

# An Eco-Evolutionary Basis for Adaptation to Climate Change

Phil Grime, University of Sheffield (UK)

Jason Fridley, Syracuse University (USA)

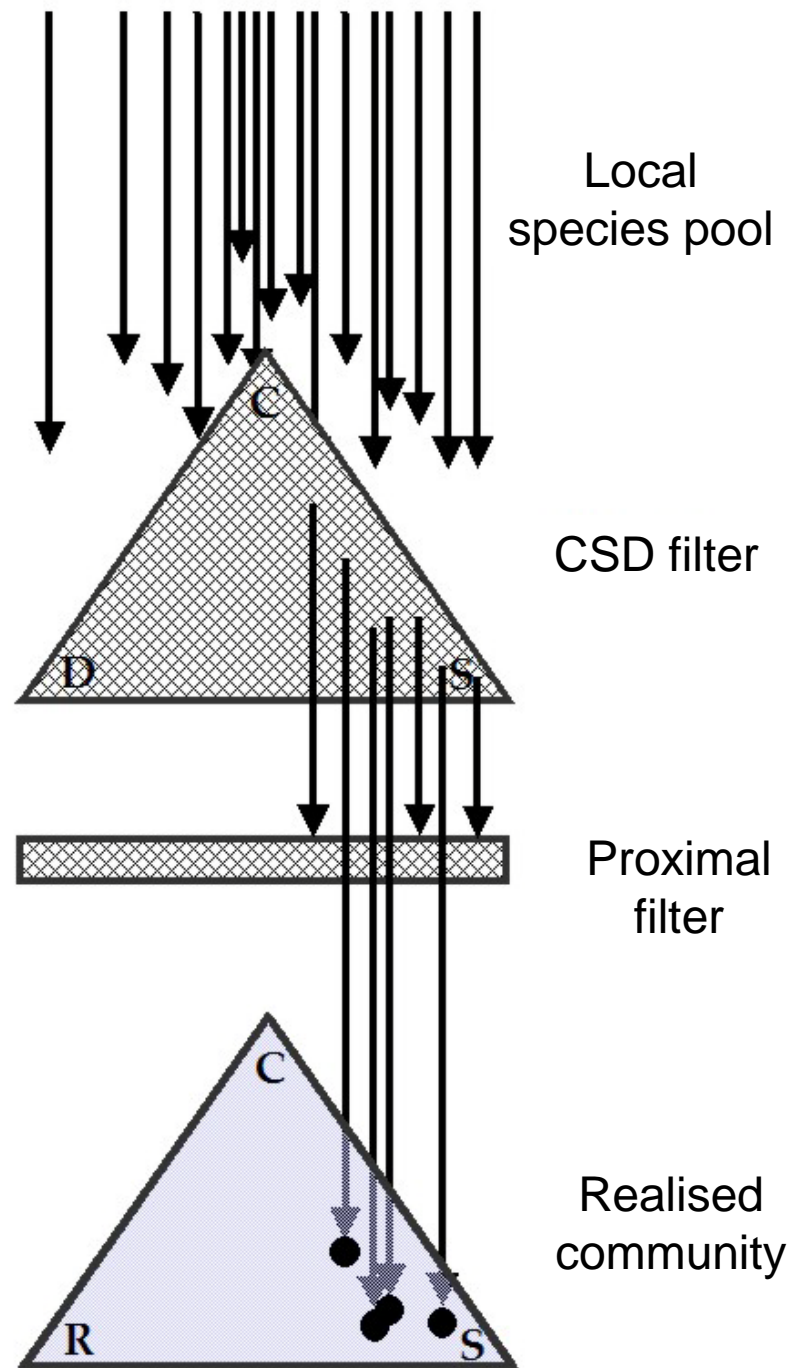
Andrew Askew, Syracuse University (USA)

Simon Pierce, University of Insubria, (Italy)

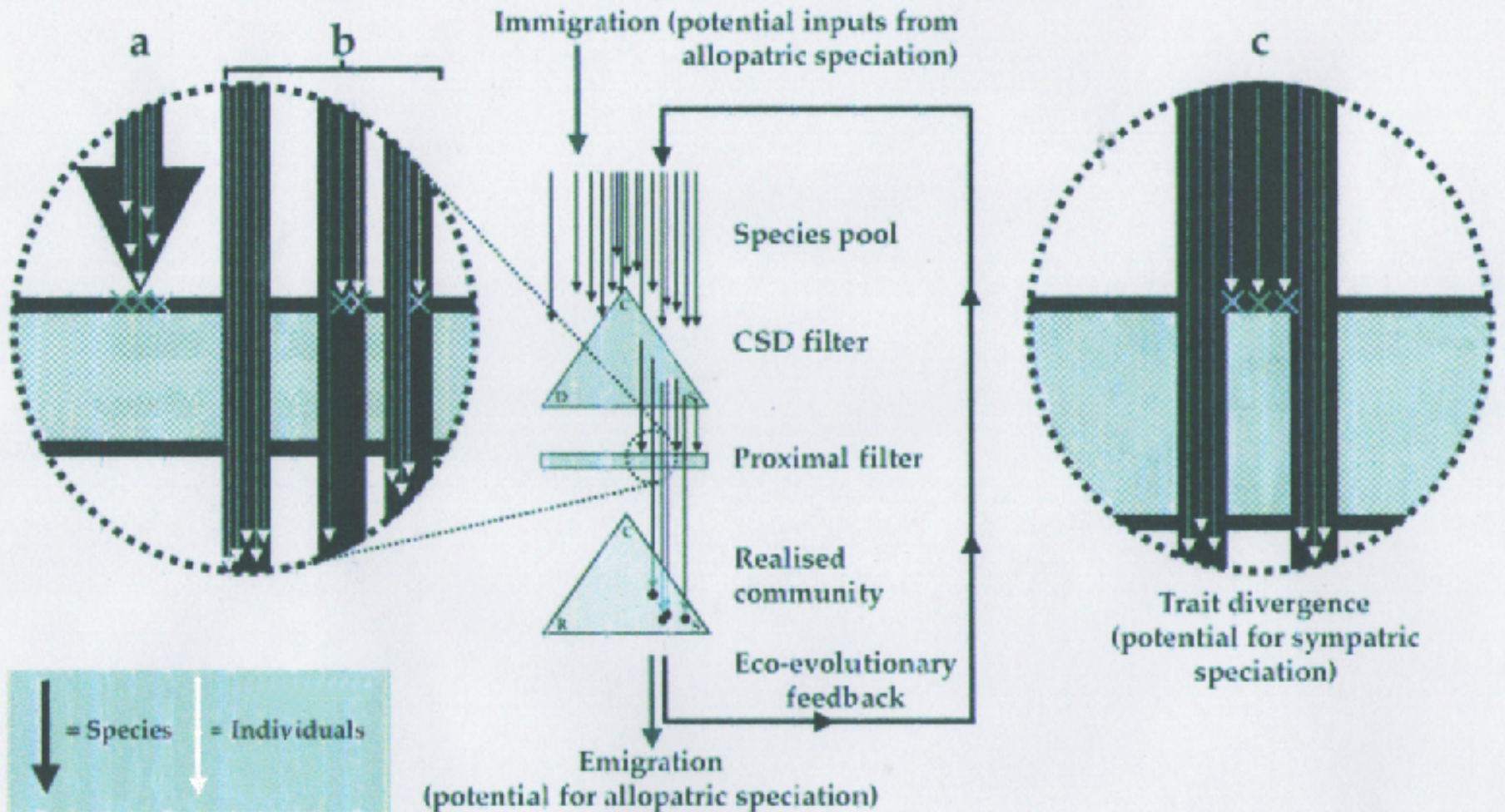
*Supported by the NSF LTREB programme (USA), the Ecological  
Continuity Trust (UK) and the Health and Safety Laboratory (UK)*

