Simulating the impact of extreme events on ecosystems with infrared irradiation in the field

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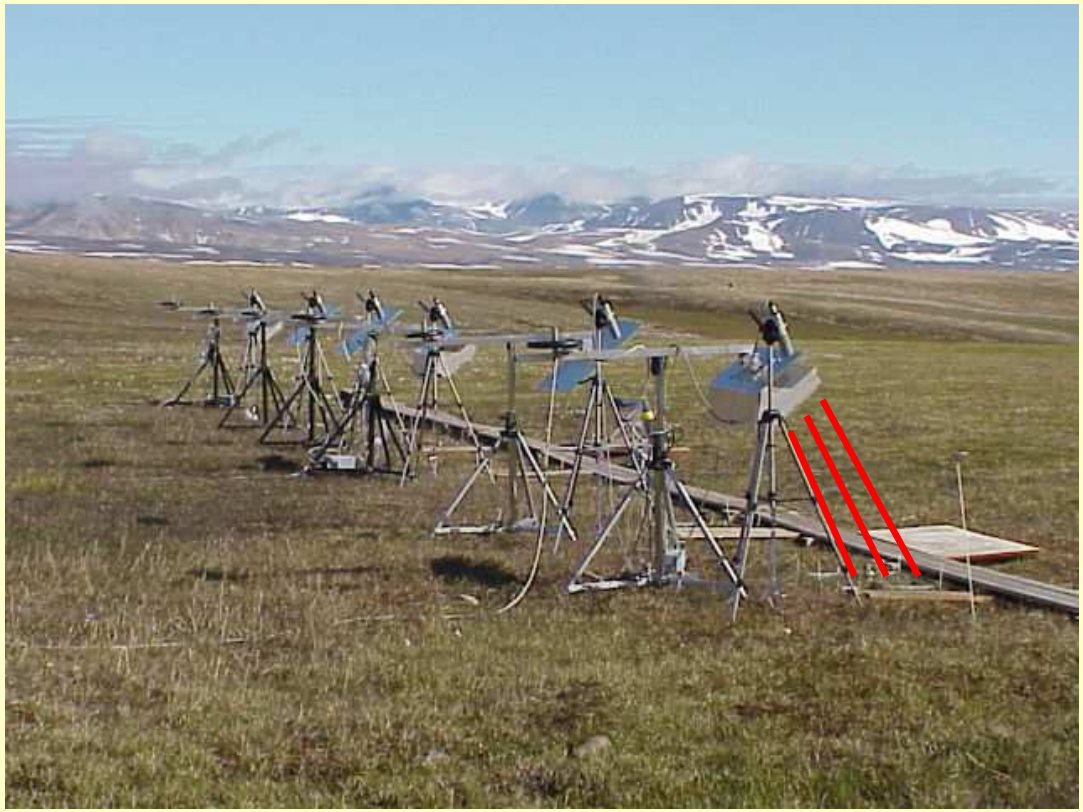
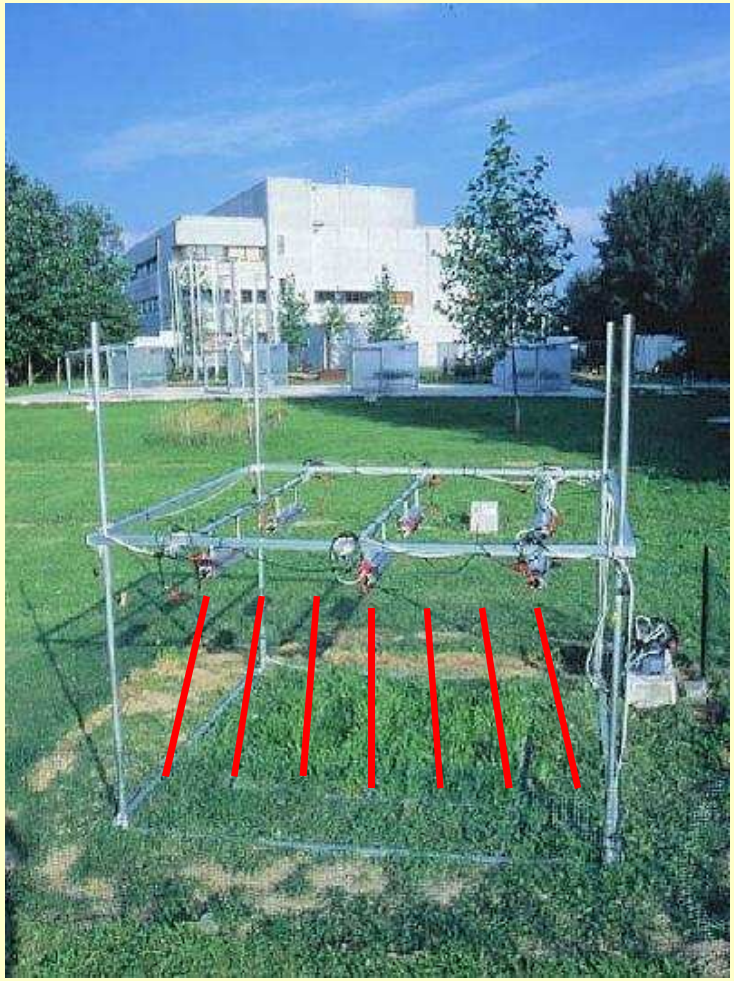
1996: ‘Free Air’ Temperature Increase (FATI) ⟶ heat waves



