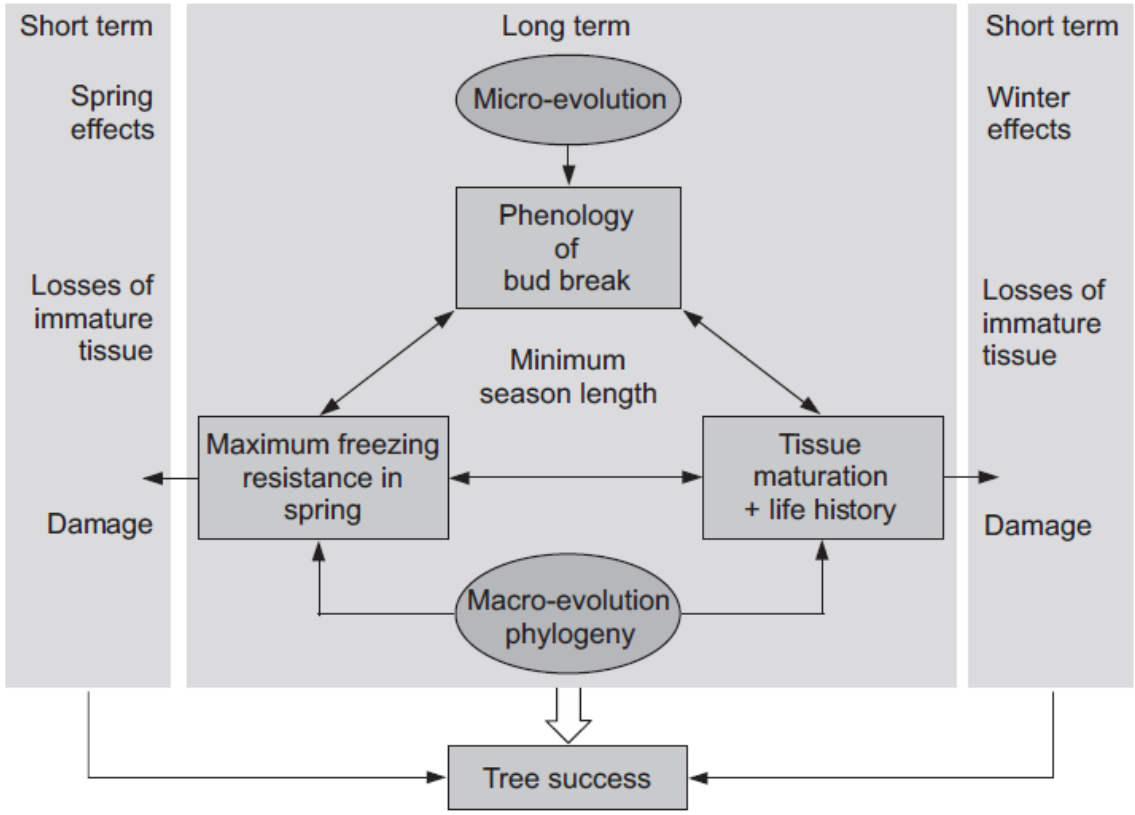
Biotoc inertia & climatic velocity



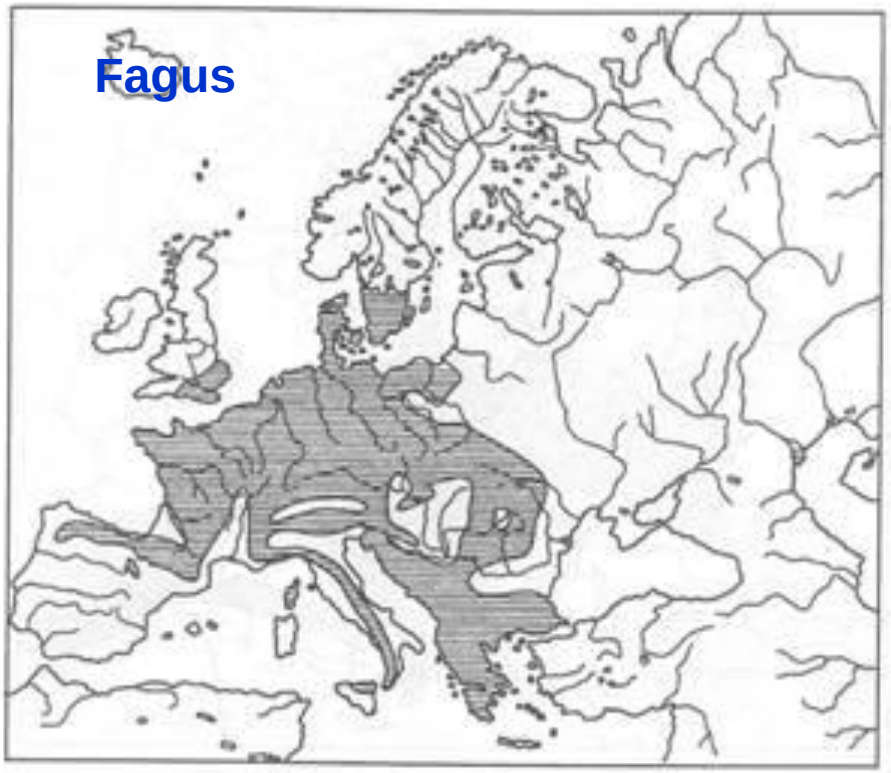
Climatic limits of temperate trees

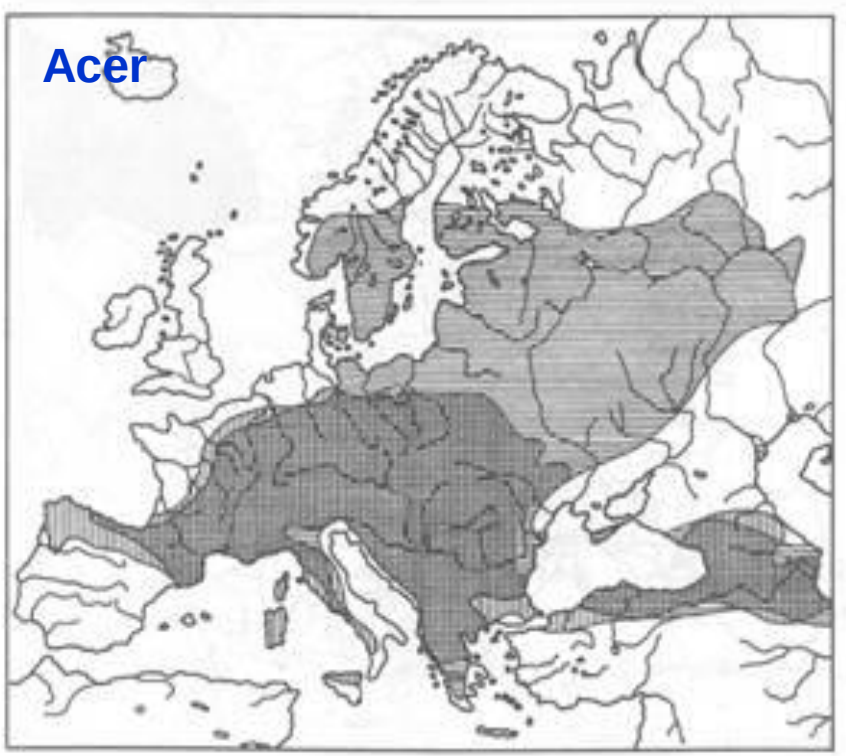
Growing season length vs. freezing resistance





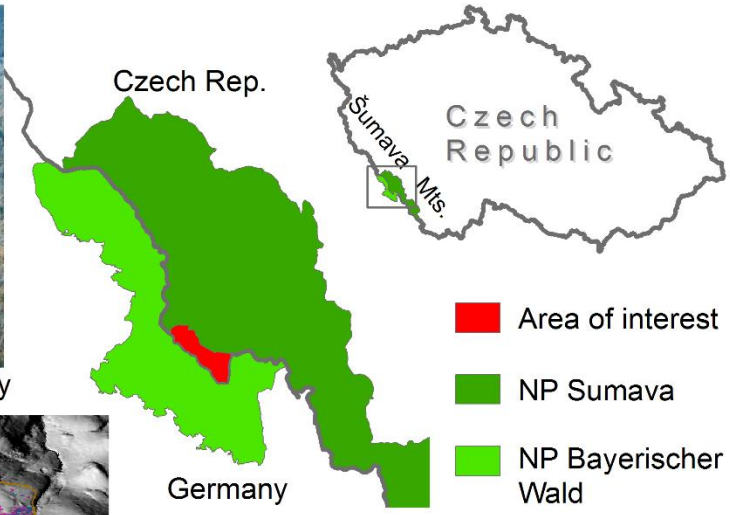
Northern limits of distribution of broadleaf trees

