

Mountains under watch 2013



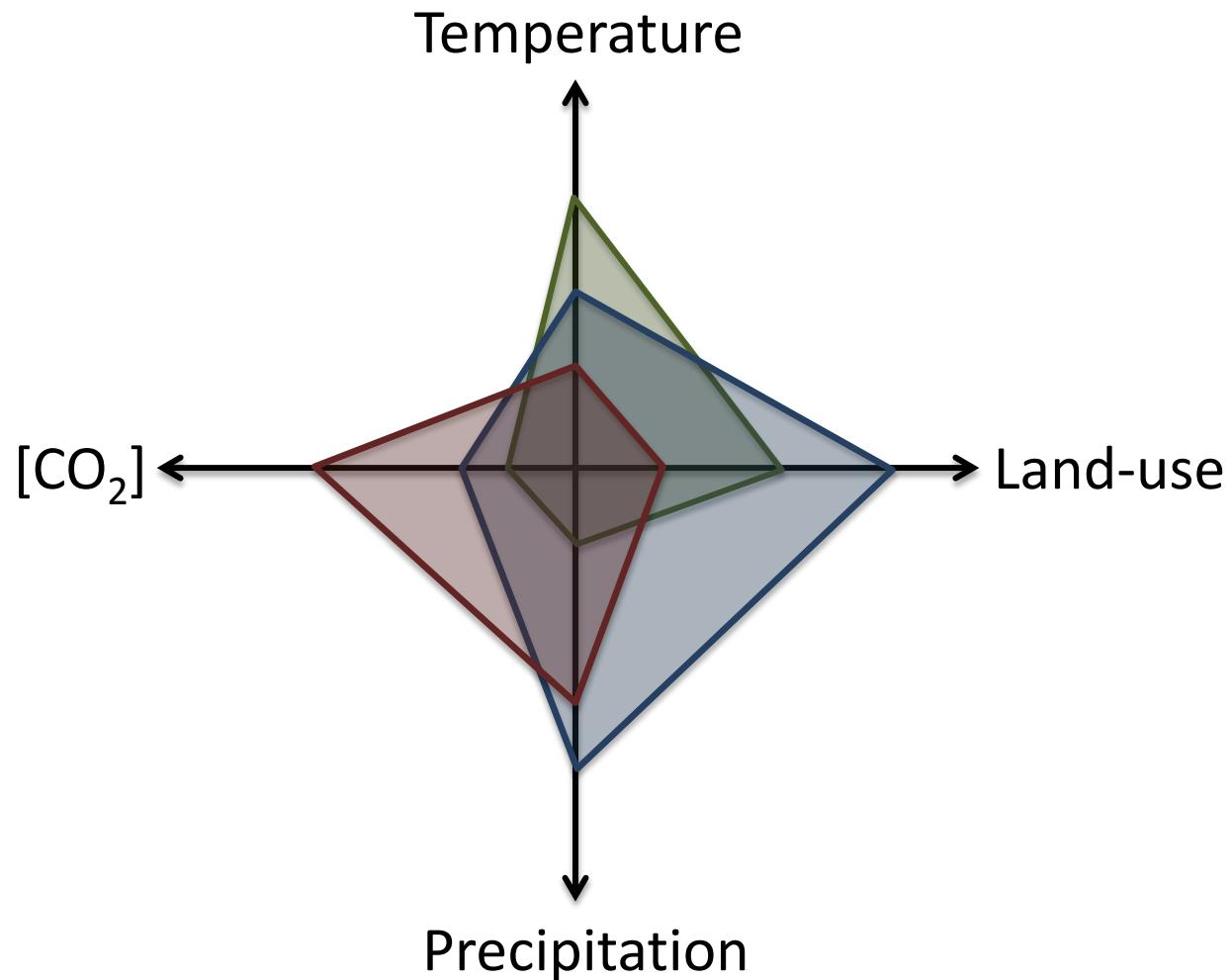
Effects of global changes on mountain ecosystems

