Effects of climate experiments and nitrogen addition on the sensitivity of shrubland communities

Dr. Daijun Liu, Chao Zhang, Romà Ogaya, Josep Peñuelas

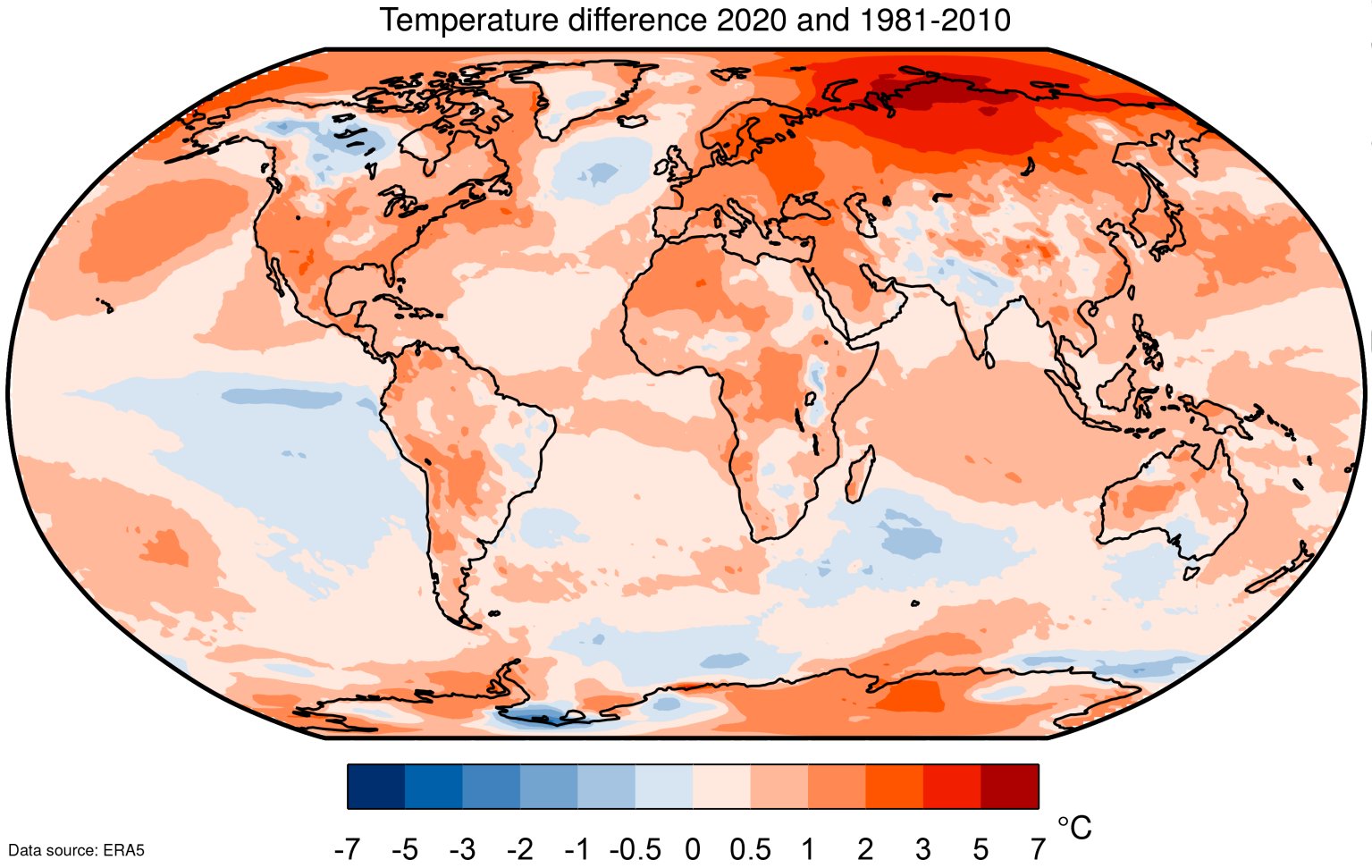
Biodiversity Dynamics and Conservation, Department of Botany and Biodiversity Research,