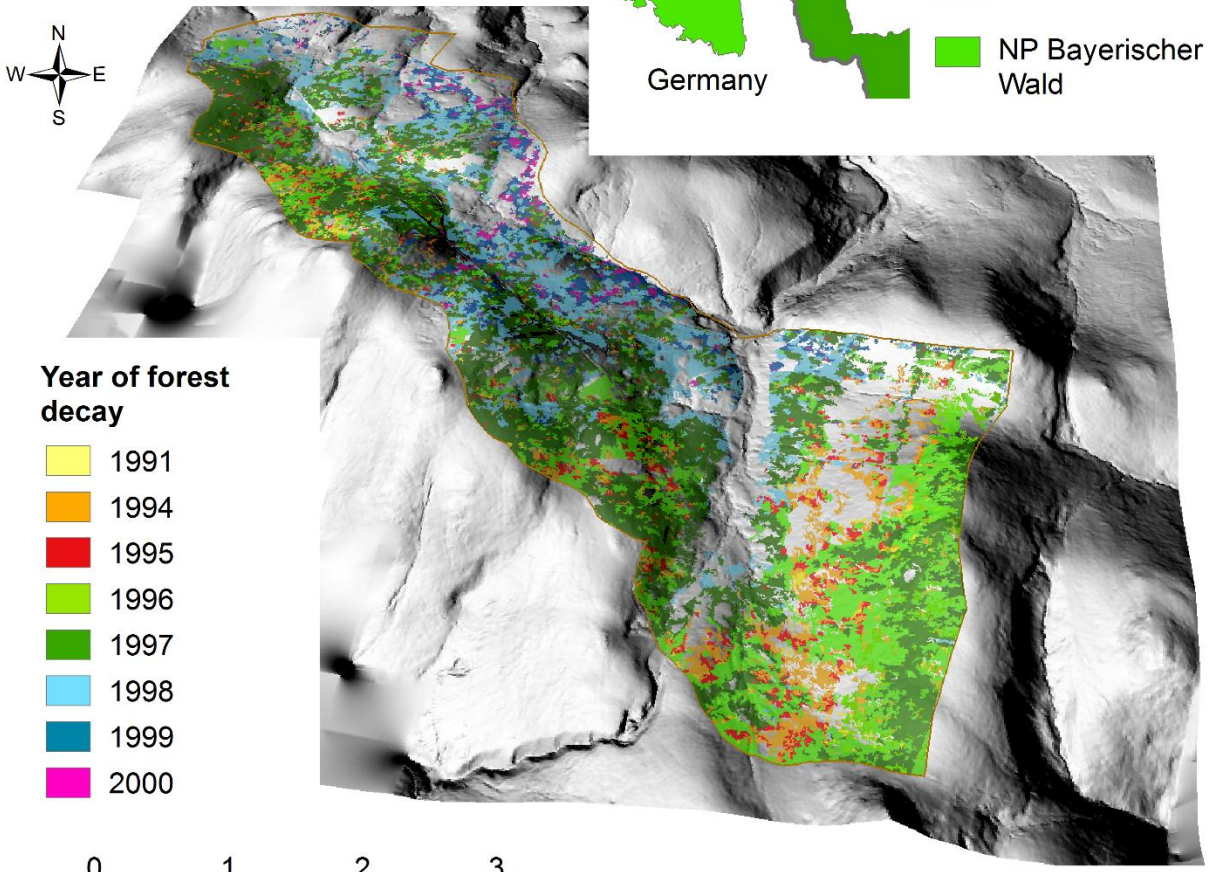




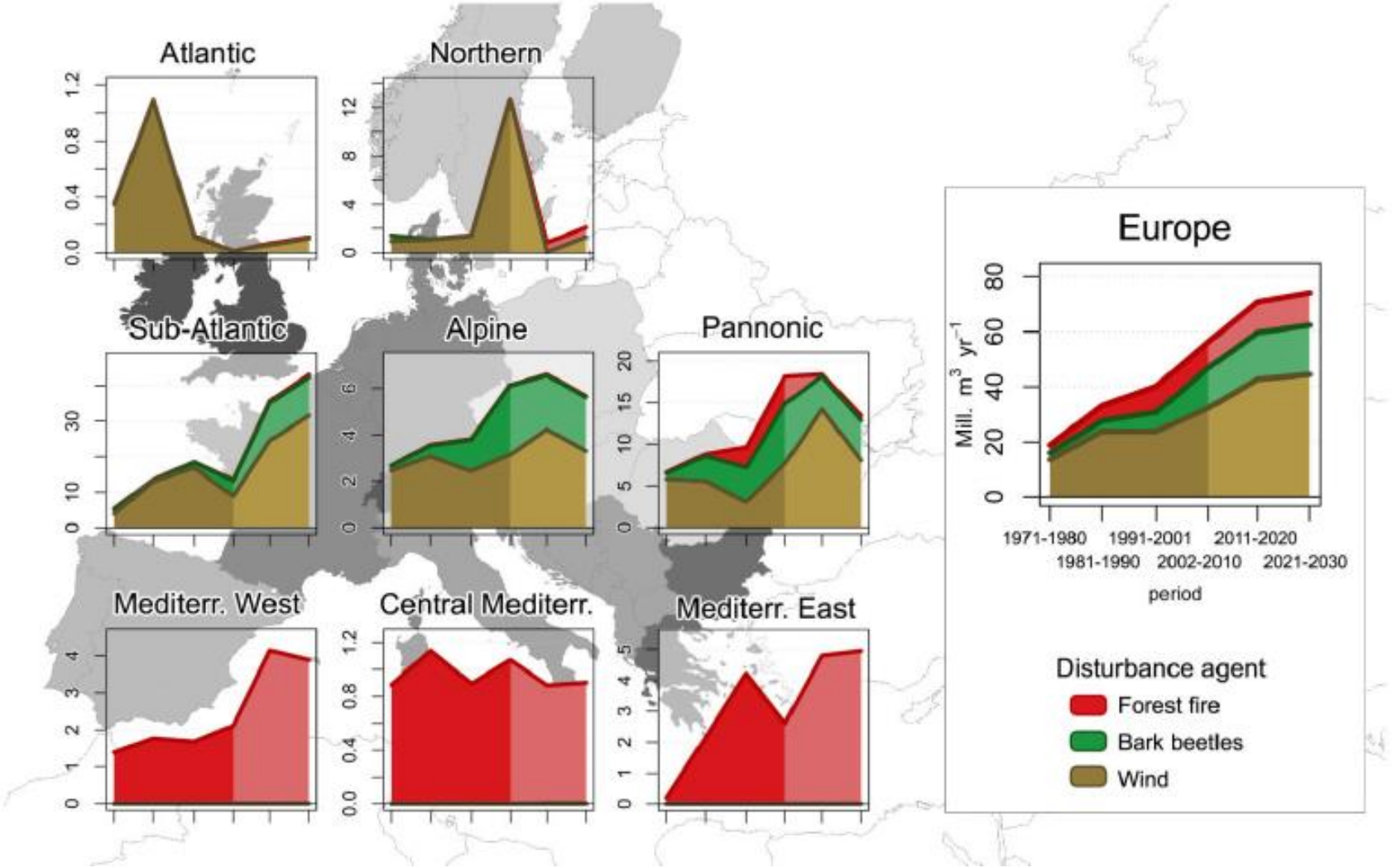
Disturbances

Lusen valley

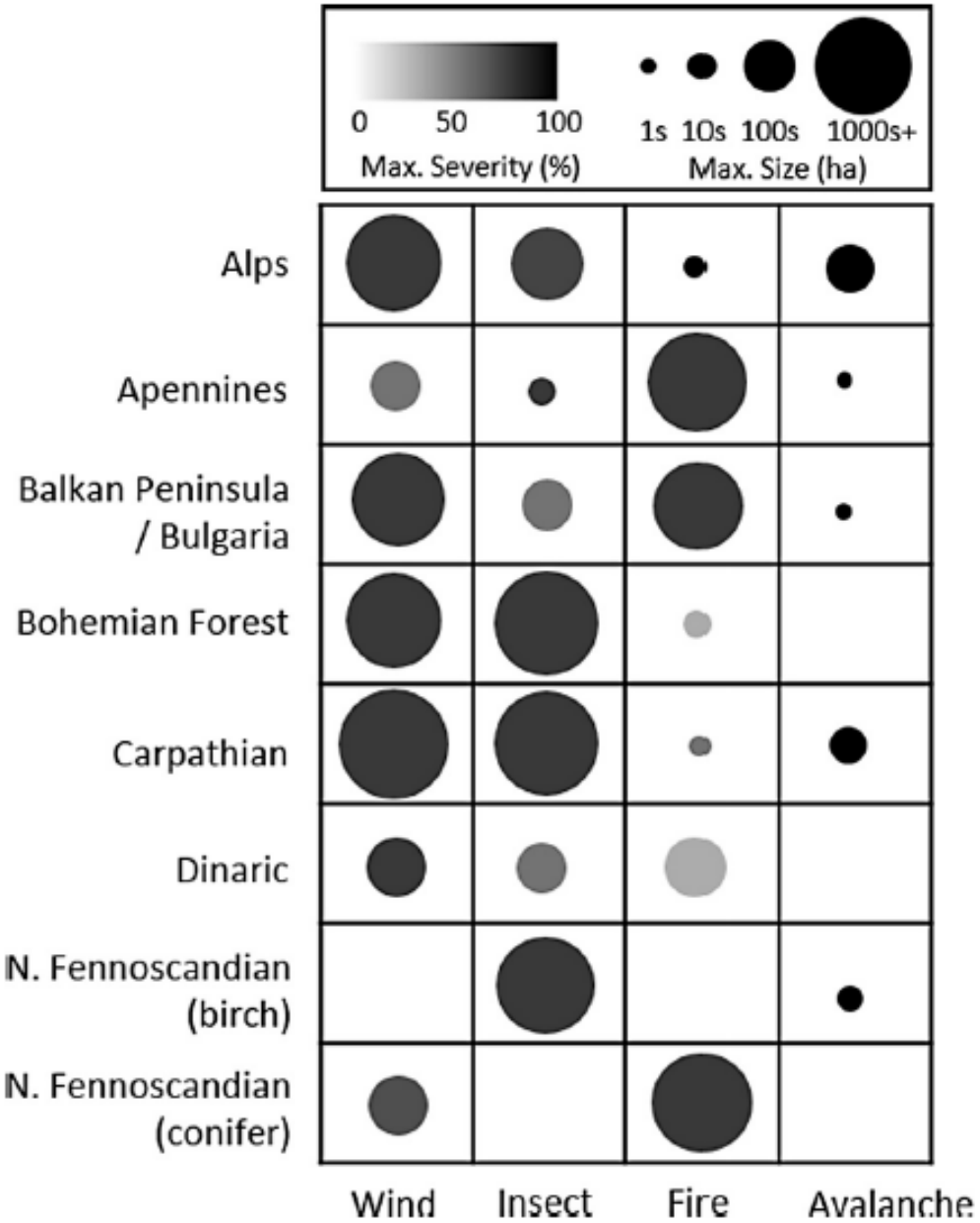