Georg Wohlfahrt (Univ. Innsbruck, Austria)

Key note, 20 February 2013, Bard, Valle d'Aosta, Italia



Drivers of change



Carbon dioxide

$9.1 \pm 0.5 \text{ PgC } \text{y}^{-1}$



$5.0 \pm 0.2 \text{ PgC } \text{y}^{-1}$

50%



$0.9 \pm 0.7 \text{ PgC } \text{y}^{-1}$



$2.6 \pm 1.0 \text{ PgC } \text{y}^{-1}$

26%



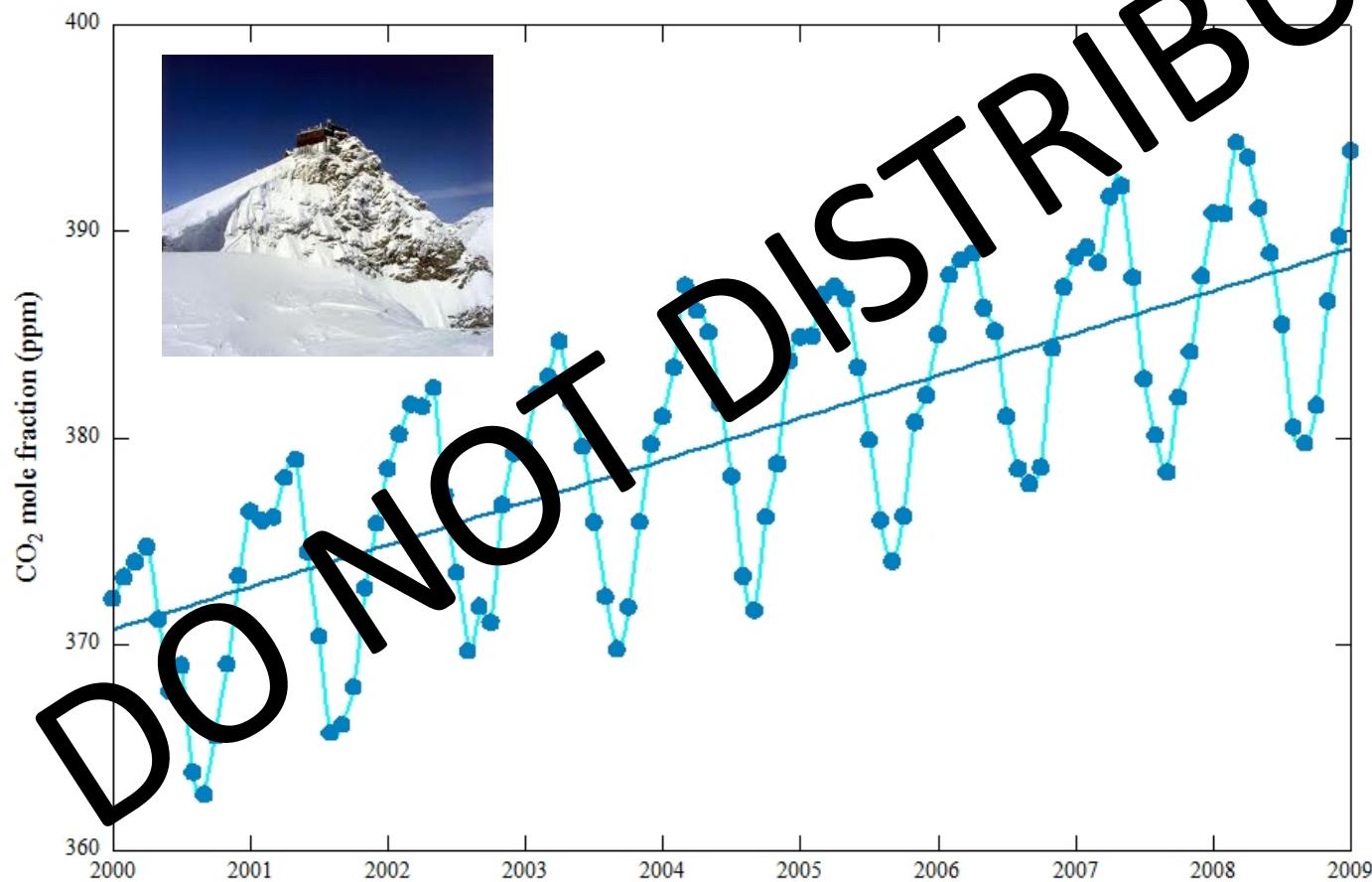
$2.4 \pm 0.5 \text{ PgC } \text{y}^{-1}$