University of Vienna, Rennweg 14, A-1030 Vienna

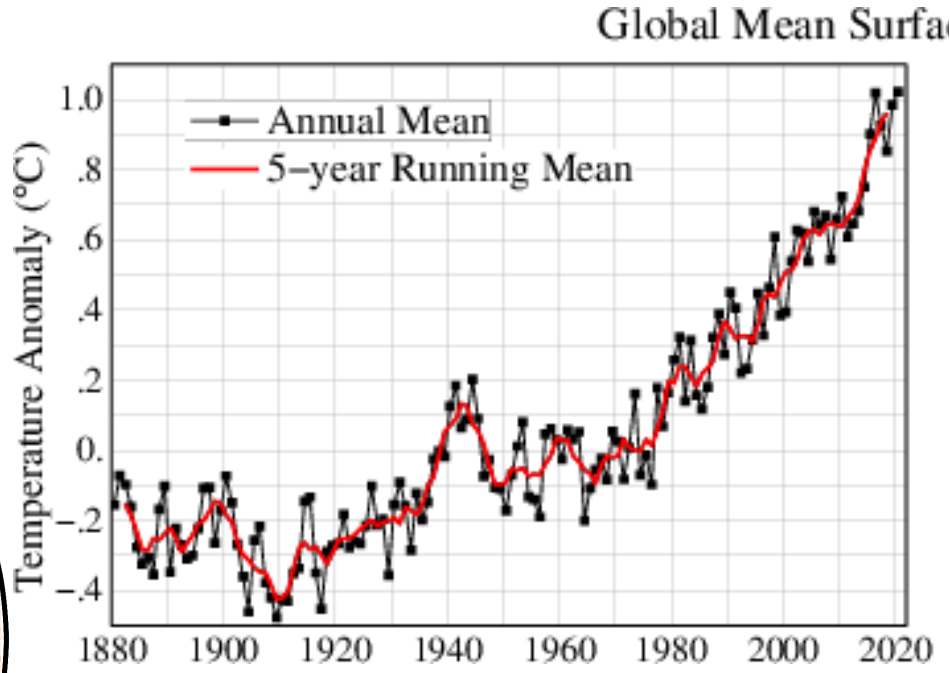
twitter:@daijunliu

Research background

Global warming



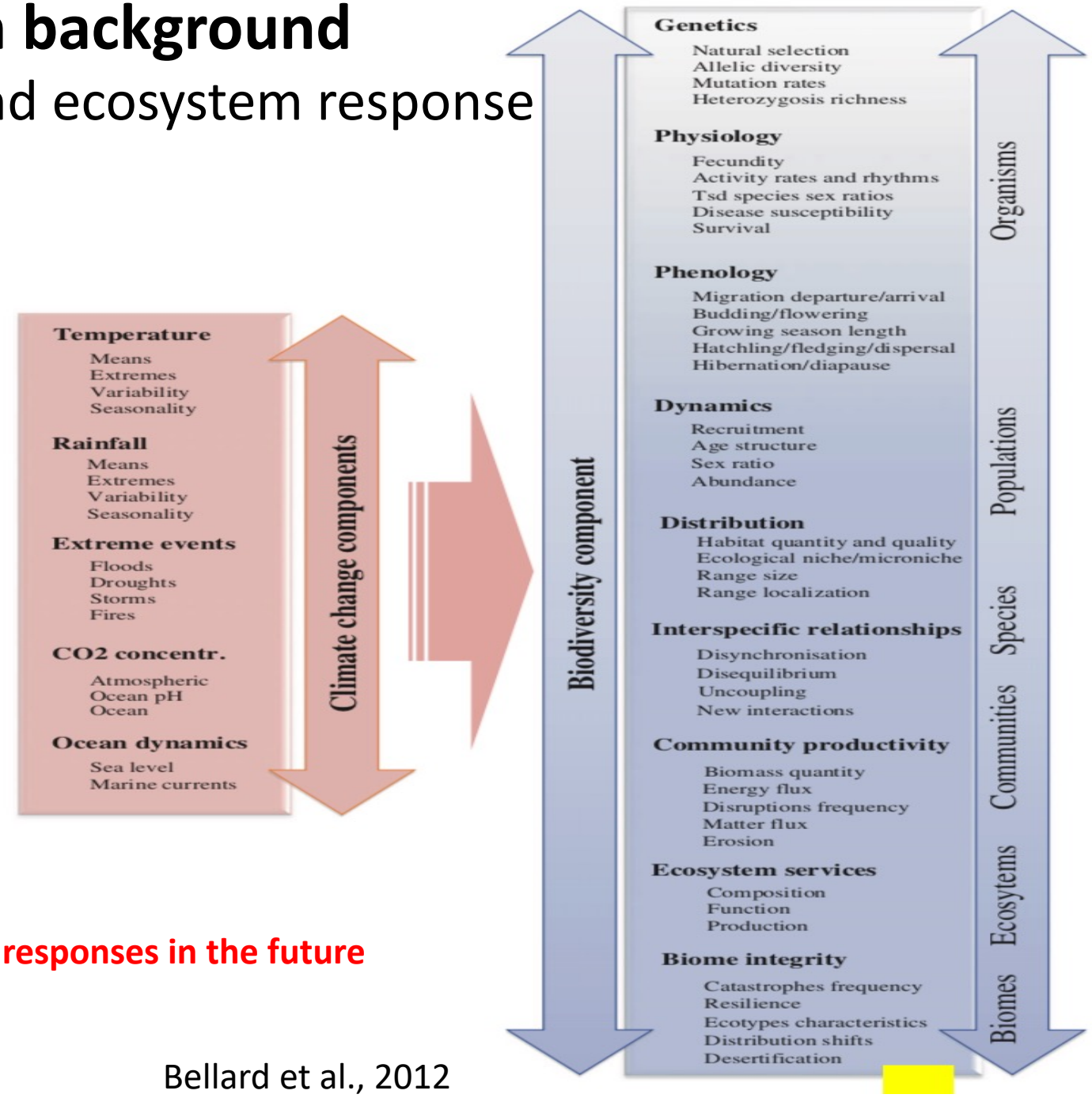
Data source: ERA5



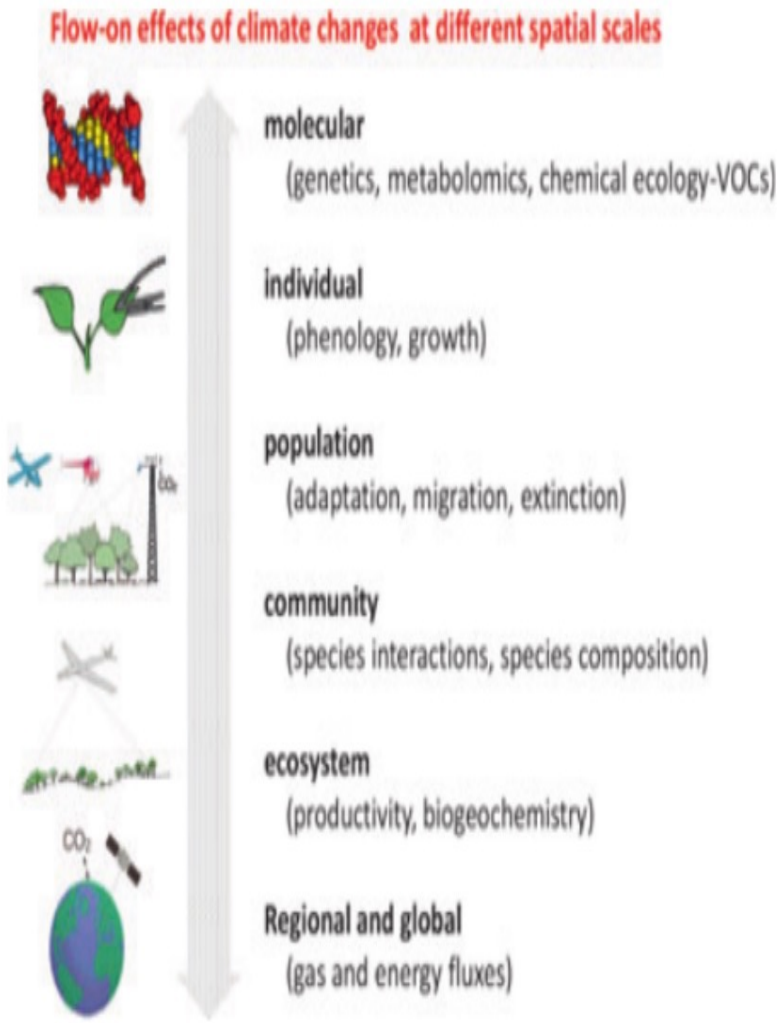
http://www.columbia.edu/~mhs119/Temperature/