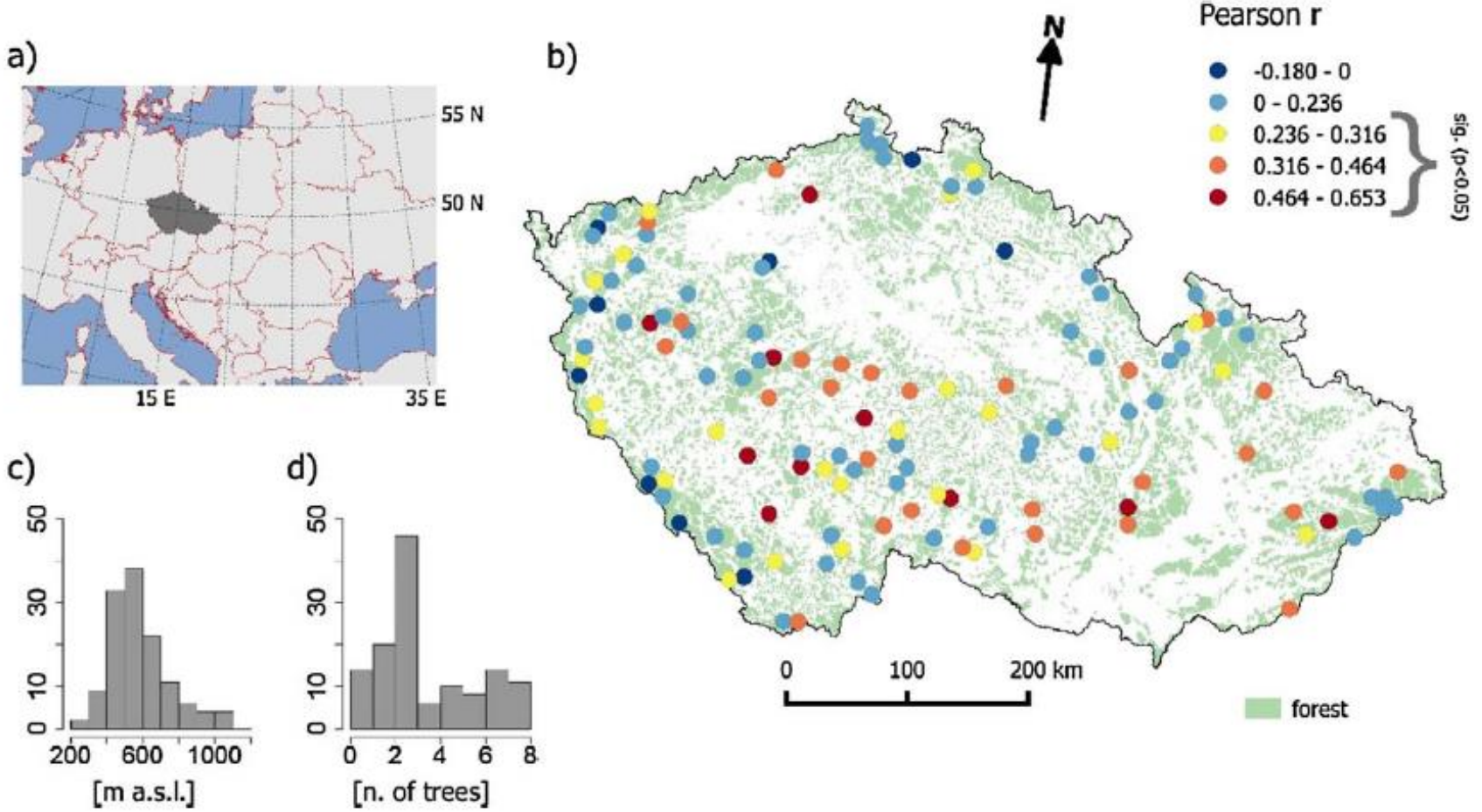
Changing frequency of disturbances

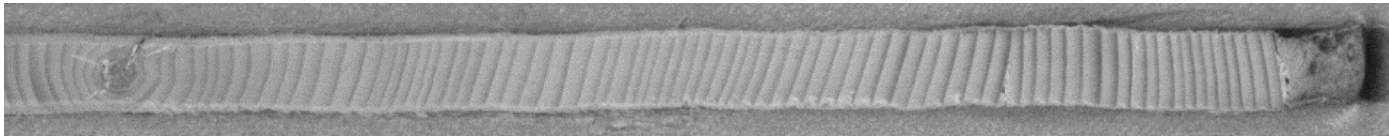


Severity and size of disturbances