# The twin-filter model of community and ecosystem assembly\*

\* Phil Grime and Simon Pierce  
(2011) *The Evolutionary strategies that shape ecosystems*. (in press)

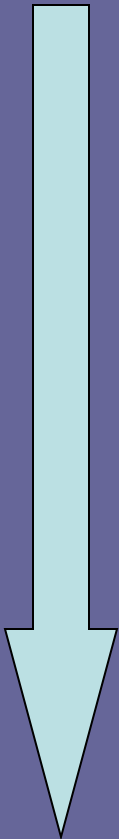


# Detail of the twin-filter model showing how ecological filters can act as evolutionary selection pressures



# 7 steps of vegetation response to climate change

Degree of ecosystem change



1. Survival and stasis due to acclimation of established plants.

2. In situ decline in some genotypes, promotion of others.

3. Local relocation/expansion of species and genotypes .

4. Decline of successful regeneration by resident species.

5. Periodic invasions by new species following extreme events.

6. Extinction of many resident species. Ecosystem changes.

7. Dominance by new species. Ecosystem modified.

# Buxton Climate Change Study

Est. 1993

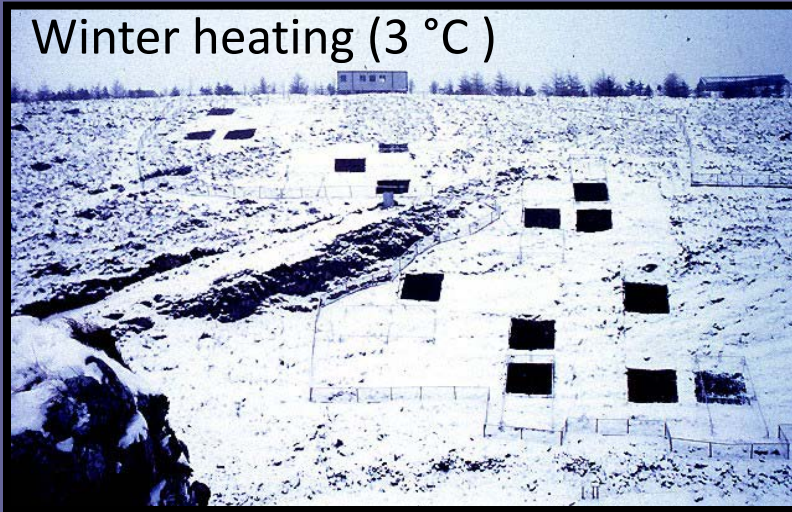


Calcareous grassland

Annually grazed, production 350-400 g/m<sup>2</sup>/yr

Buxton, England; 370 m a.s.l., 53° 20' N Lat

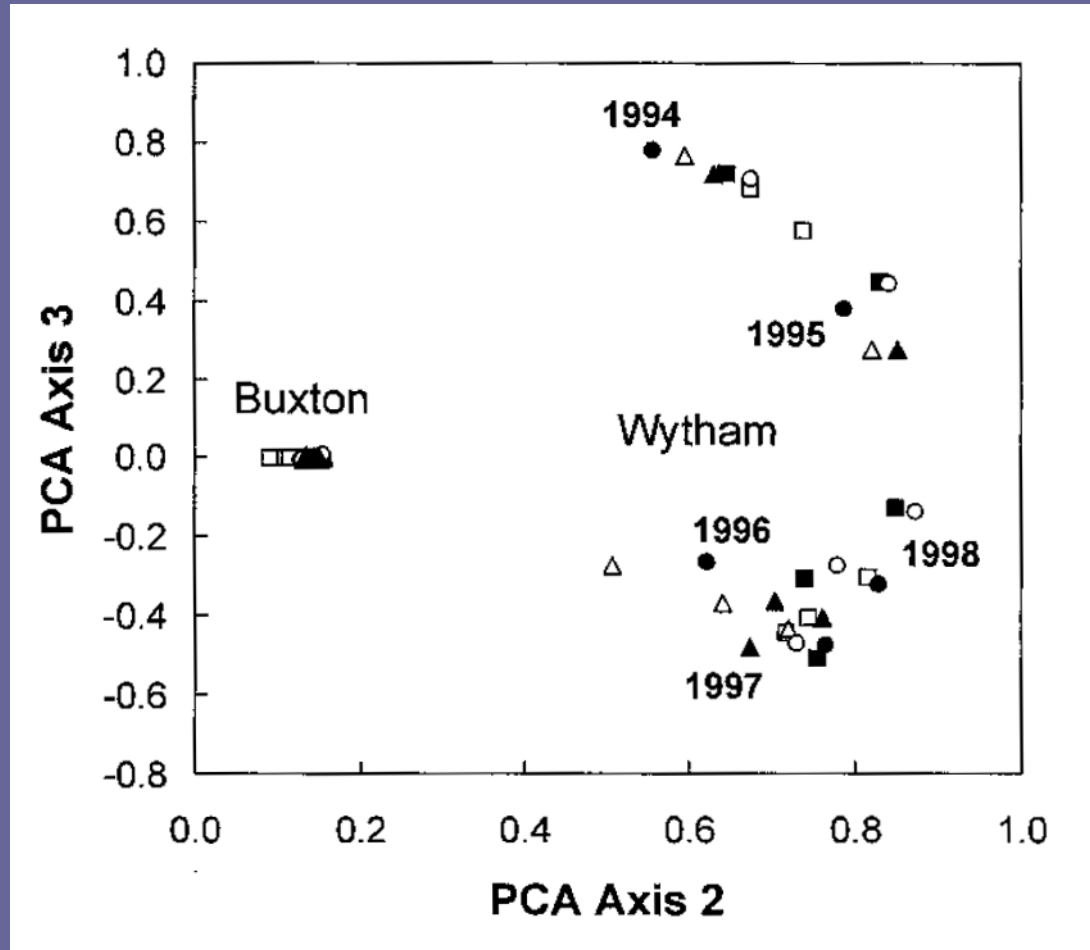
# Long-term climate manipulations



+ Temp/water interactions