Research background

Climate and ecosystem response



Bellard et al., 2012

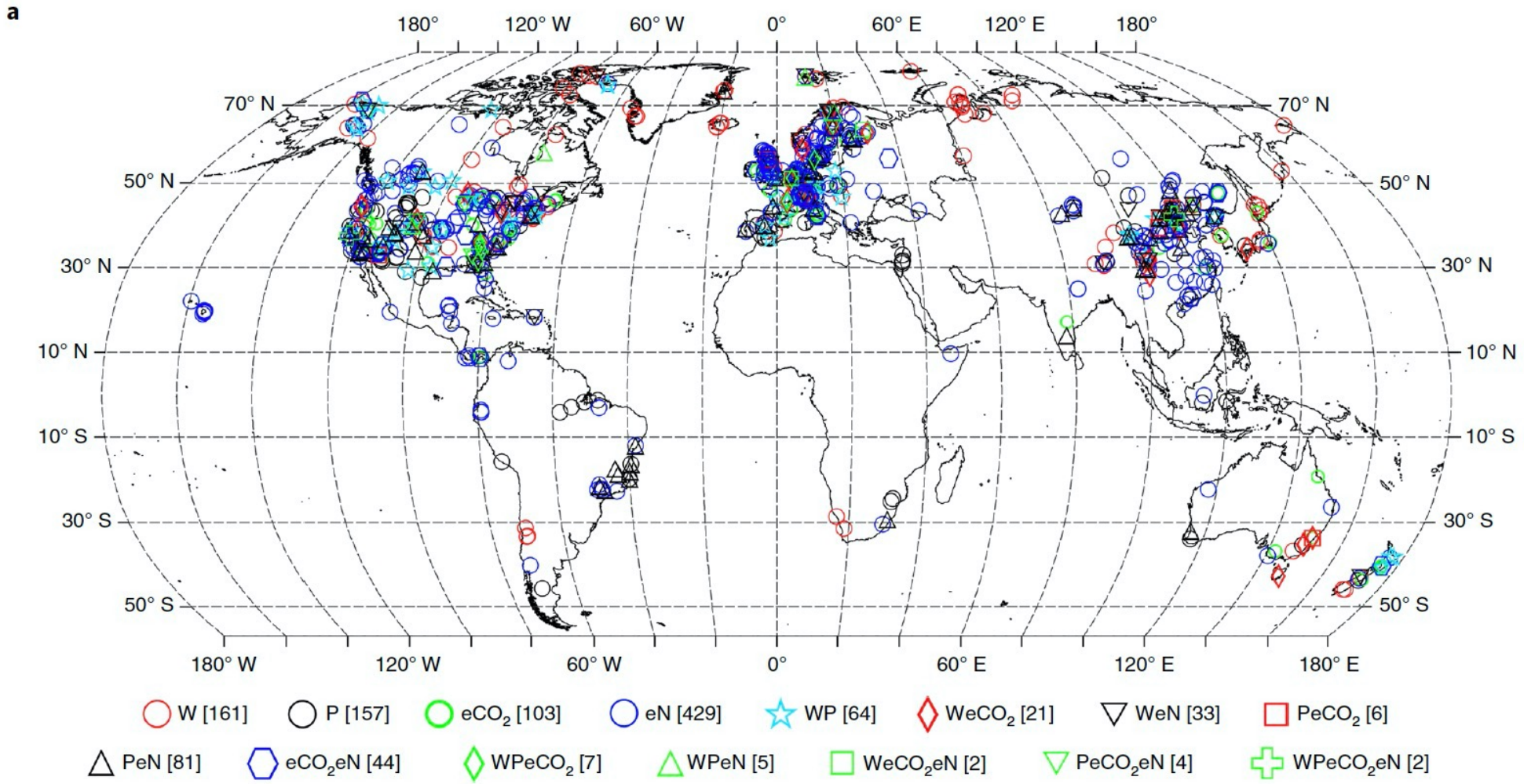


Penuelas et al., 2013

More strong responses in the future

Research background

Field experiments to simulate the ecosystem responses in future

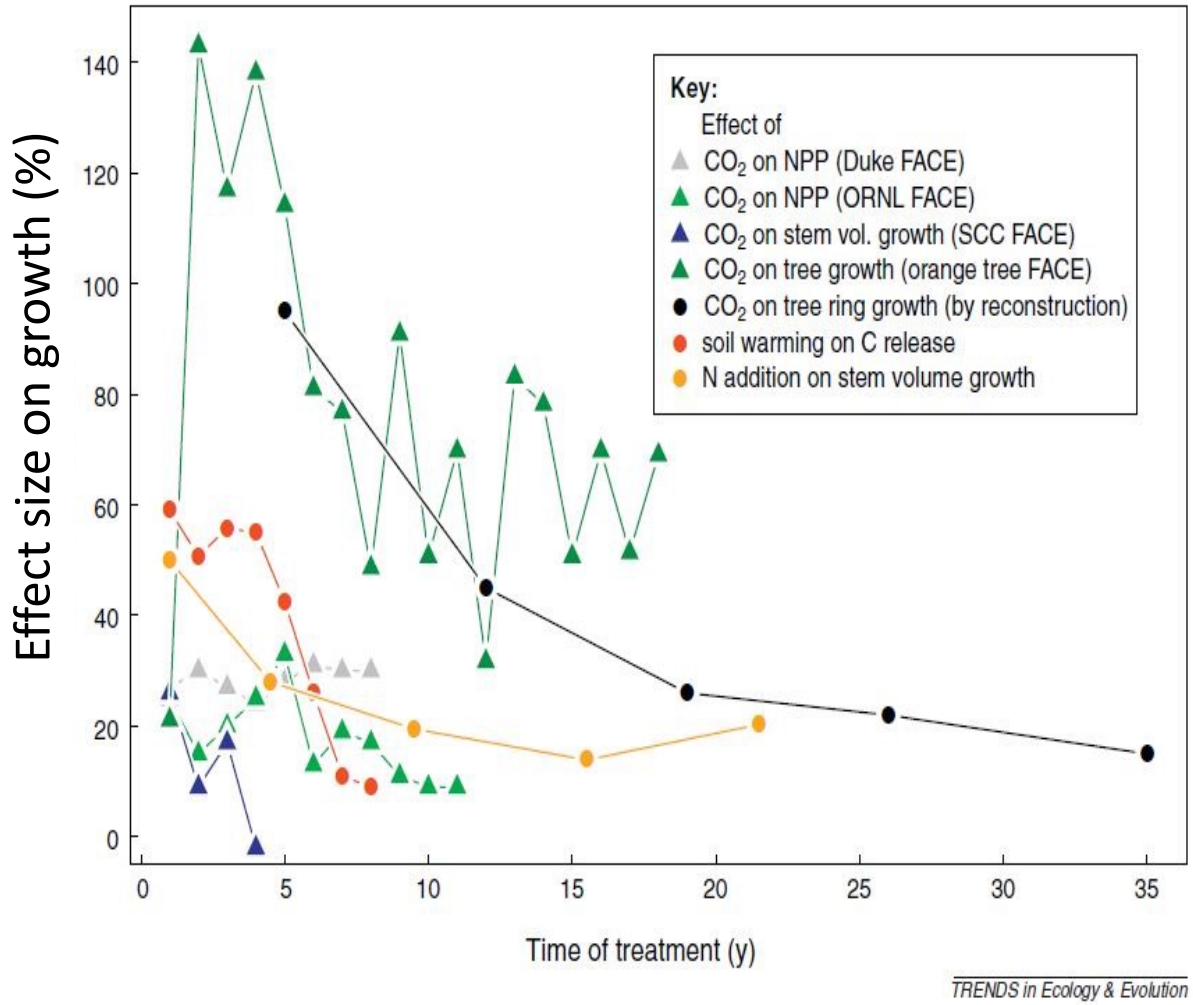


