Vulnerability assessment for European shrublands to climate change

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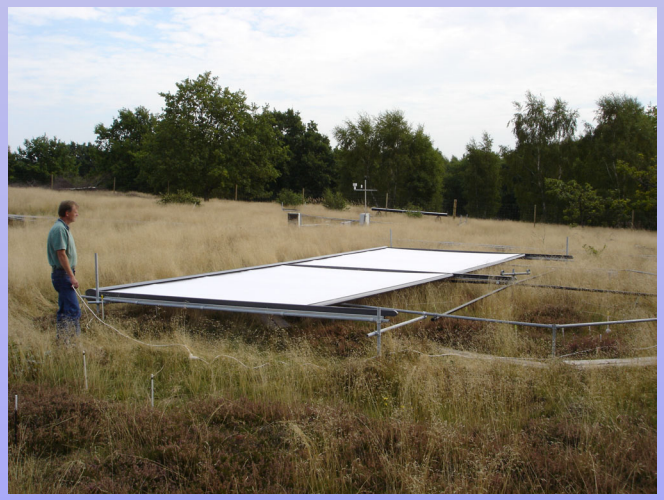

Thanks to:
Bridget Emmett (UK), Albert Tietema (NL)
Inger K. Schmidt (DK), Josep Penuelas (SP),
Paolo de Angelis (IT), Edith Kovacs Lang (HU)
and all VULCAN and CLIMAITE participants

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Manipulator

Years of experience in ecosystem manipulation studies at the field scale (acid rain, nutrients, climate change) and plot scale modelling

Biogeochemist

Nutrients, C, N

Coordinator of CLIMOOR, VULCAN
+ New Danish CLIMAITE

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Shrublands, vulnerability, climate change and experimental manipulations

Why?

Shrublands often vulnerable ecosystems
Climate change affects key biological processes, ecosystem functioning and ecosystem services
Manipulations often needed to know what happens

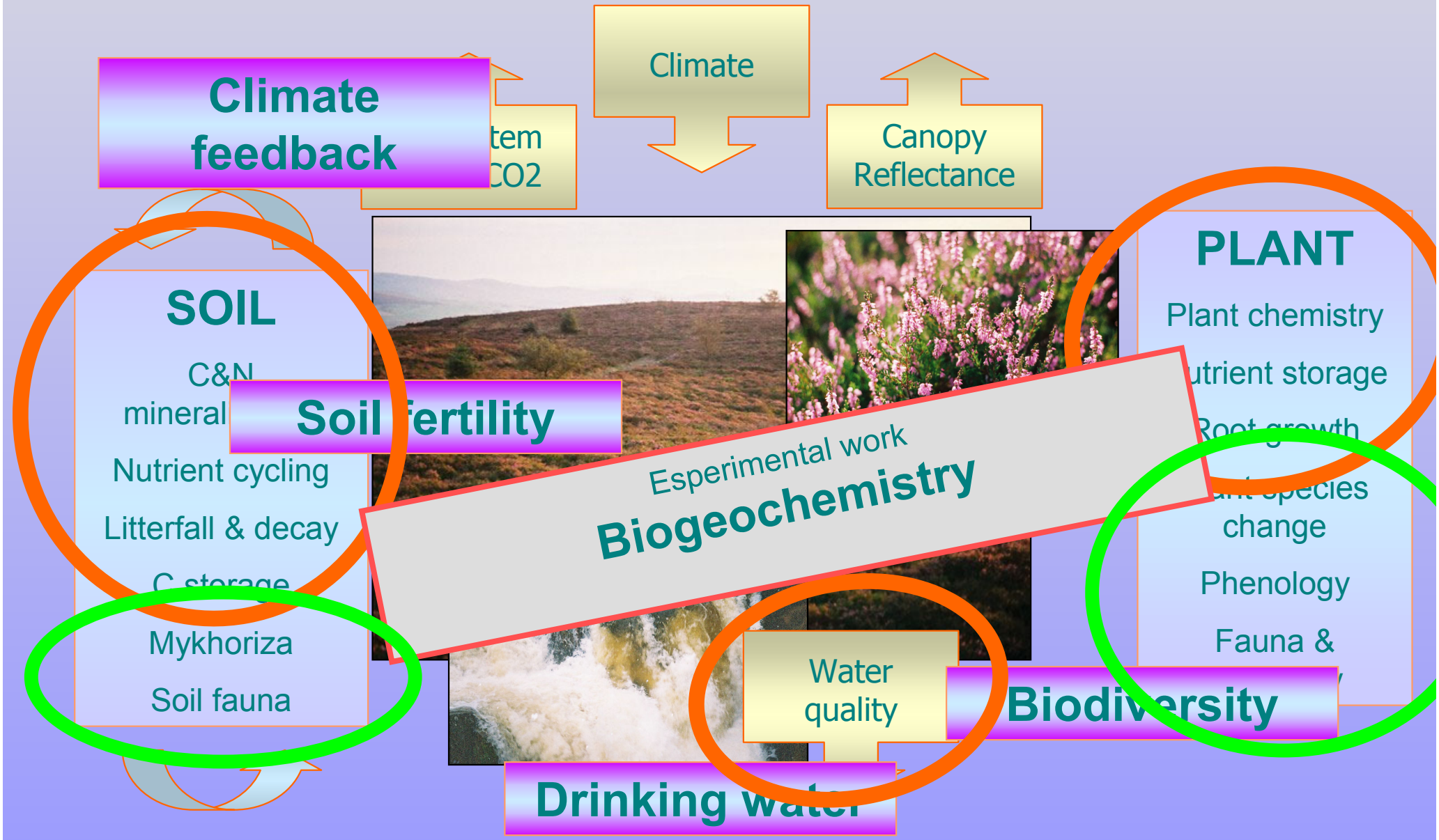
Conceptual problem

Involves at least CO_2, temp. and water = 3 factors
Experimentally challenging

What?

Climate change effects on key processes = services
Biogeochemistry, biodiversity and ecosystem/land protection
Future trends
Manipulation examples

Climate impacts on ecosystem processes and services



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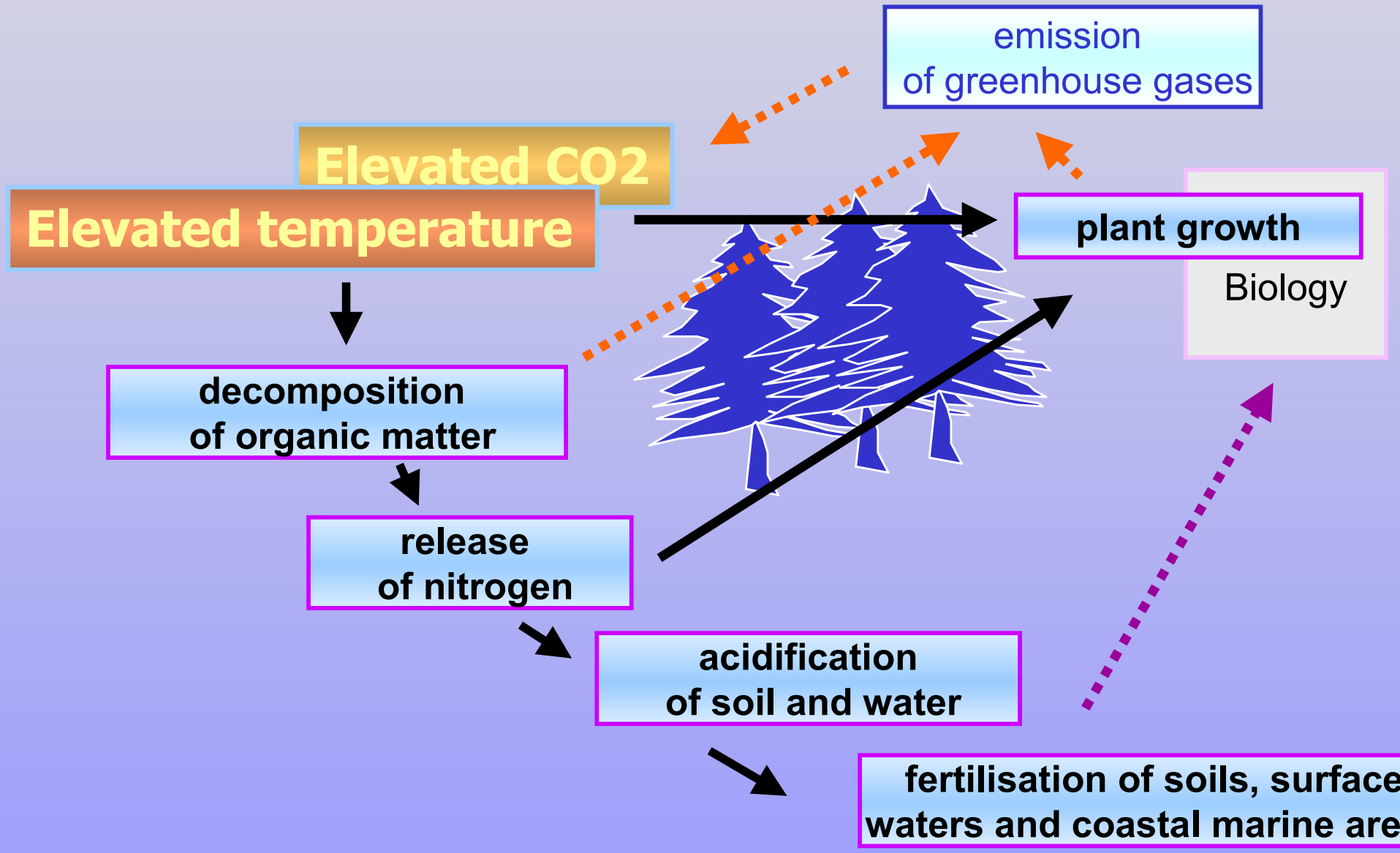
Biogeochemistry
N-balance

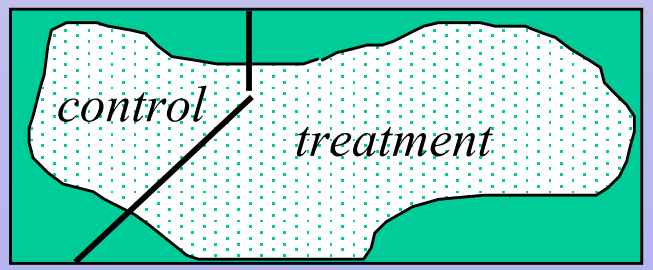
Possible biogeochemical effects of climate change



Field scale manipulation of temperature and CO_2 in Norwegian forest ecosystem

CLIMEX

KIM catchment
560 PPM CO2
+ 3-5 °C air temperature (3.7)



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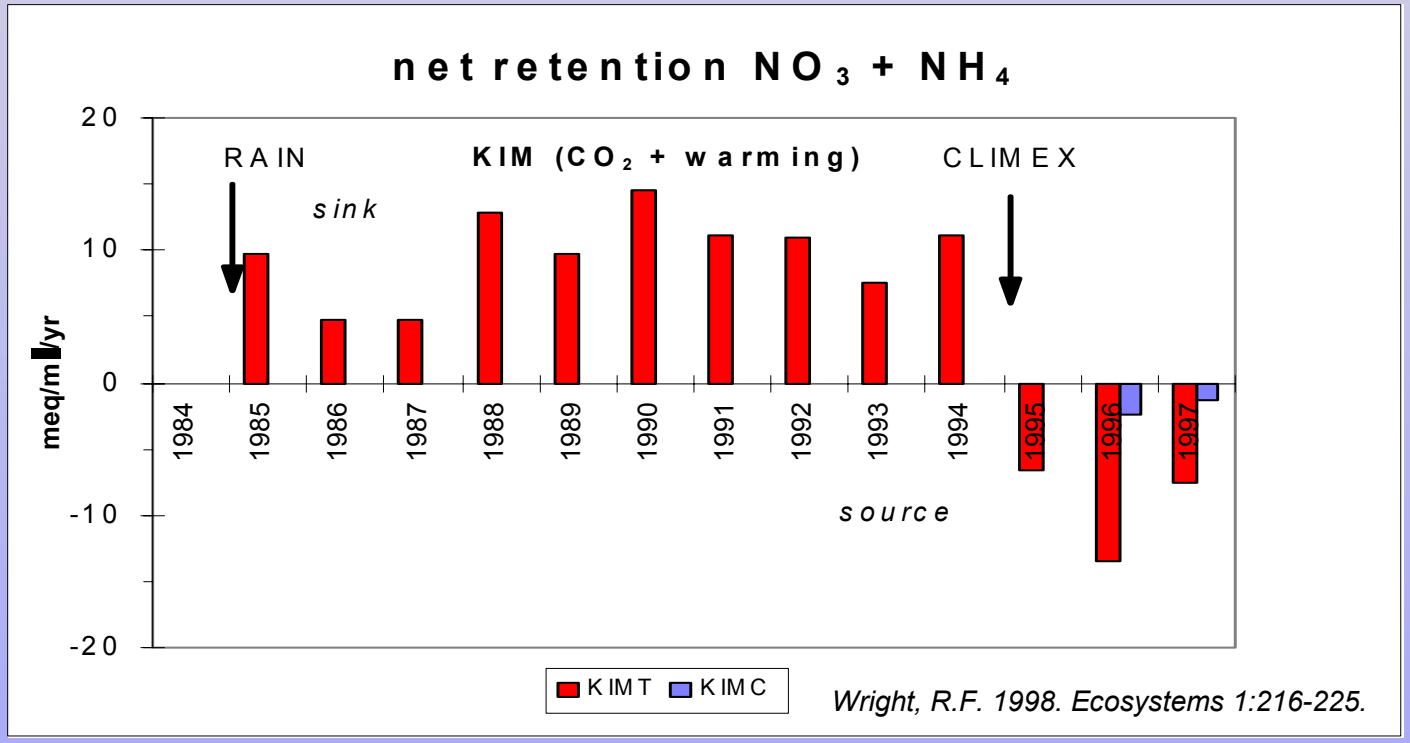
CLIMEX

Warming induced N leaching

Increased nitrogen mineralisation because of warming



Wright, R.F. 1998. Ecosystems 1:216-225.

Ecosystem switches from N sink to N source
- biogeochemistry IS affected

Climate change has the potential to affect drinking water and surface waters

Climoor

Vulcan

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Vulnerability assessment of shrubland ecosystems in Europe under climatic changes

A joint European research project funded by EU

Field scale warming and drying of heathland

Co-ordinator:
Claus Beier, RISØ National Laboratory, Denmark

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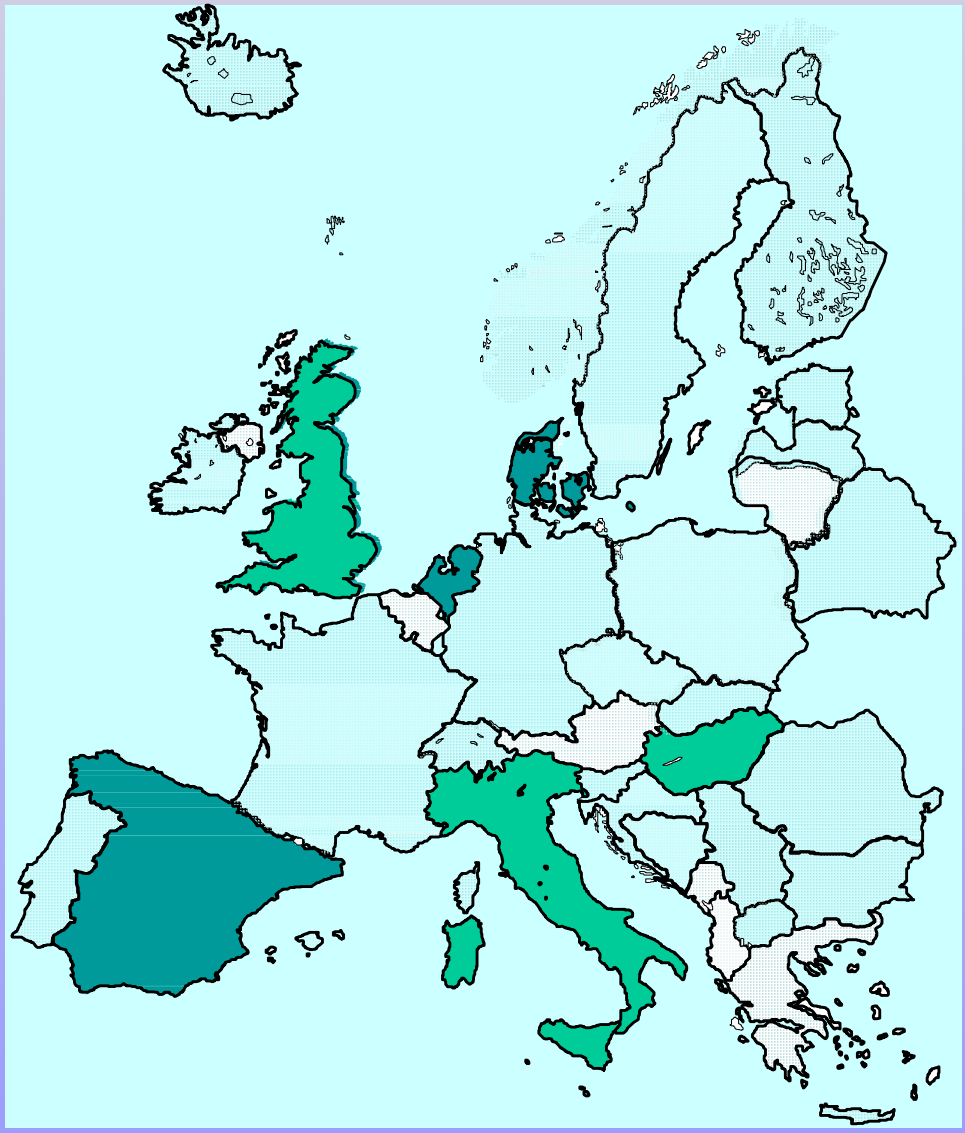
Partners



Risoe National Laboratory – RISOE – Denmark – *Claus Beier*

Danish Forest and Landscape Research Institute – DFLRI – Denmark – *Inger Kappel Schmidt*

University of Amsterdam – UVA - the Netherlands – *Albert Tietema*

Plant Research International – PLANT - the Netherlands – *Ton Gorissen*

Centre for Ecology and Hydrology – CEH – UK – *Bridget Emmett*

Centre for Ecological Research and Forestry Applications – CREAF – Spain – *Josep Penuelas*