24%





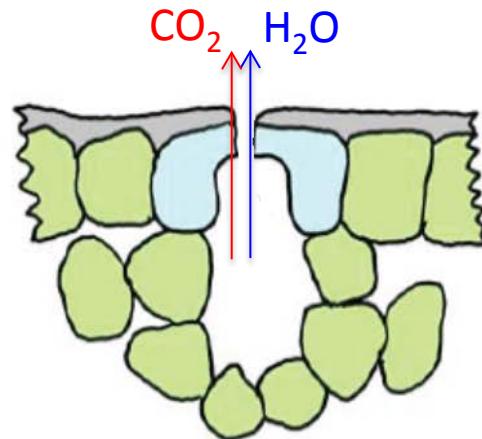
Carbon dioxide



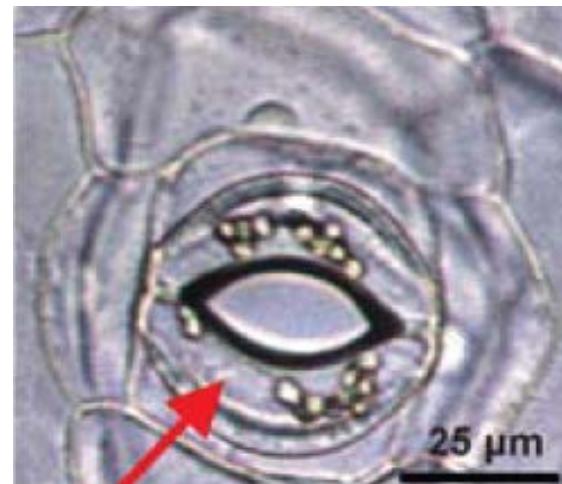
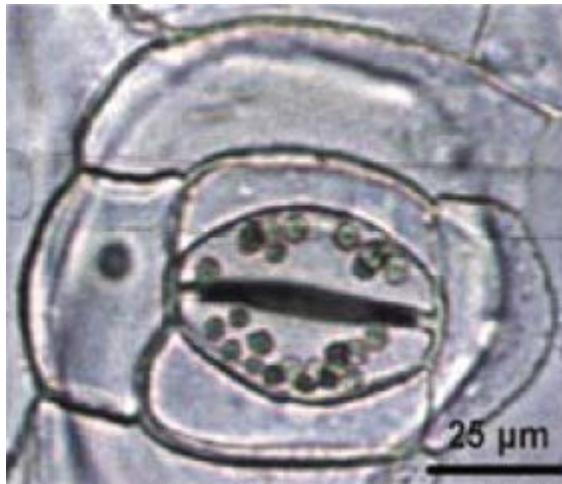
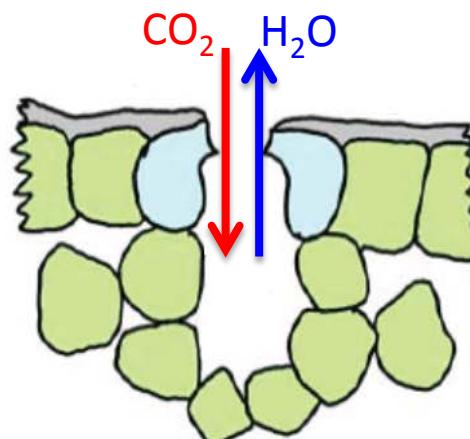