Carbon - related ecosystem function responses, but less reports on structure and composition?

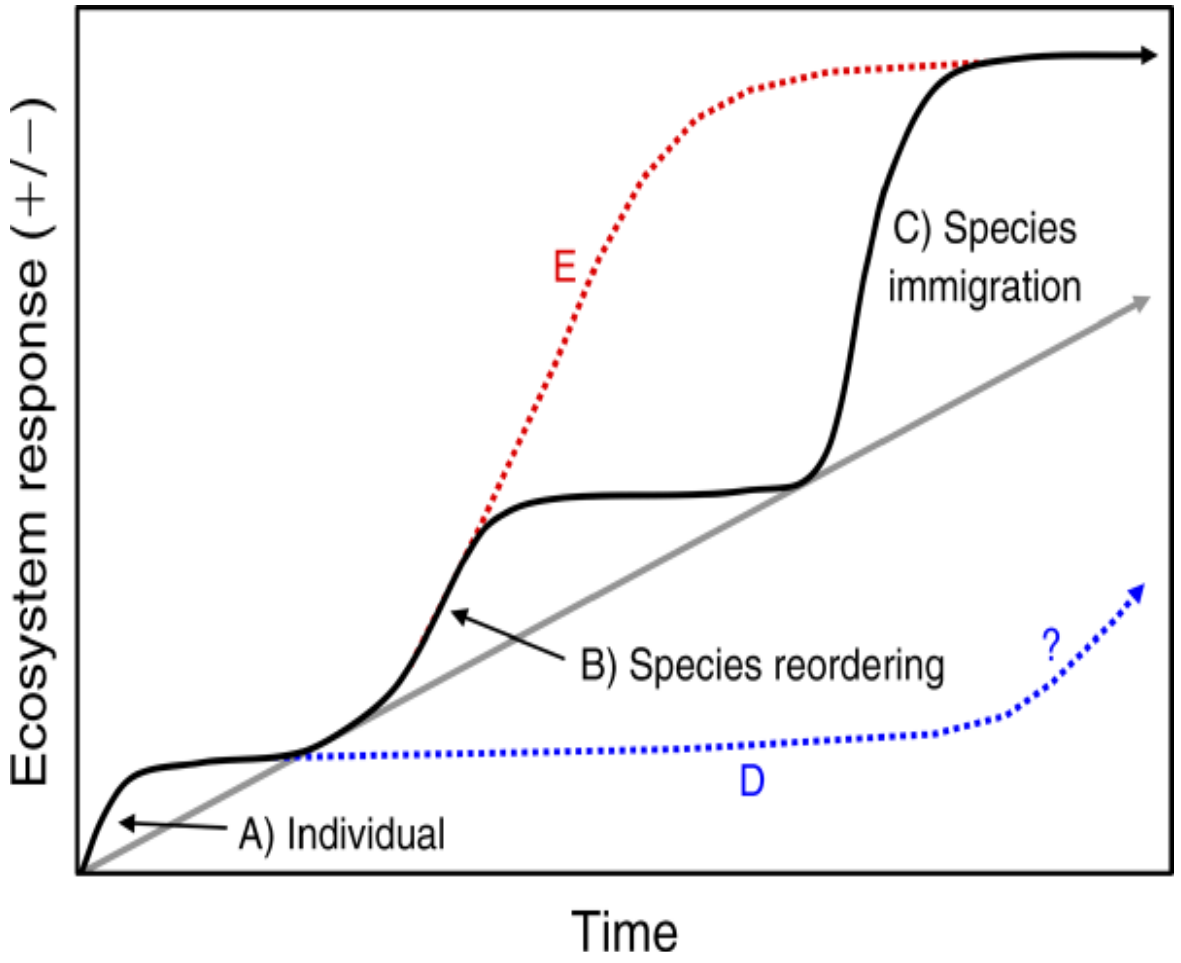
Song et al., 2019

Research background

Field experiment and vegetation responses



(Leuzinger et al., 2011. Trends in Ecology and Evolution)