University of Tuscia - UNITUS – Italy – *Guiseppe Scarascia Mugnozza*

Hungarian Academy of Sciences – IEB - Hungary – *Edith Kovacs Lang*

University of Wales – UWB – UK – *Gareth Edward Jones*

Natural History Museum – NATMUS - Denmark – *Henning Pedersen*

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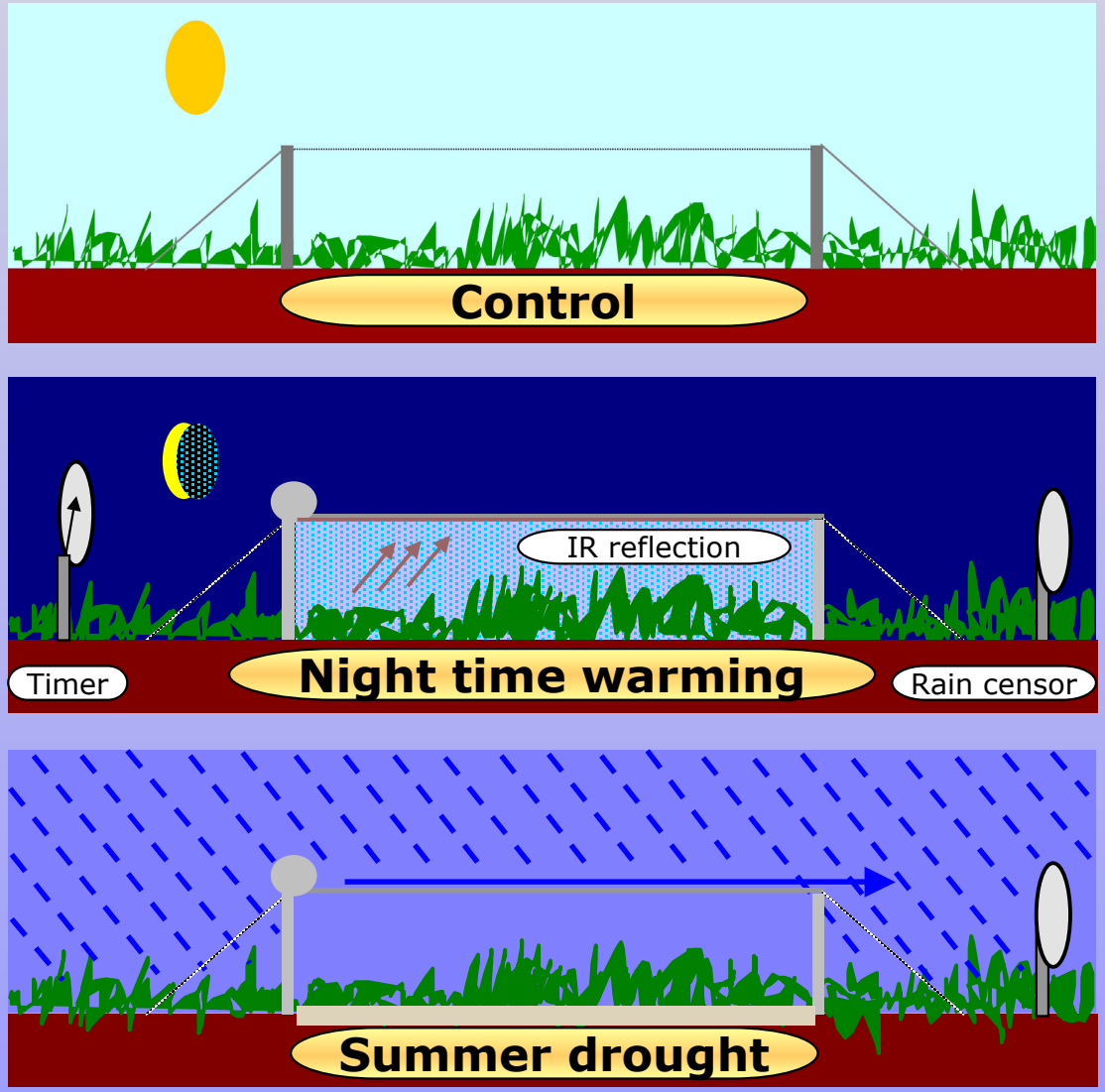
Treatment concept



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Treatments in reality

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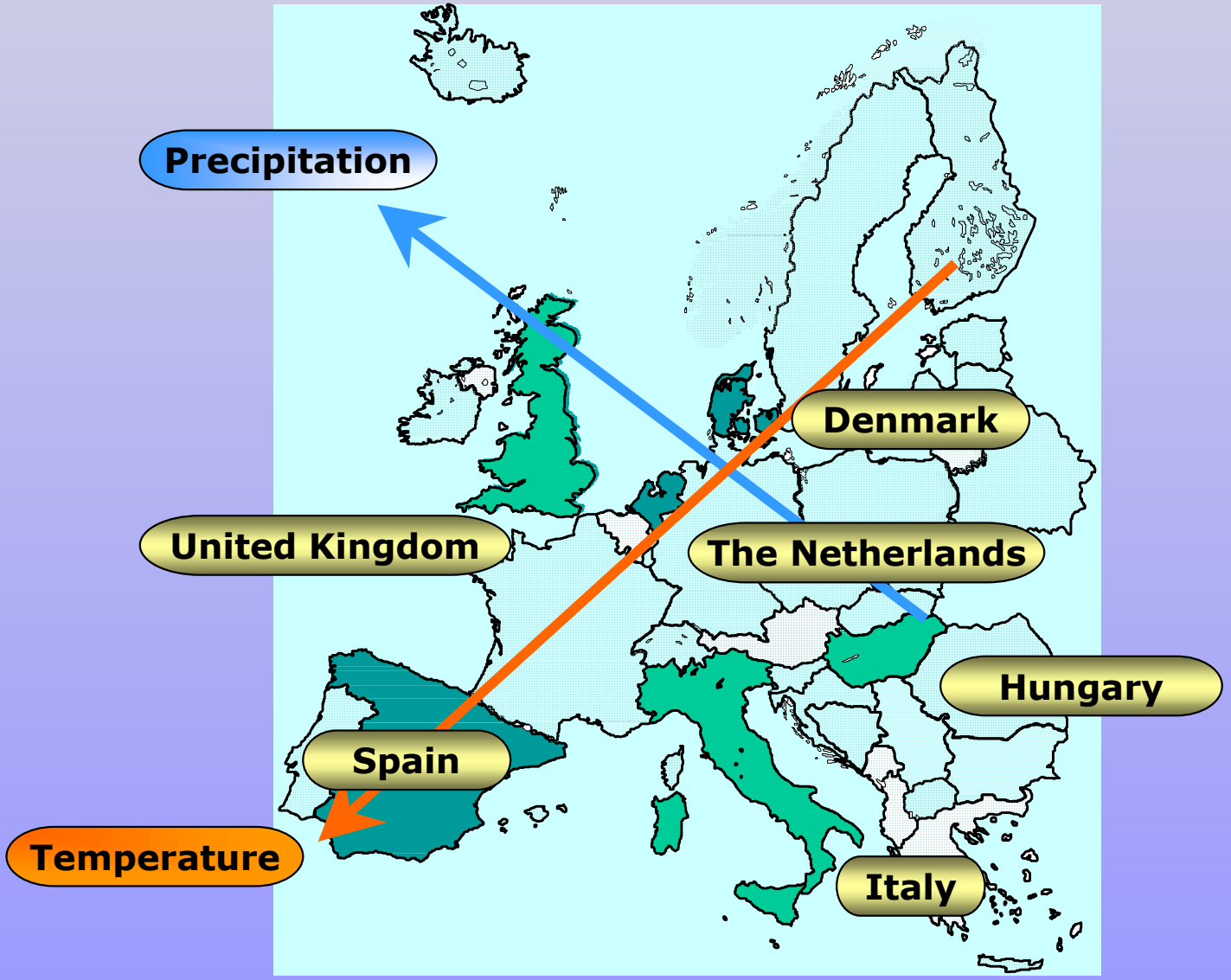
Gradients



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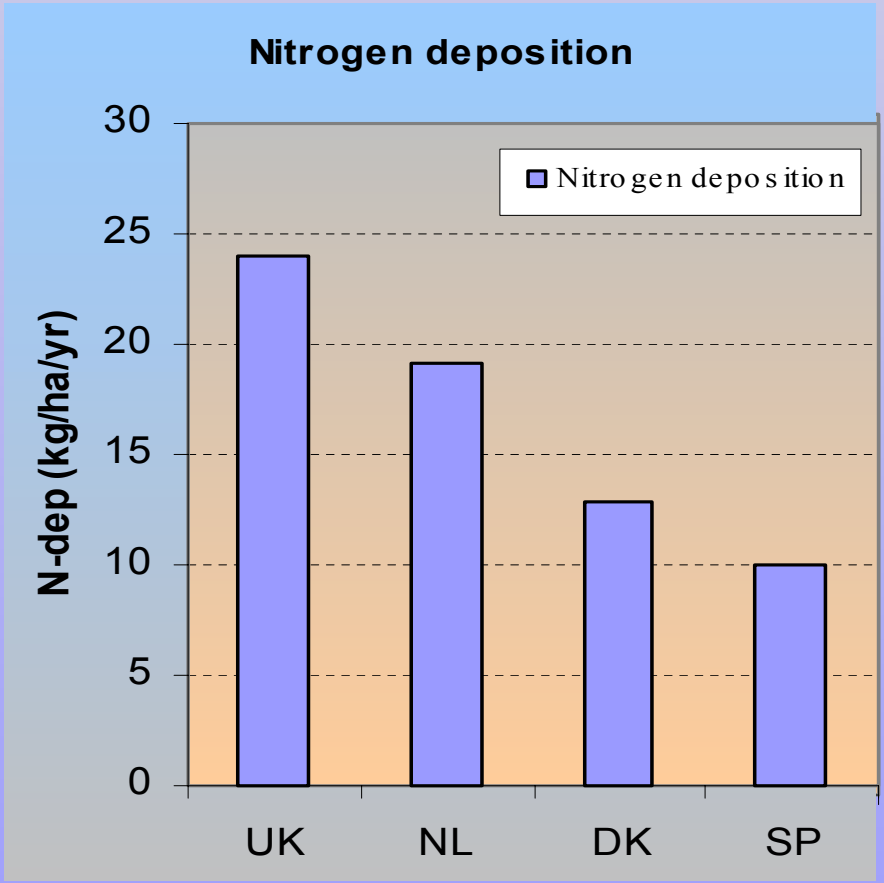
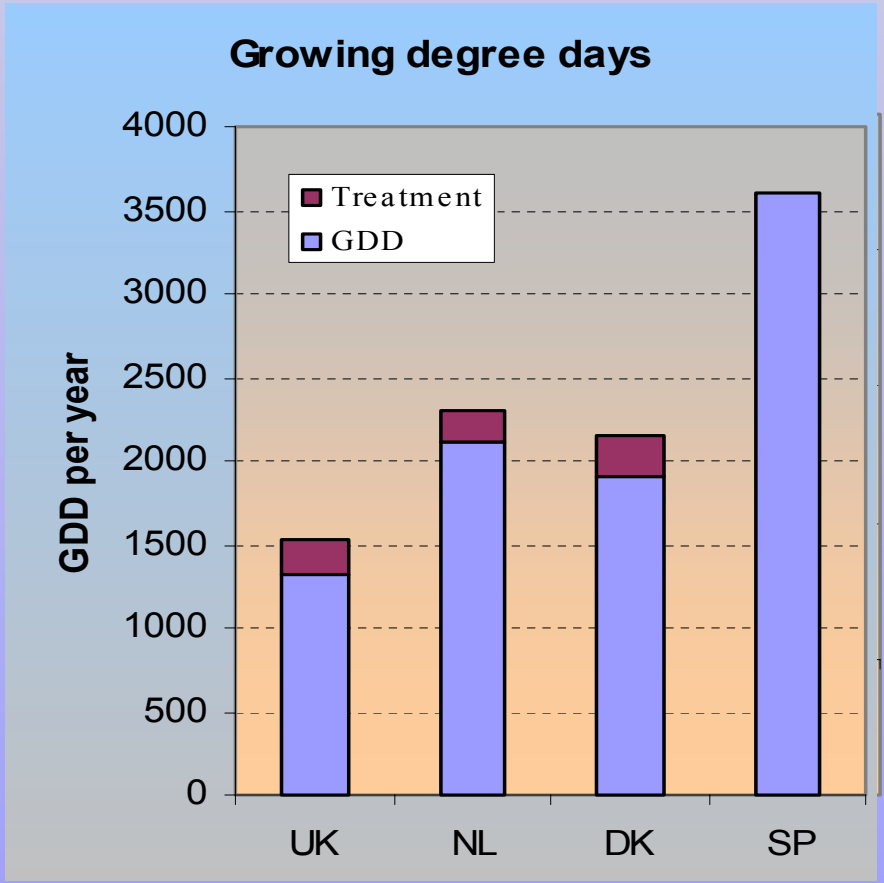
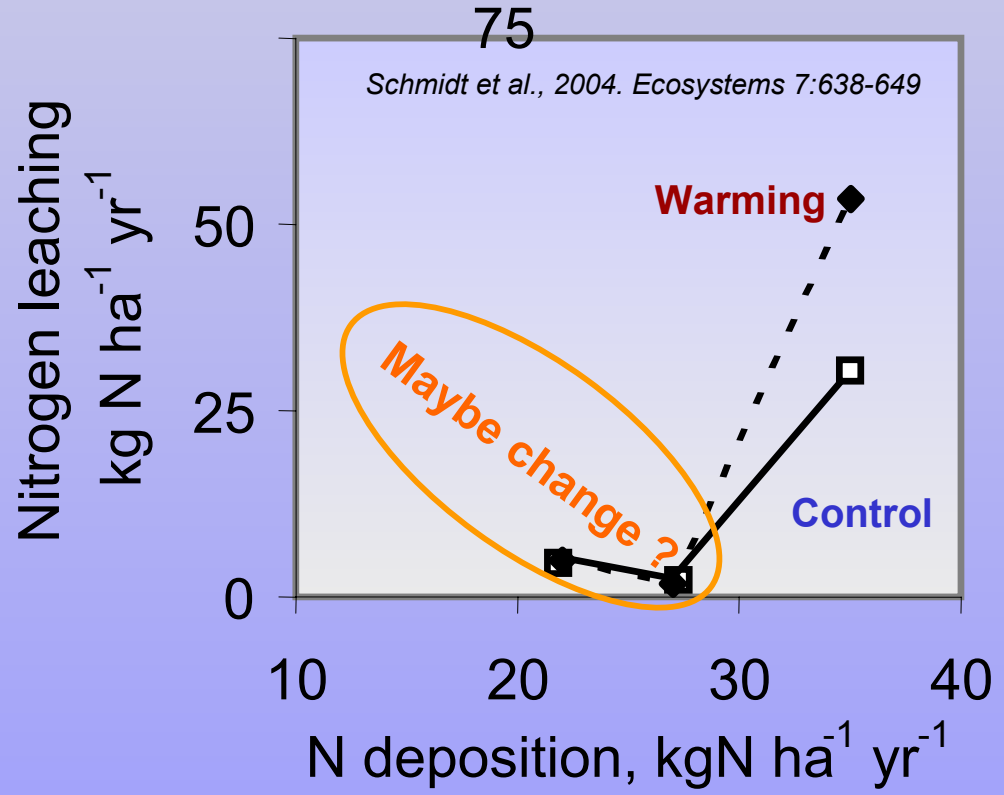
Gradients and treatments





Interaction between N deposition and climate

Leaching response depend on N status (e.g. N deposition)



Climate change has the potential to affect drinking water and surface waters
- but the effects depend on the nitrogen status

Biology may be stronger than biologists

and nitrogen may limit growth response to climate change

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Biogeochemistry
Other nutrients may determine the response to climate

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Biological effects – Limiting nutrients

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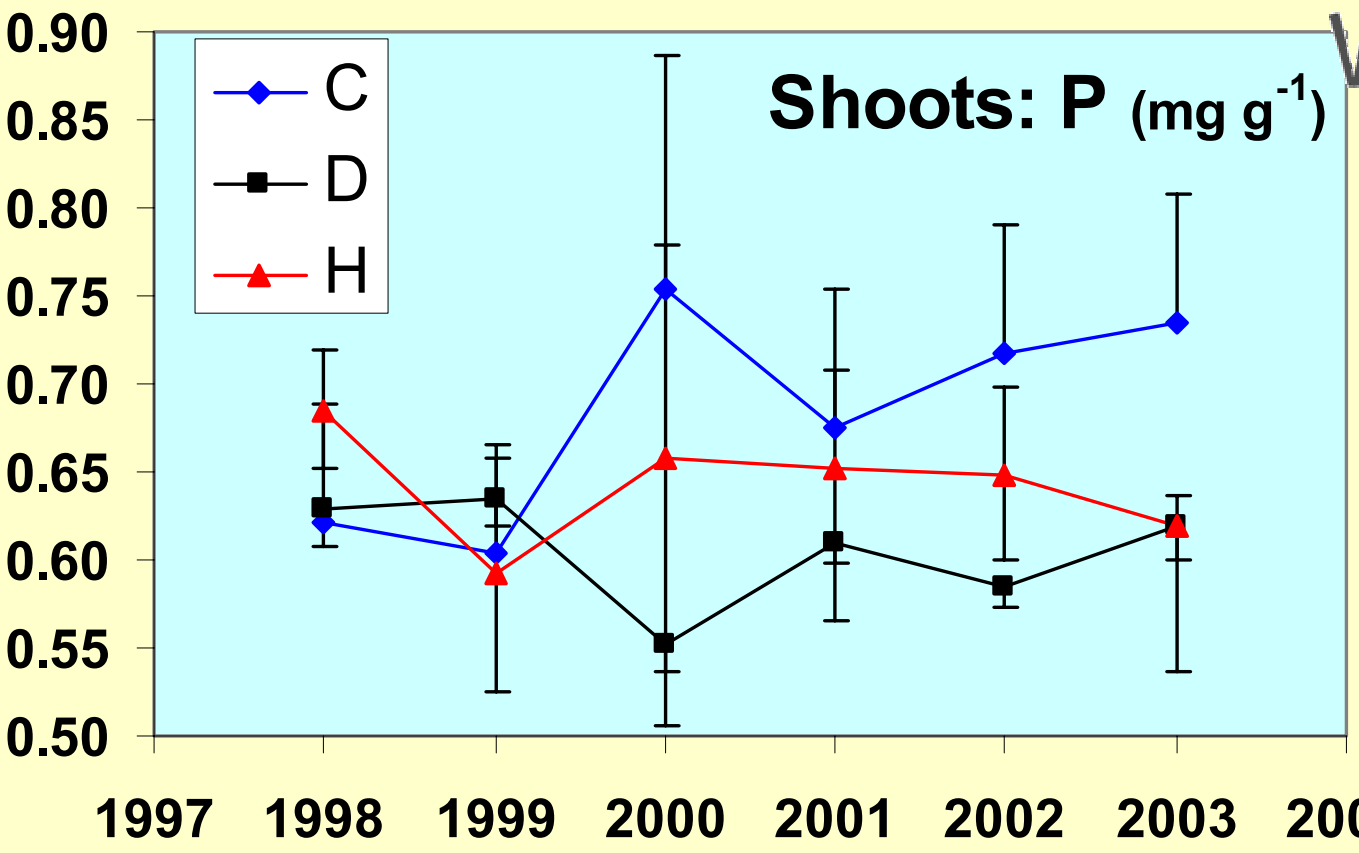

Phosphorus limits plant growth response to climate in many areas (here NL)

- progressive nutrient limitation (nitrogen often mentioned)