Big FATI



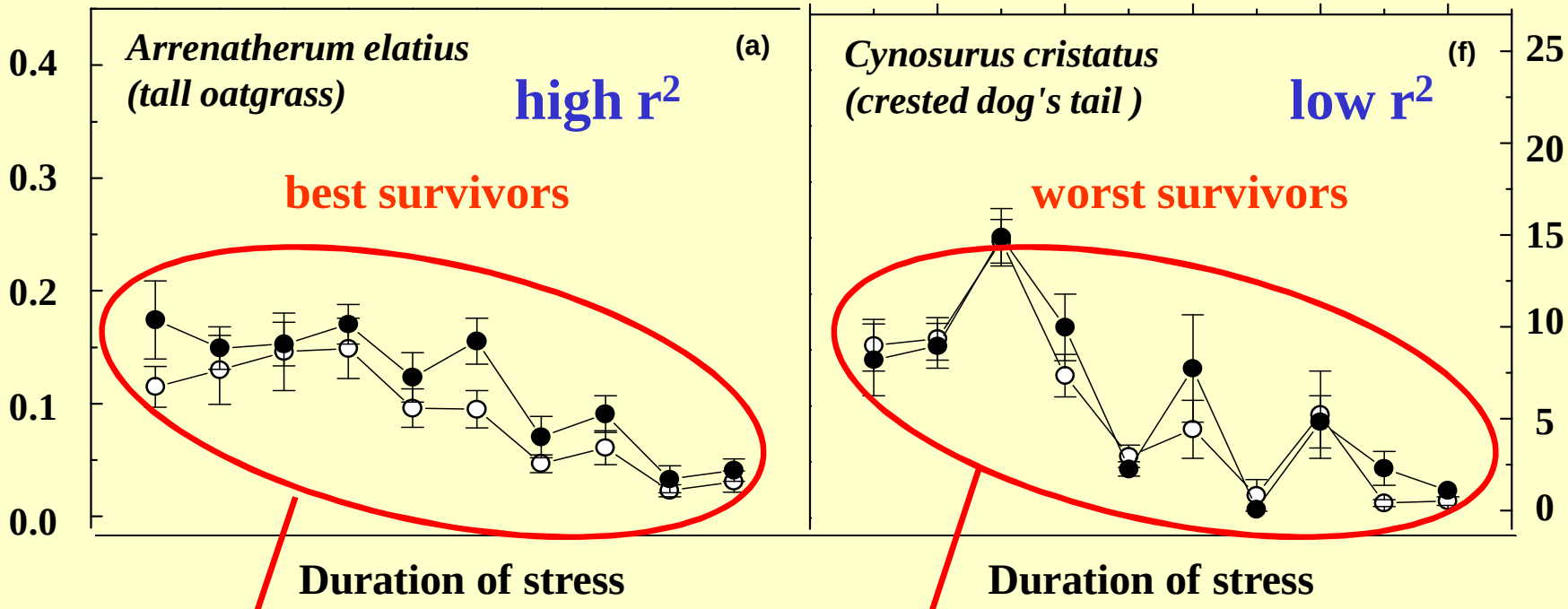
(1) Which plant attributes determine the resistance to a heat wave → predict which species are most robust?

8 temperate grasses (mono)

FATI: +11°C + drought

Survival: removal + irrigation

Stomatal conductance (○) and photosynthetic rate (●)