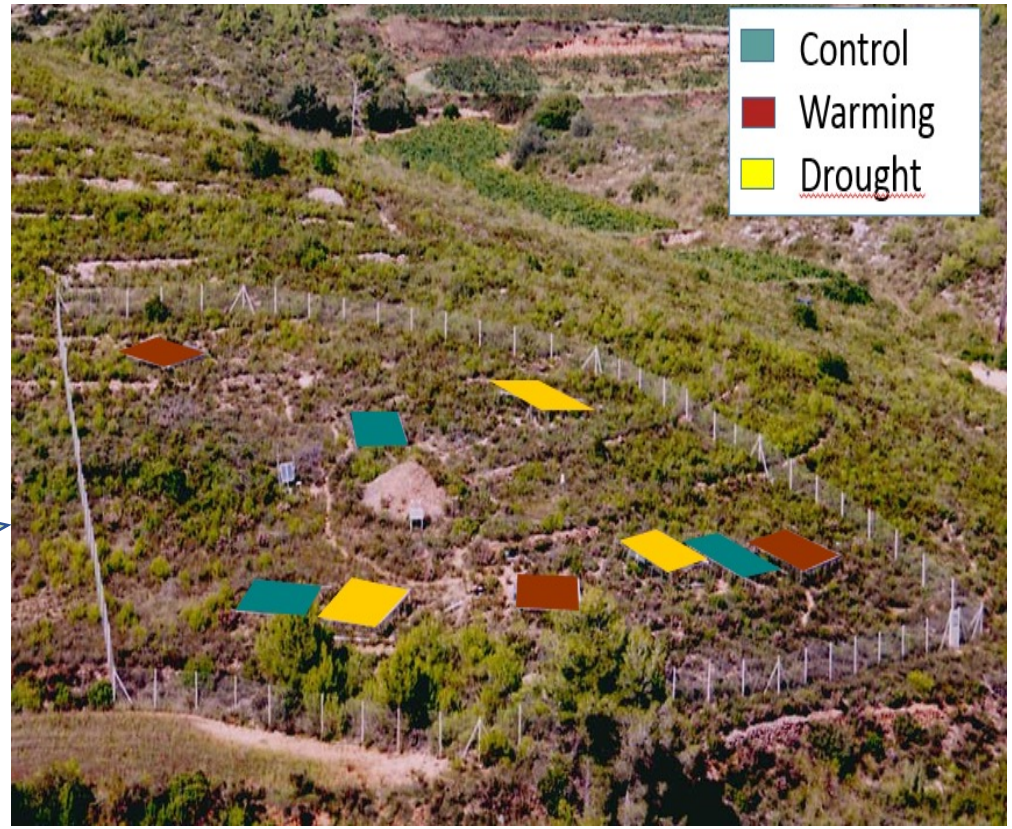


(Smith et al.,2009. Ecolog)

Research background

Long-term climatic experiments (since 1999)