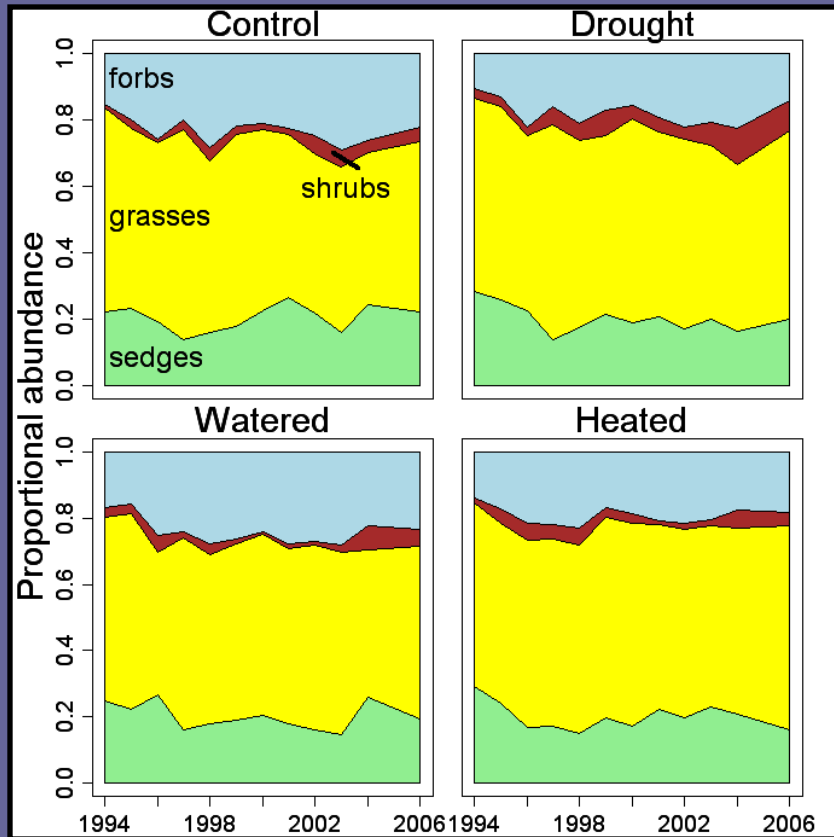
3x3 m plots, 5 replicates

# Results after 5 years

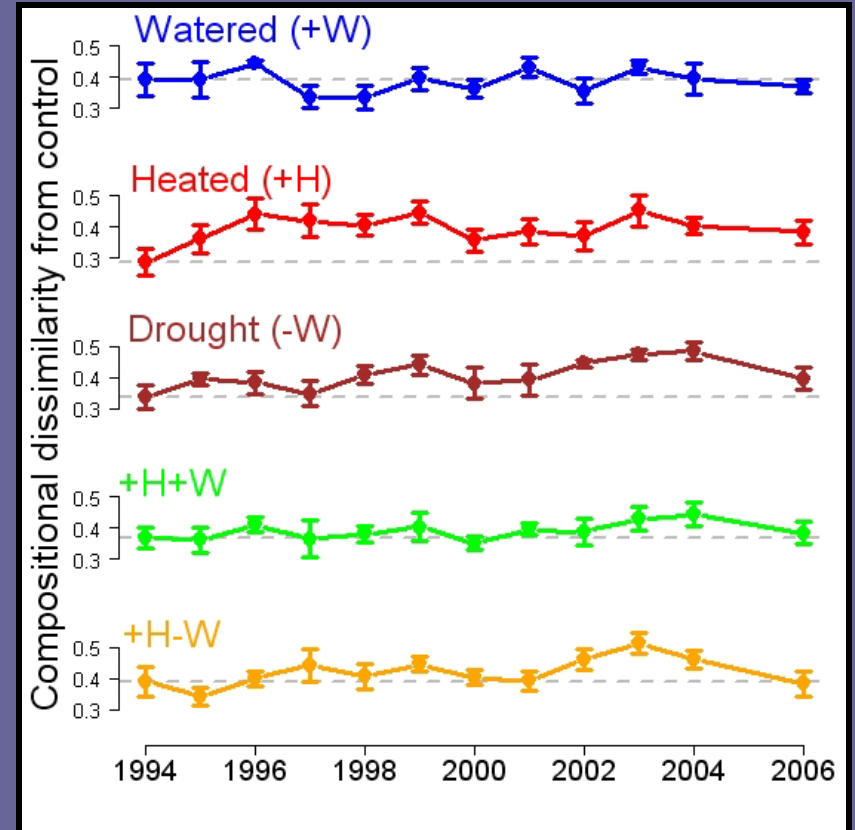


# No progressive change in composition after 13 years in 3x3 m plots

Grime et al. 2008 *PNAS*



Major life form groups  
unchanged



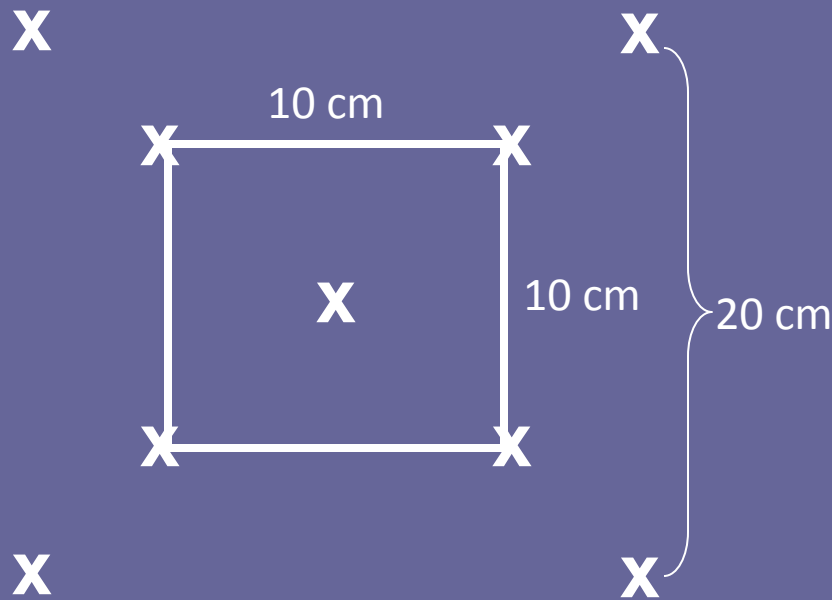
Species composition  
fairly stable



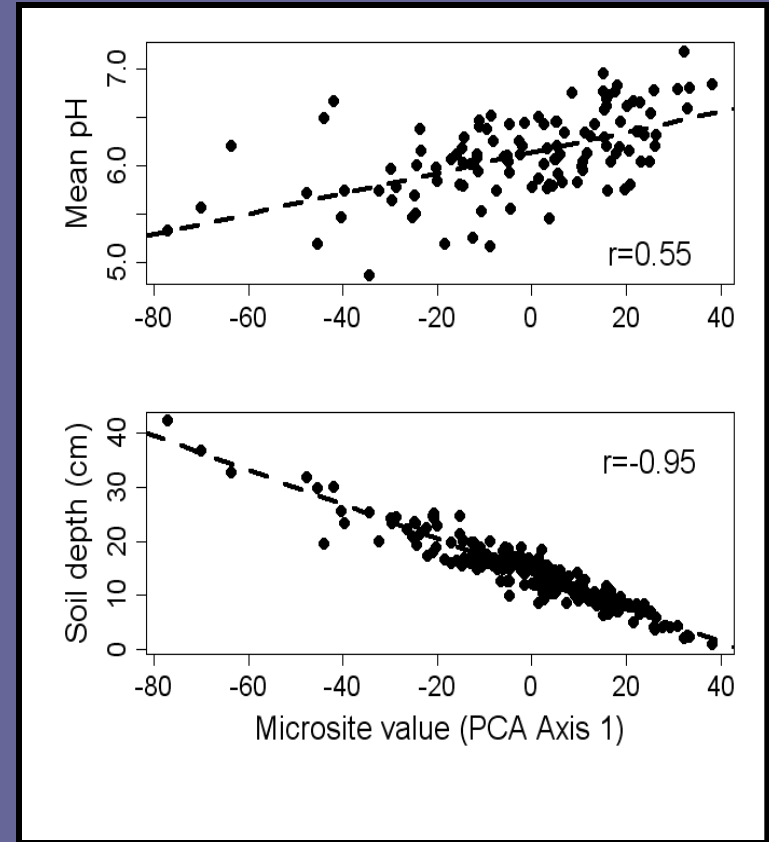
# Why does this grassland resist climate forcing?



# Fine-scale (100 cm<sup>2</sup>) vegetation and soil surveys (2008)



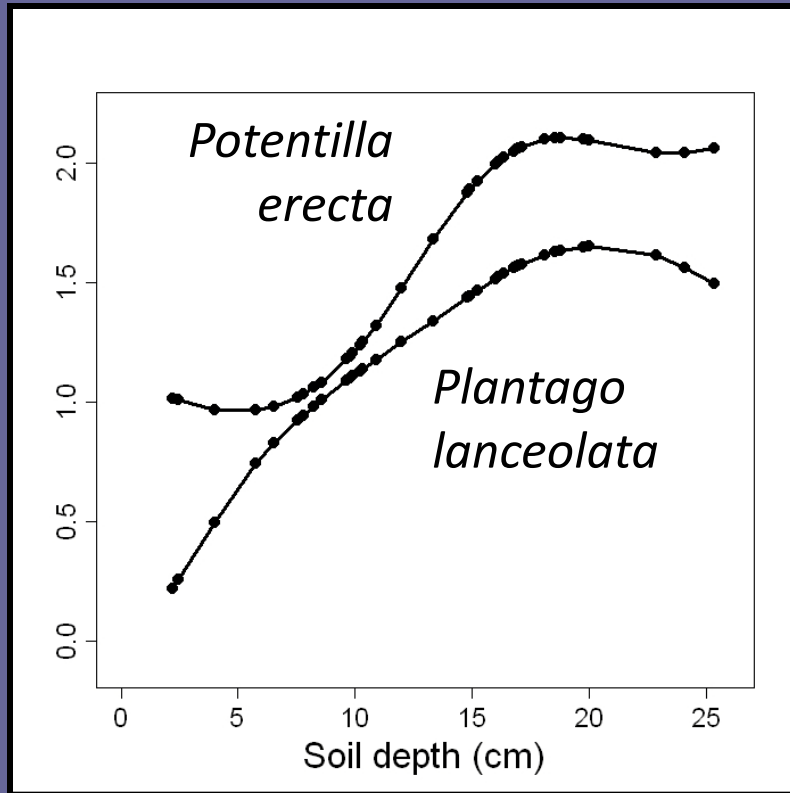
240 quadrats (8 per 3x3m plot)