Nutrients may limit growth response to climate change

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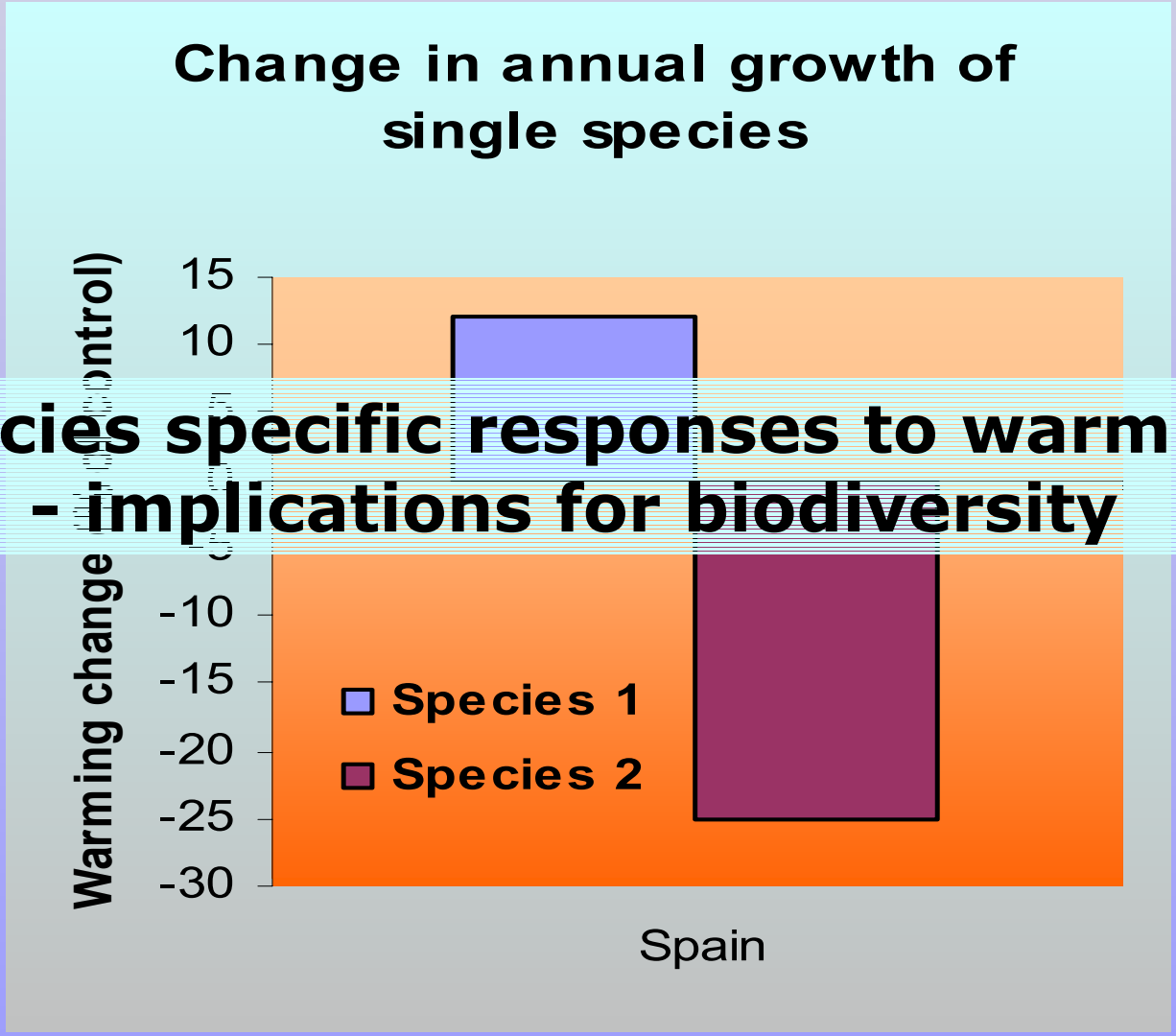
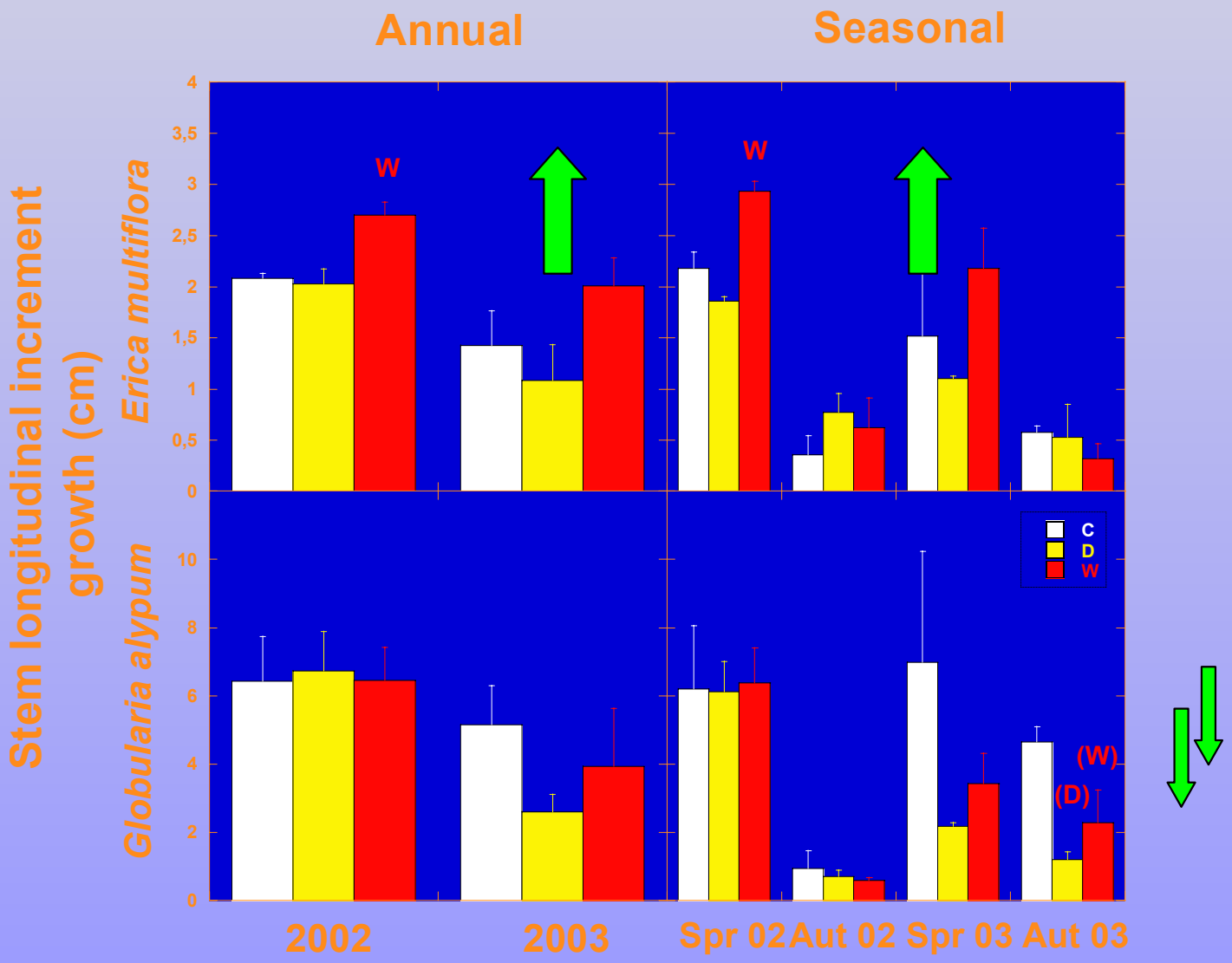
Biology
Biodiversity



Species specific responses to warming - implications for biodiversity

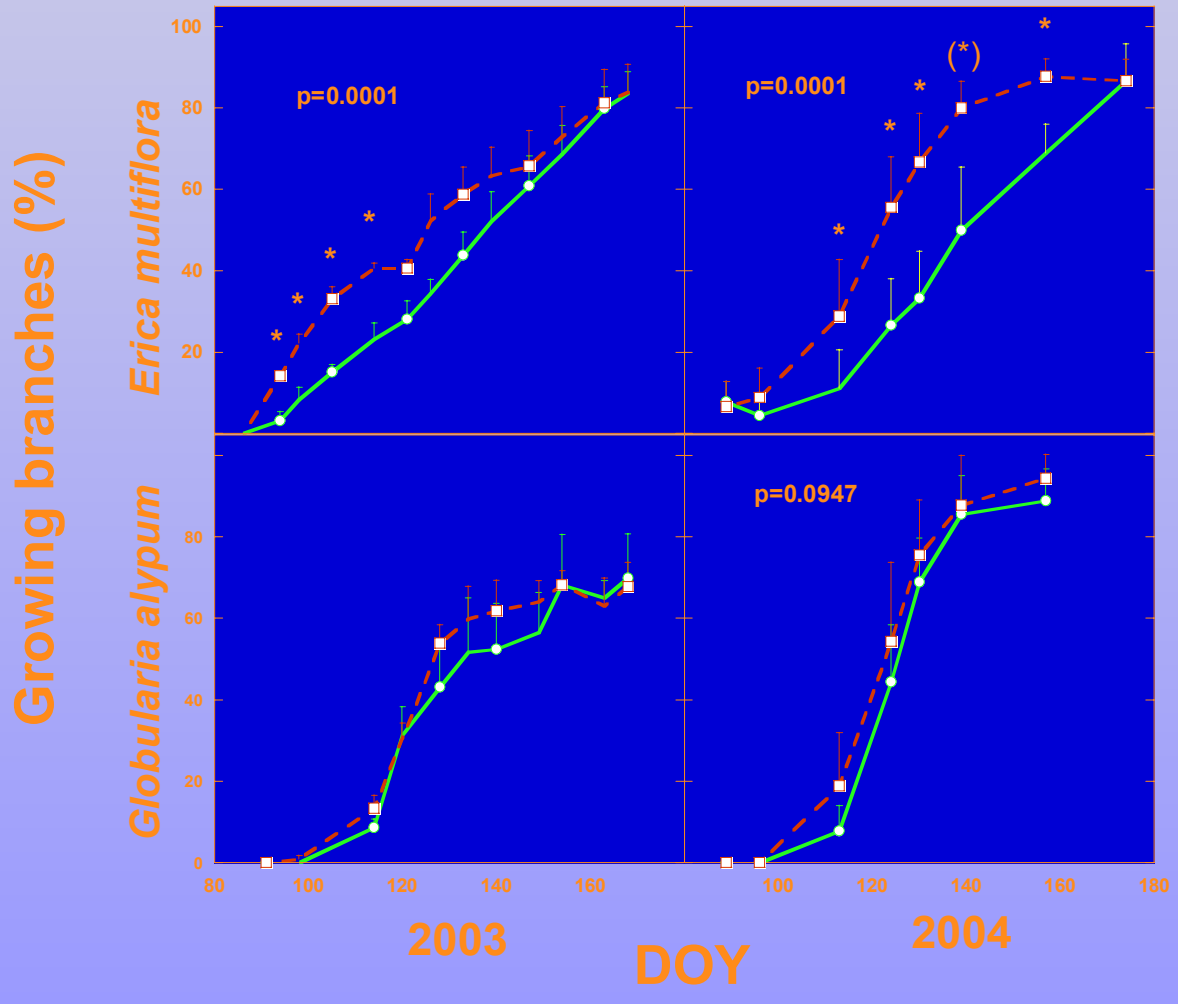
Species specific and season specific growth response



Leaf unfolding advanced under warming – species specific response

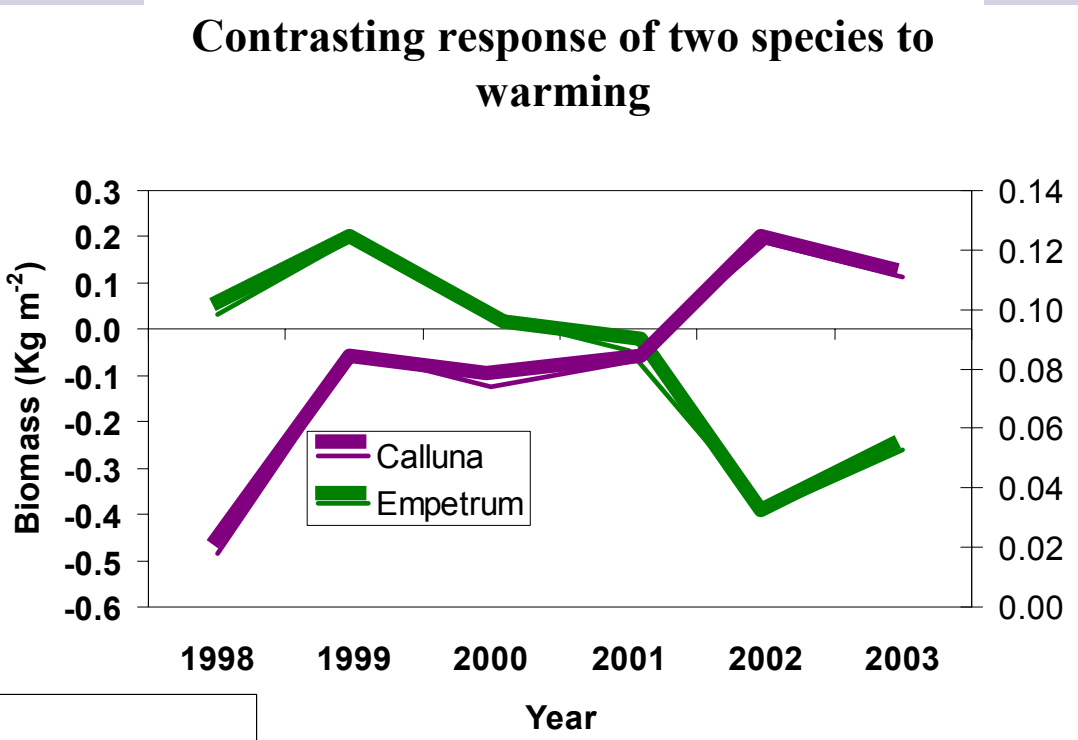
Vegetative growing phenology

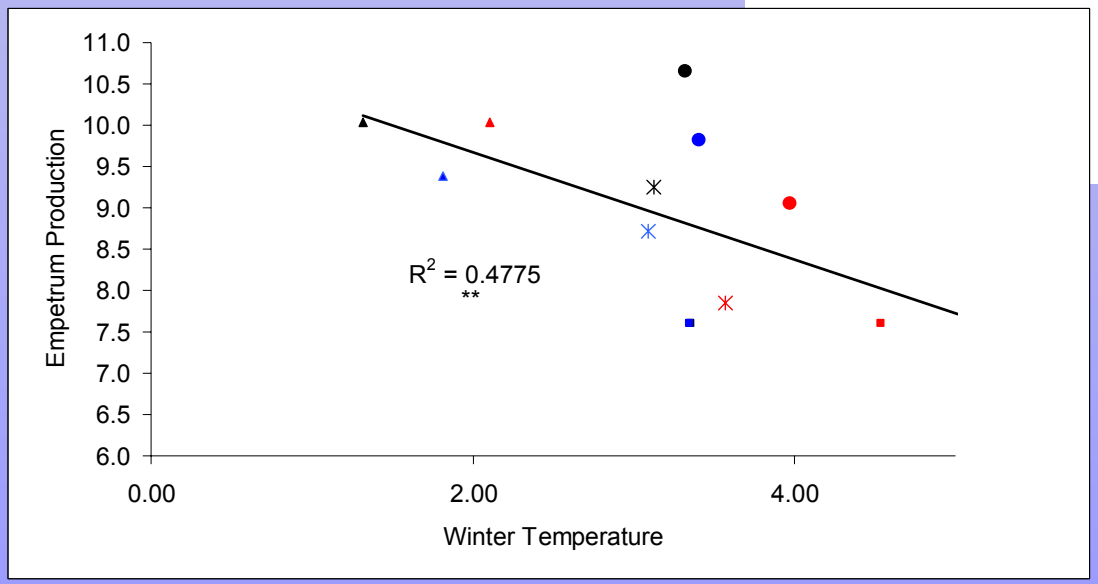
Control vs warming



Biological effects – species specific responses

- Warming by 1 deg. increases *Calluna* cover whilst *Empetrum* declines
- Why?

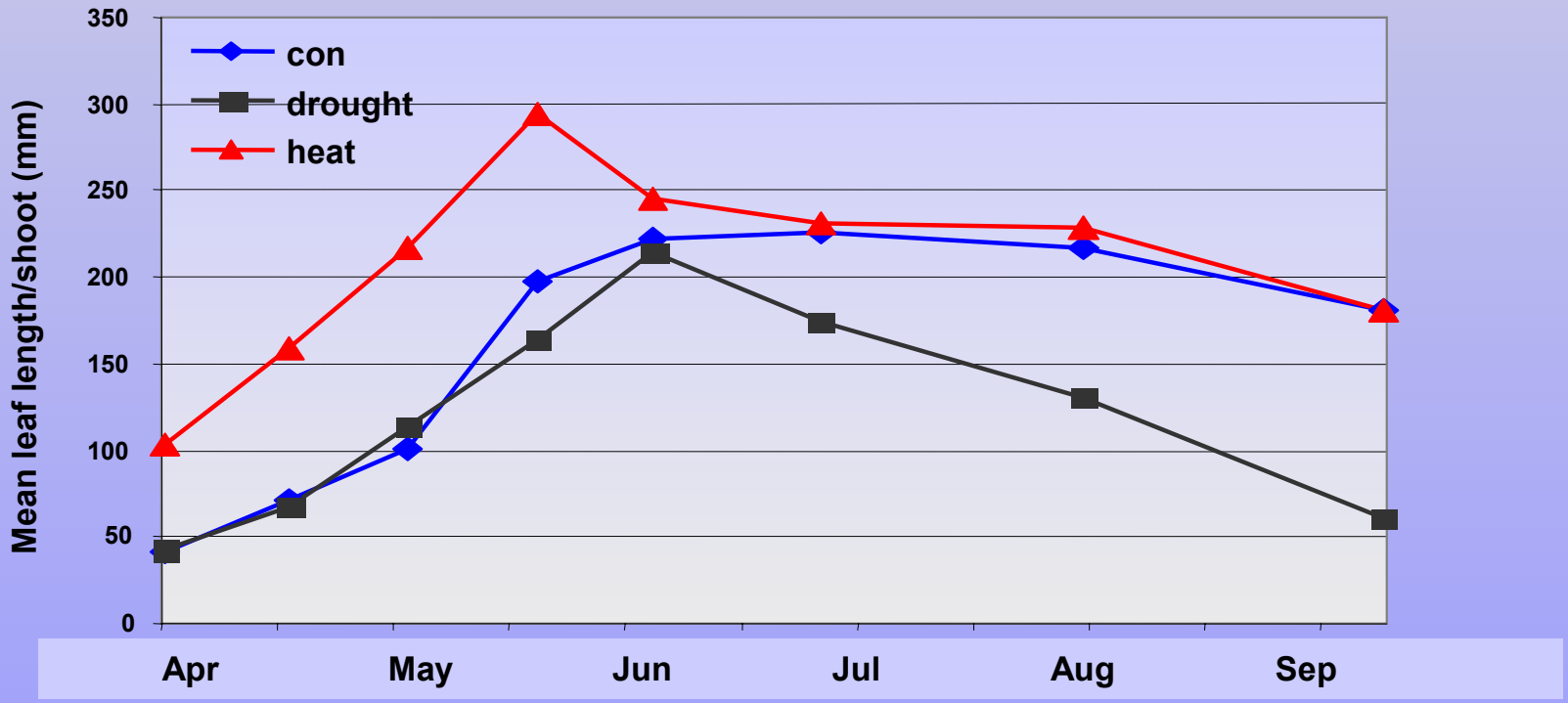




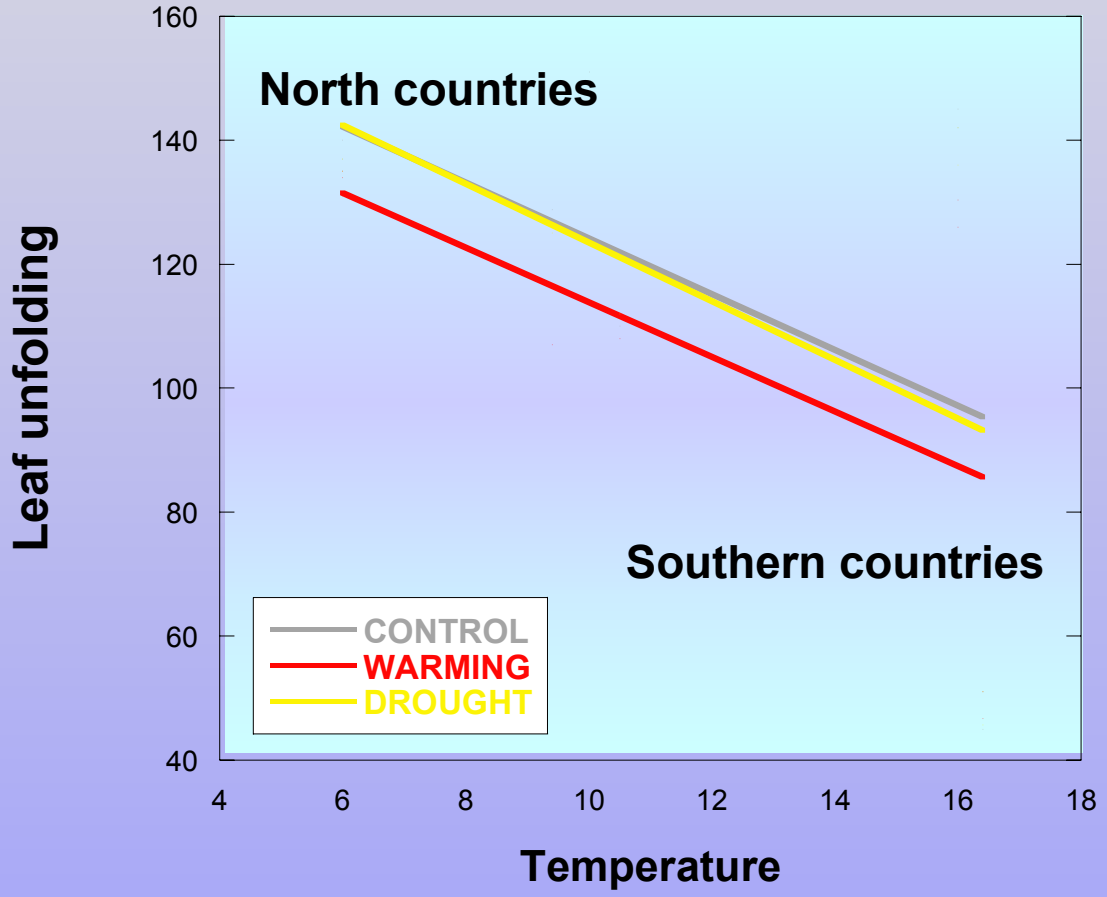
- *Empetrum* declines with winter warming