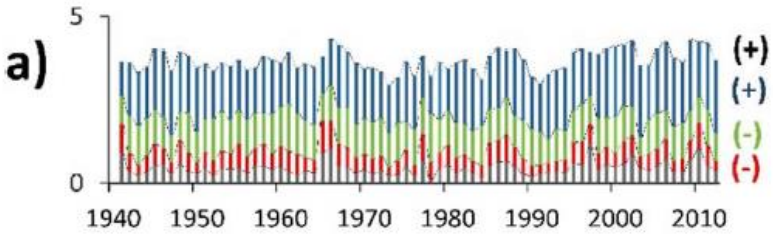


Example: Growth-climate response of Norway spruce in CZ



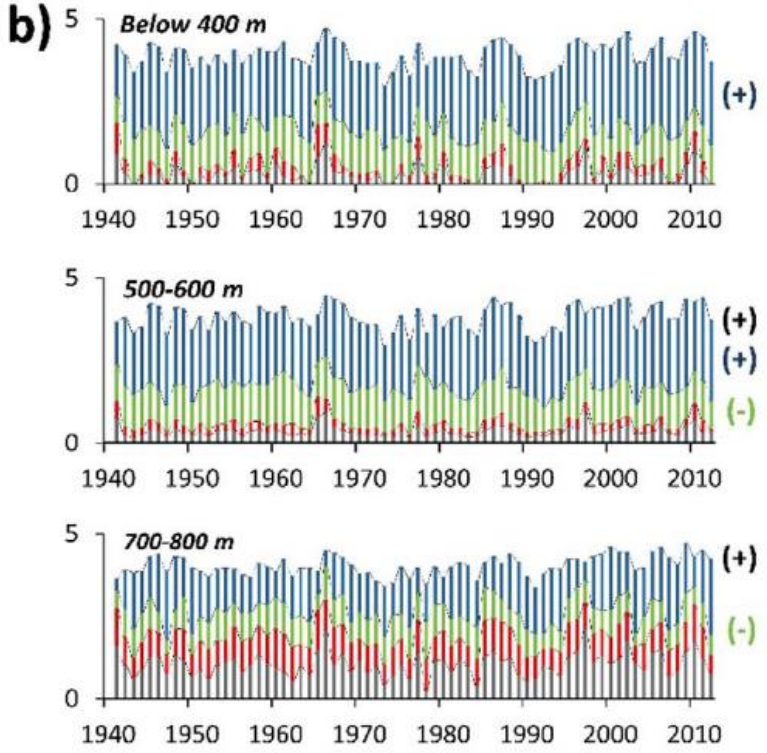