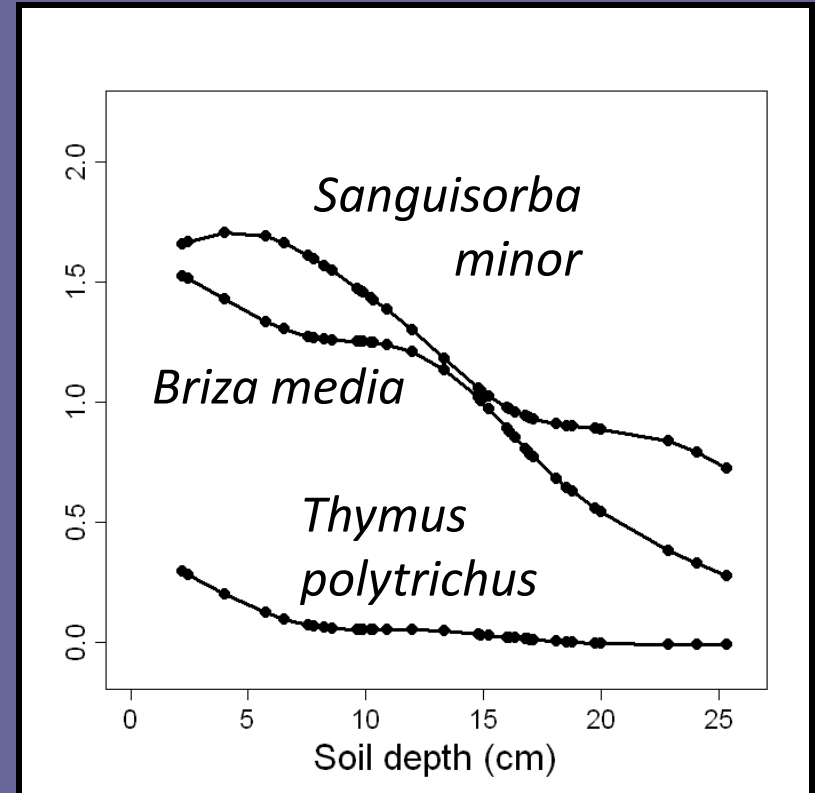
# 13 out of 25 species exhibited microsite responses in controls ( $GLM P < 0.05$ )

## Deep site specialists

Abundance (cover class)