Biological effects – why does species change

Change in phenology in Denmark – grasses
Seasonality changes – spring starts earlier



Biological effects – why does species change



Vulcan

Climate change has the potential to affect phenology (timing) – different species respond differently - potential mechanism for species change

Advanced leaf unfolding by warming

- may be an advantage for some plants

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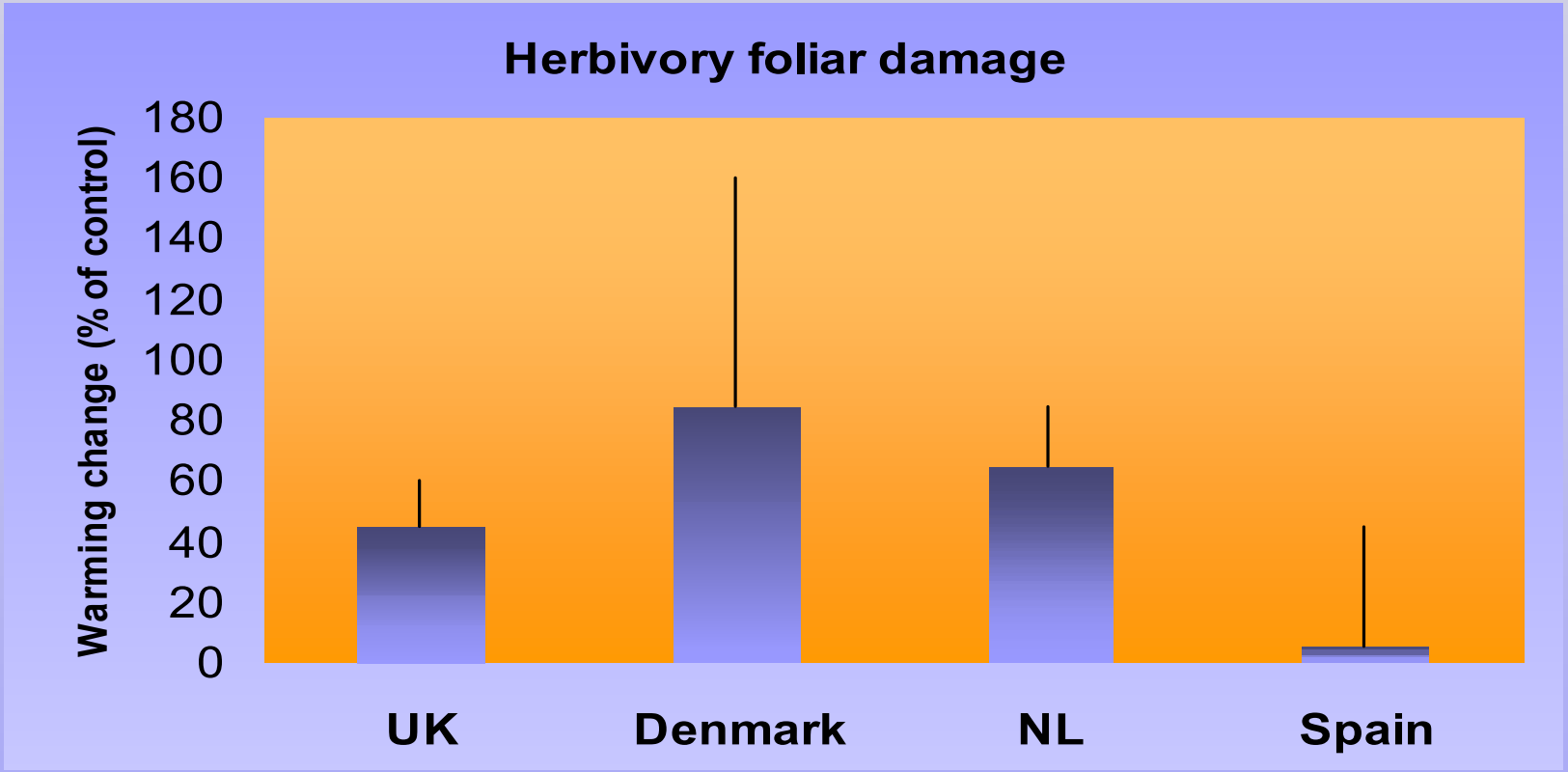
Effects on herbivory



Herbivory - responds to warming

Warming has the potential to affect herbivory
– often species specific attacks = different species affected differently

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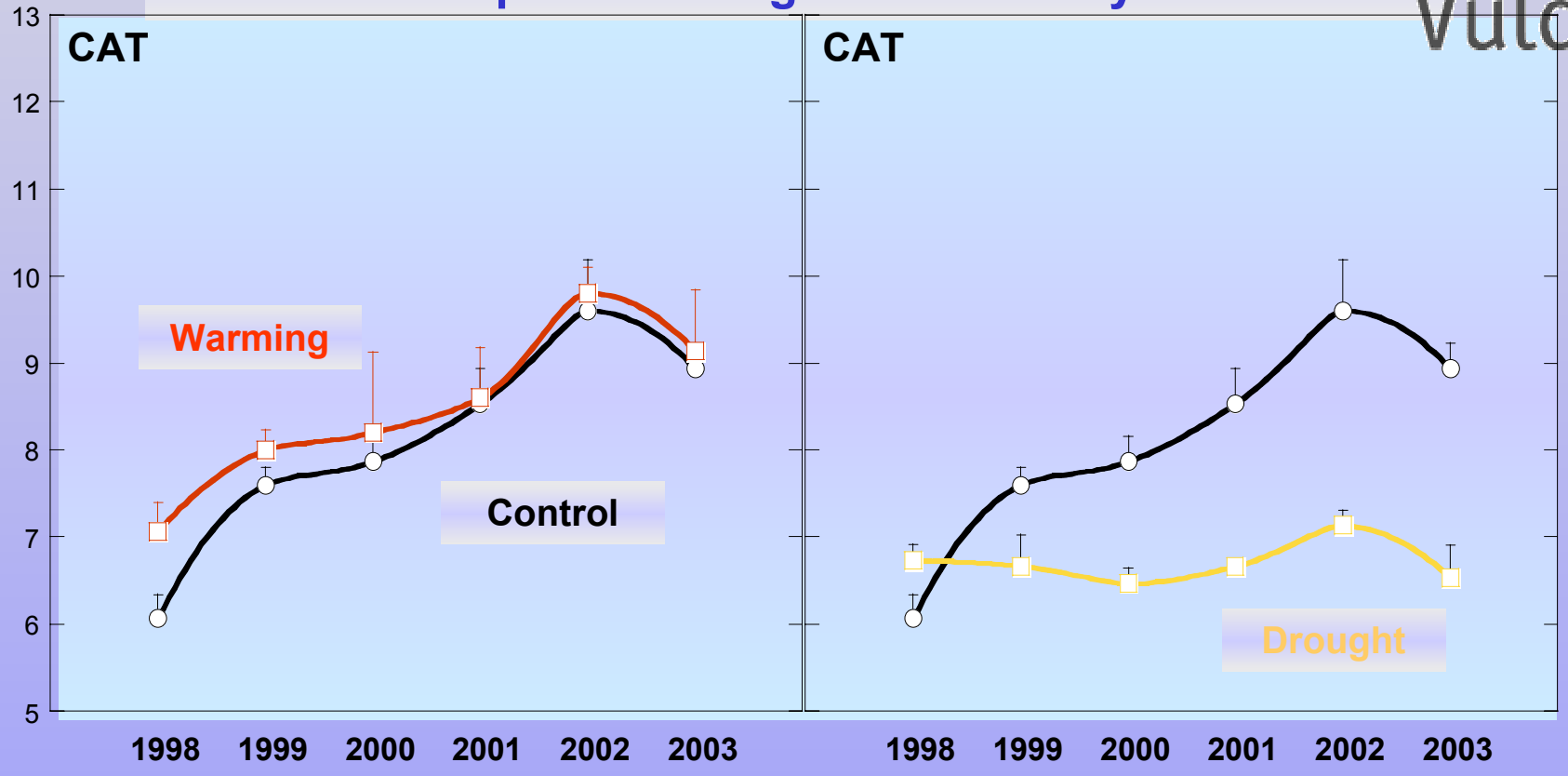
Biological effects – species loss

Loss of species in Spain with (warming) and drought

Species change - biodiversity

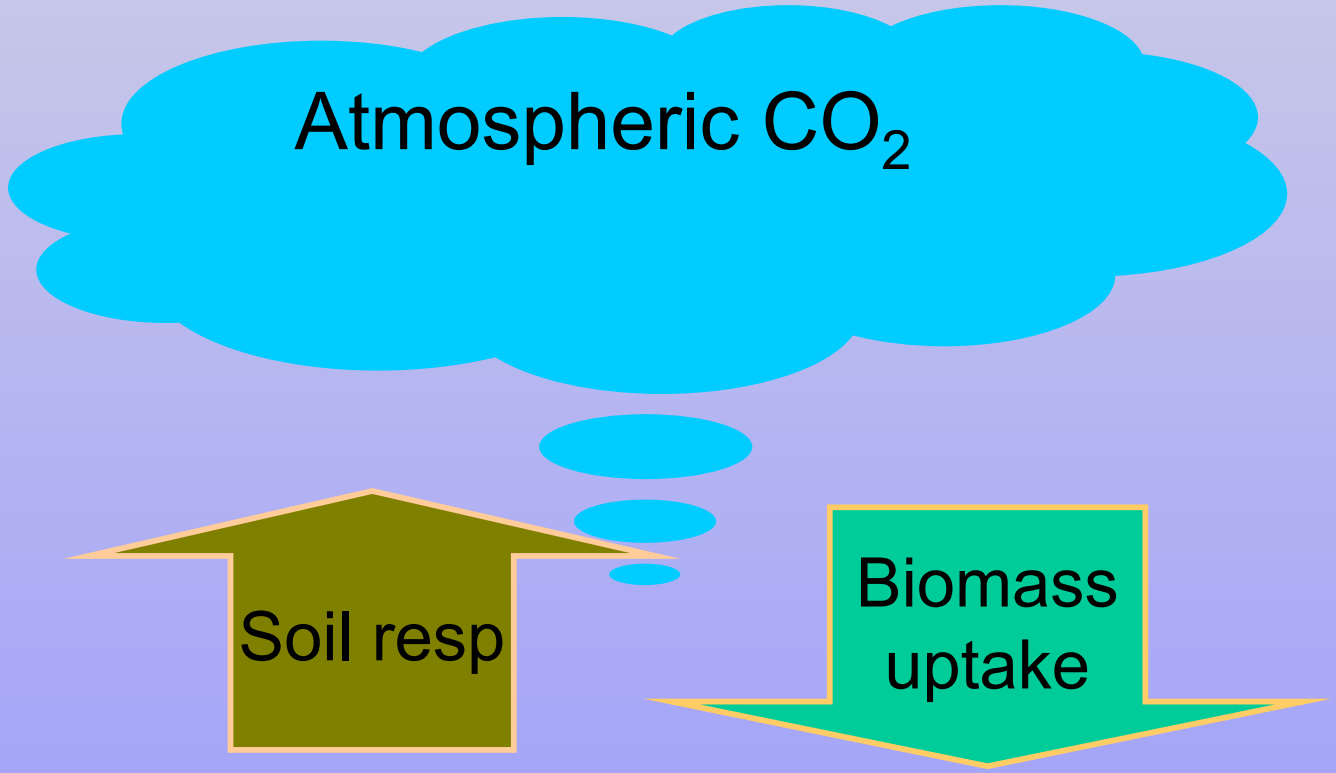
Vulcan



Climate change has the potential to affect species composition – implications for biodiversity

C-balance

C-balance and climate change



Which one is most reactive to climate change??

Carbon loss

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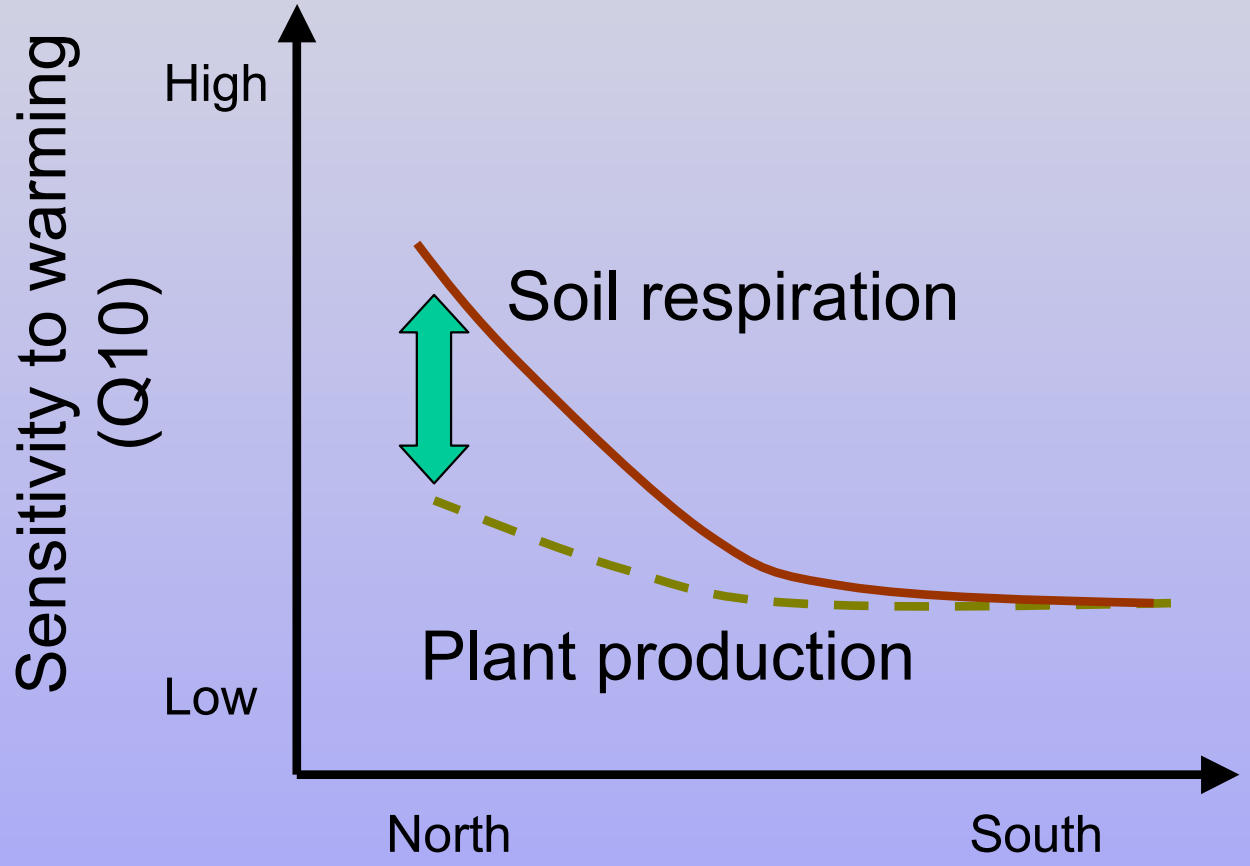
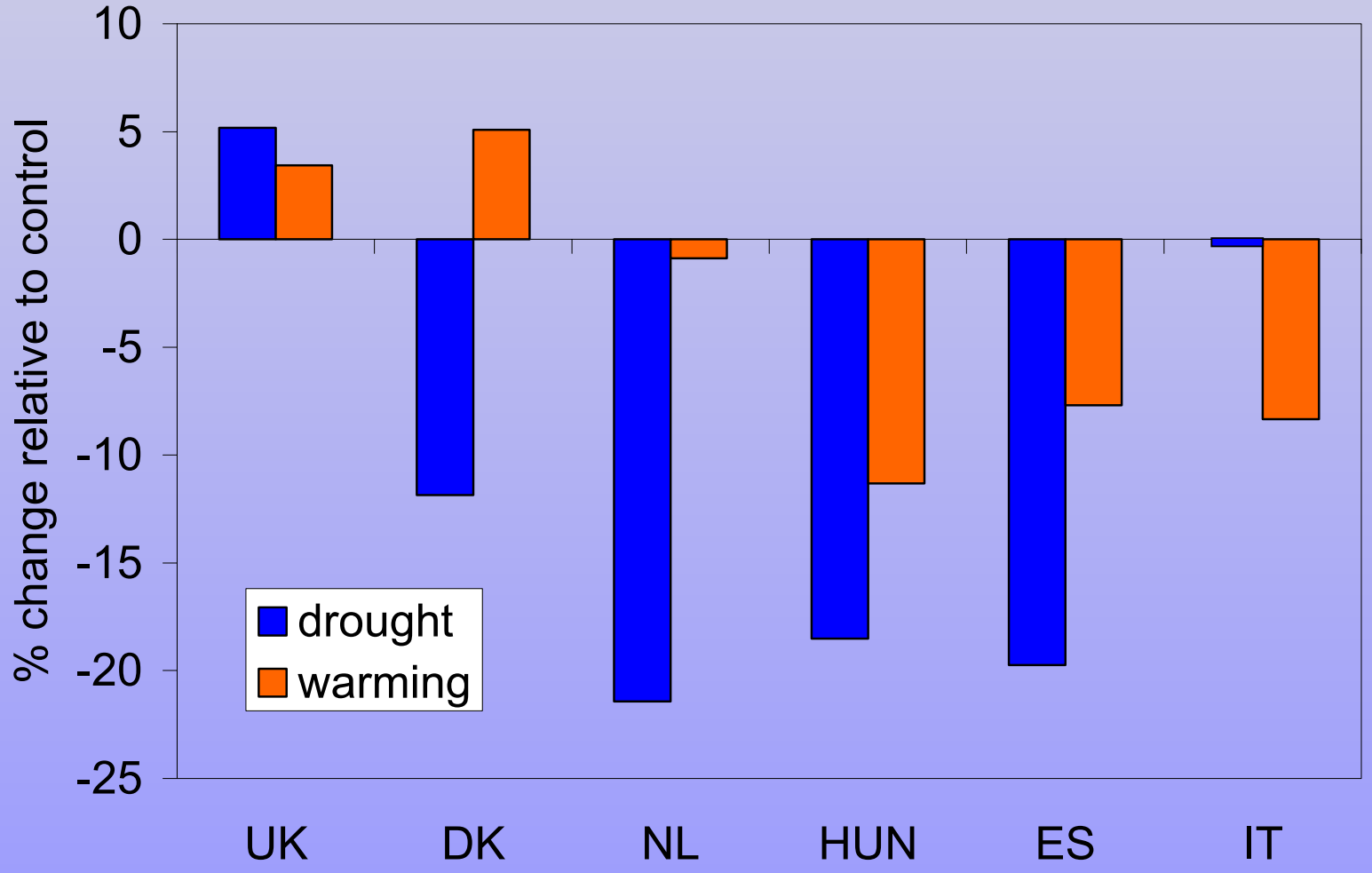
Laboratory studies – general expectation for carbon