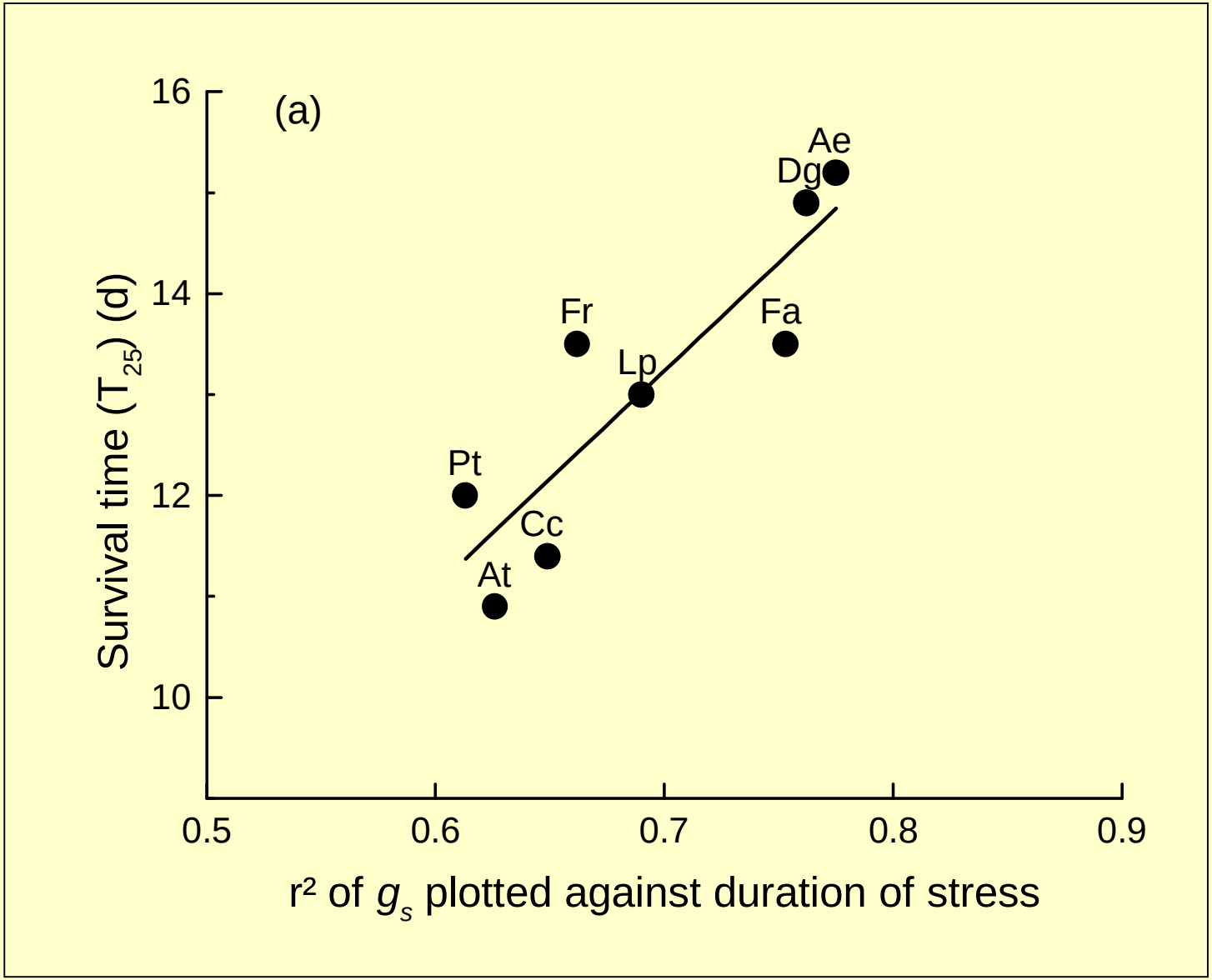


variance explained by increasing stress

g_s strongly coupled to soil water availability

variance explained by response to environmental factors

g_s weakly coupled to soil water availability

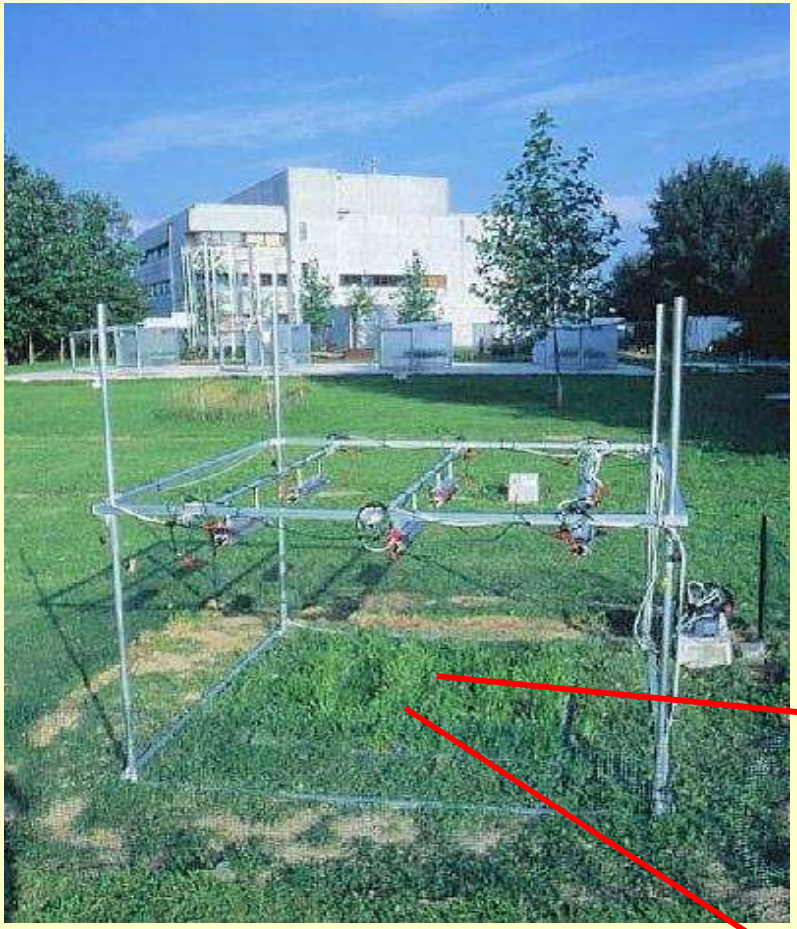


Ann Milbau et al. (Physiol. Plantarum)

(1) Which plant attributes determine the resistance to extremes in individuals plants?

Unexpected traits : resistance to extremes might be governed by other mechanisms than resistance to moderate heat and drought

(2) Does high species richness in a community protect against heat and drought extremes?