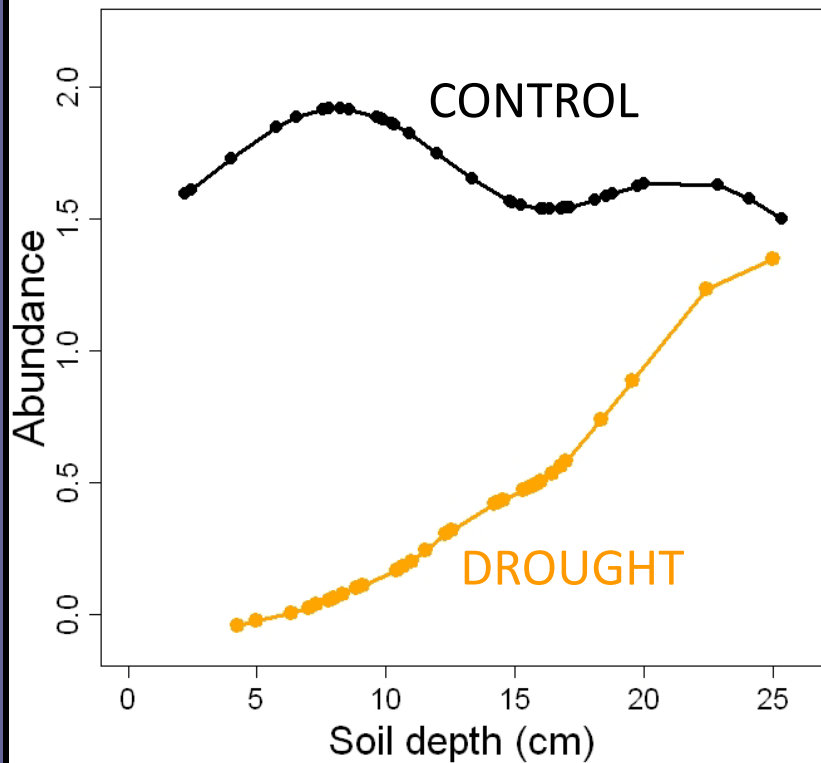
## Shallow site specialists



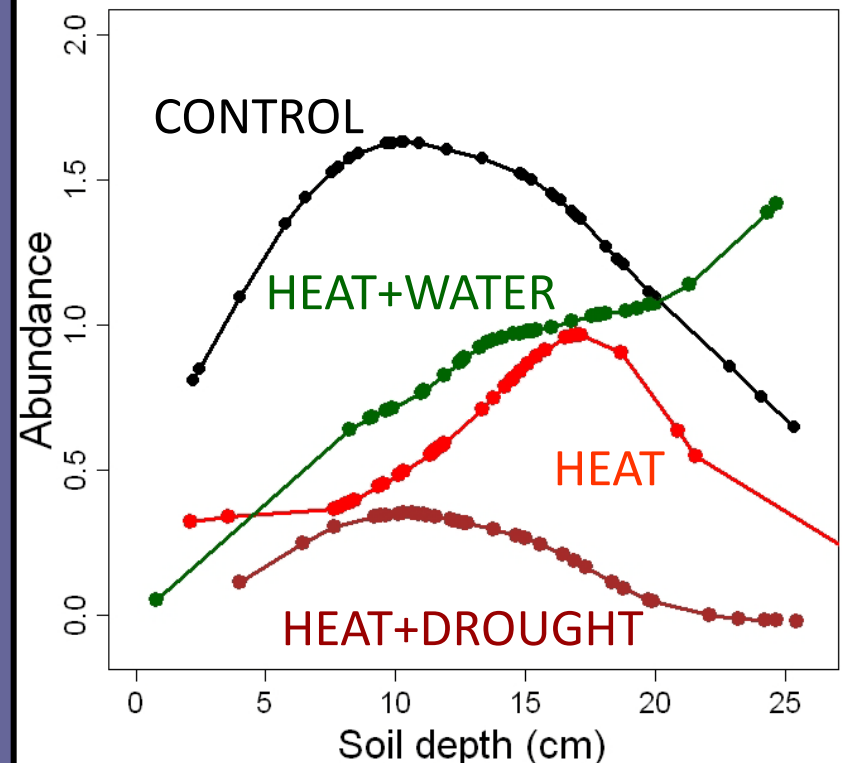
Generalized Additive Models (GAM)

# Microsite variation prevented species loss in response to climate change

*Lotus corniculatus*



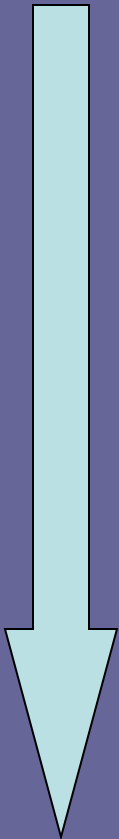
*Carex panicea*



9 out of 25 species exhibited a microsite-treatment interaction (GLM  $P < 0.05$ )

# 7 steps of vegetation response to climate change

Degree of ecosystem change



1. Survival and stasis due to acclimation of established plants.

2. In situ decline in some genotypes, promotion of others.

3. Local relocation/expansion of species and genotypes .

4. Decline of successful regeneration by resident species.

5. Periodic invasions by new species following extreme events.

6. Extinction of many resident species. Ecosystem changes.

7. Dominance by new species. Ecosystem modified.

# The search for genetic responses to the long-term manipulations of the Buxton climate

- *Plantago lanceolata*, *Festuca ovina*, *Potentilla erecta*, *Carex flacca*, *Carex panicea*, *Briza media*, *Sanguisorba minor*.
- Catherine Ravenscroft
- Raj Whitlock
- Sarah Buckland



# Screening for plant adaptation

The purpose of this study is to investigate potential mechanisms of persistence in two contrasted but widespread constituents of limestone grassland;

*Briza media* (Quaking grass) and *Carex flacca* (Carnation sedge).

The investigation will examine adaptation by:

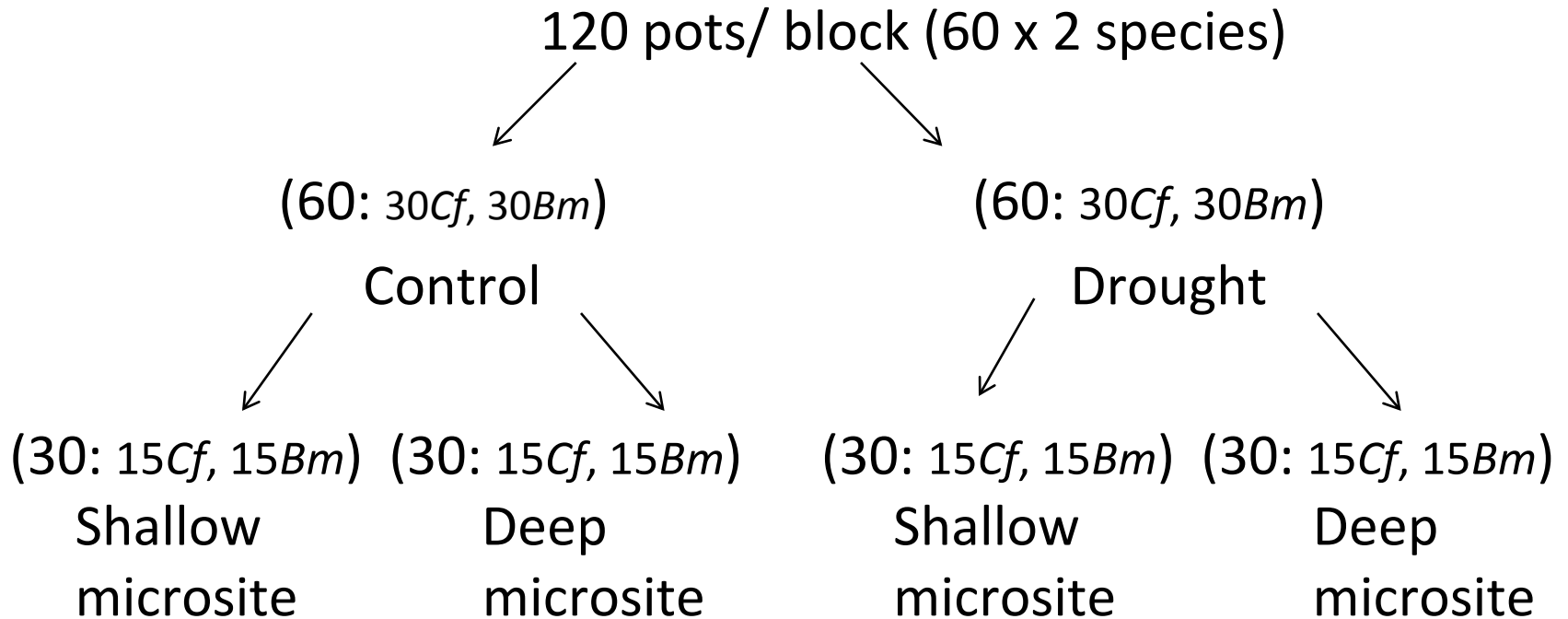
- a) **phenotypic plasticity** (through measurement of growth of underground rhizomes) and
- b) **contemporary evolution** (using microsatellite analysis to detect genotypic variation)