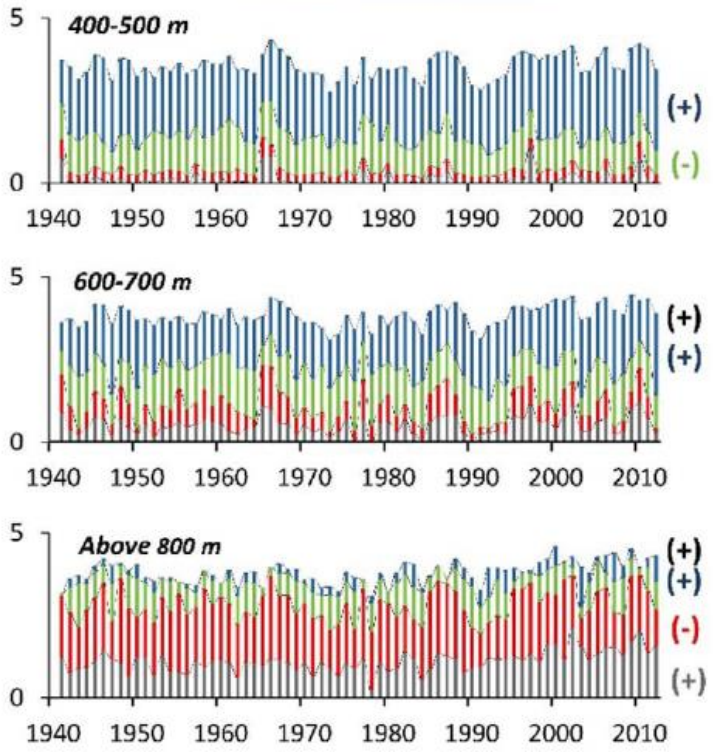
Example: Growth-climate response of Norway spruce in CZ



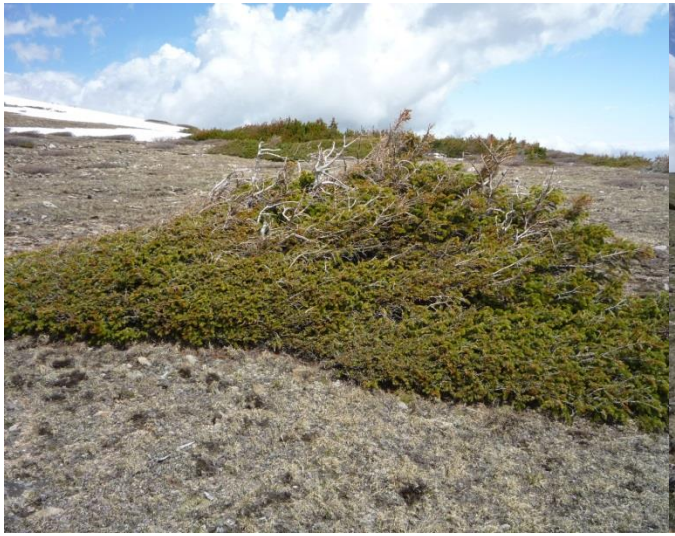
c)