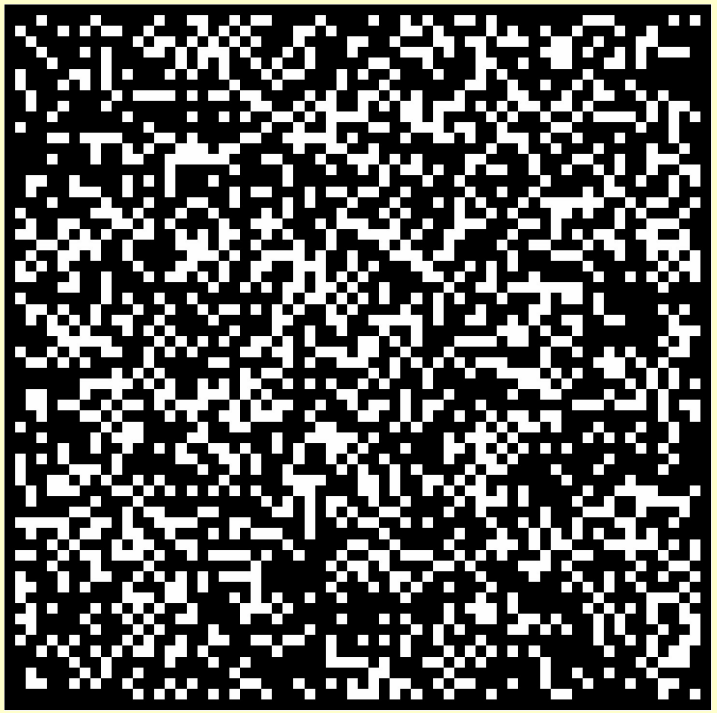


A
B
C
D
AB
AC
AD
BC
BD
CD
ABC
ABD
ACD
BCD
ABCD

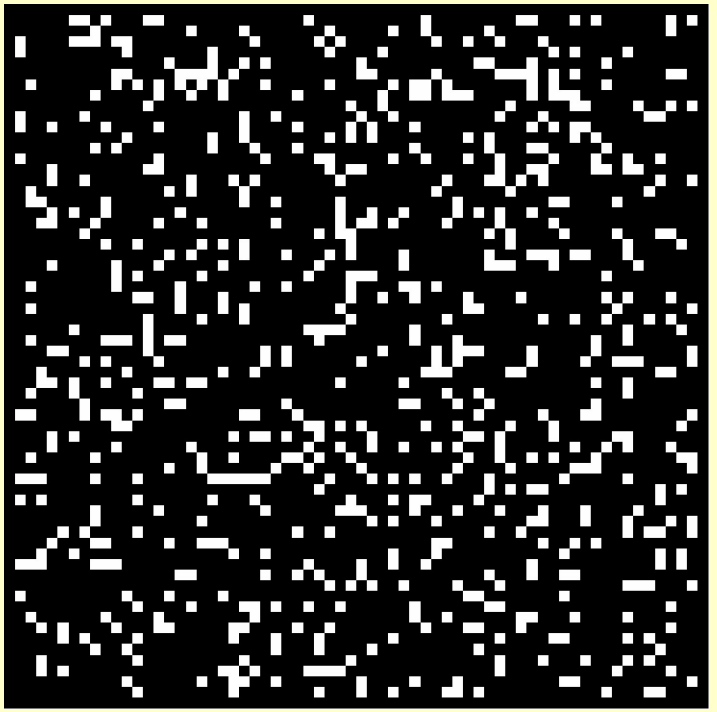
computer reconstruction of measured survival after the heat wave

□: alive

■: dead



average monoculture

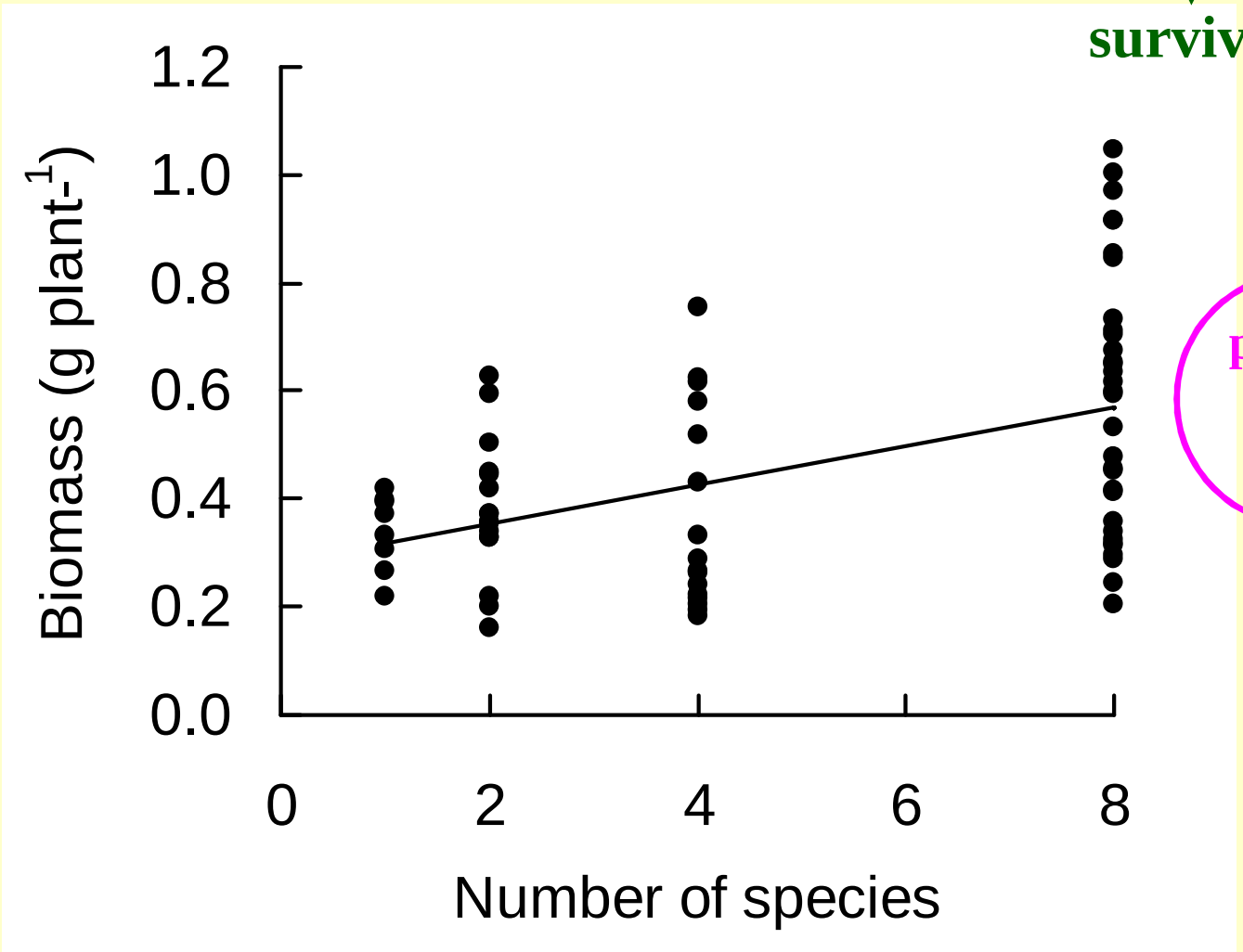


average 8-species community

Liesbeth Van Peer et al. (Ecosystems & Funct. Ecol.)