Carbon dioxide

Night

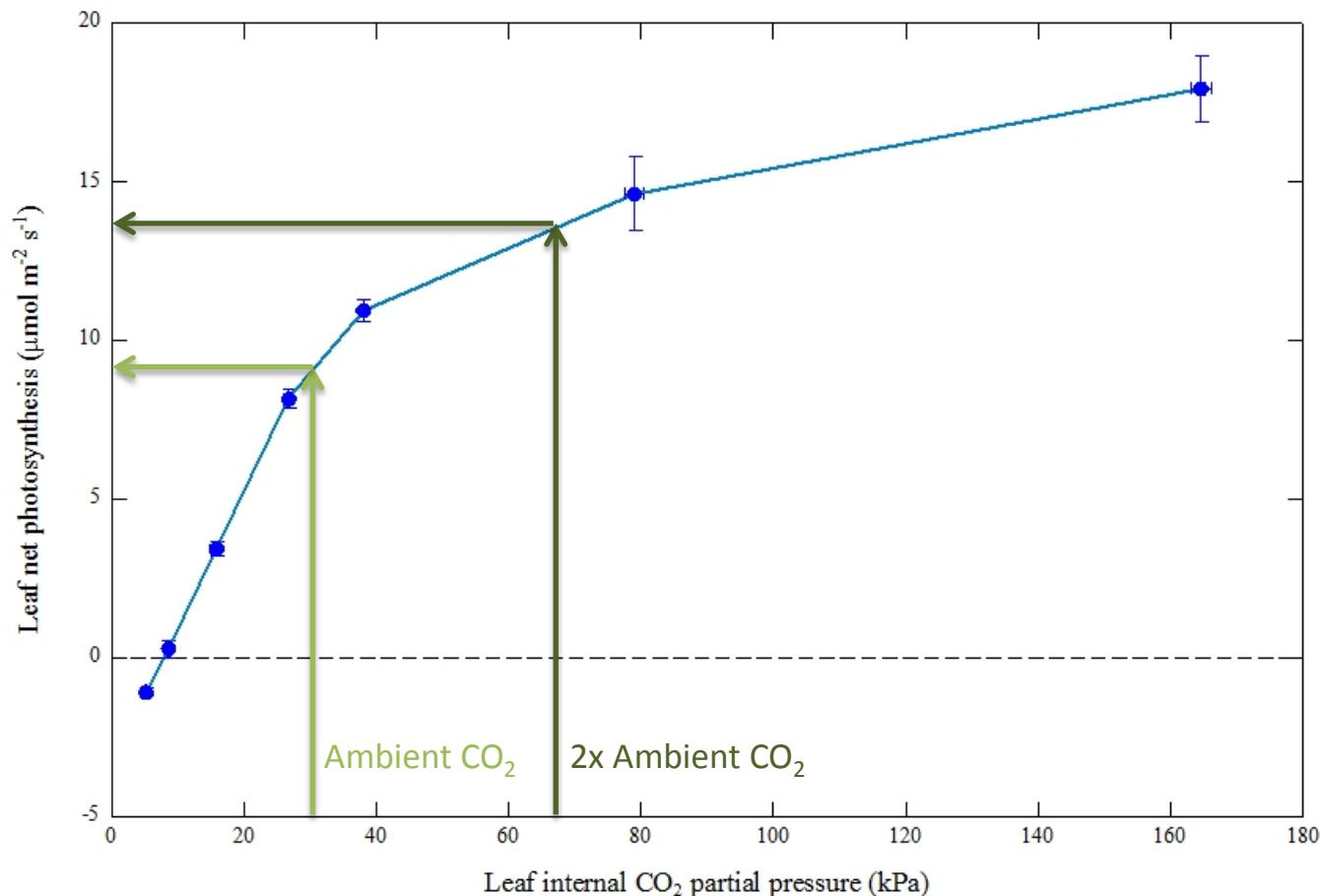


Day



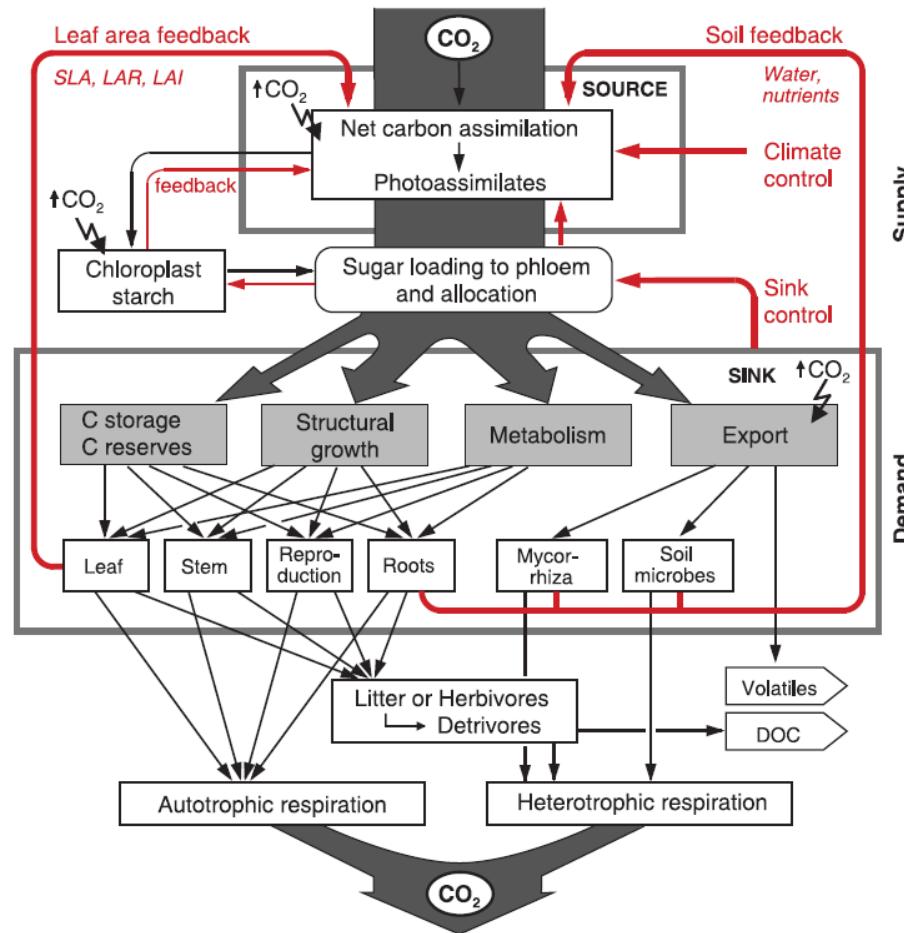


