

Climate challenges and opportunities in northern and southern Europe

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role of management and exploitation of plant traits in the adaptation of grasslands

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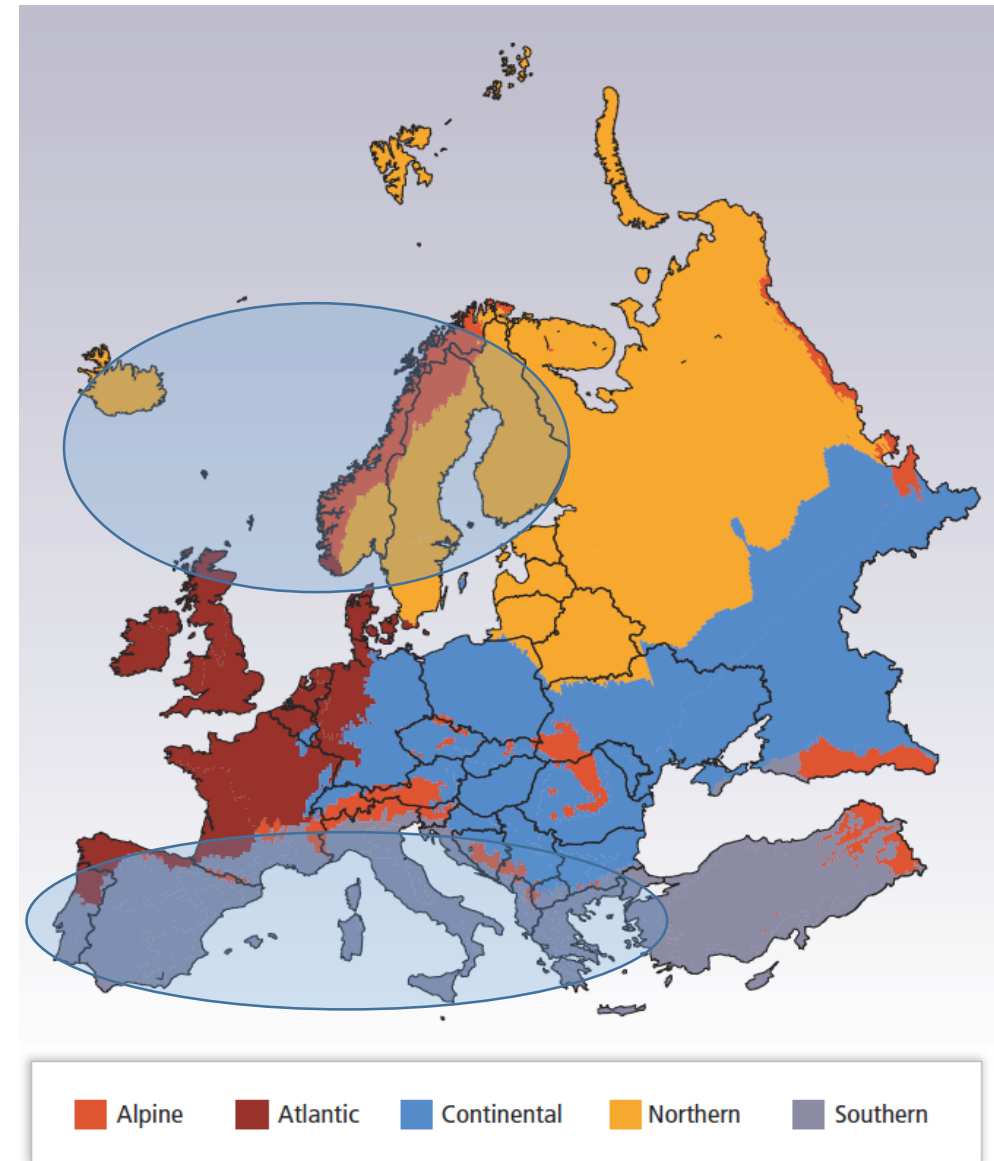
Outline

- Climate change in northern and southern Europe
- What does it mean for grassland production?
- Adaptation through management, breeding and utilization of plant traits

Climate change in northern and southern Europe

N ↑ ↓ S	Higher +	More	Winter
	Temperature	Precipitation	Time of largest change
	Higher	Less	Summer