species richness → community biomass → evapotranspiration

survival



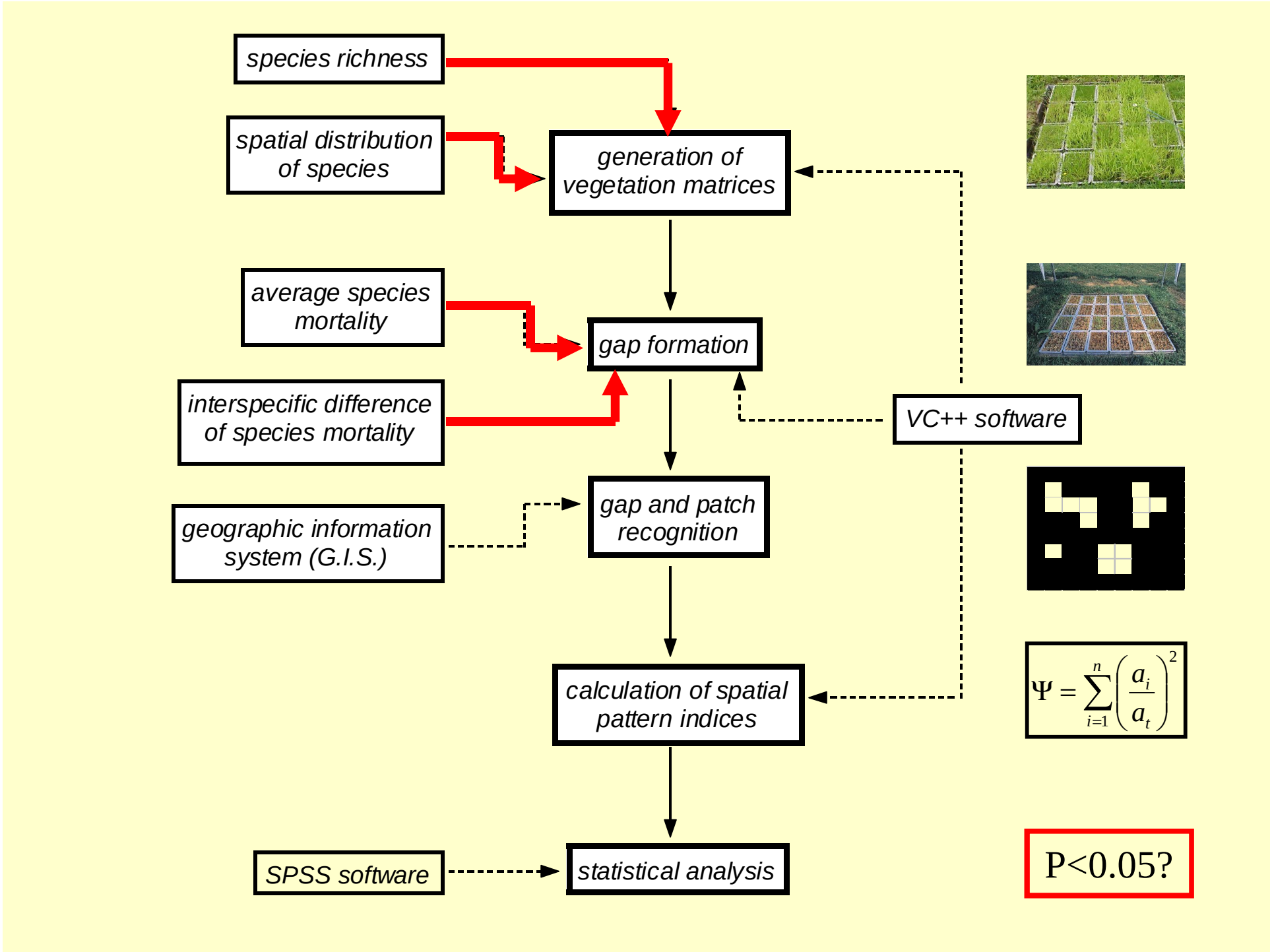
prior to heat wave

2) Does high plant diversity in a community itself protect against extremes?

No

(3) Does plant diversity determine the gap spatial pattern that emerges after an extreme event?

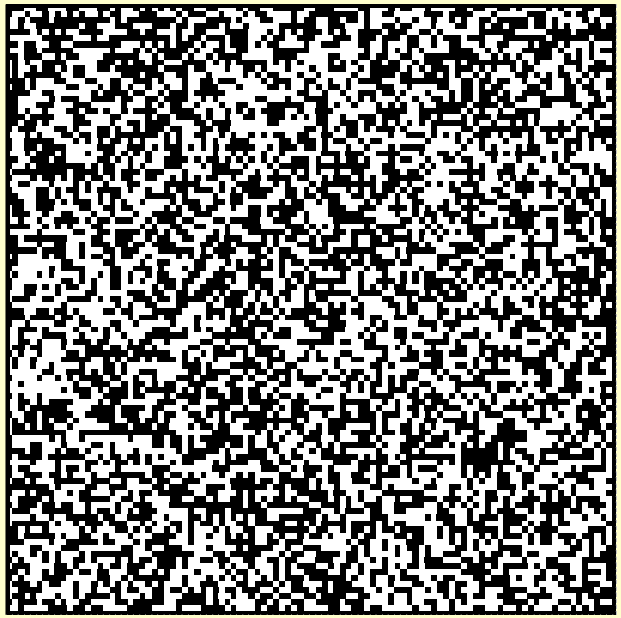
Zhen Qing Li et al. (Ecography)


species richness
spatial distribution of species
generation of vegetation matrices
average species mortality
gap formation
interspecific difference of species mortality
VC++ software
geographic information system (G.I.S.)
gap and patch recognition
calculation of spatial pattern indices
SPSS software
statistical analysis
$\Psi = \sum_{i=1}^{n} \left(\frac{a_i}{a_t} \right)^2$
P<0.05?