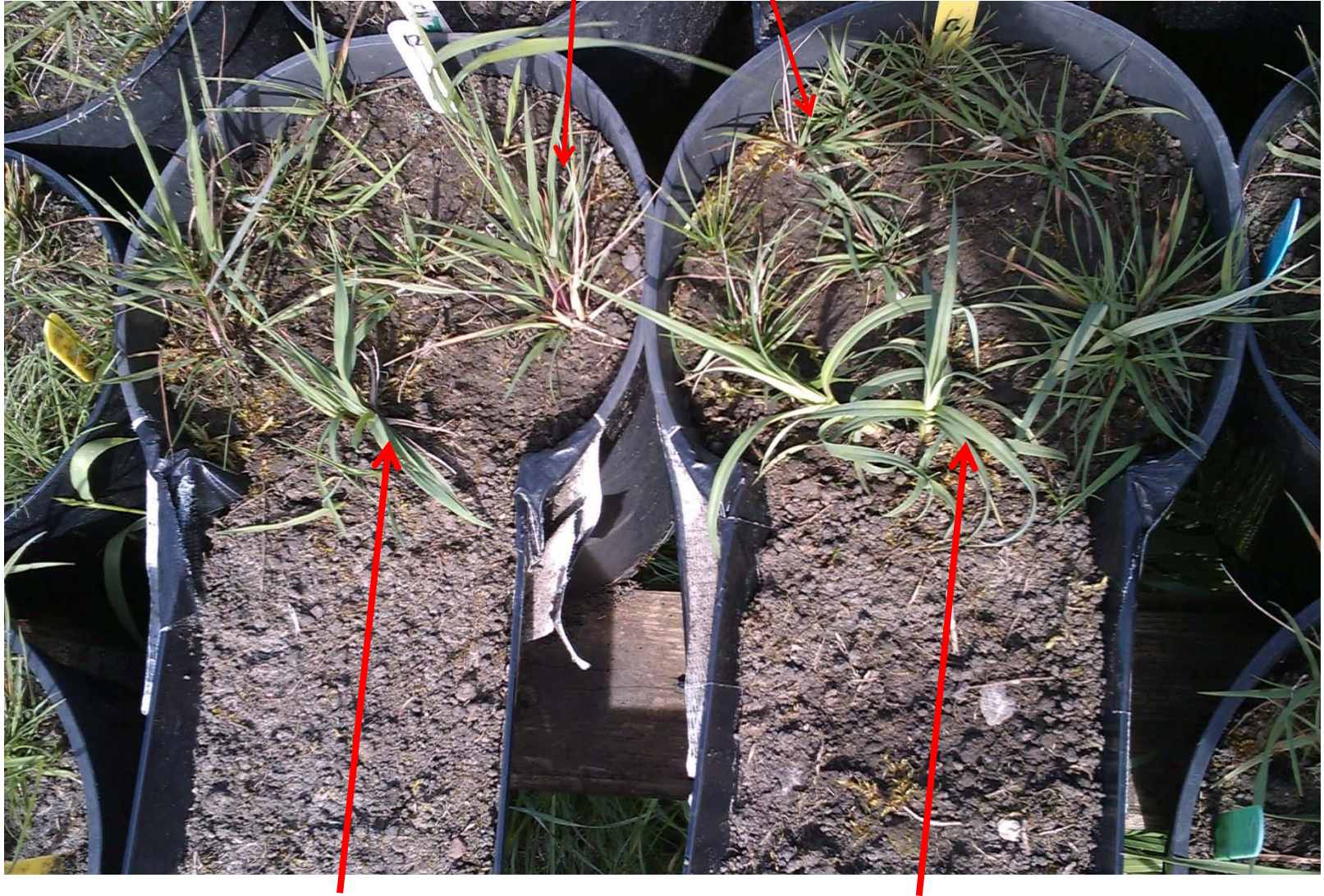
# Experimental Design

Individuals of *Cf* and *Bm* (60 of each) were collected from microsites in the control and droughted plots and the plants were grown to provide clones to give **four replicate blocks** for the pot experiment as seen below:



[15 clones= 3 plants/plot x 5 blocks (A-E) of main experiment ]