Mediterranean shrubland



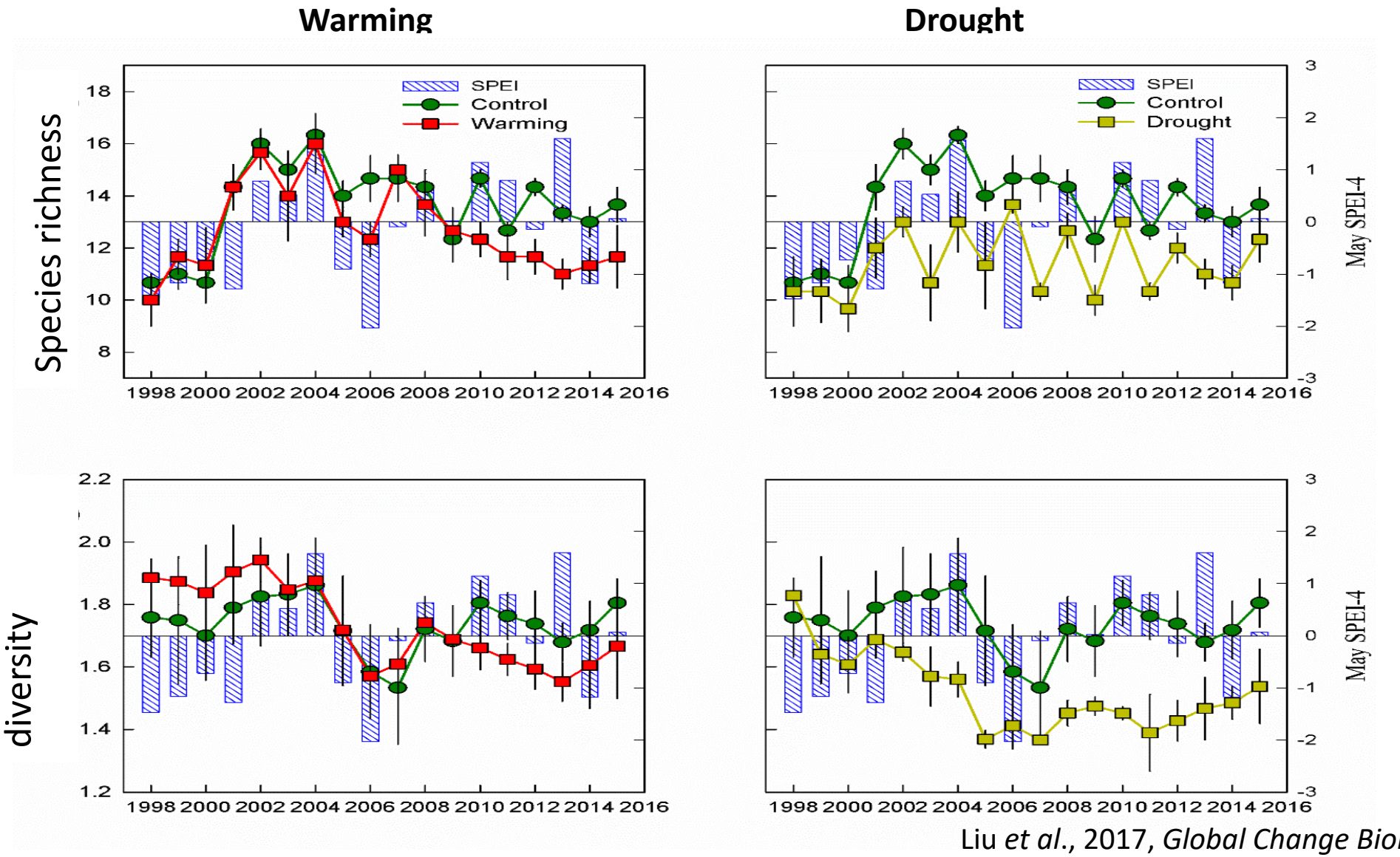
Warming: **+ 0.6**°C

Drought: **-17%**

Liu et al., 2020, JVS

Research background

Species diversity and composition



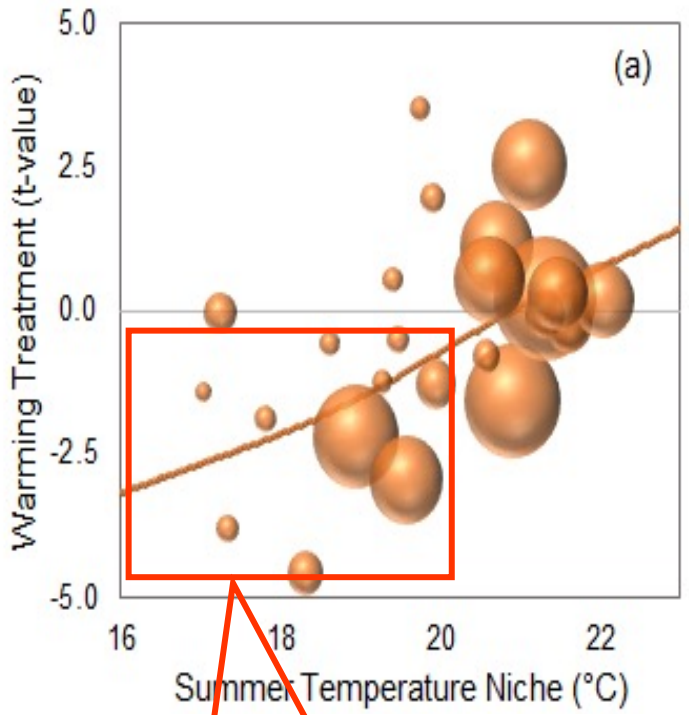
Liu *et al.*, 2017, *Global Change Biology*

Research background

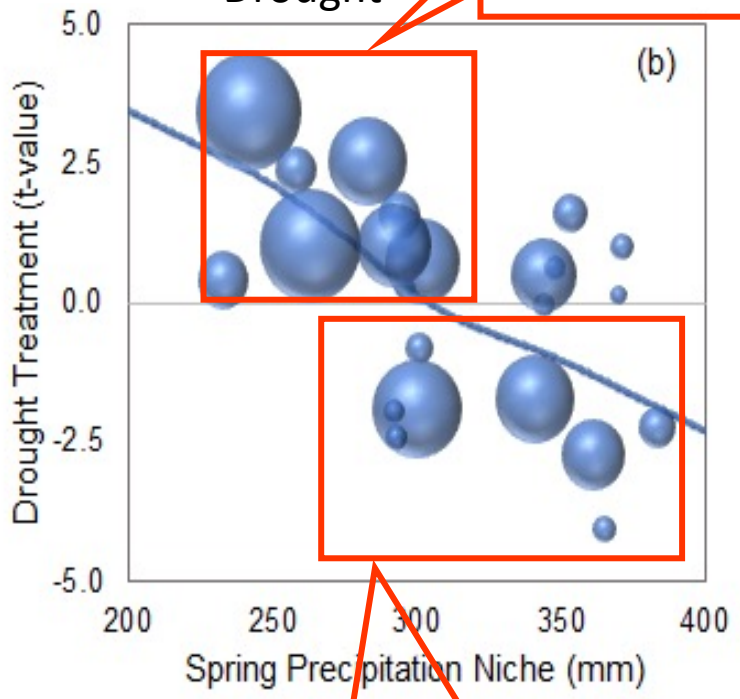
Abundance changes at species level

Note: Bubbles represent relative abundance to commuity

Warming



Drought



Drier species increased under drought

Colder species decreased under warming

Wetter species decreased under drought

Liu *et al*., 2018, *New Phytologist*

Hypothesis and Methods

Shrubland:

-Plant communities are dominated by shrub species.

Field treatments:

-Warming, increase precipitation, nitrogen addition and drought, as well as their interactions

Literature review:

-90 publications representing 78 study sites

Vegetation metrics to W, P, N and D:

-Functioning: aboveground biomass (AGB), aboveground net primary production (ANPP).

-Structure: vegetation cover (COV), density (DEN), species richness (SP), Shannon diversity index (H).

-Shrub encroachment: shrub ratios (Ratio_S), shrub aboveground biomass (AGB_S).

Calculation of sensitivity:

$$\text{Sensitivity to treatment } (\%) = \frac{(X_t - X_c)/X_c}{T_t - T_c} \times 100$$

Hypothesis and Methods

Hypothesis:

- All vegetation metrics relating to structure and functioning are response to climate and nitrogen addition.

- Test the sensitivity difference to 0.