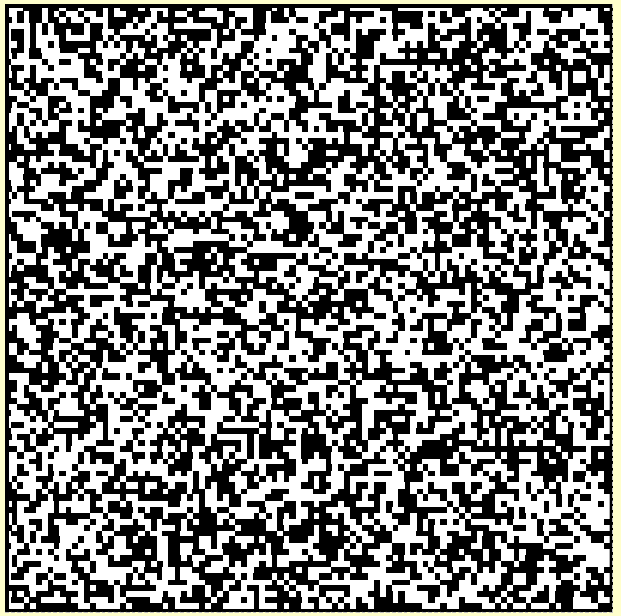
Mixture 4 species: m_i=0.50

Mixture 50 species: m_i=0.50

Mixture 4 species: m_i=0.50

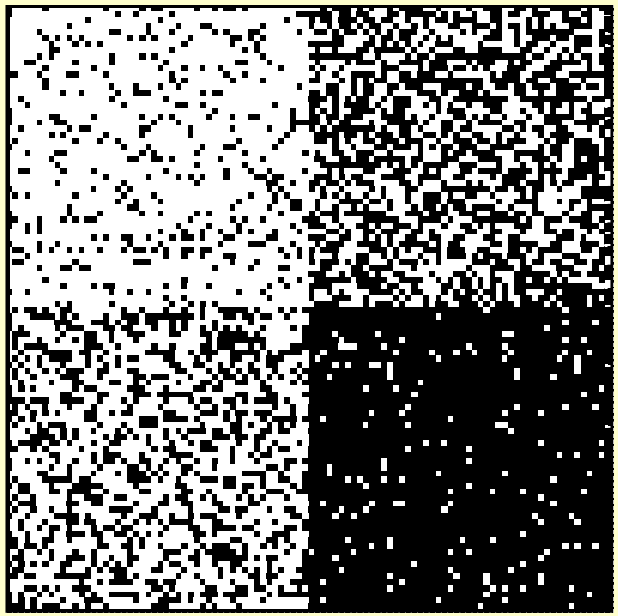


Mixture 50 species: m_i=0.50

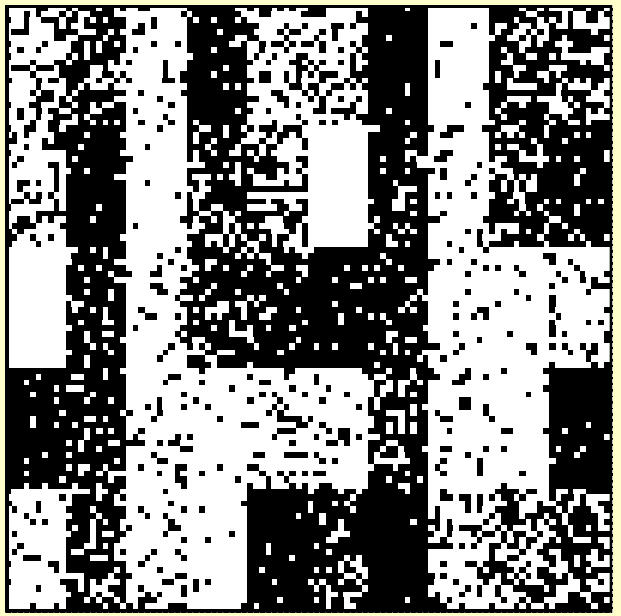


Random vegetation: the spatial pattern emerging after the extreme is the same

Mixture 4 species: m_i=0.70



Mixture 50 species: m_i=0.70

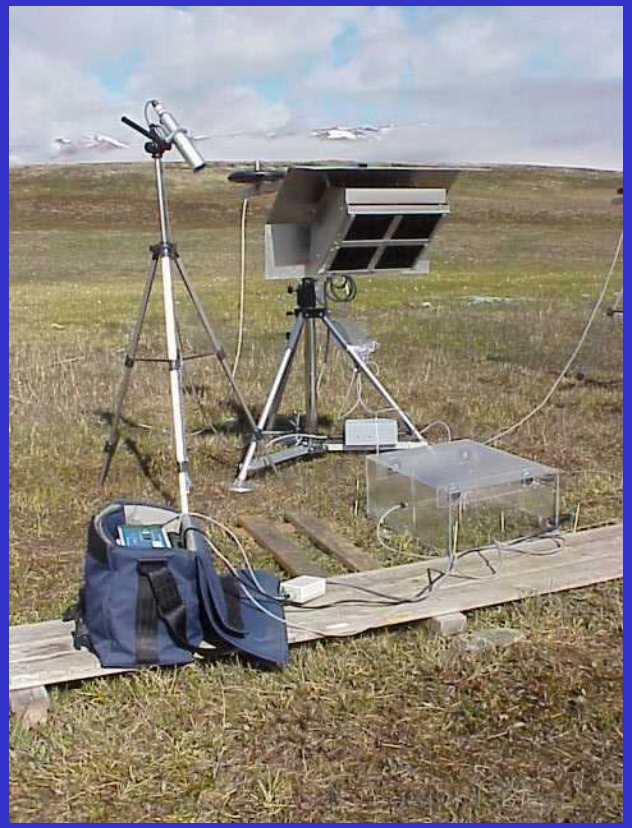


Clumped vegetation: the spatial pattern emerging after the extreme is different

3) **Does plant diversity determine the gap spatial pattern that emerges after an extreme event?**

It depends. On the pattern (random or clumped).