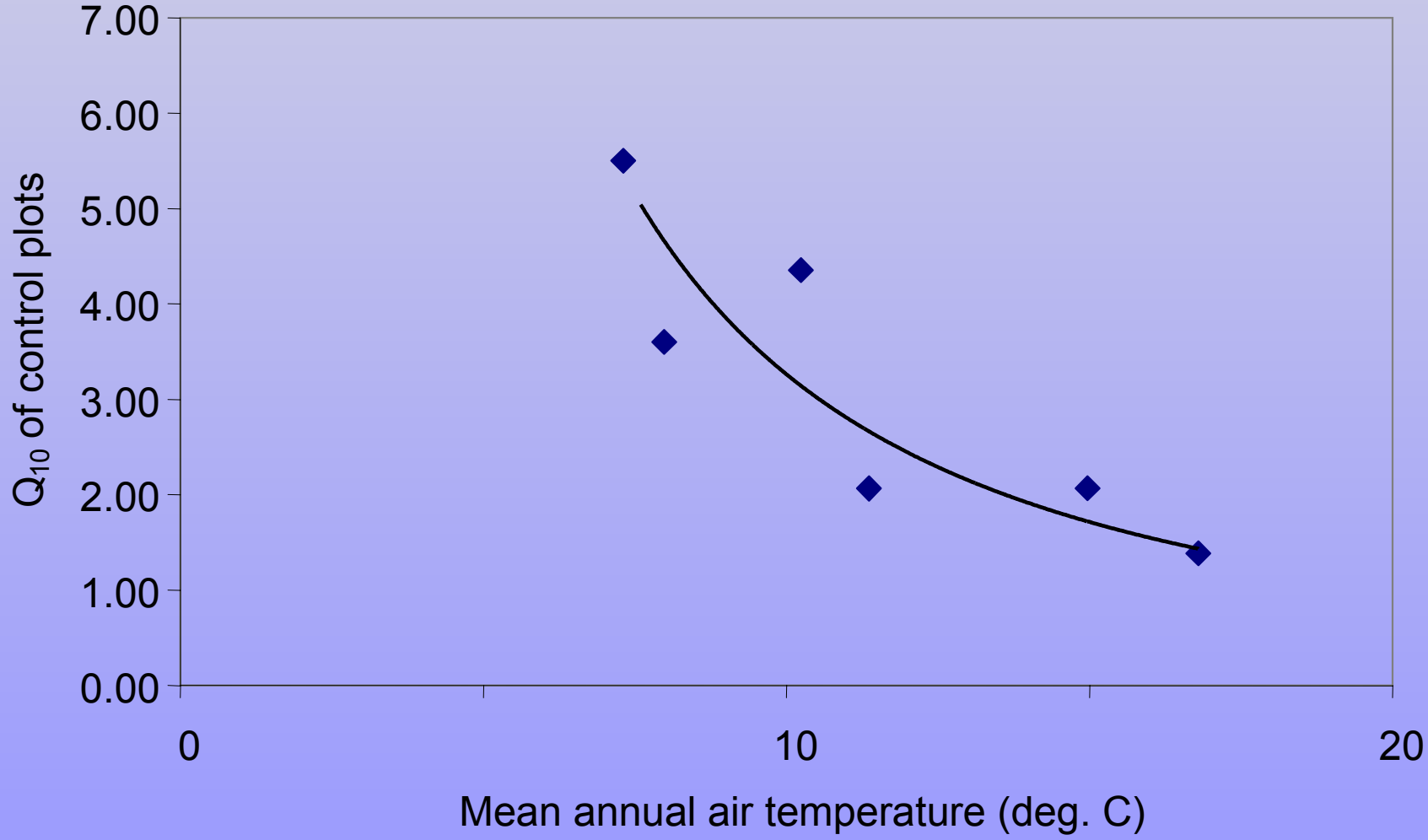
- we expect soils and plants to be sensitive to warming – most in North
- and soils to be more sensitive than plants – especially at colder climates

Effects on carbon loss

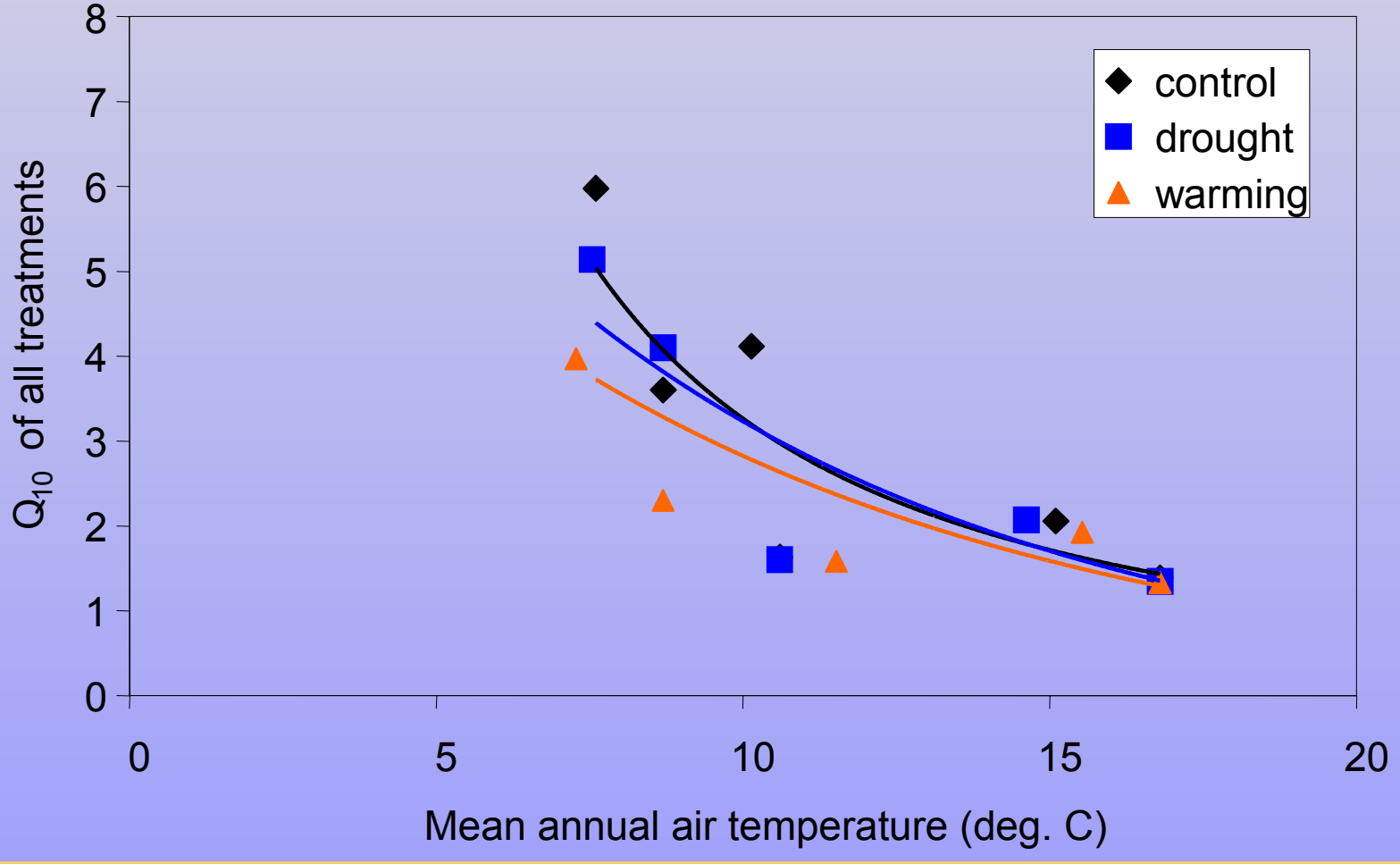
Increased carbon loss at northern sites, reduced loss in southern sites



Theoretical sensitivity of soil respiration to warming confirmed across Vulcan sites

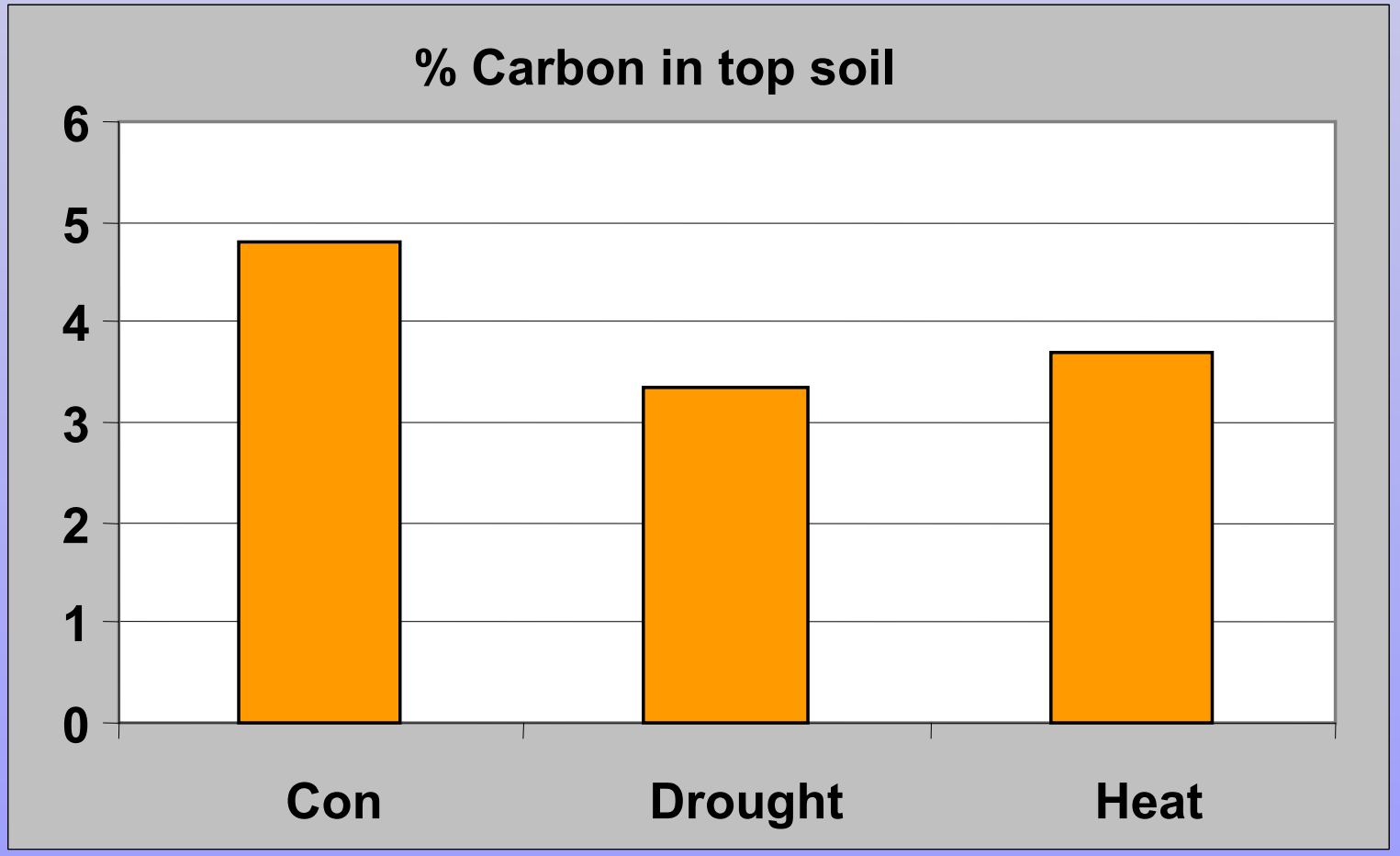


But treatments affect this relationship

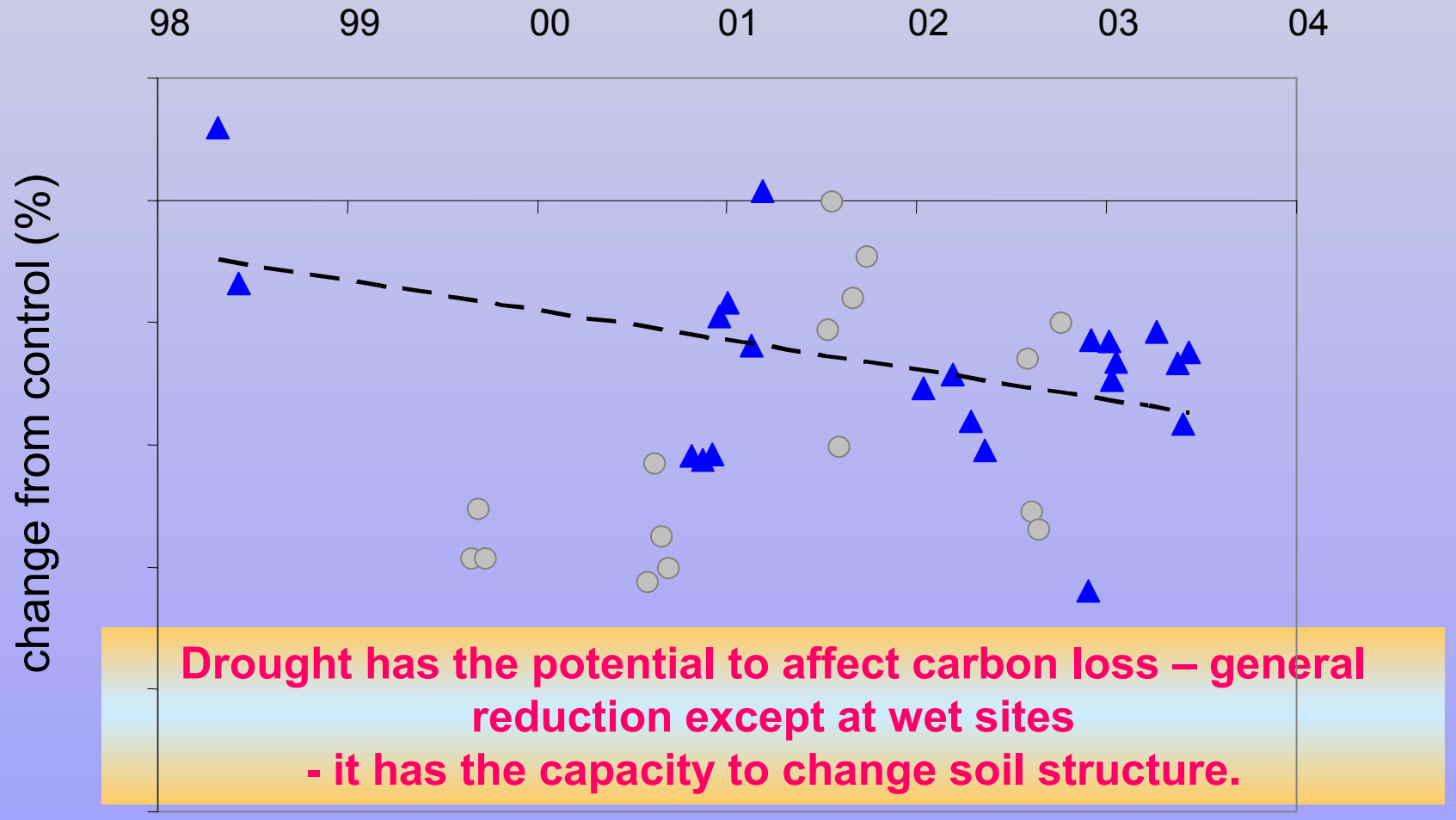


Climate change has the potential to affect carbon loss – but the response is not equaly strong at all climates

15% loss in the amount of carbon in the top soil in Denmark …..and this is with only moderate climate treatments



..and causes a long term change in the capacity of soil to hold water (Wales and NL)

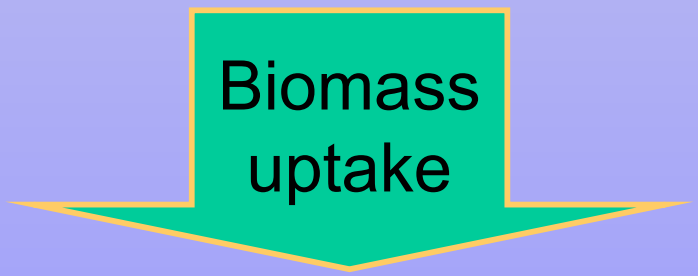


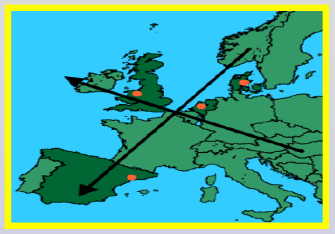
Drought has the potential to affect carbon loss – general reduction except at wet sites
- it has the capacity to change soil structure.