North-south gradient in climate change



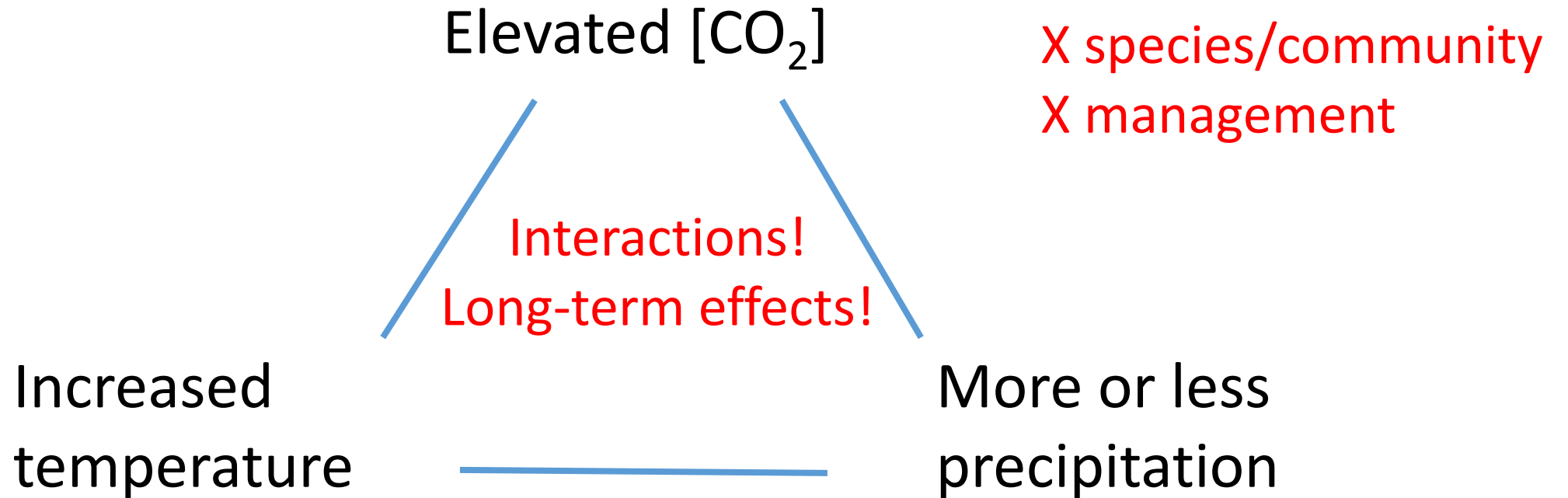
Kovats et al. IPCC 2014

Giannakopoulos et al. *Glob Planet Change* 2009

Mikkonen et al. *Stock Environ Res Risk Asses* 2015

Lehtonen et al. *Int J Climatol* 2014

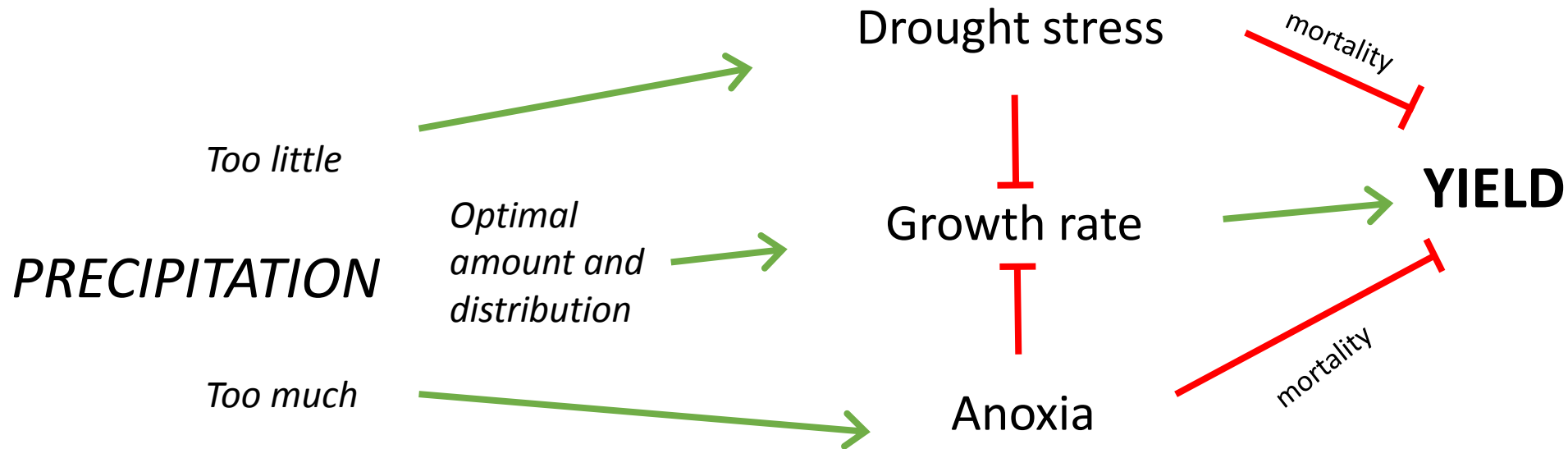
Three main players



The effect of changes in precipitation on yield?

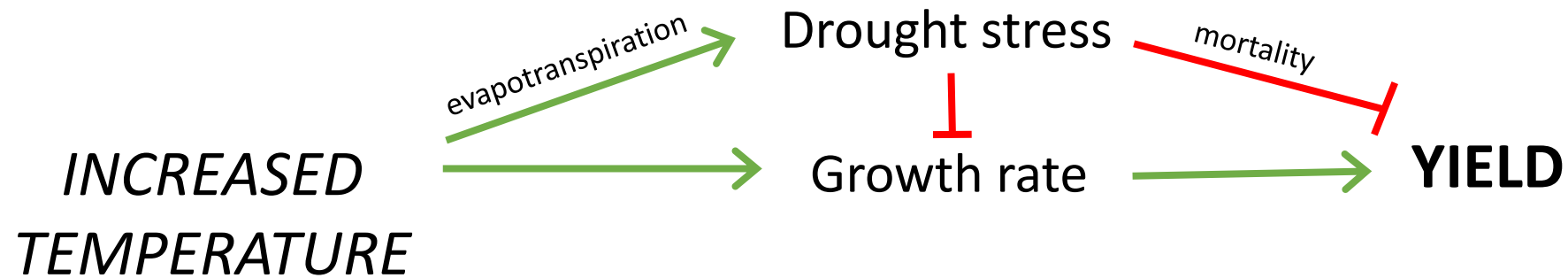
Plant level

→ Positive effect +
— Negative effect -



The effect of increased temperature on yield?

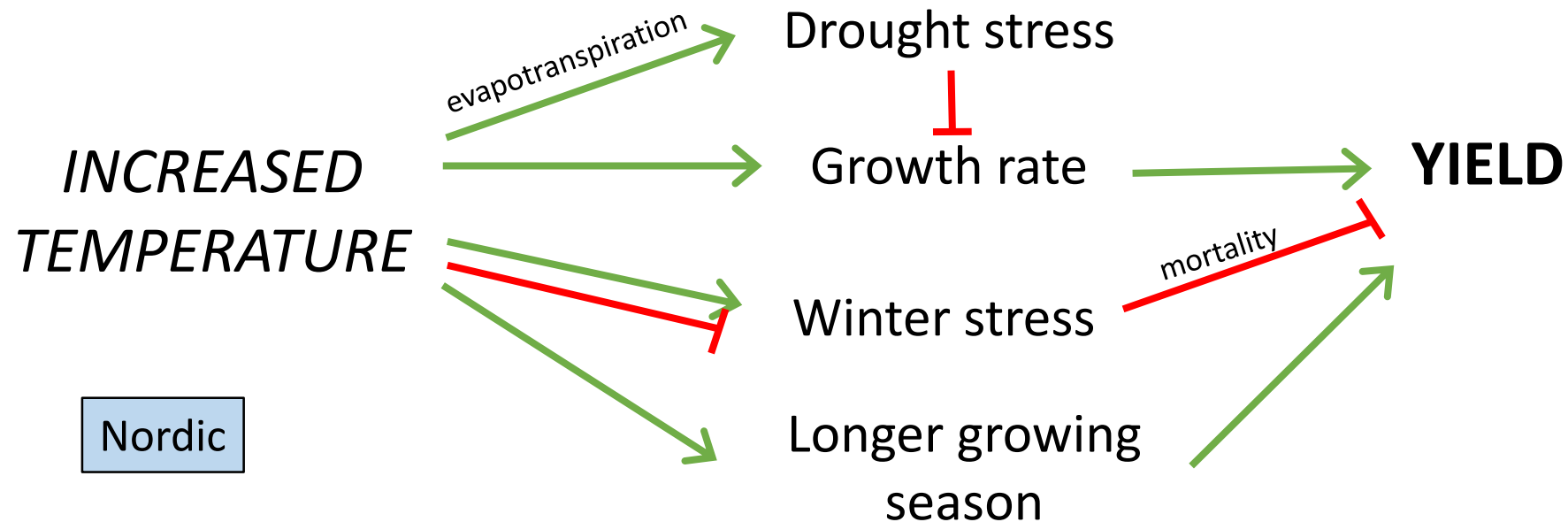
→ Positive effect +
→ Negative effect -





Mediterranean

The effect of increased temperature on yield?