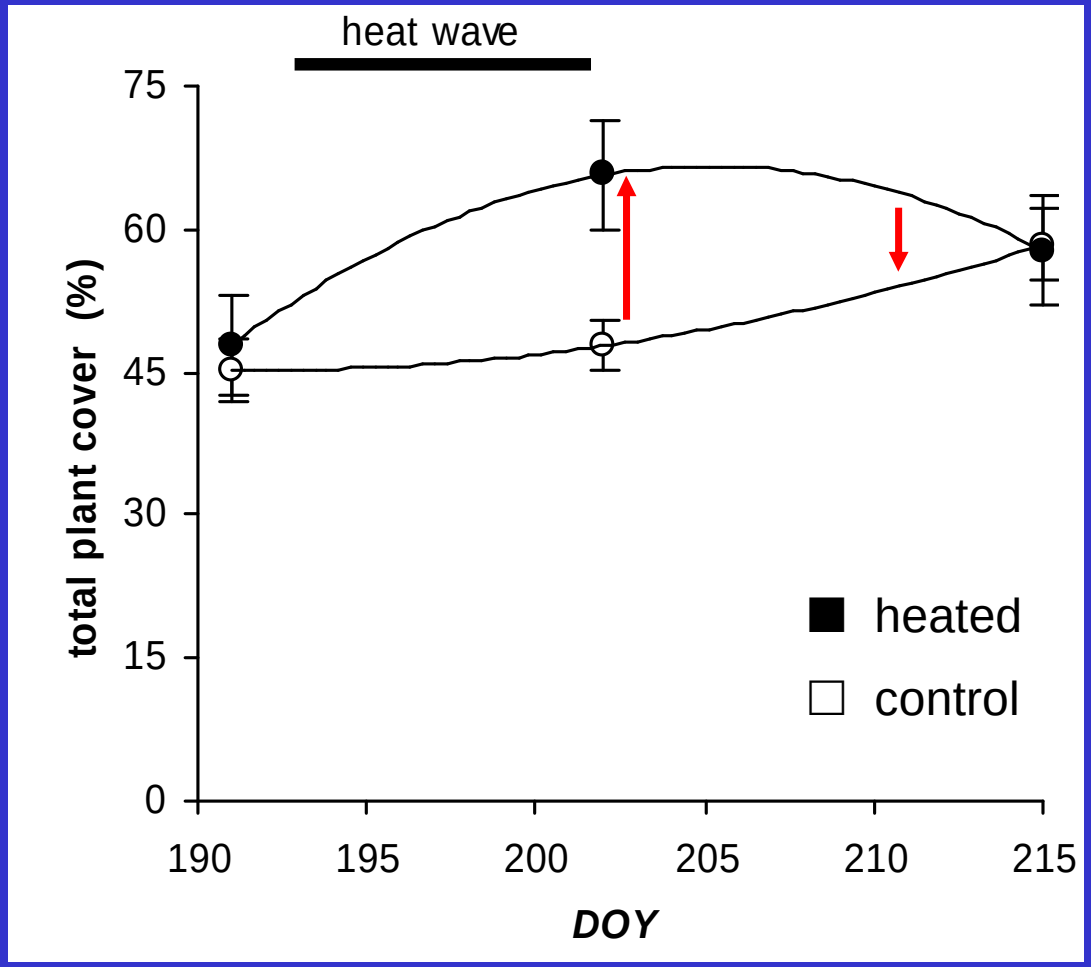
4) Similar impact of heat waves effect in a different biome?



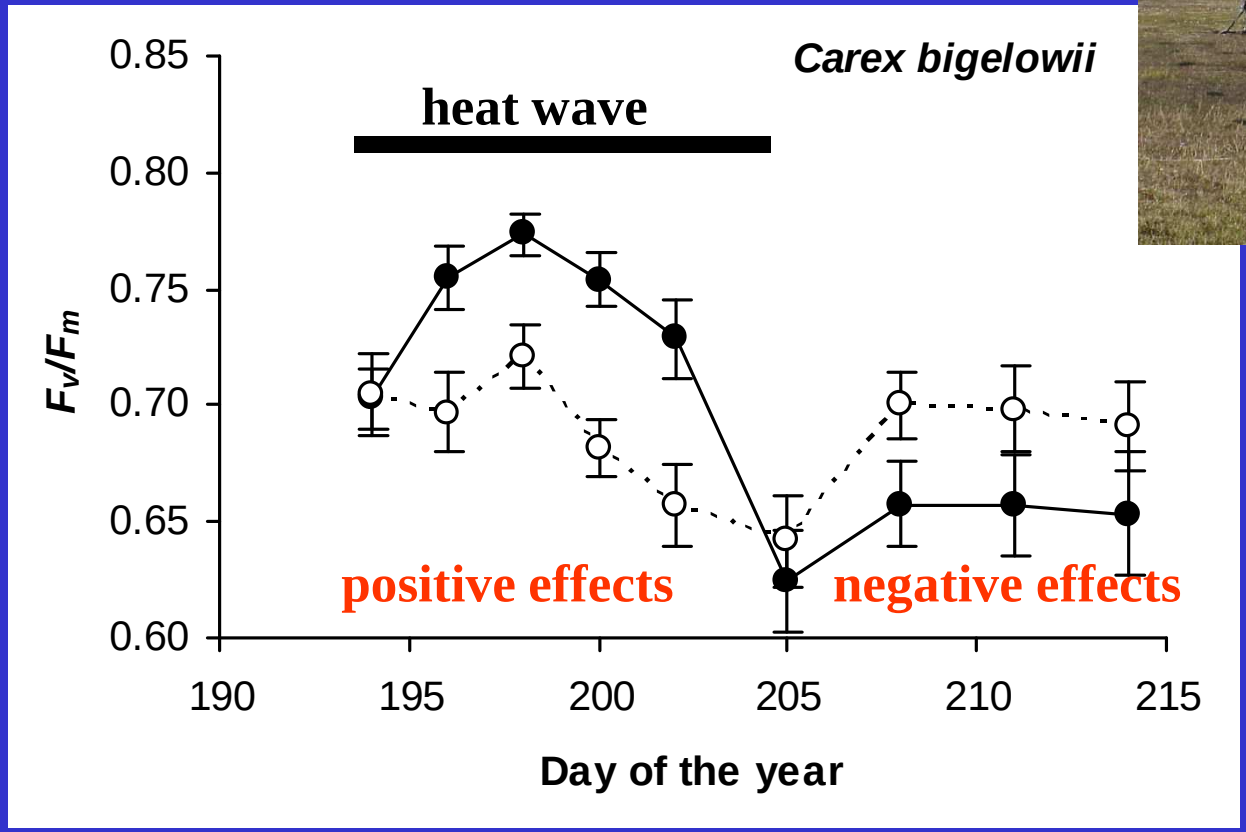
Fleur Marchand et al.