Elevation belt	$g_M(t)$	$g_{MIX}(t)$	$g_T(t)$	$g_{UN}(t)$
Below 400 m	56.6	30.1	6.6	5.7
400-500 m	58.1	32.0	7.1	2.8
500-600 m	51.2	35.9	5.6	7.3
600-700 m	38.8	34.1	16.0	11.1
700-800 m	33.9	21.4	22.6	22.1
Above 800 m	7.2	21.9	45.3	25.6
All	45.7	28.1	14.0	12.2

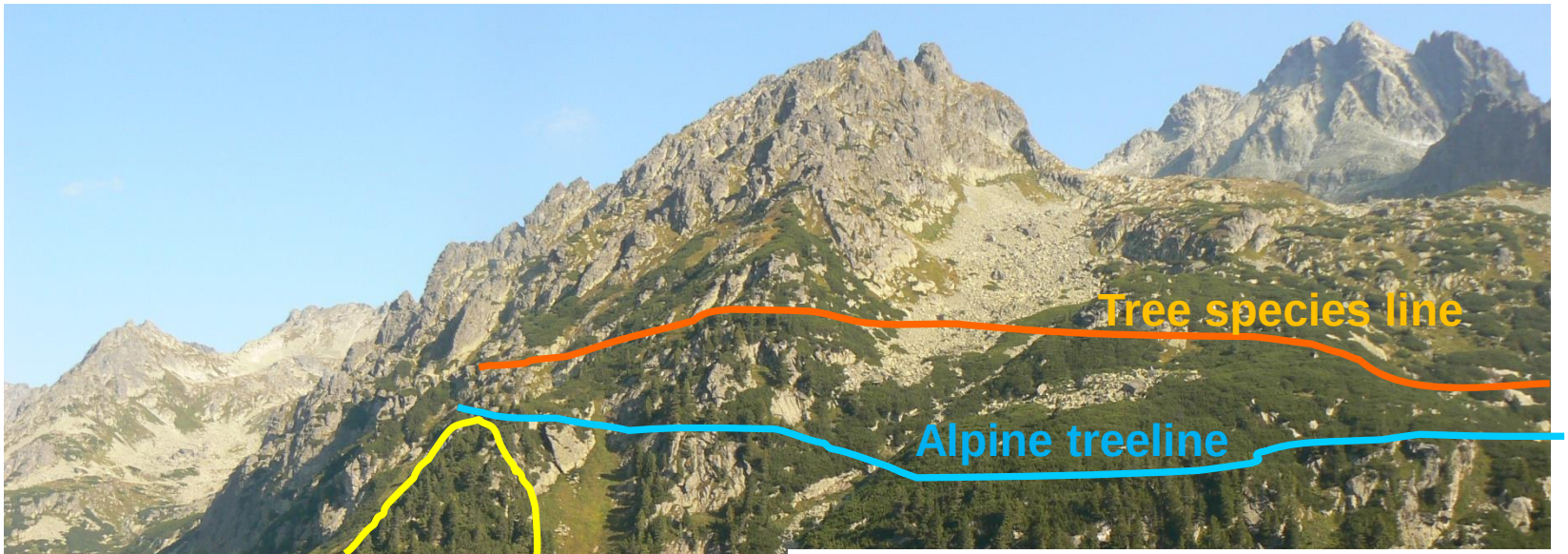


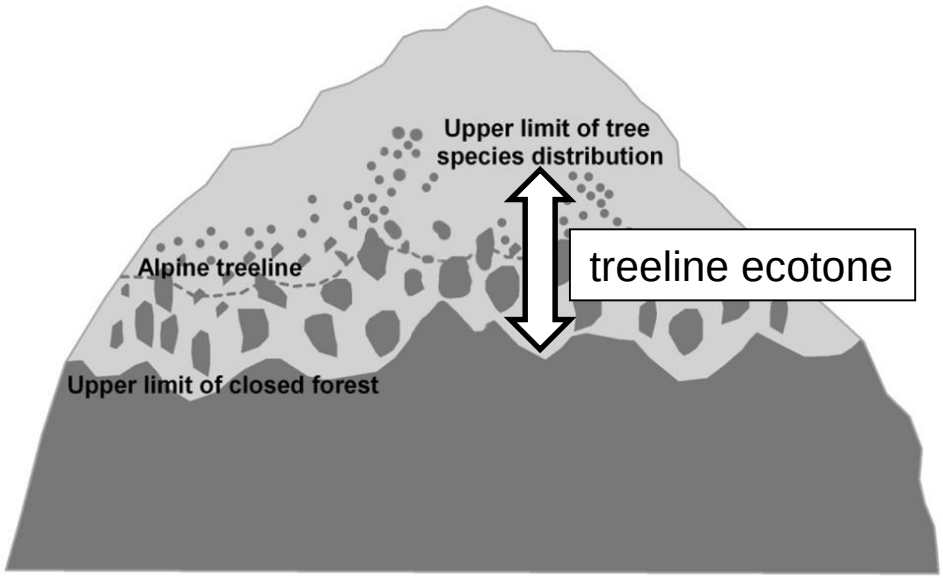


Example: treelines



Treeline terminology





Why are treelines formed?

Because of decreasing temperatures along elevation gradients.

Hypotheses focusing on tree growth

Source-limited growth

Insuficient amount of asimilates, nutrients

Sink-limited growth

Inability to invest carbon and nutrients into new tissues

Hypotheses focusing population dynamics

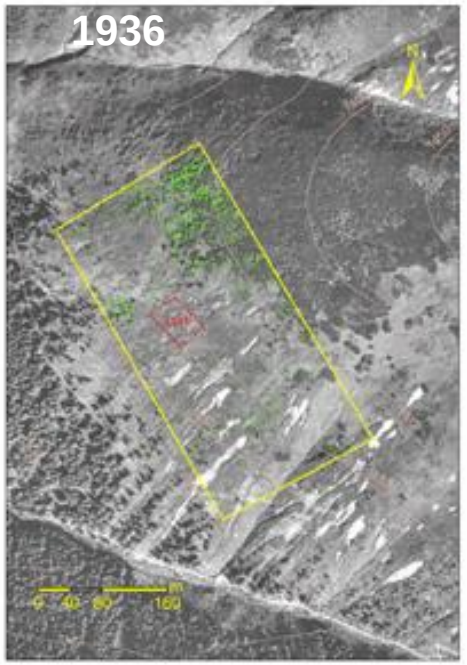
- Seed production/viability
- Seedling establishment
- Seedling survival

Oecologia (1998) 115:445–459

Christian Körner

A re-assessment of high elevation treeline positions and their explanation

Treelines are advancing upwards and polewards in consequence of warming.