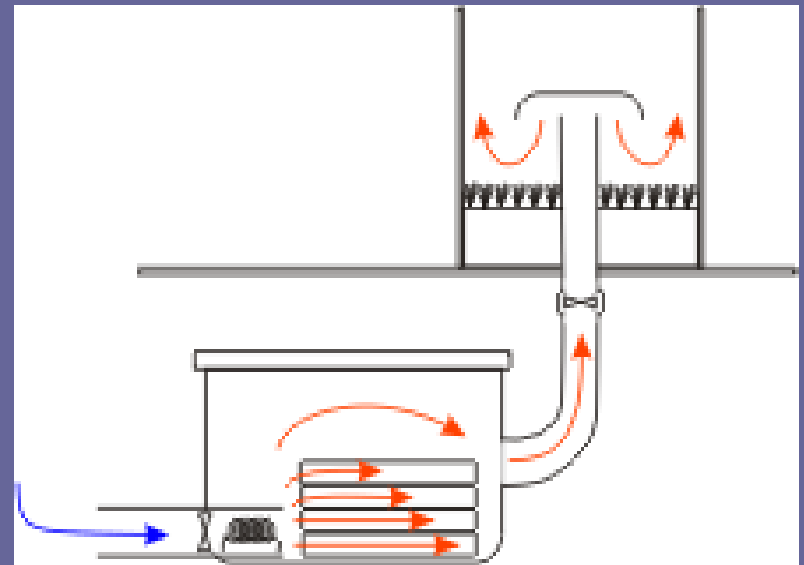
*Agrostis capillaris*



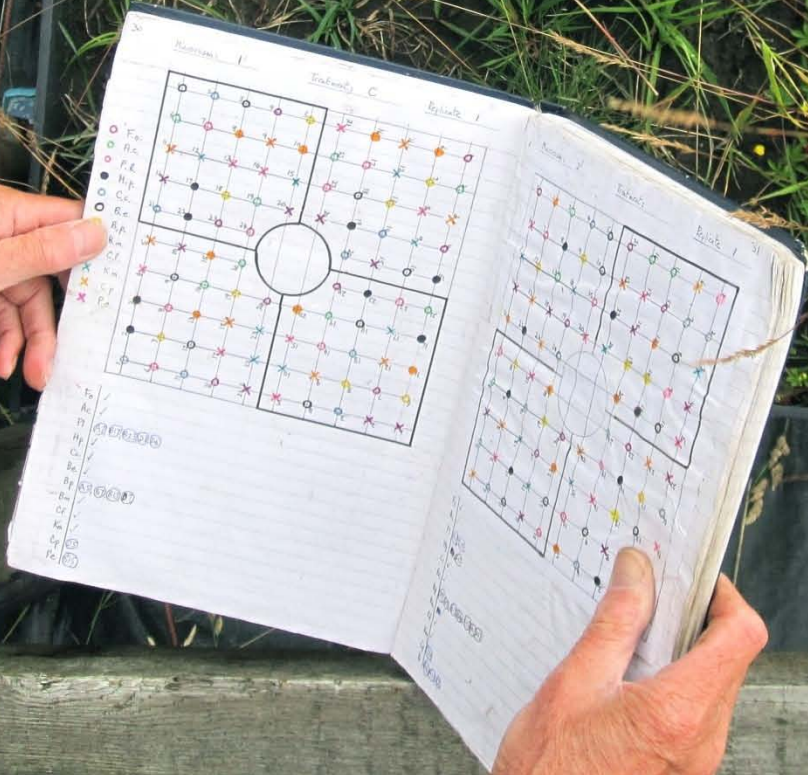
*Briza media*

*Carex flacca*

# The Seasonal Warming Experiment

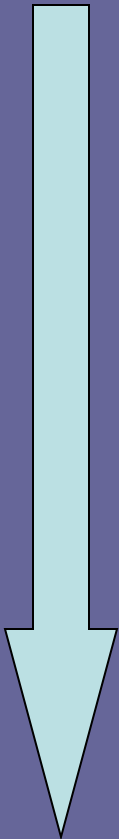






# 7 steps of vegetation response to climate change

Degree of ecosystem change



1. Survival and stasis due to acclimation of established plants.

2. In situ decline in some genotypes, promotion of others.

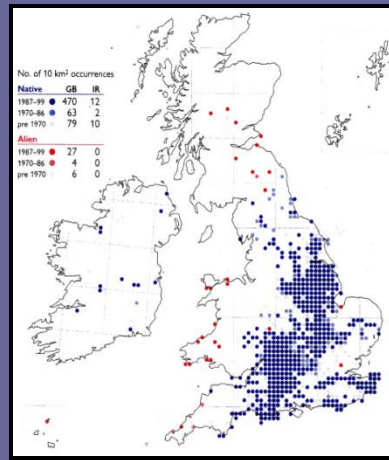
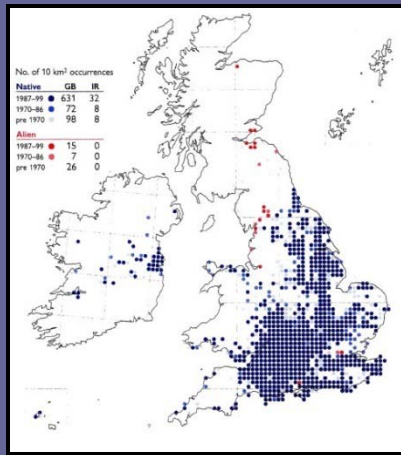
3. Local relocation/expansion of species and genotypes .

4. Decline of successful regeneration by resident species.

5. Periodic invasions by new species following extreme events.

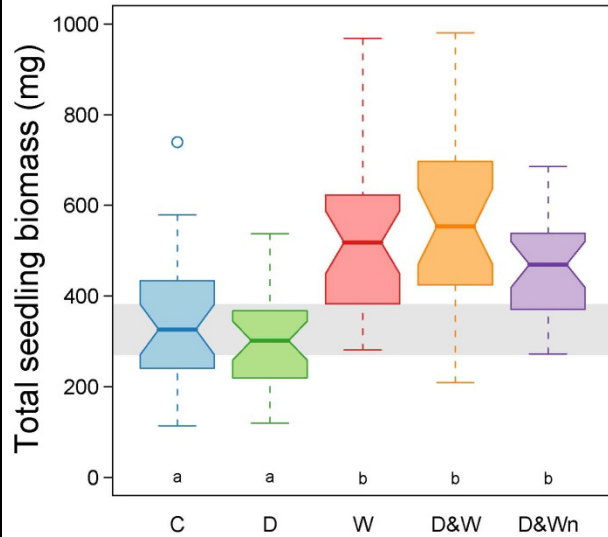
6. Extinction of many resident species. Ecosystem changes.

7. Dominance by new species. Ecosystem modified.



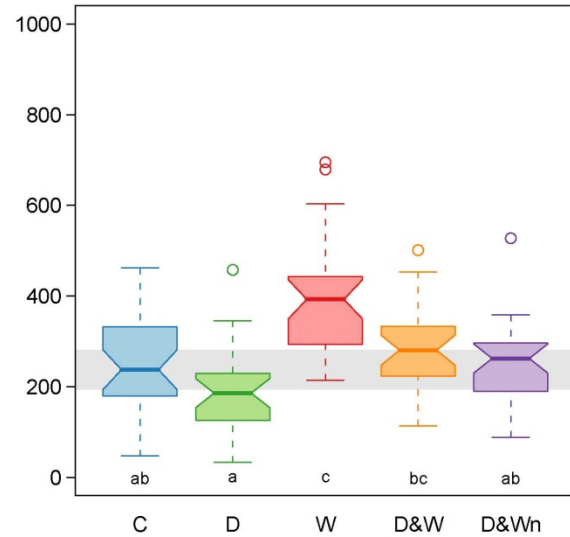
B. Moser et al., (2012)  
Journal of Ecology

*Bromus erectus*



Heated

*Brachypodium pinnatum*



Heated