Global Change Biol.
New Phytol.
Funct. Ecol.

Plant cover


heat wave
75
60
45
30
15
0
total plant cover (%)
190
195
200
205
210
215
DOY
heated
control

Chlorophyll fluorescence: PSII photochemical efficiency



4) Similar impact of heat waves in a different biome?

Performance of High Arctic tundra plants improved *during* but deteriorated *after* a simulated extreme temperature event

species-specific responses

5) Do extreme events influence seedling establishment?

13-day heatwave (FATI): ΔT ranging from 0-8°C

Seeds placed in gaps at the start of the heating (West Greenland)

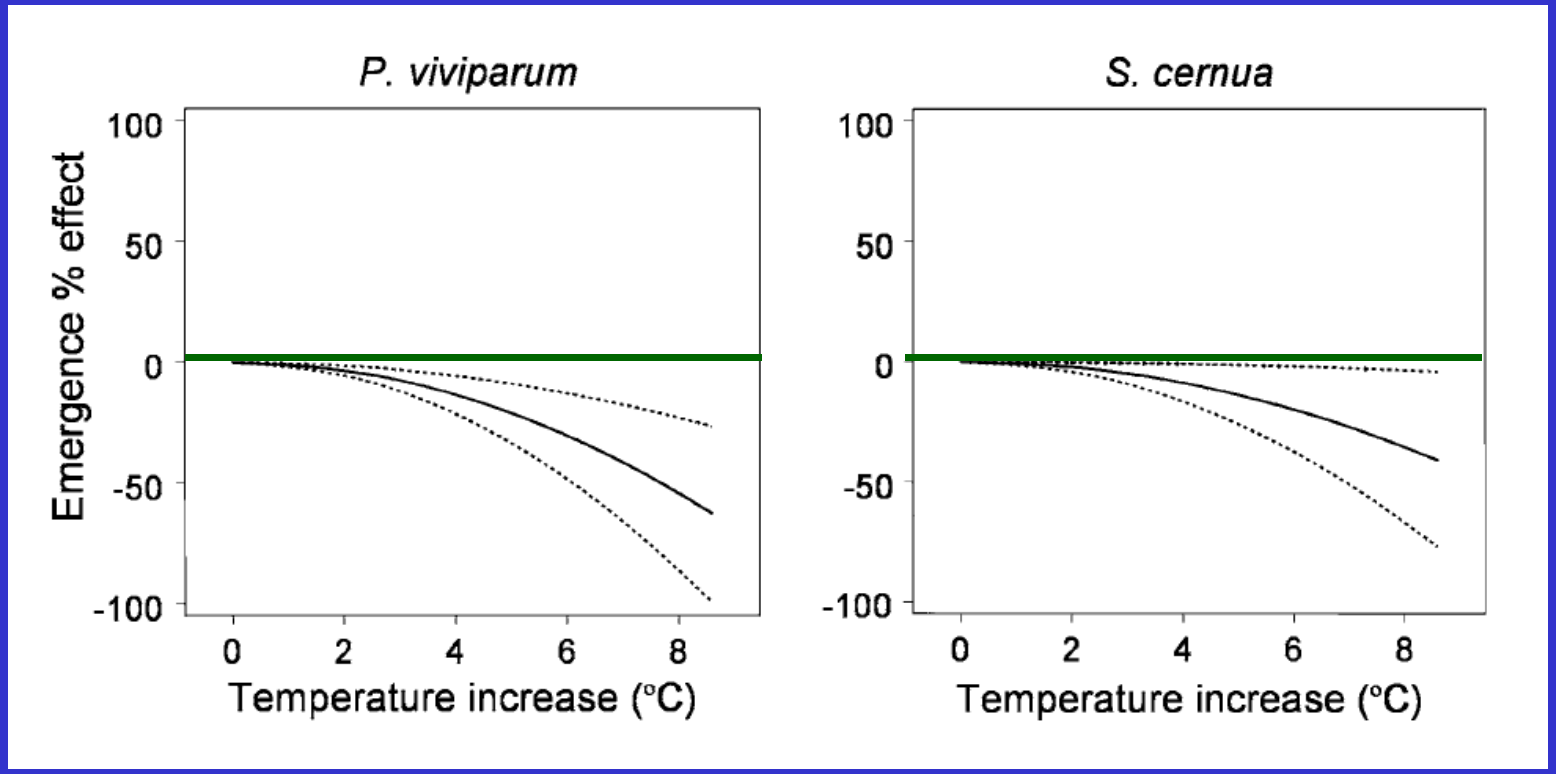
Polygonum viviparum

Saxifraga cernua

Cerastium alpinum

5) Do extreme events influence seedling establishment?

Relative change in seedling emergence



Climatic extremes: a regeneration barrier?

Bente Graae et al. (Polar Biology)

Take home

(1) different types of studies are needed:

- **physiology of individual plant species: resistance**
- **complex plant communities, other trophic levels**
- **simulations: changes in vegetation patterns**
- **reproduction: regeneration barriers**
- **different biomes**
- **extremes today vs. in a future climate**

(2) climate extremes and biodiversity interact

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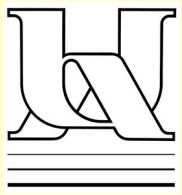

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