○ Measurements taken during the drought treatment

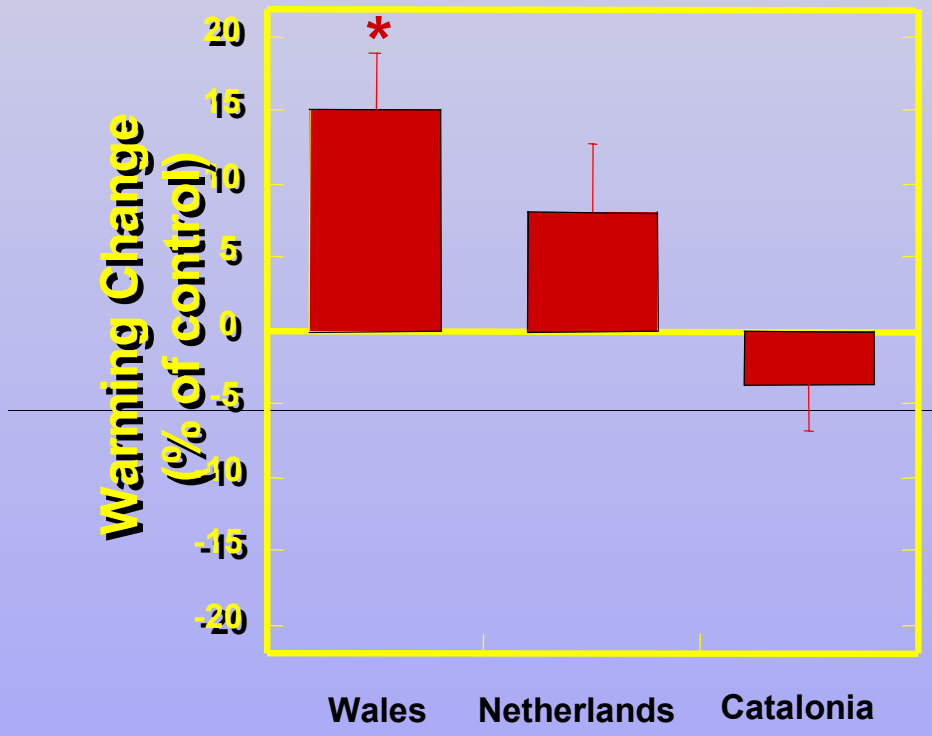
▲ Measurements taken outside the drought period

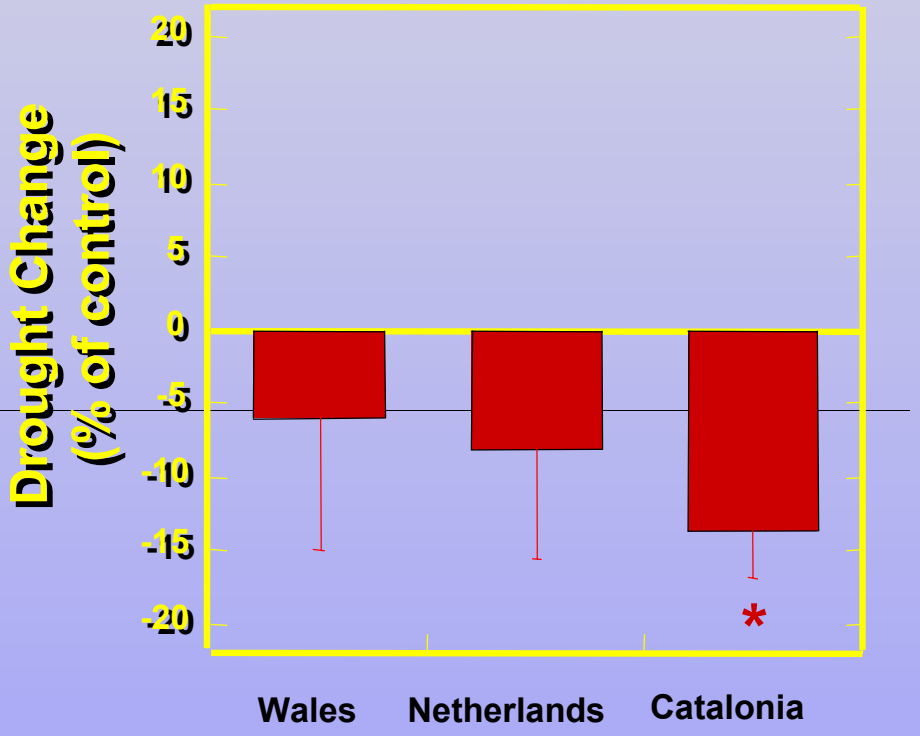
Carbon gain





Total aboveground biomass (1998-2000)

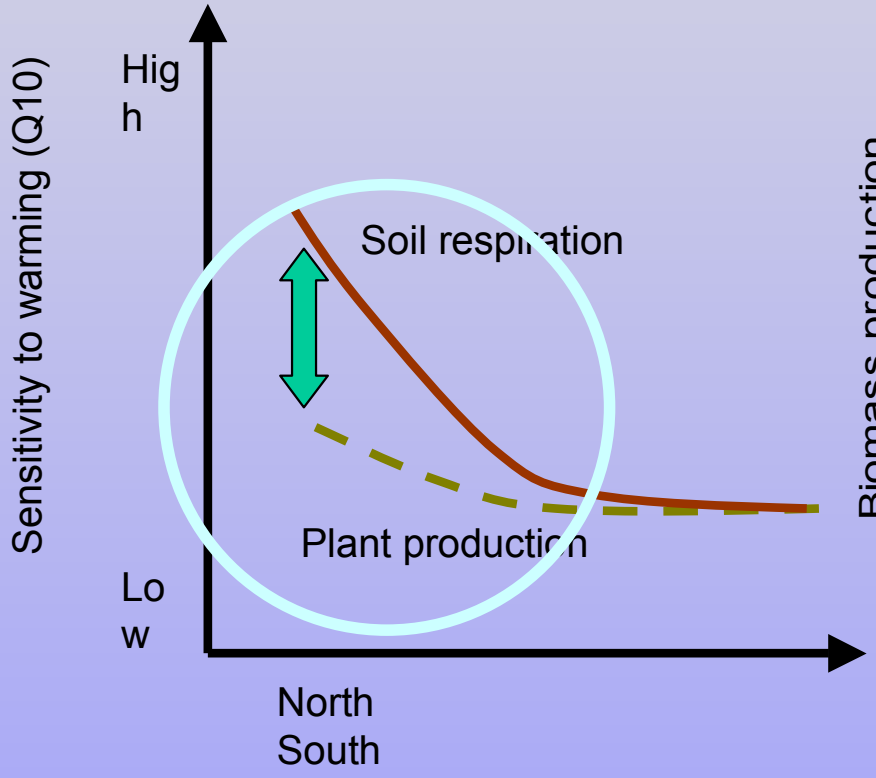


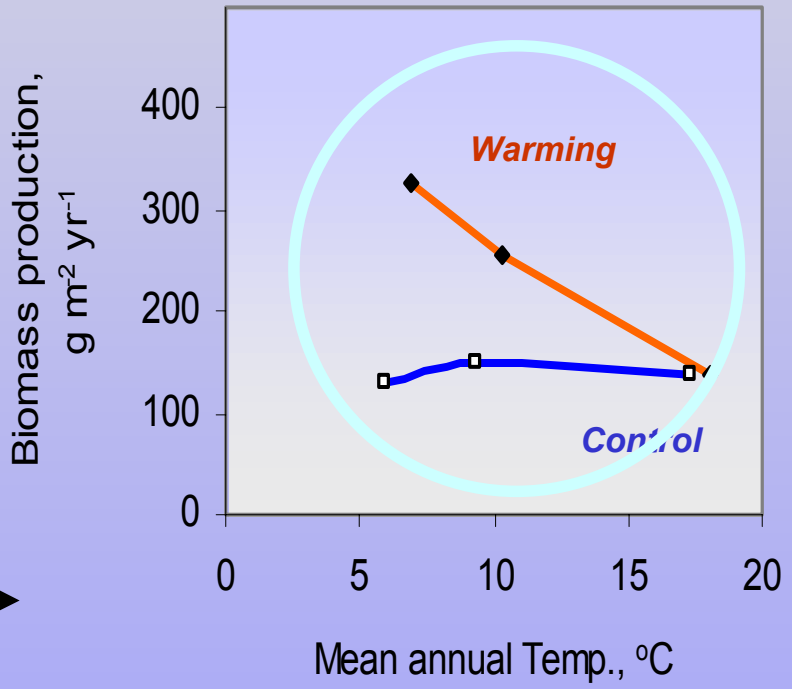


↑ 1ºC -> ↑ 15% biomass production in warming plots in Wales

↓ 22% -> ↓ 14% biomass production in drought plots in Garraf

Carbon gain





Long term gradient – what if species change?

Short term experiment – what if species change?

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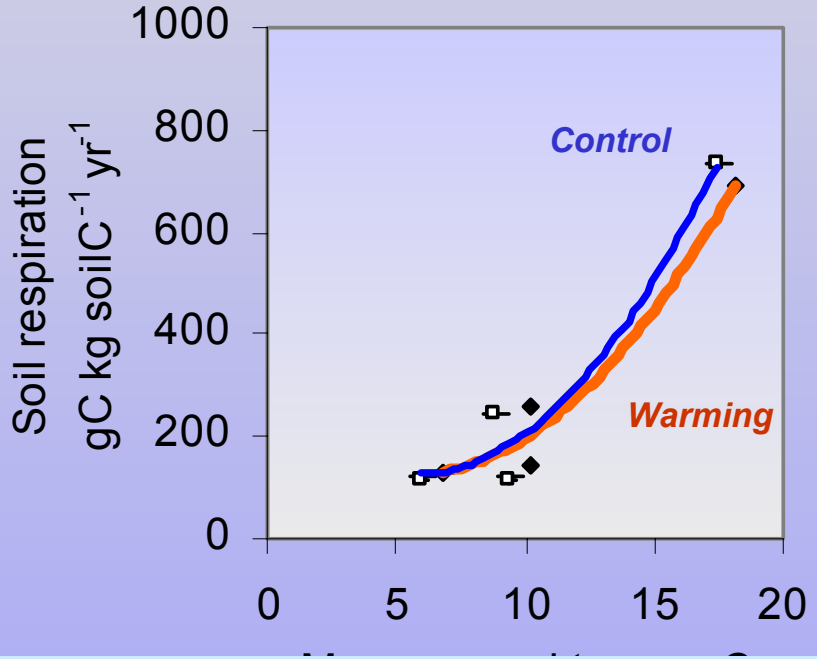
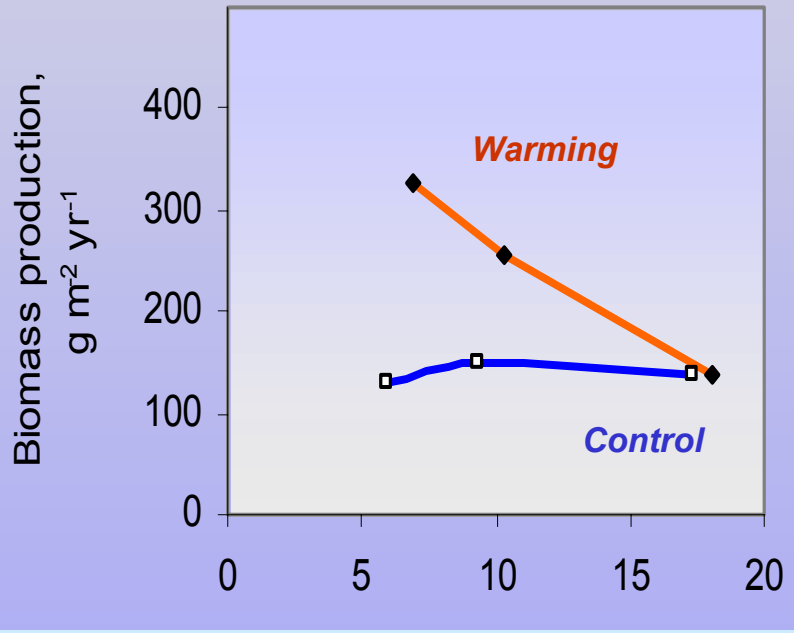
Soil respiration and plant growth - relationship to temperature

Vulcan





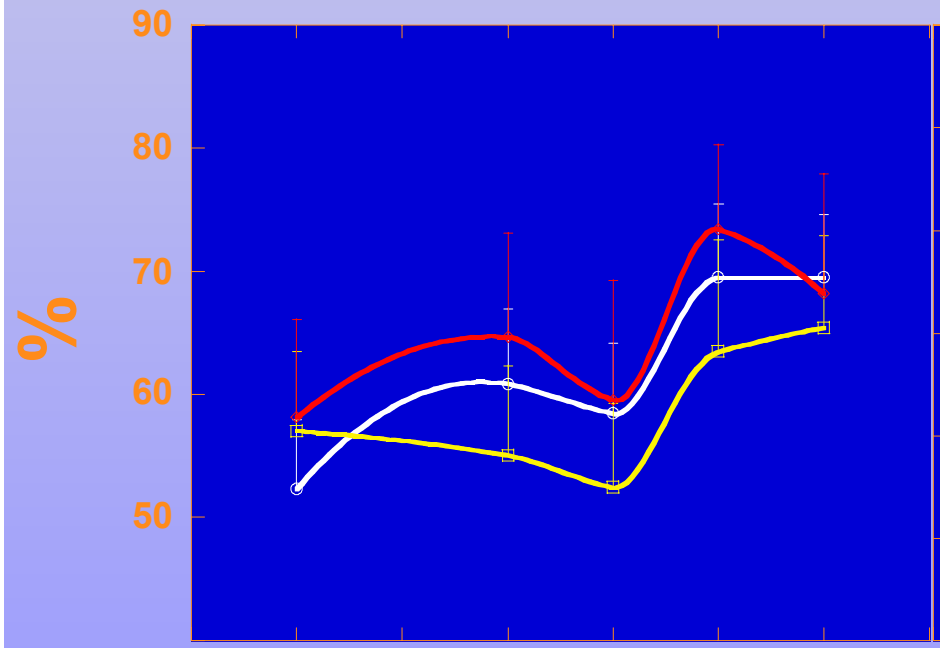
3 years experiment (short term)
- soil respiration is sensitive to warming
- but less than plant growth (on the long term balance must shift)

Warming has the potential to increase growth – mainly at colder sites (on the short term)
– response stronger than expected
- we still do not know which C process is the strongest

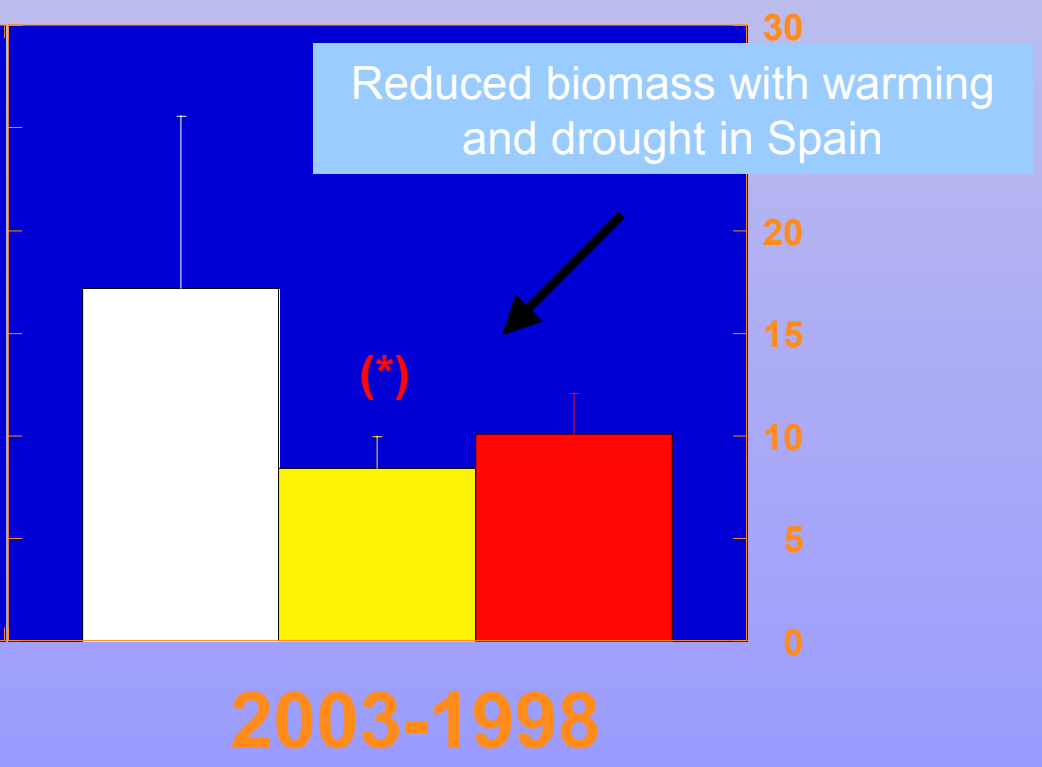
Reduced plant cover in southern countries will increase erosion risk.