Carbon dioxide



Carbon dioxide

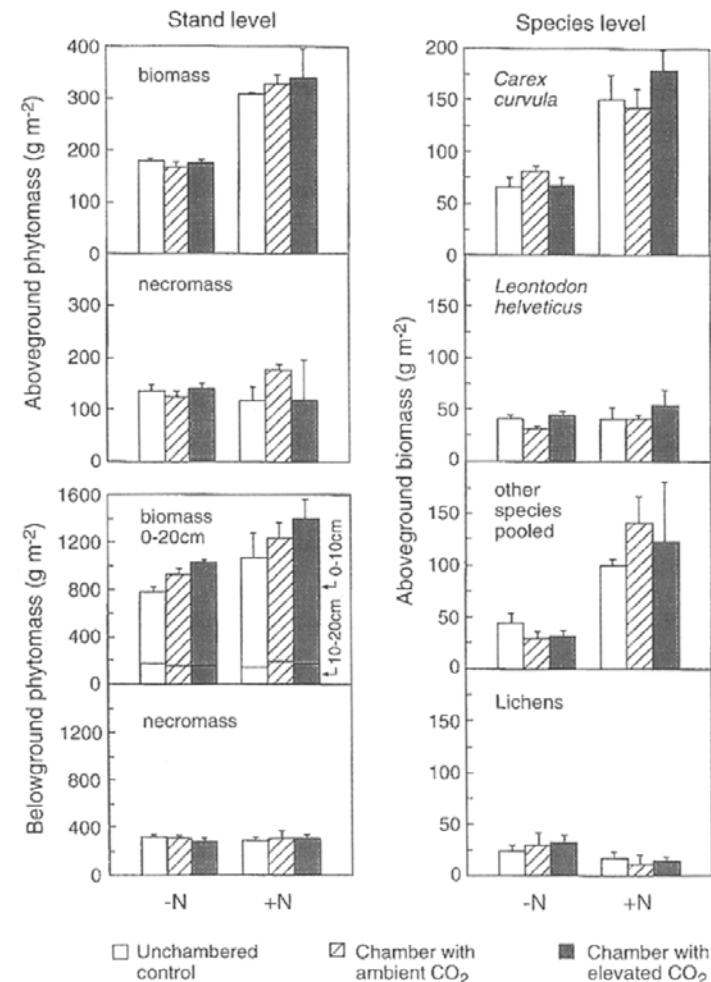
The fate of carbon in plants