Consequences for
- Surface albedo
- Species distribution

However, there are also stable trelines
(~ 46 % according to Harsch et al. 2009 in Ecology Letters)

Why?

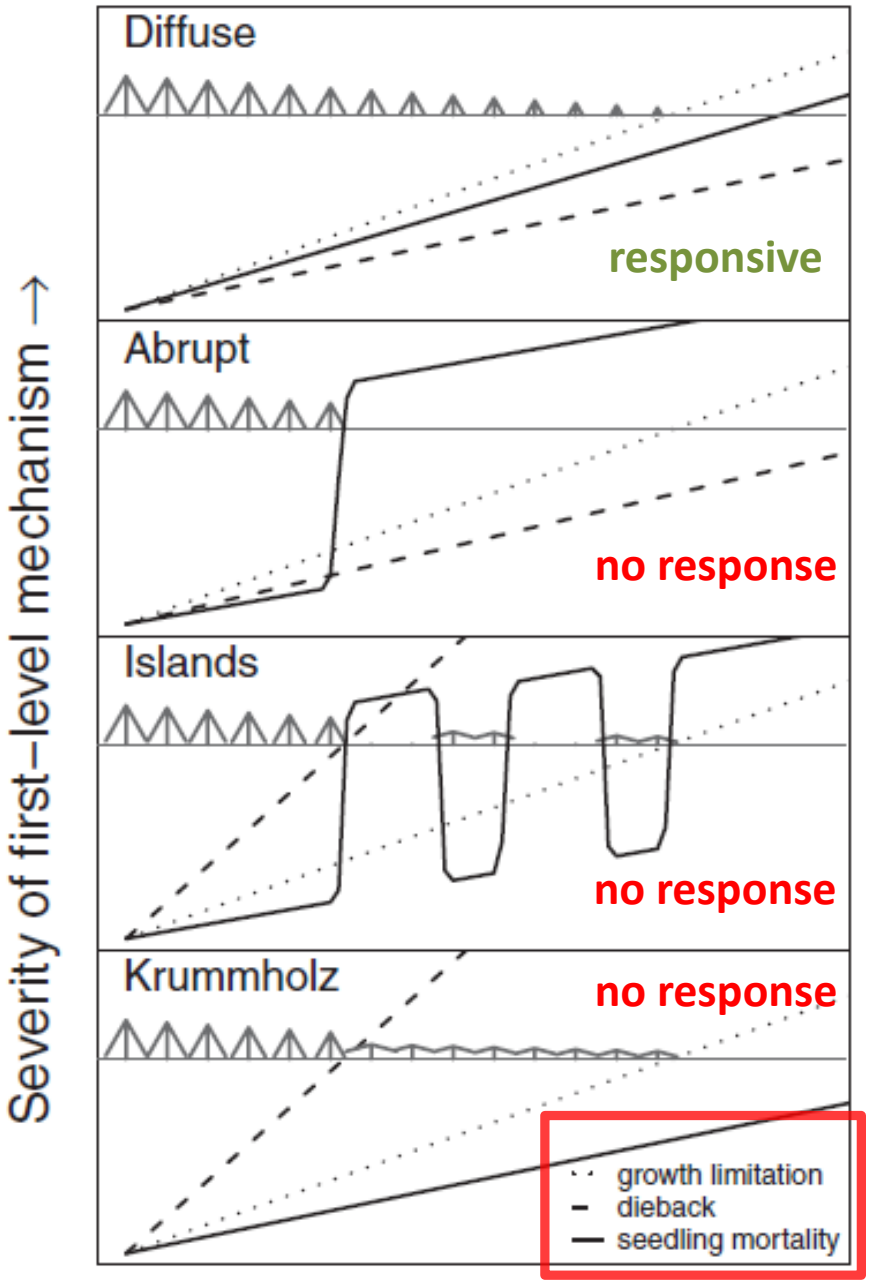
- Not all treelines are probably exlusively temperature-limited

Treeline form reflects prevailing limiting mechanism of tree occurrence in cold environment. (*Harsch and Bader 2011, Glob. Ecol. Biogeogr.*)

Diffuse treeline – temperature limited growth

Abrupt treeline – establishment limit (seedling mortality)

Krummholz treeline – high biomass loss

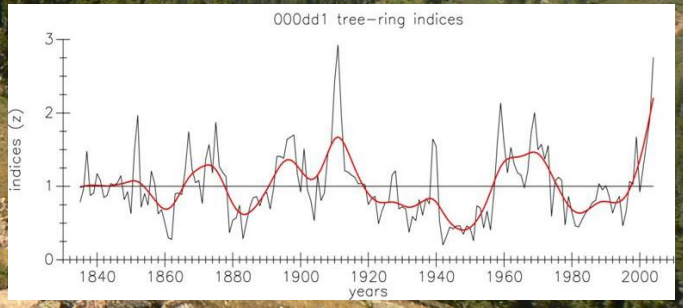


Harsch and Bader 2011, Glob. Ecol. Biogeogr.