→ Positive effect +
→ Negative effect -



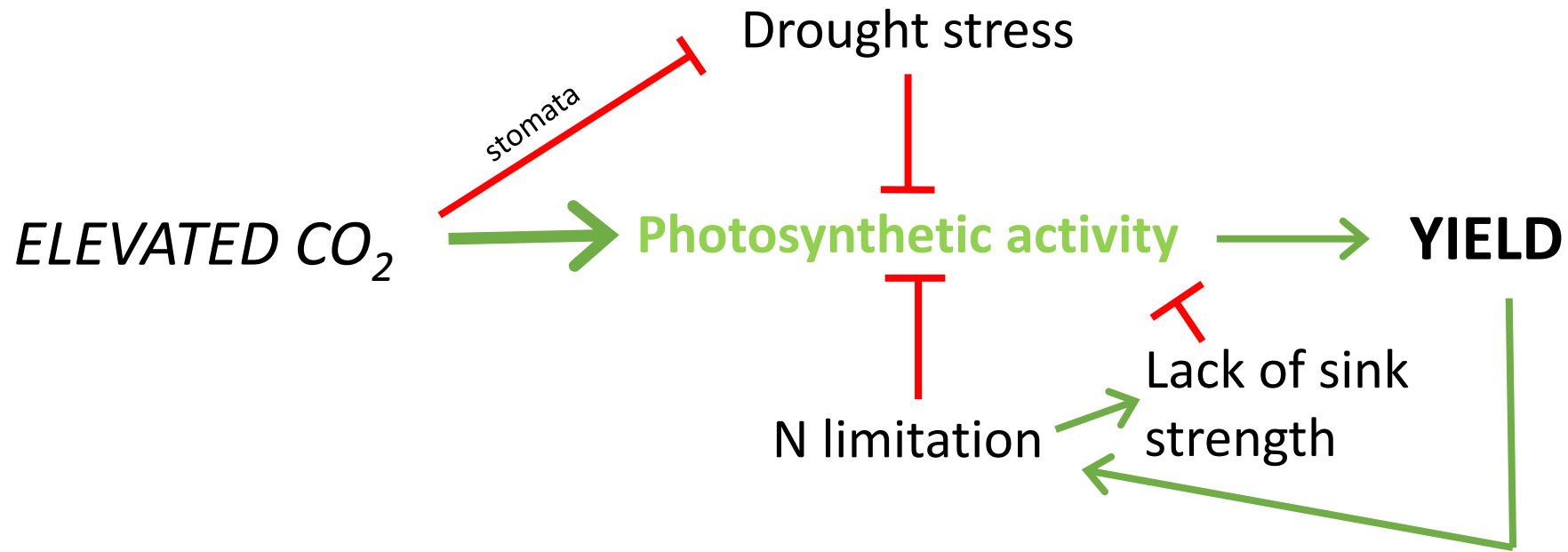
The effect of elevated CO₂ on yield?

 Positive effect +
 Negative effect -

ELEVATED CO₂  **Photosynthetic activity**  **YIELD**

The effect of elevated CO₂ on yield?

→ Positive effect +
⊥ Negative effect -



Effects on agro/ecosystem level

- **Geographical distributions** of species and **interactions** between species
 - Forage plants, other plants, pests and pathogens
 -Due to variation between species in:
 - Growth response functions
 - Regulation of life cycle events
 - Stress tolerance
 - Phenotypic plasticity, potential for rapid evolution
- **Cycling** of N and other nutrients
- Precipitation: **management restrictions** in timing of ploughing, harvesting. Soil compaction and erosion.

Predictions for Mediterranean France, up to 2099

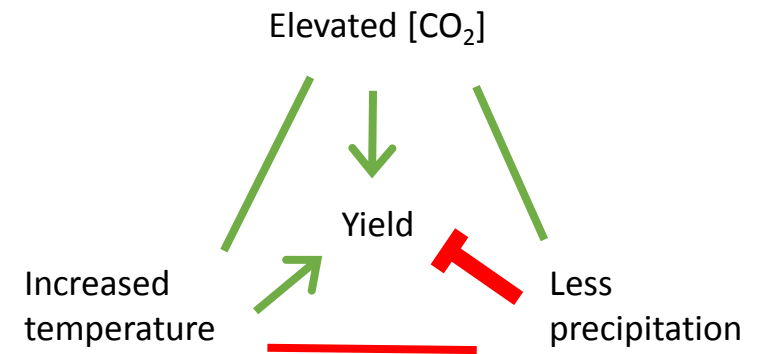
- Increase in annual production

Summer production ↓

Autumn/winter/spring production ↑

Graux et al., *Agric Forest Met*, 2013

Summer:



Predictions for Mediterranean France, up to 2099

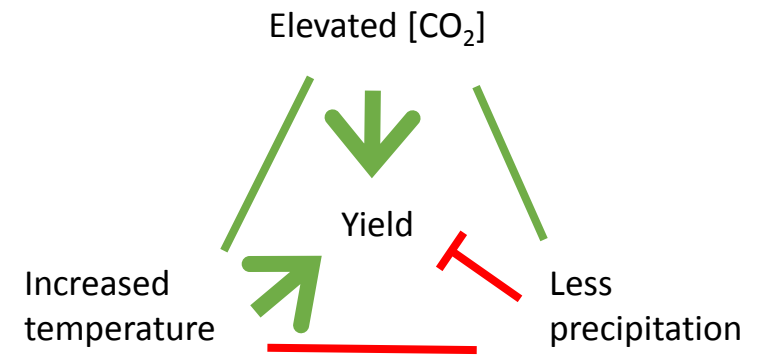
- Increase in annual production

Summer production ↓

Autumn/winter/spring production ↑

Graux et al., *Agric Forest Met*, 2013

The rest of the year:



Predictions for Mediterranean France, up to 2099

- Increase in annual production

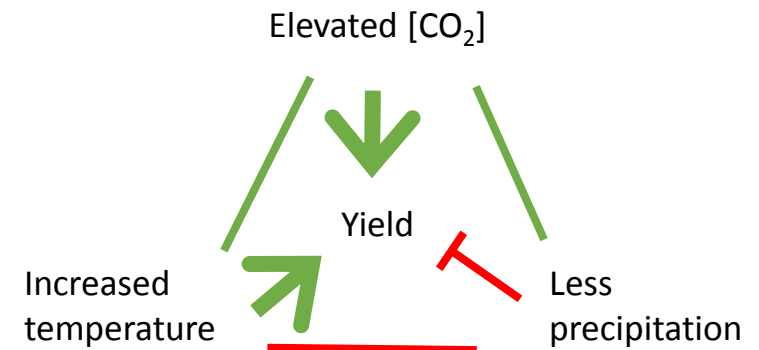
Summer production ↓

Autumn/winter/spring production ↑

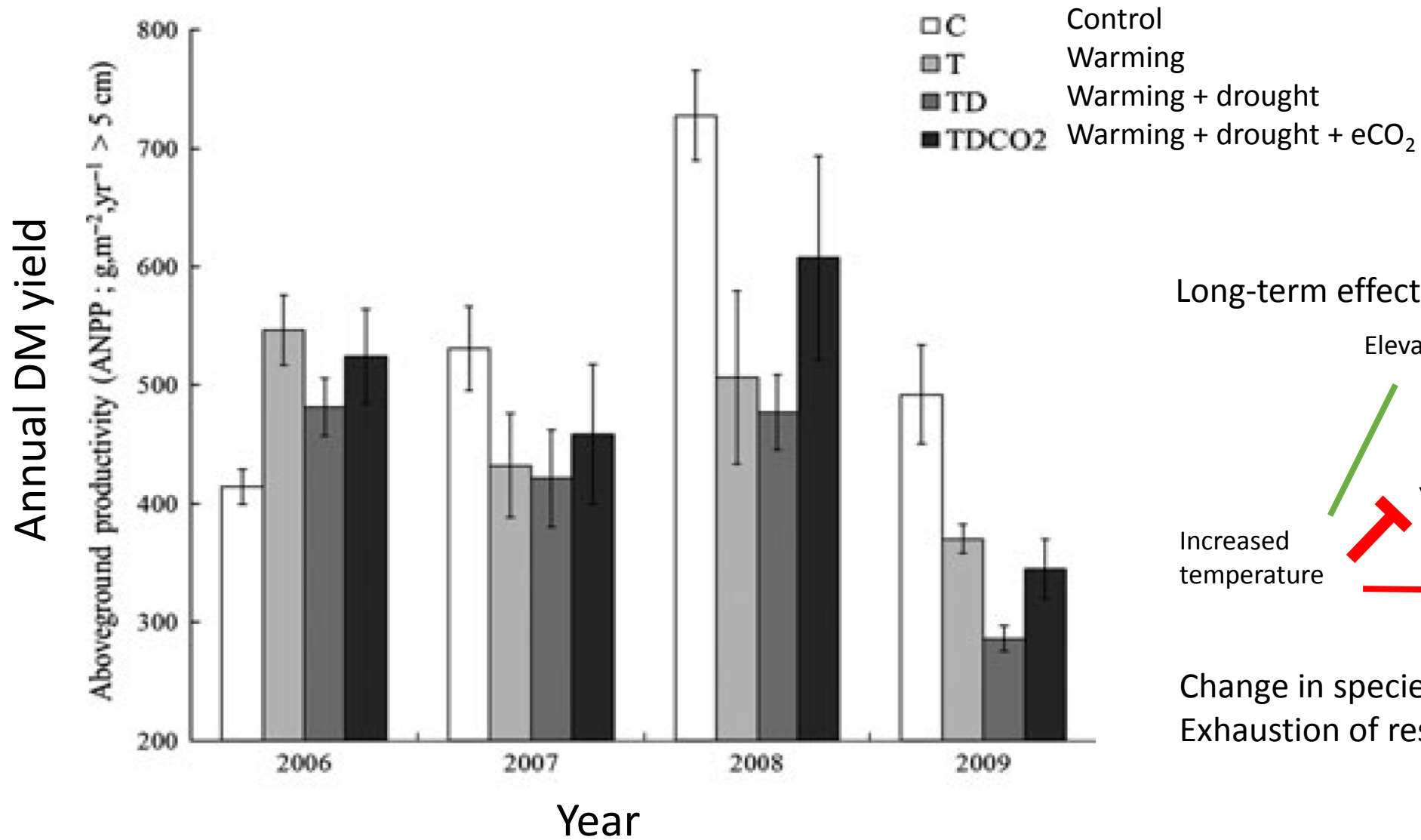
Graux et al., *Agric Forest Met*, 2013

- Not all factors are accounted for, i.e:
 - Changes in species composition
 - Mortality due to stress

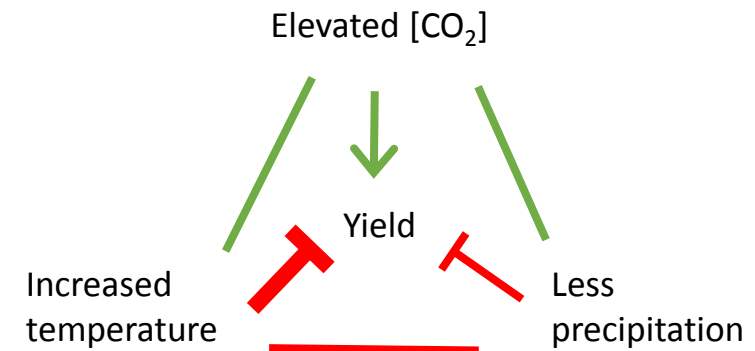
The rest of the year:



UNCERTAINTIES...



Long-term effect:

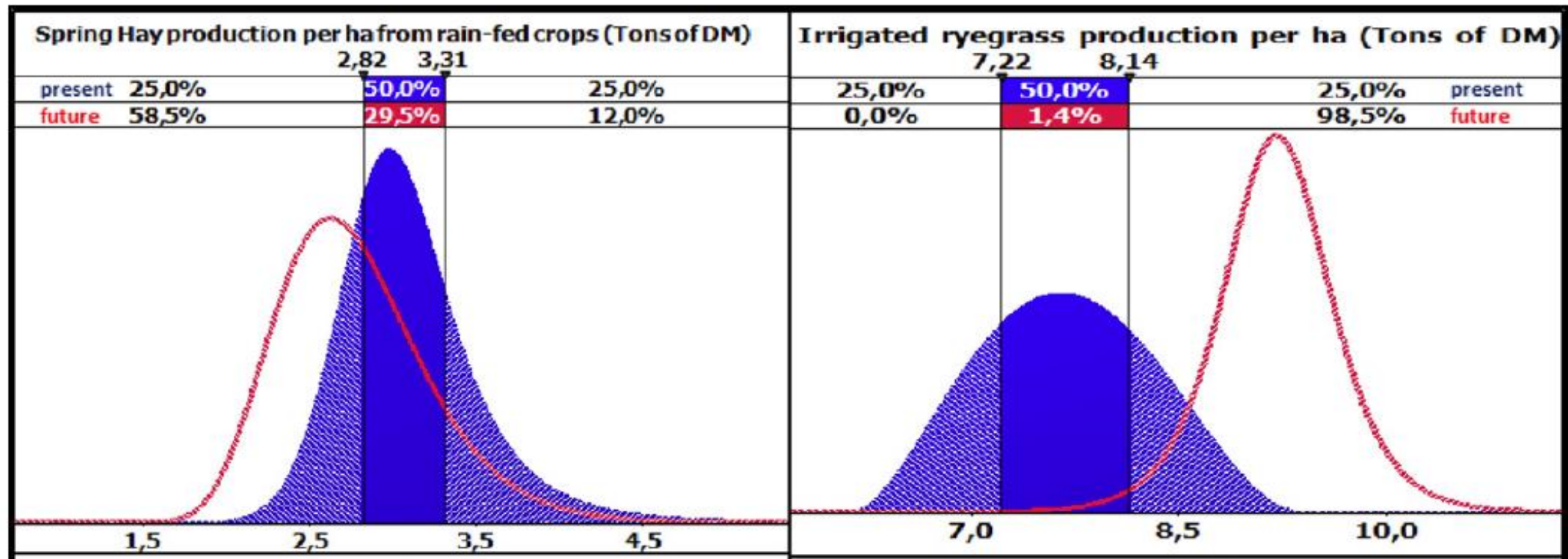


Change in species composition?
Exhaustion of reserves?