Warming and drought has the potential to reduce plant cover at warm sites – increased risk for soil erosion

Total aboveground plant biomass

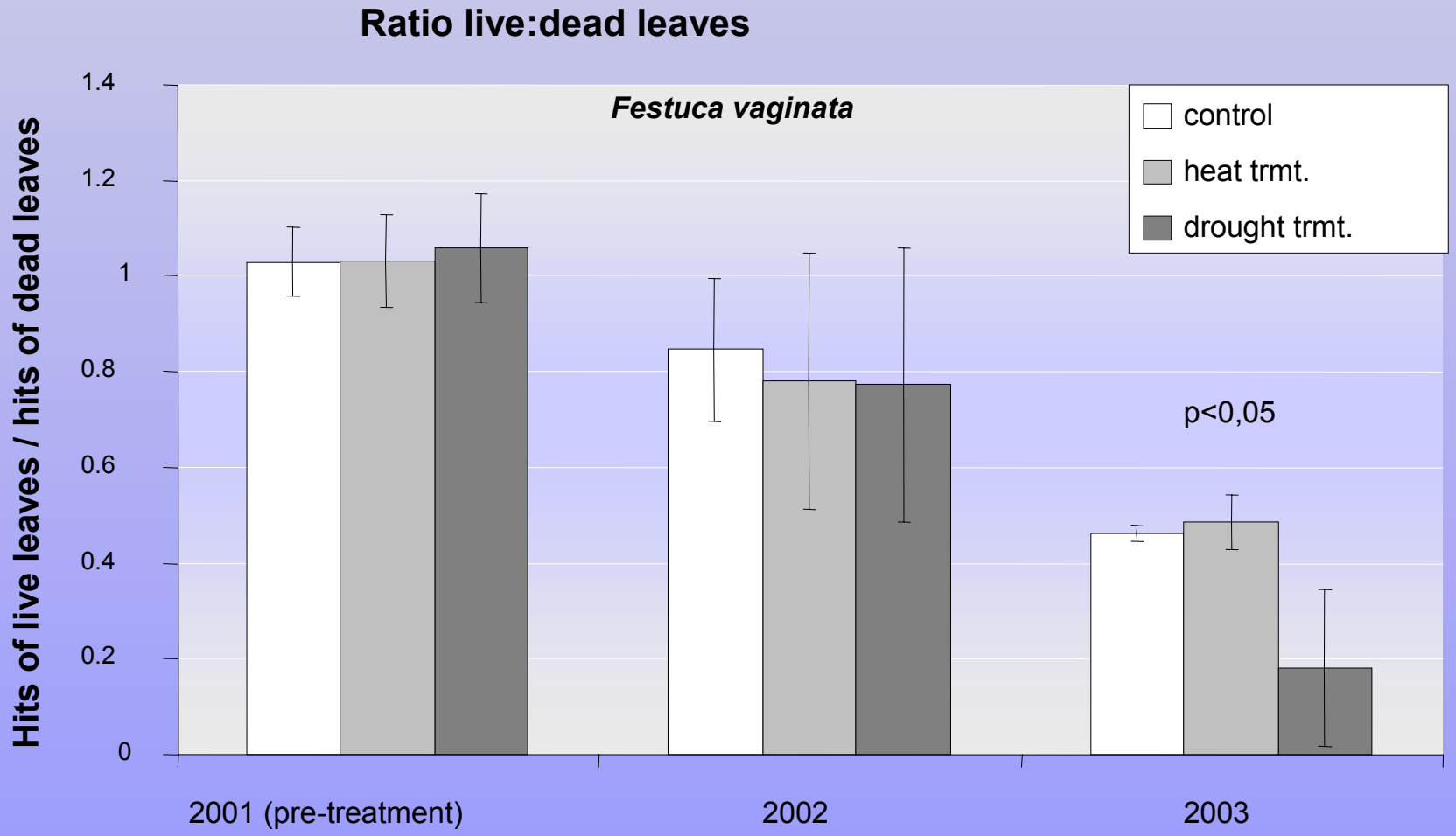


Changes in total a aboveground plant biomass



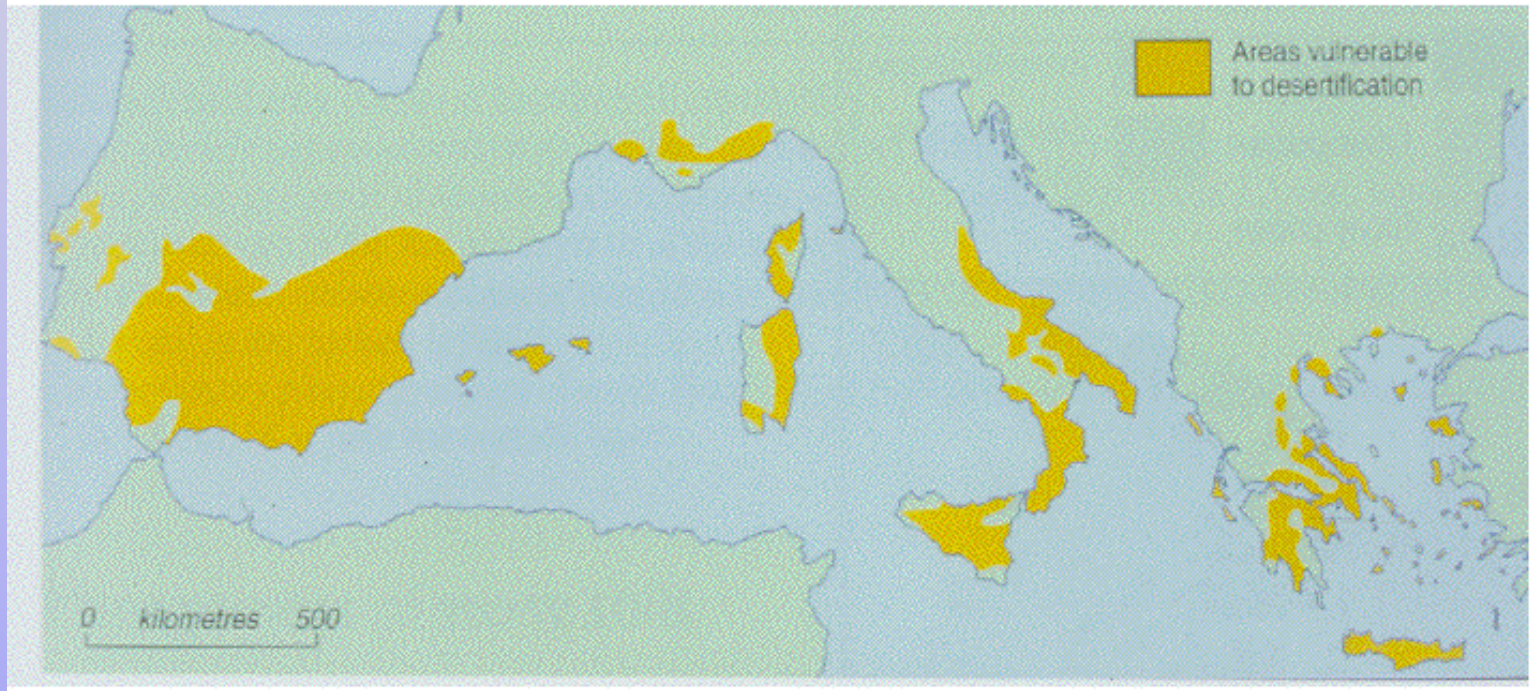
Relatively more dead plants (HU) more fuel - increased fire risk

Drought has the potential to increase dead plant material fraction – increased risk for fires



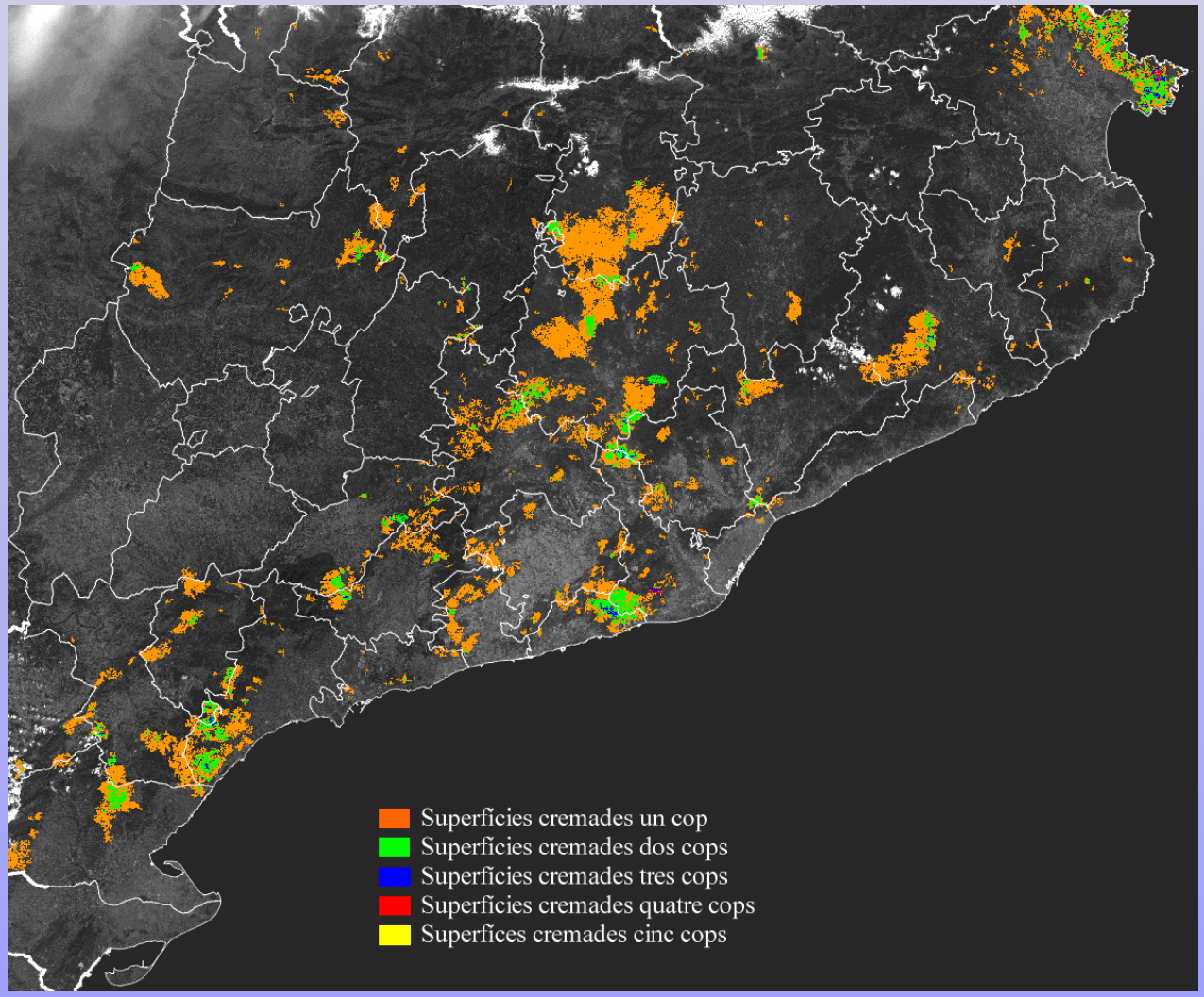
16. EROSION AND DESERTIFICATION

Vulnerable regions



Recurrence of fires

Recurrència d'incendis >30 ha
1975-1995



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Break?

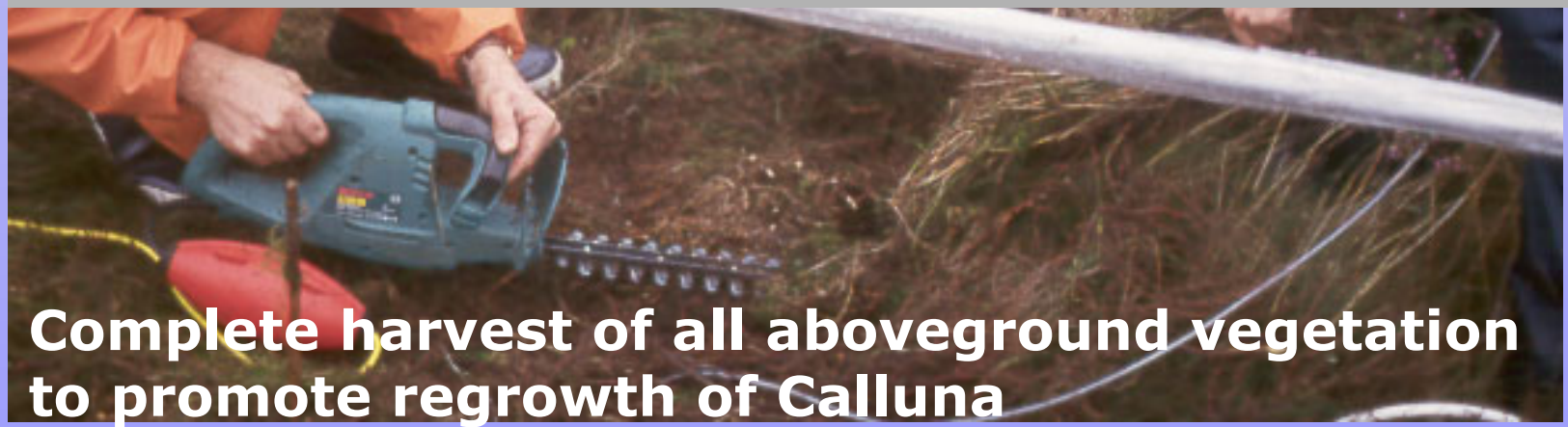
Risk assessment and socio-economic analysis

What are the relative risks to shrublands in the UK, Spain and Hungary, arising from climate change and other impacts?

What are the associated costs?

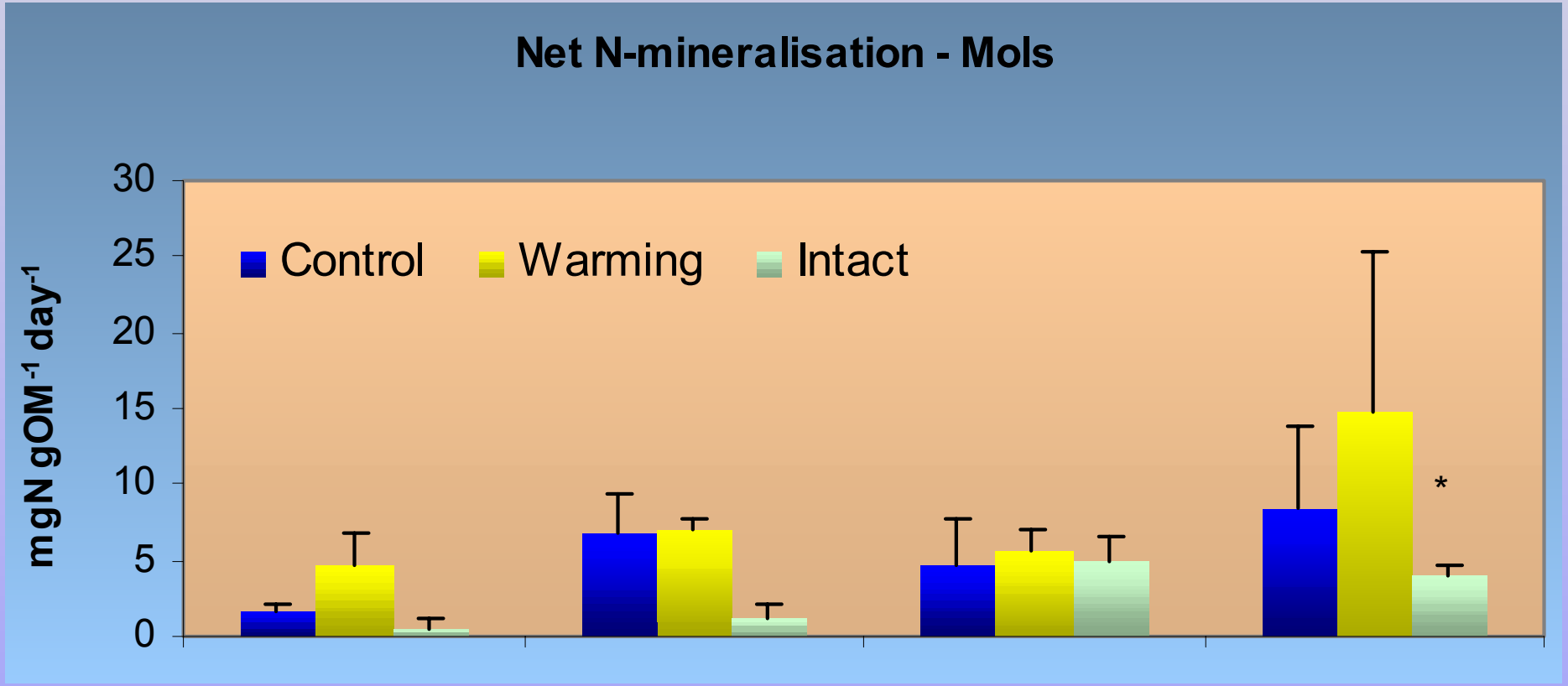
Ecosystem disturbance =

Heather beetle infestation 1999 - 2000
+ complete harvest September 2000



Complete harvest of all aboveground vegetation to promote regrowth of Calluna

Effect on mineralisation



Beetles stimulate mineralisation

Warming/grazing stimulates mineralisation

Vulcan

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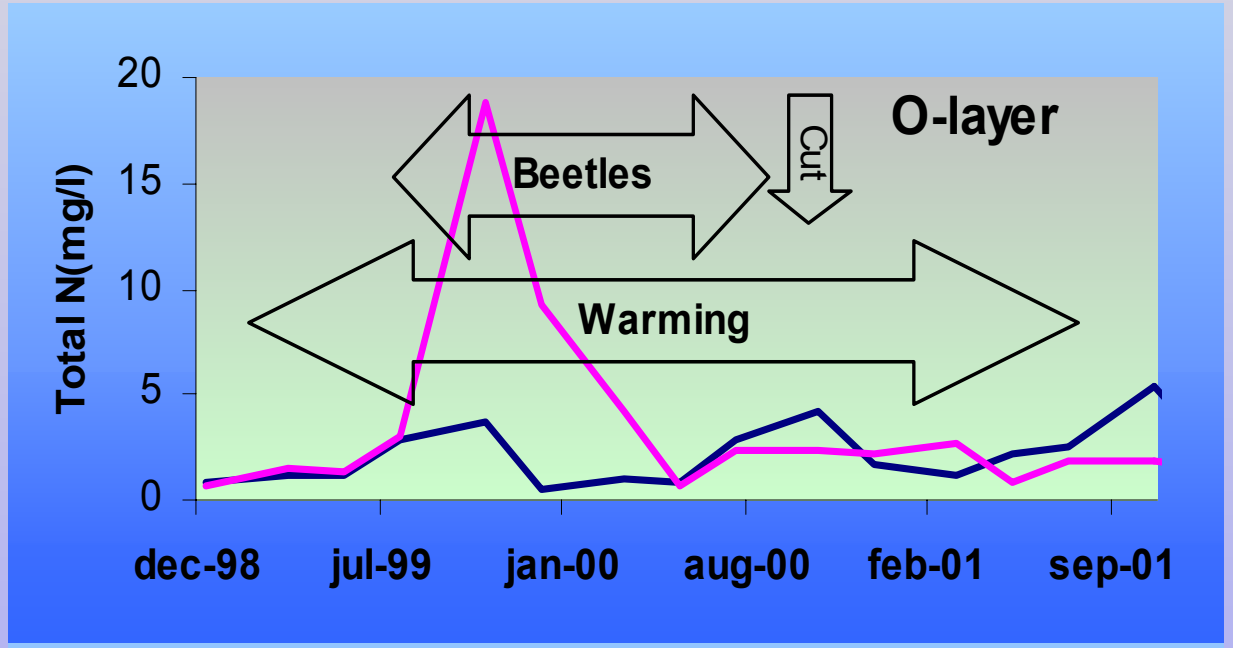
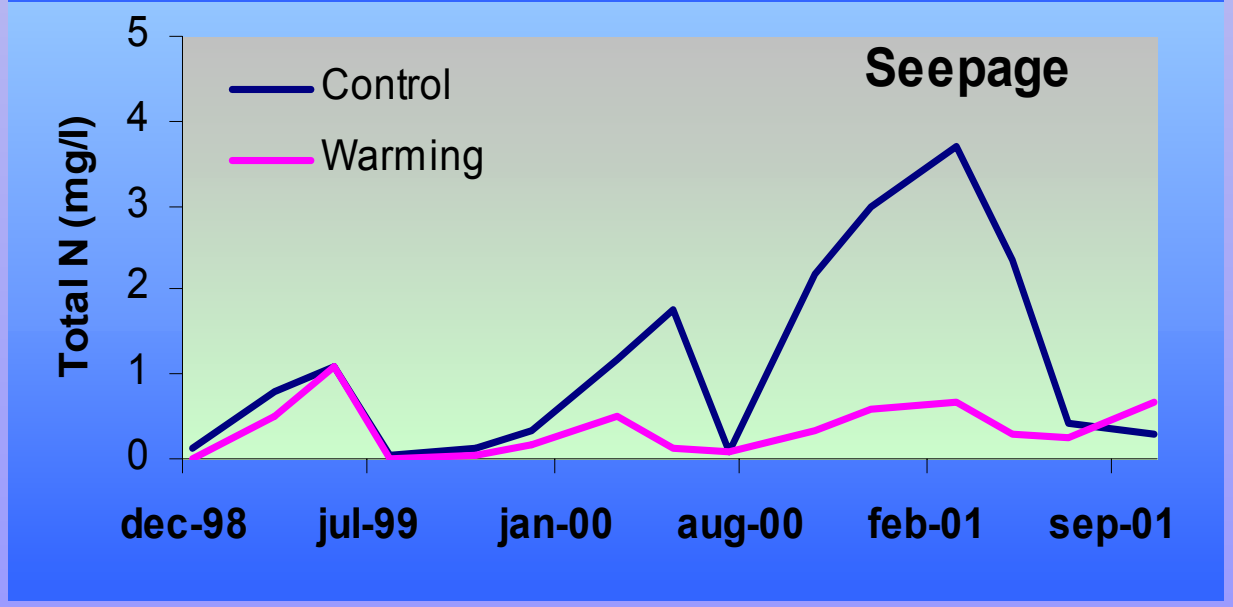
Effects on soil solution