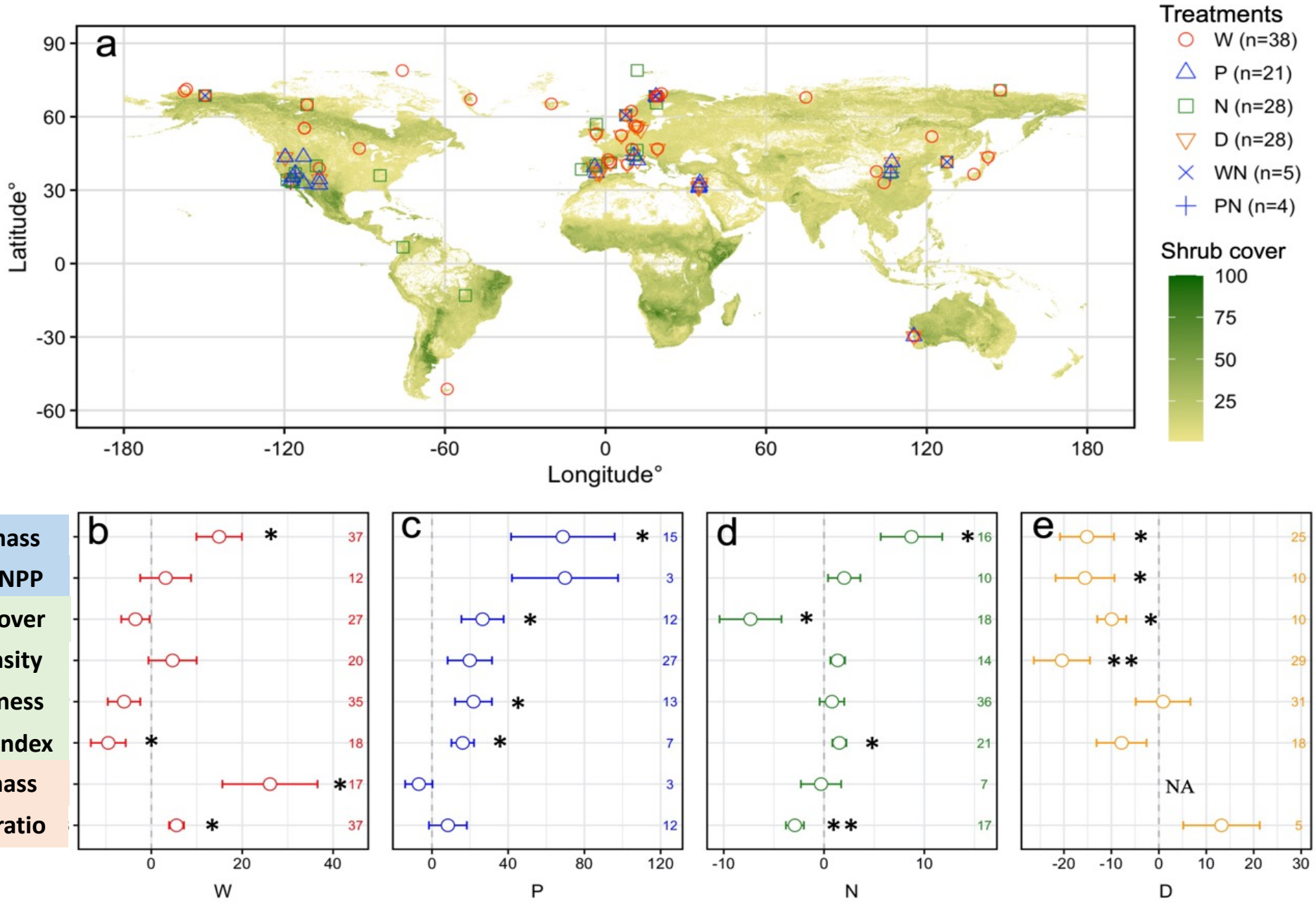
- The responses can be different for experimental duration and for the successional status

- Test the differences between short-term (1-4 year) vs long-term (>5 years) and differences between stable vs disturbed communities.

- The responsiveness will be strongly associated with habitat climate of the study sites.

- Test the correlations with AI, MAT, meantT_Q, meanP_Q

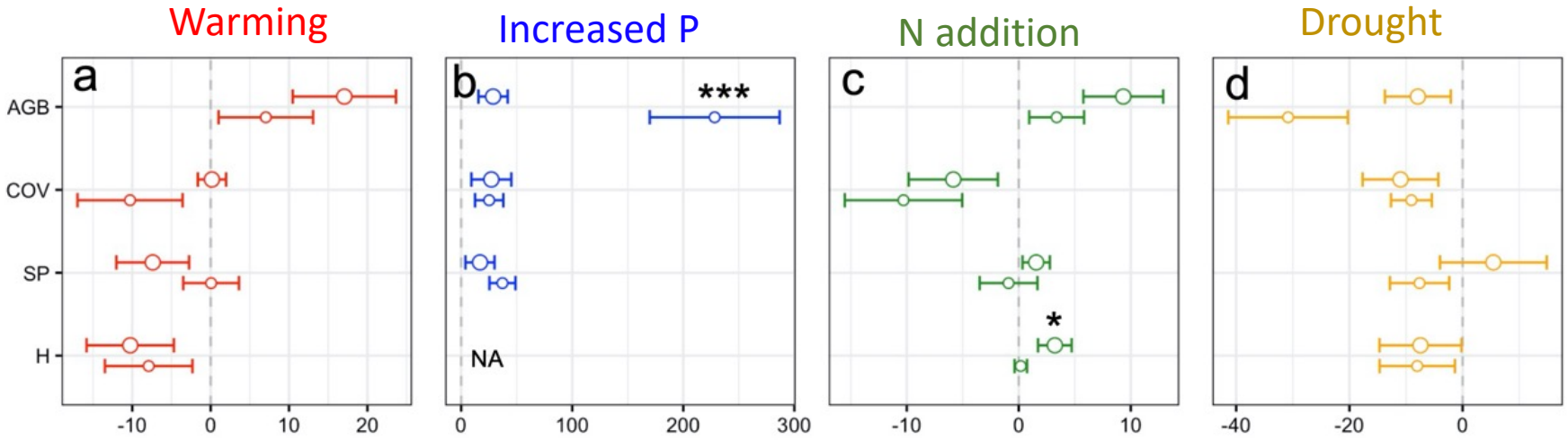
Result



All the vegetation metrics are responsive to climate and nitrogen addition.