Predictions for an area of Sardinia

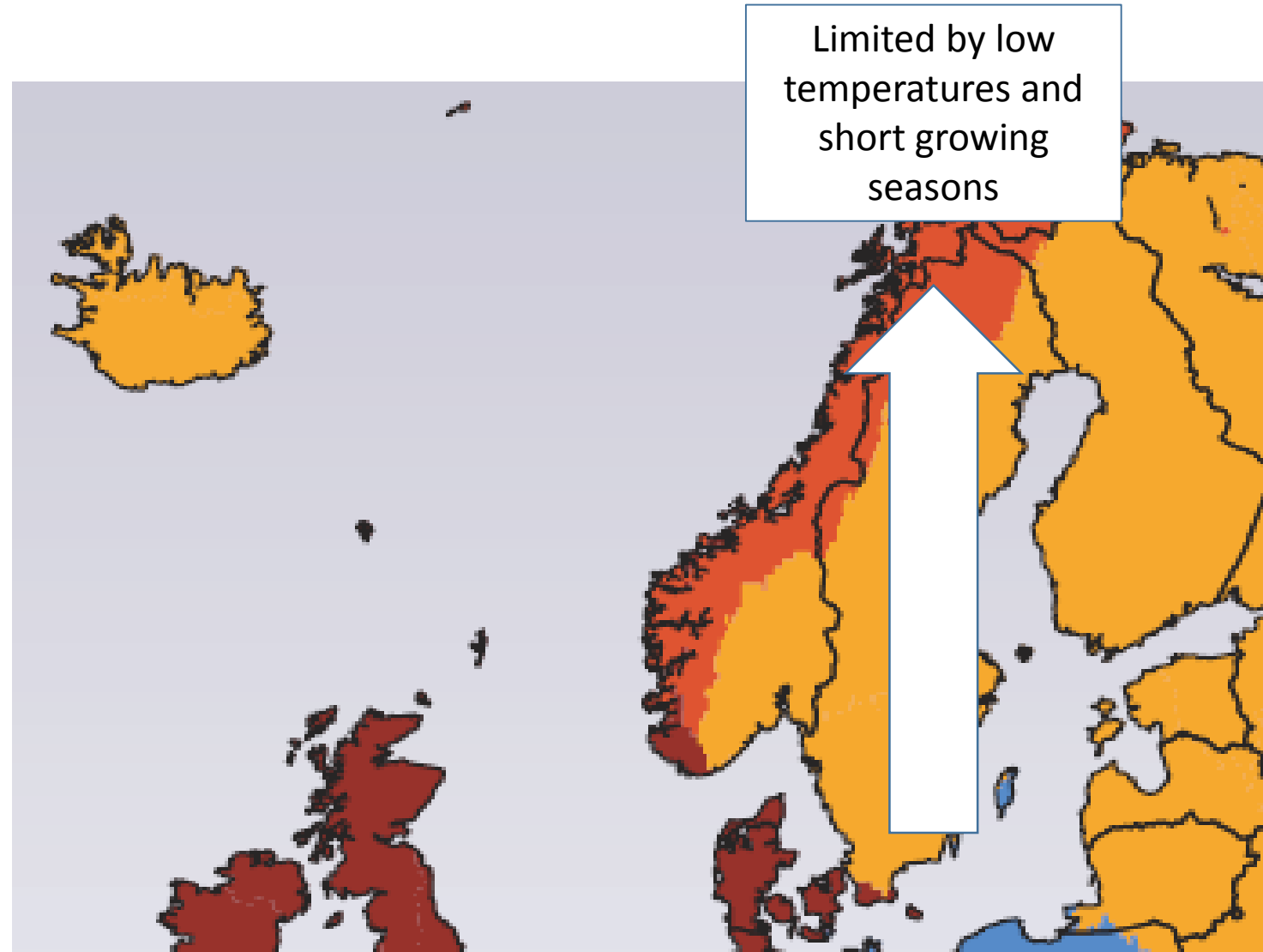
Dono et al., *Agric Syst*, 2016

- Clear difference between irrigated and non-irrigated forage crops/grasslands, 2020-2030 vs. 2000-2010

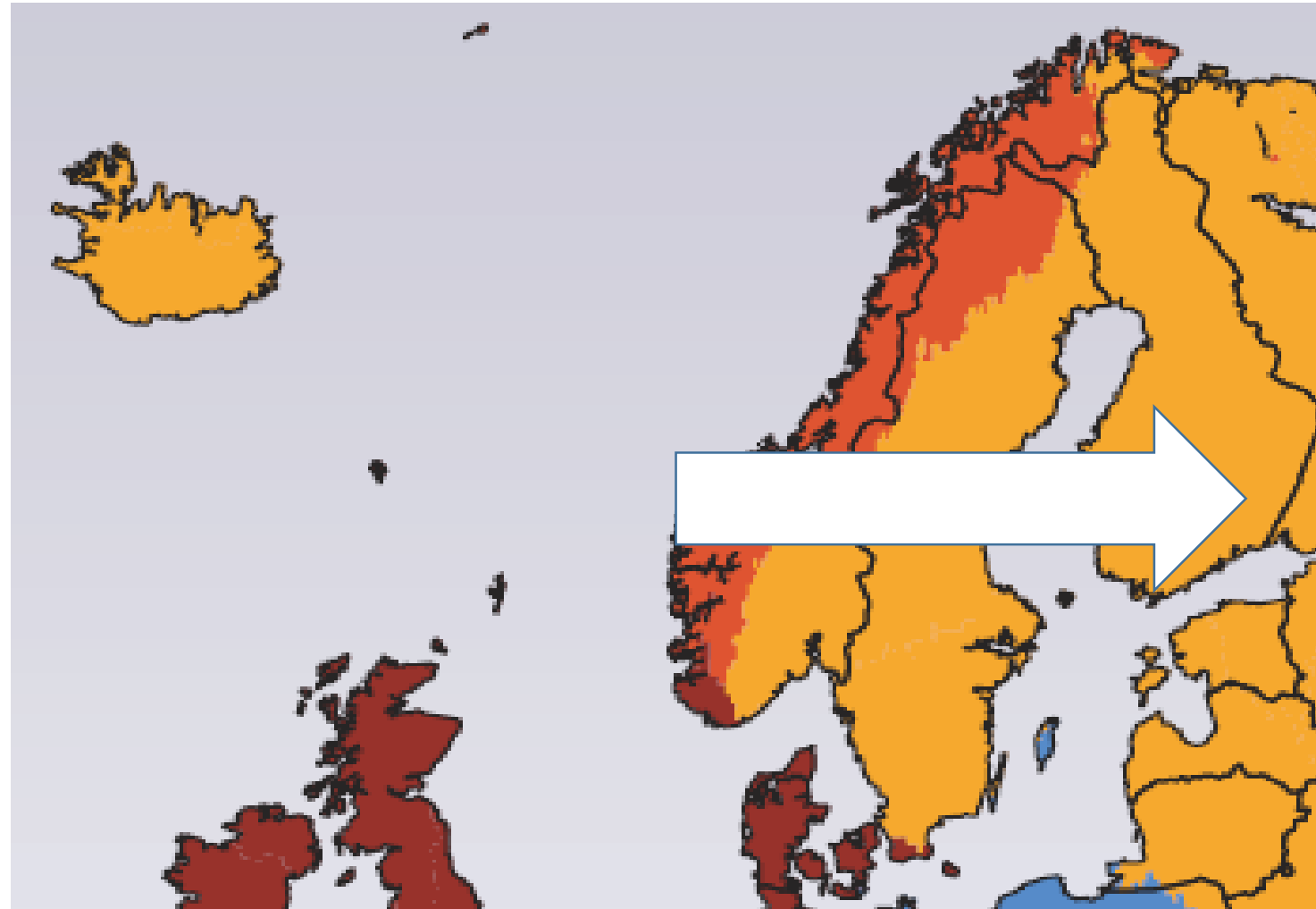


Probability distributions for DM yield

Grassland production in the Nordic region



Grassland production in the Nordic region



Limited by water availability in the growing season

Predictions for the Nordic region

Höglind et al., *Agric Forest Met*, 2013

2040-2065 vs 1960-1990:

- 11 % yield increase
- 2 weeks earlier 1st harvest
- one more cut per year

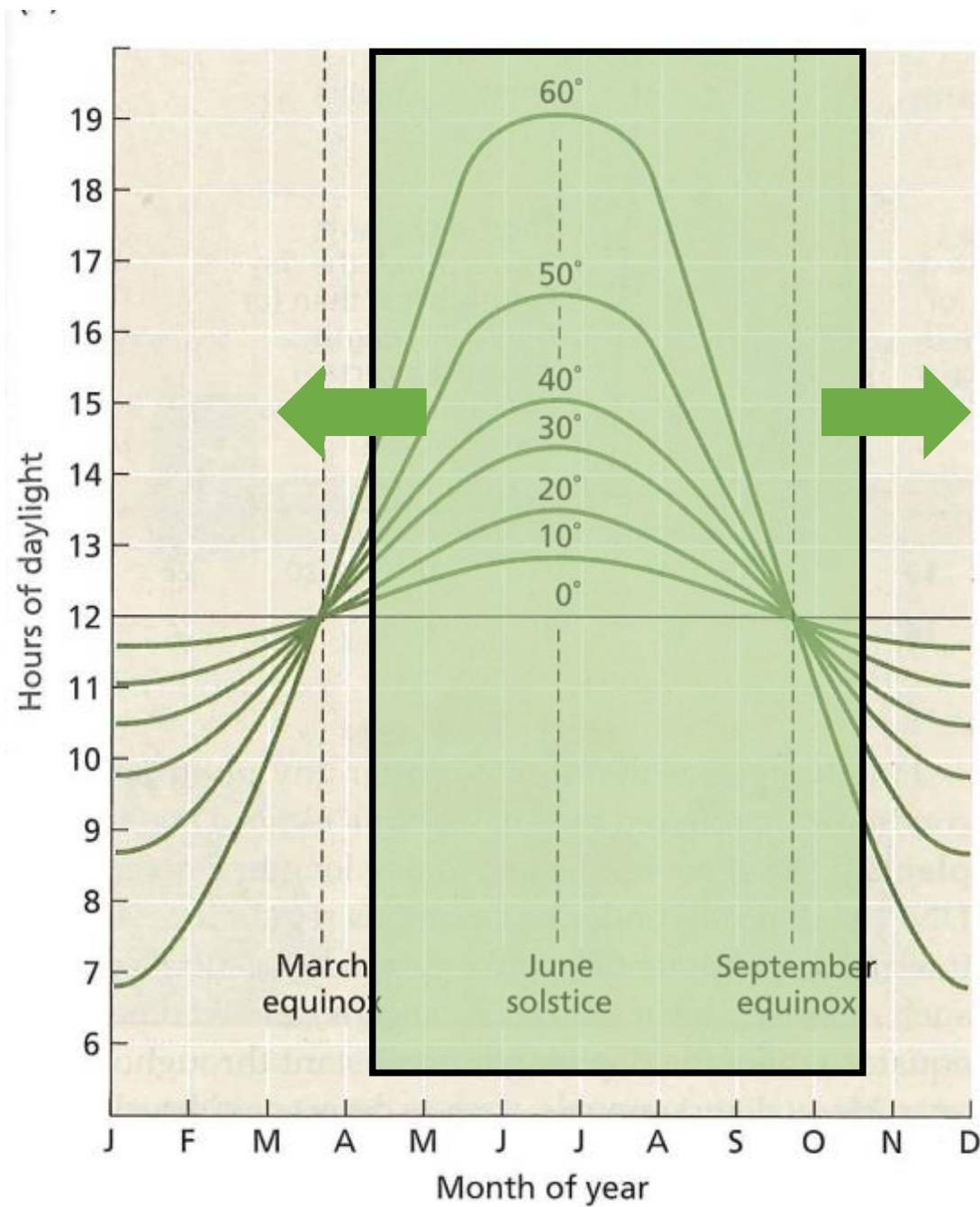
Limitations of the model:

- Timothy pure stands
- Current [CO₂]
- No winter mortality



Earlier springs:

Higher risk of deacclimation followed by freezing



Extended thermal growing season:
- Can we utilize it?

Later autumns:

Enough light?

- for production
- for cold acclimation

High precipitation

- possible to harvest?
- diseases

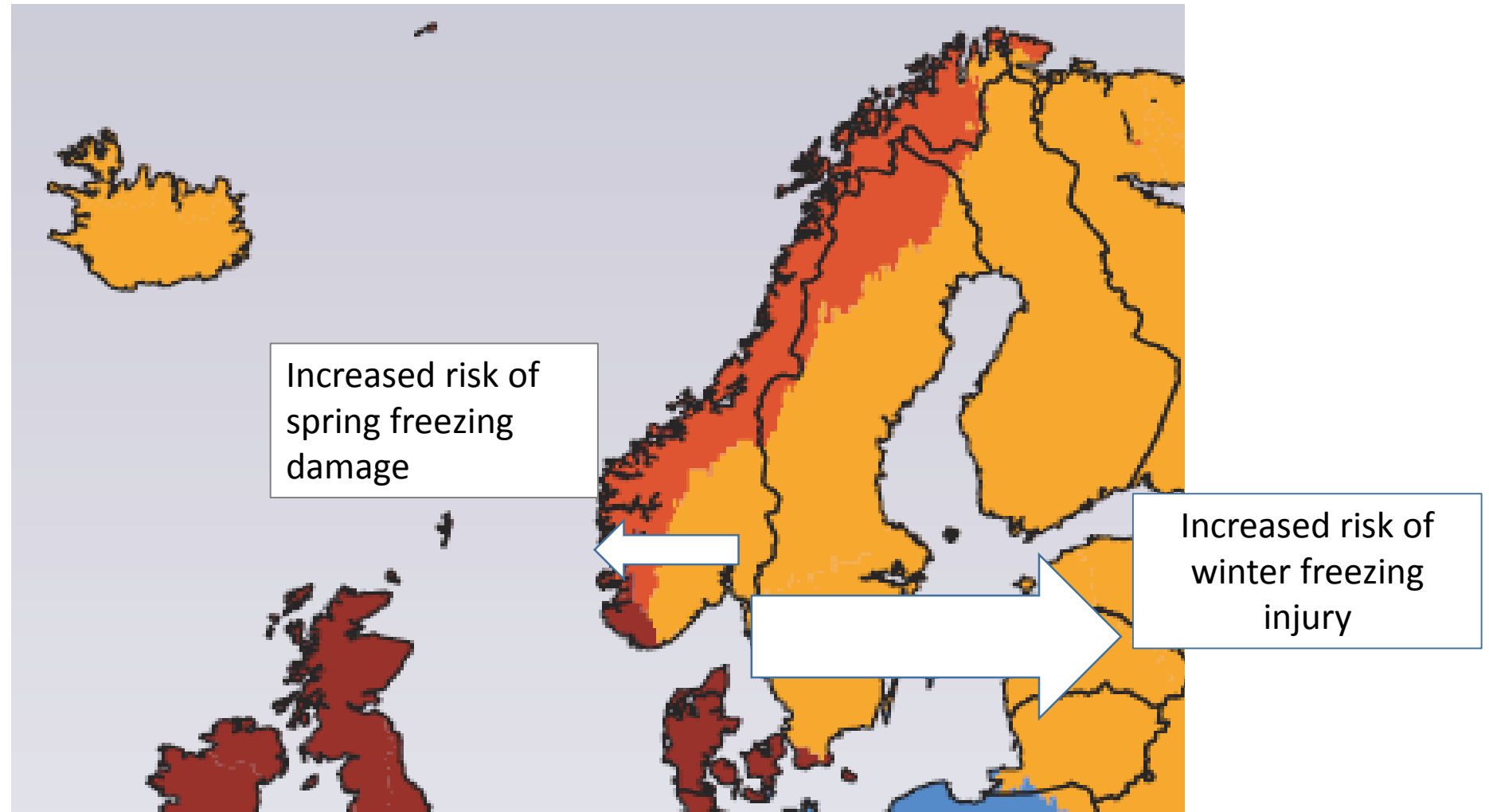
More or less winter damage in the future?