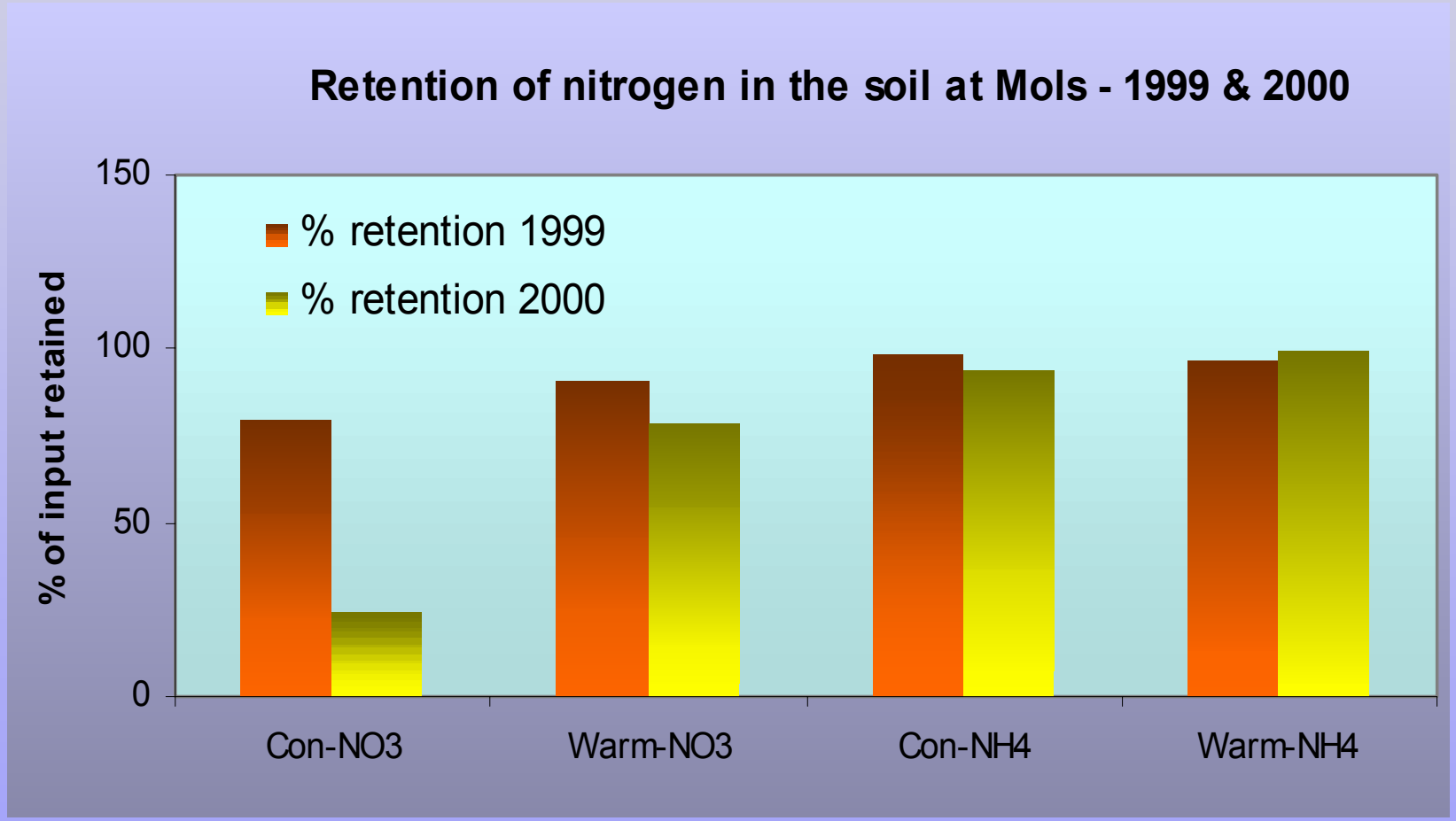


Warming (& beetles) stimulates leaching in O-layer



Beetles & cutting cause leaching

Warming induced plant growth increase retention



Beetles induce short term high loss

Effects of disturbance

- significant increase in nitrogen mineralisation – bigger than warming
- periodic increase in soil water concentrations
- reduced retention of nitrogen
- dramatic changes in ecosystem characteristics (new ecosystem type) – probably dependent on ecosystem status before disturbance

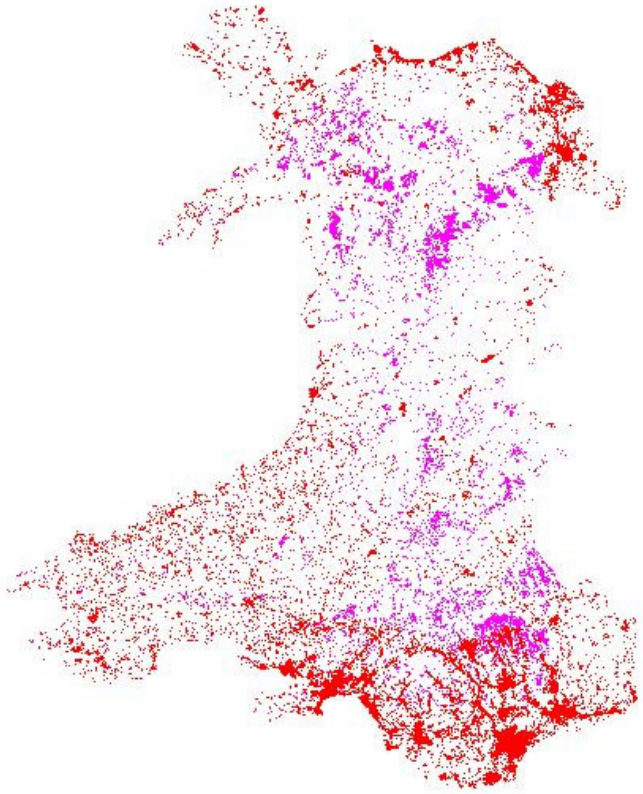
Risk analysis and costs

Very different risks identified for the 3 countries (urbanisation, abandonment etc)

In Spain, erosion the greatest concern for people

2 degree warmer Spain

36 - 69 Euros/person/year



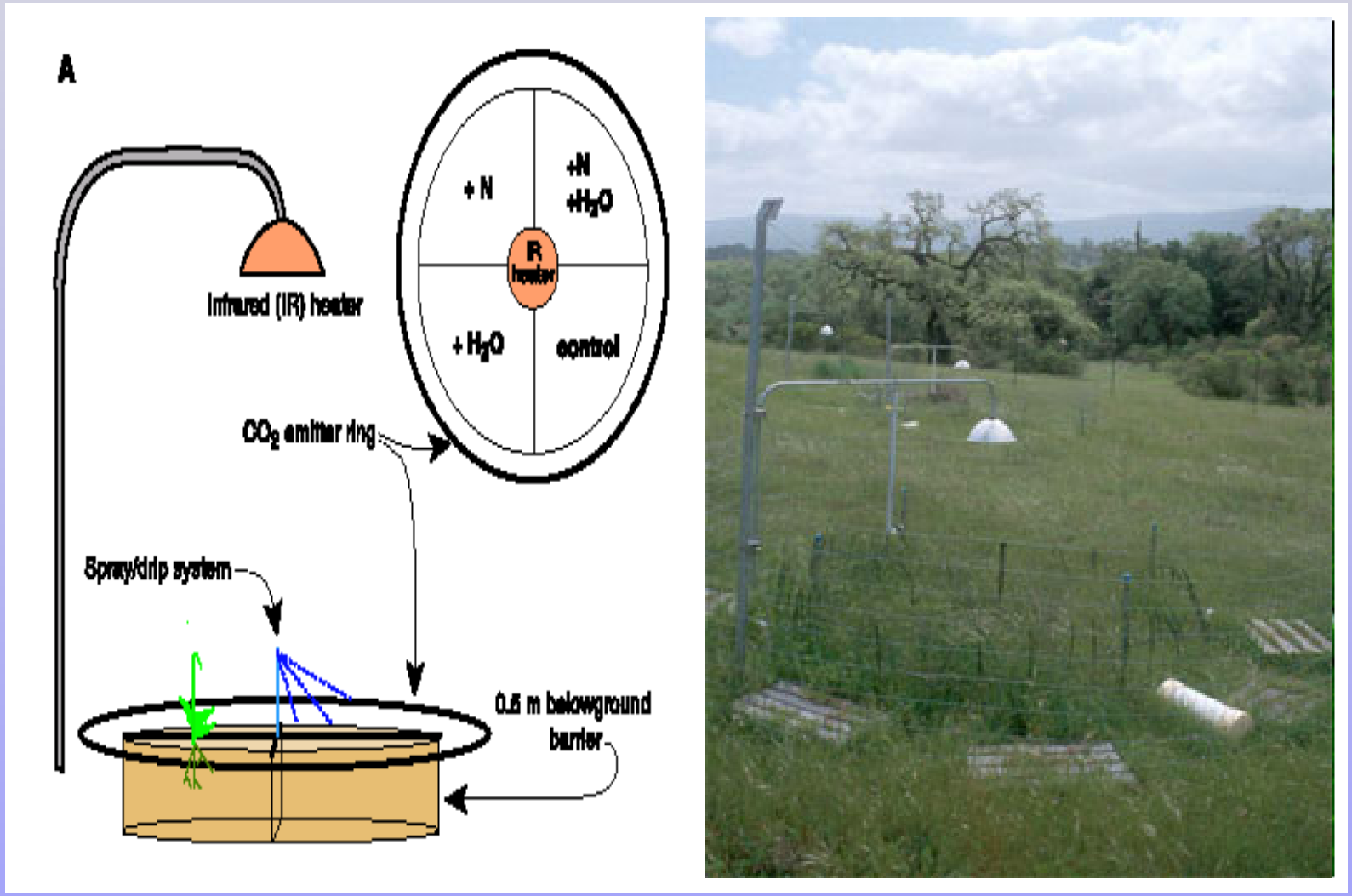
Climate change is a multifactor problem

All you have seen so far was based on single factor experiments

Next generation experiments

RISØ

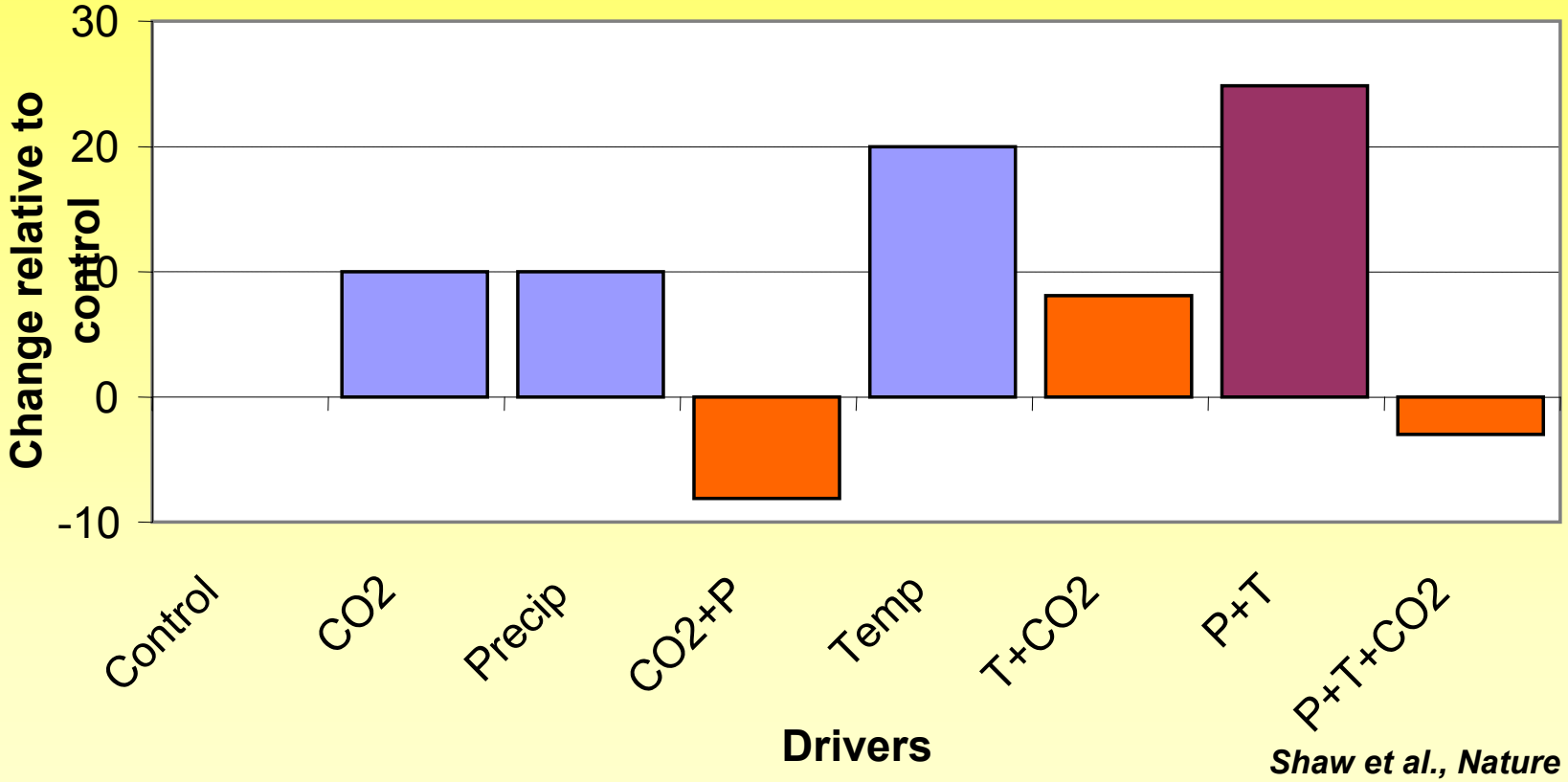
Multifactor experiment



CO2 (FACE) warming, water and N at Jasper Ridge, US

Jasper Ridge – effects on growth

Effect of climate drivers on NPP



Shaw et al., Nature 2002

Effects of elevated CO_2, temperature and altered precipitation –effects are not additive

Maybe because of soil-plant interactions – e.g. microbial removal of nutrients

RISØ

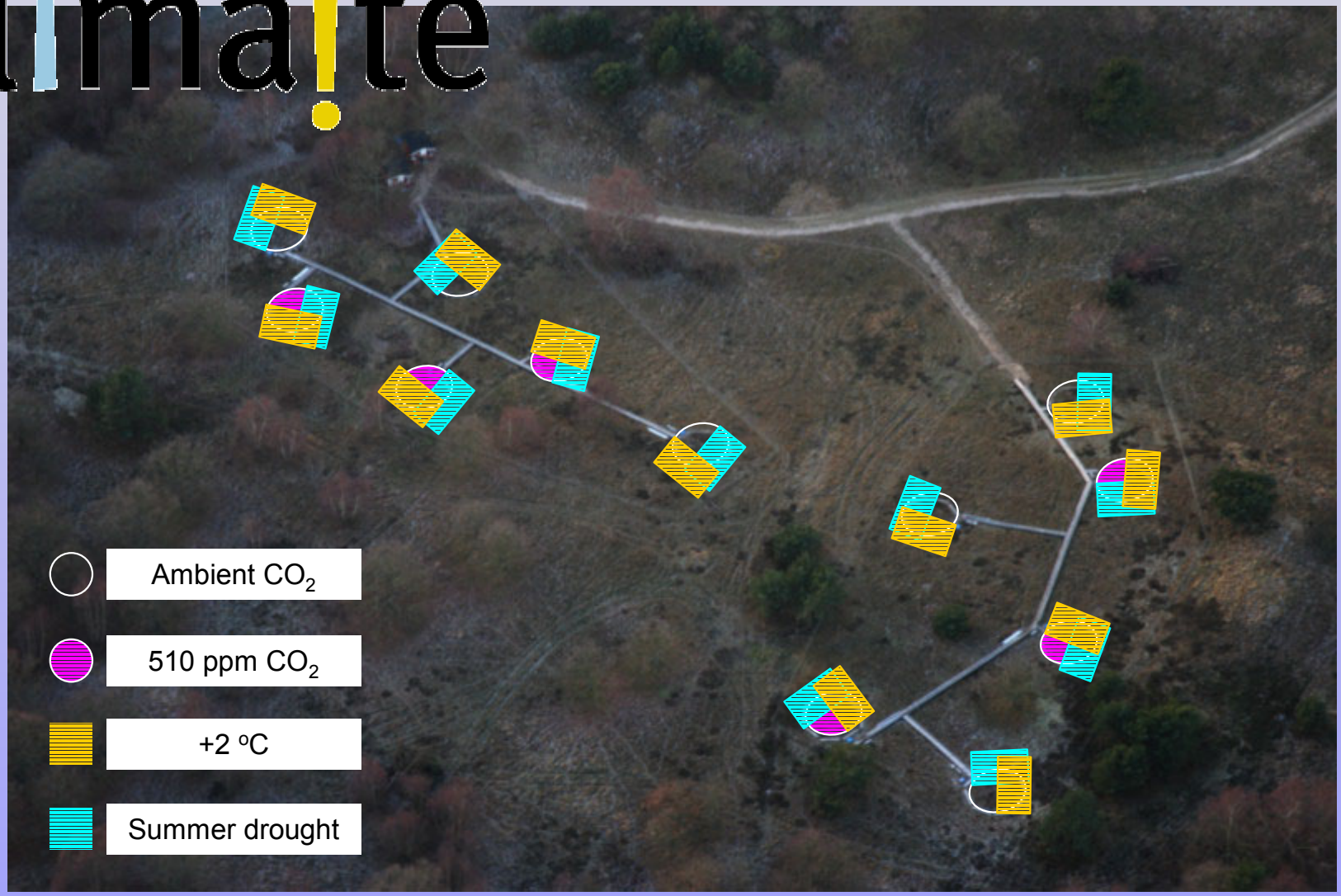
A new Danish multifactor project

Climaite

RISØ

CO_2, temperature and water manipulations

Climate



RISØ

climate

CO_2, temperature and drought

Vulcan

RISØ

Conclusions – climate change and service threats

Biogeochemistry

Climate change has the potential to affect drinking water and surface waters
- but the effects depend on the nitrogen status
- and nitrogen (nutrients in general) may limit growth response to climate change

Carbon storage

Warming has the potential to increase carbon loss from soil – most in cold sites and less in warm (maybe even negative)

Drought generally reduce C loss from soils, except at wet sites – but also interaction with plant growth)

Warming has the potential to increase growth at colder sites on the short term – and response stronger than expected

Biology

Climate change has the potential to affect species composition – implications for biodiversity (species and season specific responses – e.g phenology, winter temperature, herbivory)

Soil structure – growth media

Warming has the potential to reduce plant cover at warm sites – increased risk for soil erosion

Drought has the capacity to change soil structure.

Fire protection

Drought has the potential to increase dead plant material fraction – increased risk for fires

Experimental manipulations and climate change
Questions to the biodiversity community

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Discussions

What are the problems with experiments? – and with observations? – what is a good climate change experiment?

Biodiversity – we need studies focussing on ”functional implications” and”ecosystem functioning” = what are the functional implications if biodiversity change (opposite to traditional taxonomy)

Genetics and adaptation – is genetic diversity parallel to species diversity?

How do we compare climate and LUC?

What do the modellers need?

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The end