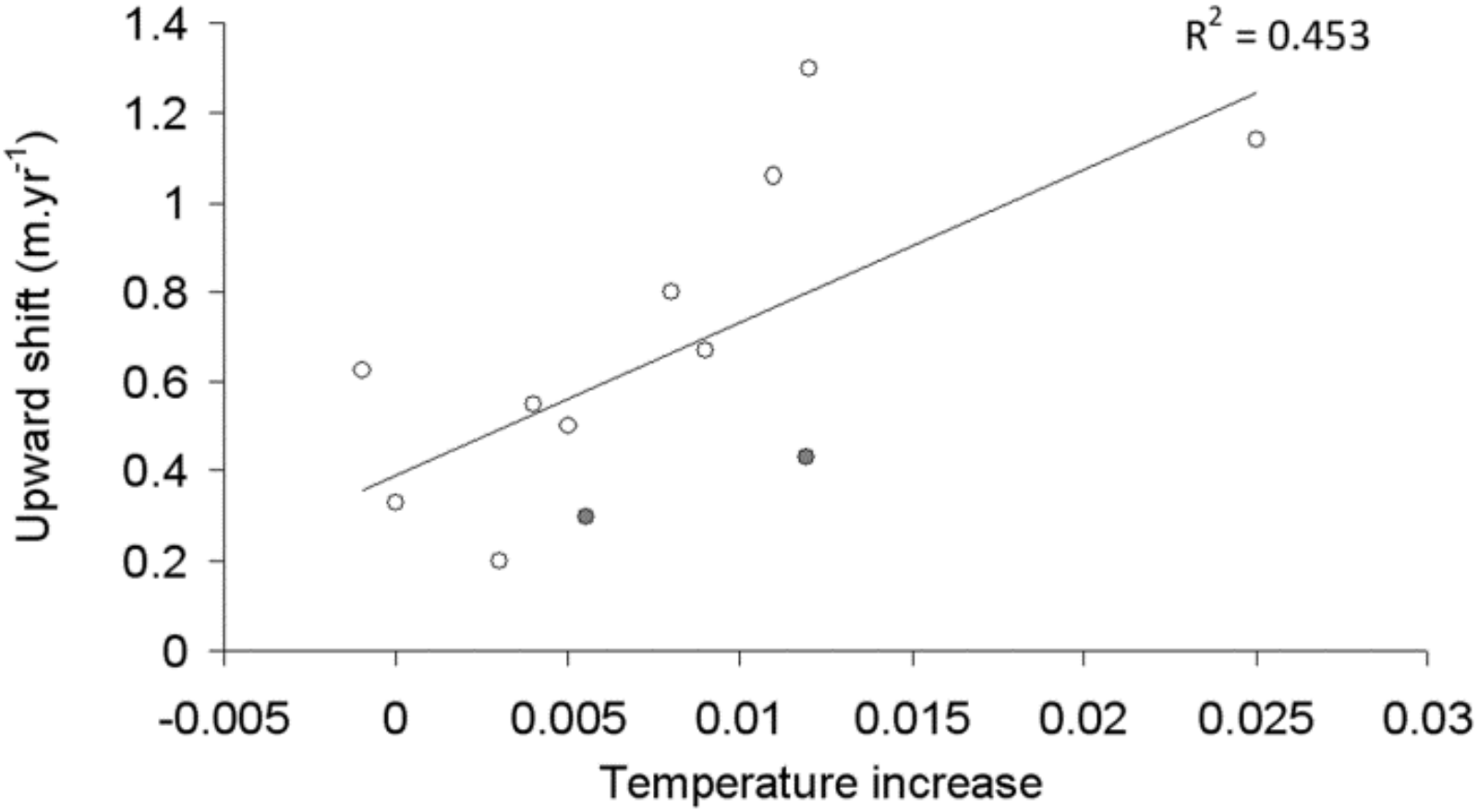

Krummholz
Niwot ridge - south


Diffuse
Rollins pass

Abrupt
Berthoud pass



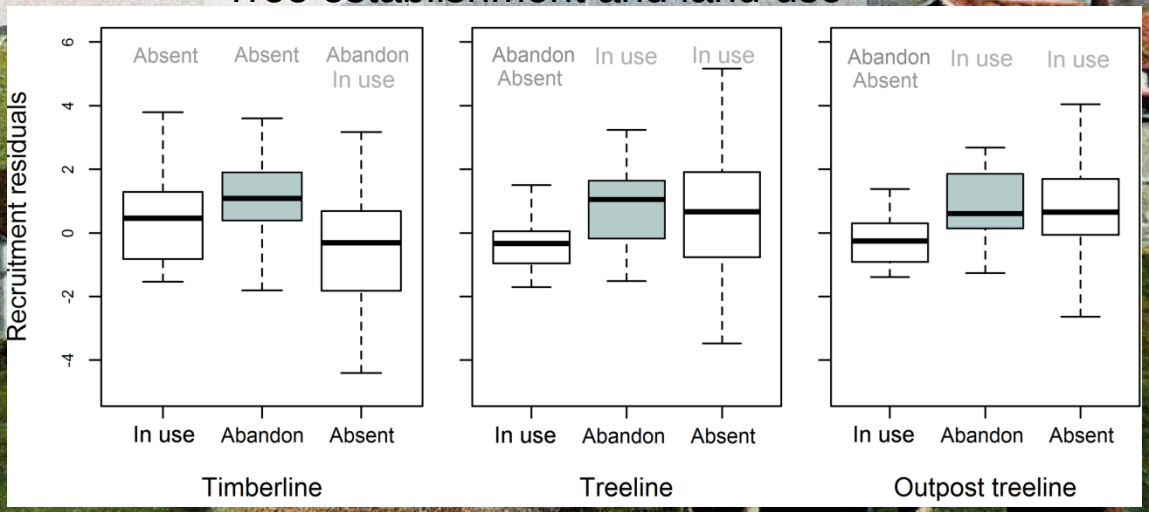
Upward shift of treeline in Europe (1950s-2010)



Riesengebirge. Wiesenbaude 1400 m ü. M. Blick auf die Schneekoppe.

Land-use change and temperature increase

Tree establishment and land-use



Take-home messages

- Plants are increasing their productivity in response to CO_2 and warming;
- Plant growth is increasingly limited by drought (however WUE helps);
- Spring phenology is earlier;
- Plants are changing their distribution, however there are differences between leading and trailing edges; biotic inertia matters;
- The frequency of disturbances is increasing (facilitate species shifts);
- Cold-adapted plant communities response relitively most sensitively.