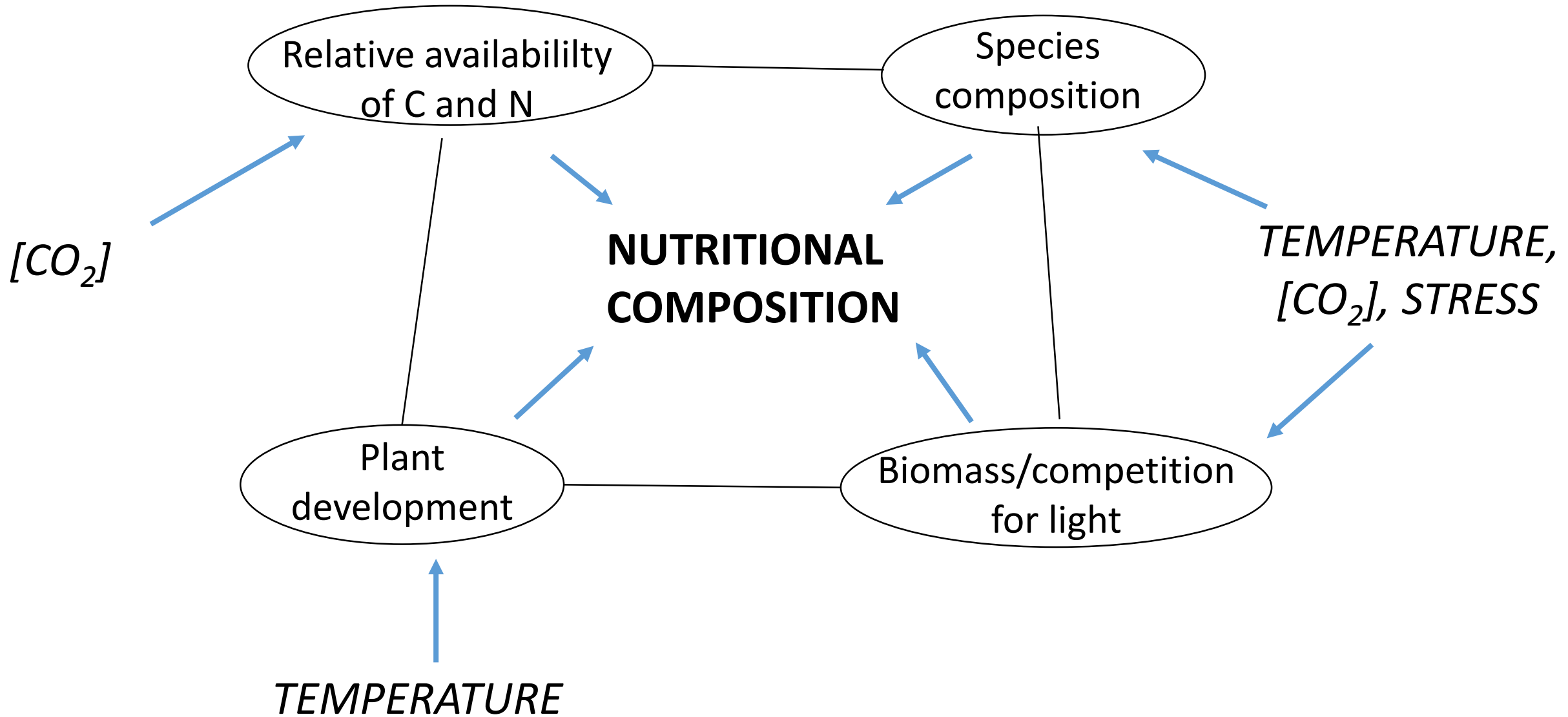
- Milder winters, but...
- Less optimal conditions for cold acclimation
- Less protective snow cover
- More ice cover
- Deacclimation followed by freezing
- Higher respiration rates

Risk of winter damage in the future

(2040-2065 vs 1960-1990)

Höglind et al., *Agric Forest Met*, 2013





Nutritional composition: effects found in a metastudy of climate change experiments

Dumont et al. *Grass For Sci* 2015

- Elevated [CO₂]
 - No effect on structural carbohydrates or digestibility
 - Higher concentration of non-structural carbohydrates
 - Lower N concentration
- Drought
 - Some increase in N concentration with increasing drought
- Warming
 - No consistent effects
- [CO₂]-effect on N concentration was not seen in Mediterranean sites
 - Counteracting effect of drought or of increasing legume abundance?

Conclusions – yield and quality

Nordic region

Higher **productivity**?

Negative effect on **digestibility** can be handled through management?

Mediterranean Europe

Non-irrigated grasslands:

- A shift in annual **productivity** patterns?
- Negative effect on **digestibility** counterbalanced by drought and increase in legume proportion?

Irrigated grasslands/forage crops:

- Higher **productivity**?
- Negative effect on **digestibility** can be handled through management?

Climate challenges and opportunities

- Challenges

- Handle **uncertainties**
- Adjust to new **seasonality** patterns
- Manage plant **stresses**: drought, freezing, anoxia, diseases
- Manage **practical problems** due to increased precipitation

- Opportunities

- Utilize elevated [CO₂] to increase production, or limit drought stress
- Utilize higher temperature and new parts of the year to increase production
- Utilize «better» species or genetic material

Adapting through management: Harvesting, grazing and nutrient supply

Nordic region

- Increase **defoliation frequency**
- Increase **nutrient supply** (fertilization or legumes)
- Take care to avoid **soil compaction**

Mediterranean Europe

Non-irrigated grasslands:

- Modify annual patterns of **defoliation** and **nutrient supply**

Irrigated grasslands/forage crops:

- Increase **defoliation frequency**
- Increase **nutrient supply**

Adapting through choice of plant material and breeding: Plant material for sown grasslands

Nordic region

- Plants with a high **growth potential** and **defoliation tolerance**, flexibility in timing of harvesting
- Plants that cope with relevant winter **stresses**, drought and anoxia
- Plants that fit new **seasonality**

Mediterranean Europe

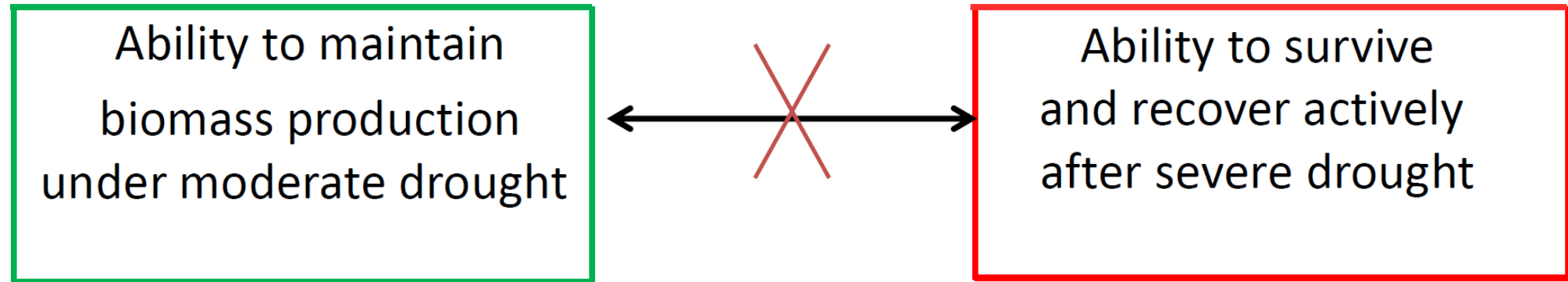
Non-irrigated grasslands:

- Plants that cope with **drought**
- Plants that fit new **seasonality**

Irrigated grasslands/forage crops:

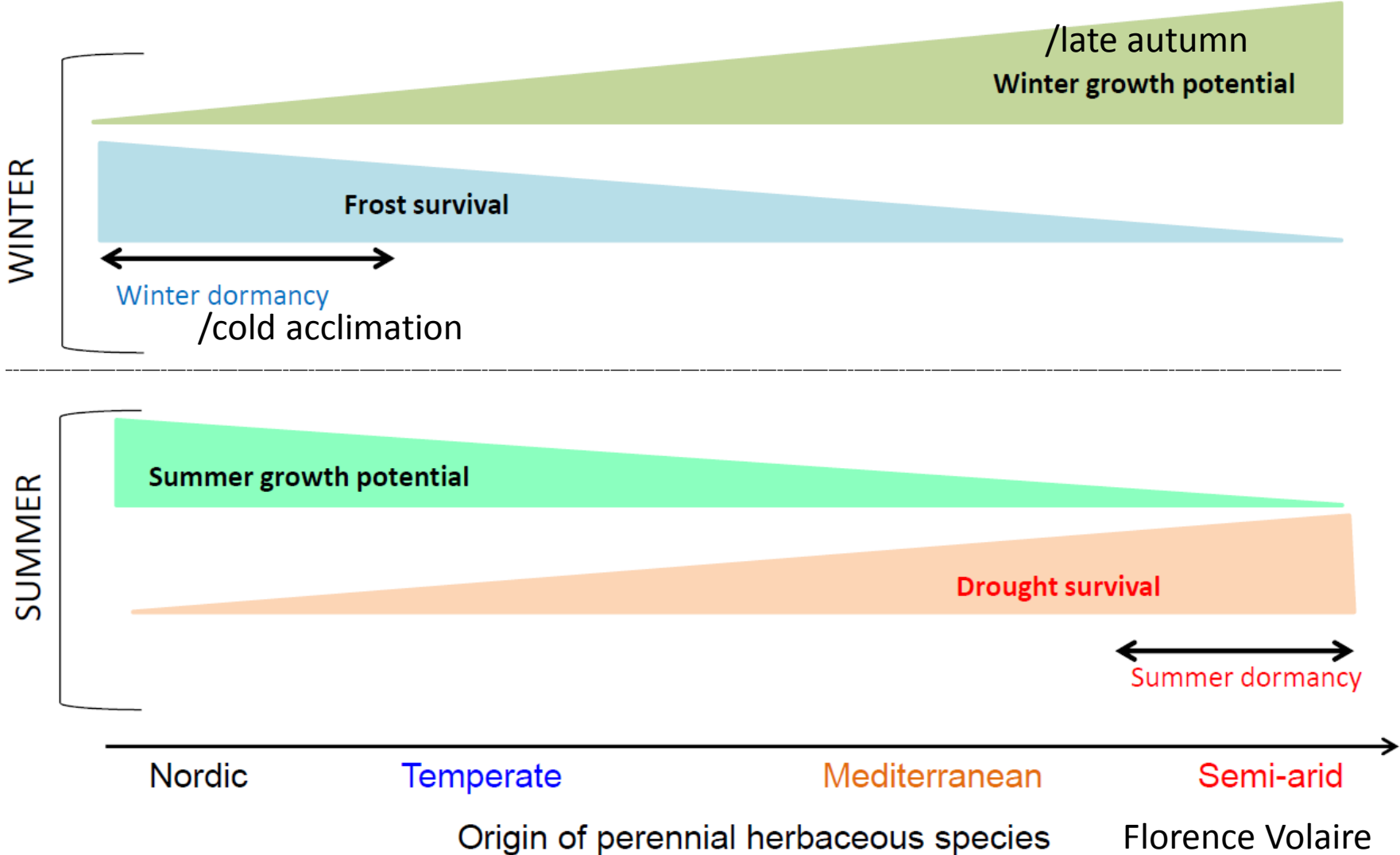
- Plants with a high **growth potential** and **defoliation tolerance**

Different plant strategies to handle stress



A **trade-off** between
yield and survival

A general trade-off between growth and stress survival



Growth/survival strategies



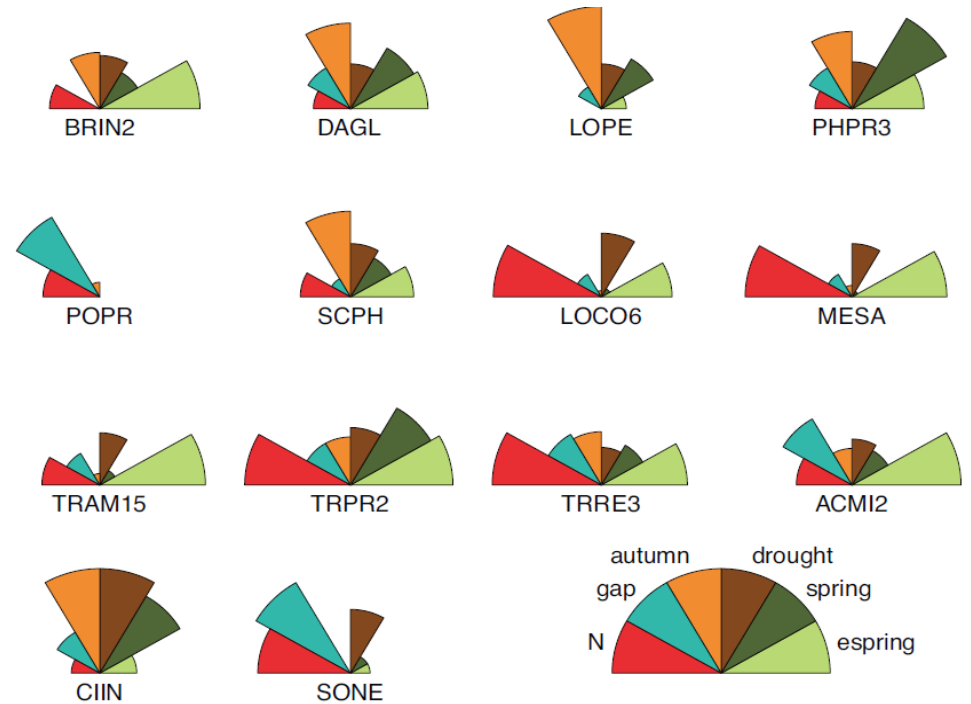
Seasonality regulated by temperature and photoperiod

Amongst all the tradeoffs and environmental variation: what is the optimal genotype?

- Use grassland models to identify the optimal combination of traits (ideotype) Van Oijen and Höglind, *Euphytica* 2016
- Genomic selection for efficient selection

Adapting through choice of plant material: Composing better mixtures

- Goal: obtain optimal combination of
 - Yield and nutritional composition
 - Yield and nutritional stability
 - Resilience
- Partly relies on trait complementarities
- Method development



Not only problems – opportunities also!

Diversity is a strategy to handle uncertainty and variability:

- Types of forages and grasslands
- Species mixtures
- Genetic diversity within species
- **AND a diversity of PEOPLE!**