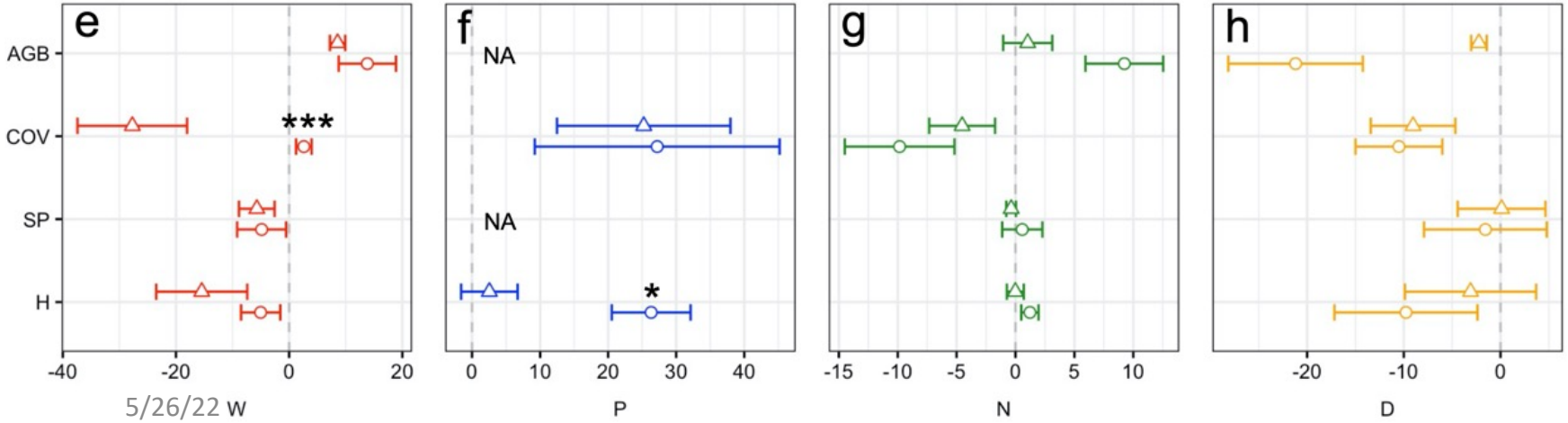
Result

Sensitivity between short-term vs Long-term



No differences between short-term (small circle) and long-term (large circle)

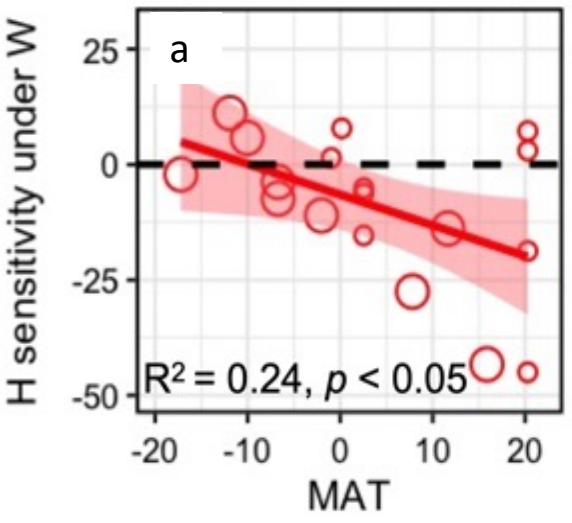
Sensitivity between disturbed vs stable status



No differences between disturbed (triangle) and stable Status (circle)

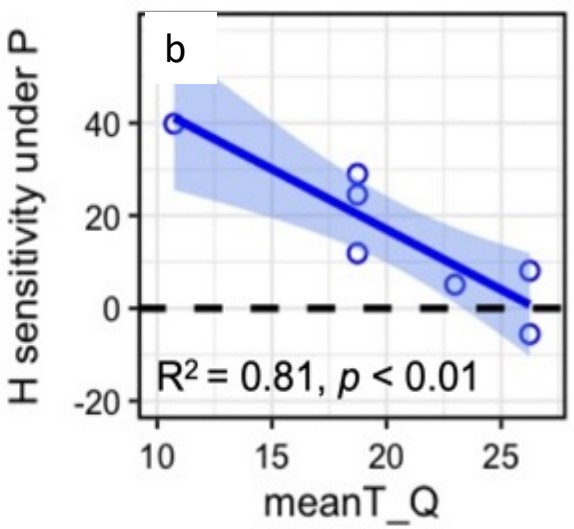
Result – Sensitivity and background climate of the sites

Warming



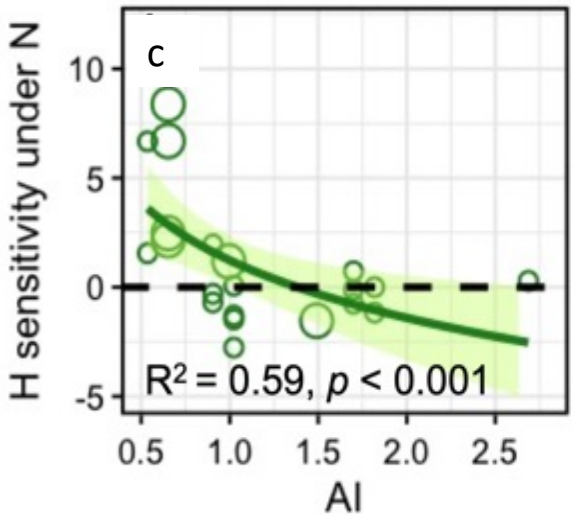
More negative to warming in high MAT sites

Increased P



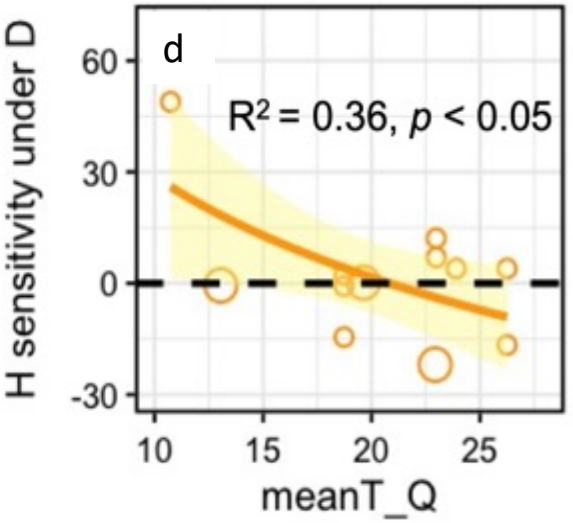
More positive to P in the sites with low mean temperature of warmest quarter.

N addition



More positive under N in more arid sites.

Drought



More negative to D in high mean temperature of warmest quarter.

Take home message

- 1) Shrubland structure and functioning were responsive to climate experiments and nitrogen addition globally.

- 2) Few temporal and successional differences for the sensitivity.

- 3) The magnitudes of the sensitivity were associated with background climate of the study site.

Any questions?

Email: daijun.liu@univie.ac.at

Twitter:  Daijun Liu
@daijunliu