Carbon dioxide

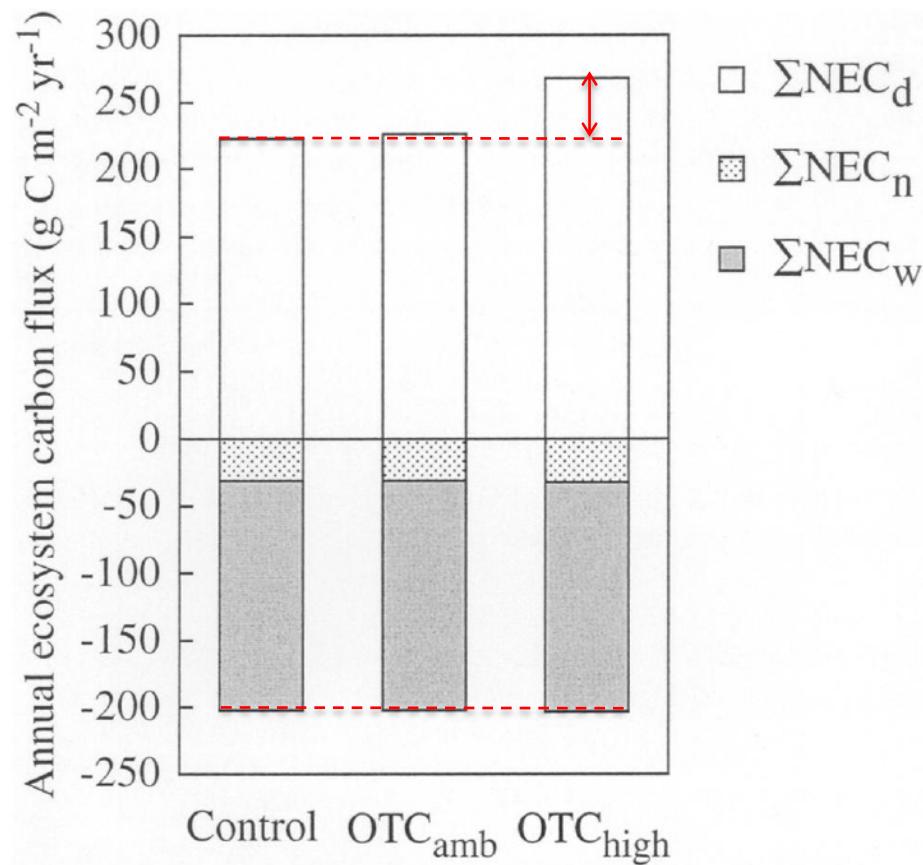
Curvuletum





Carbon dioxide

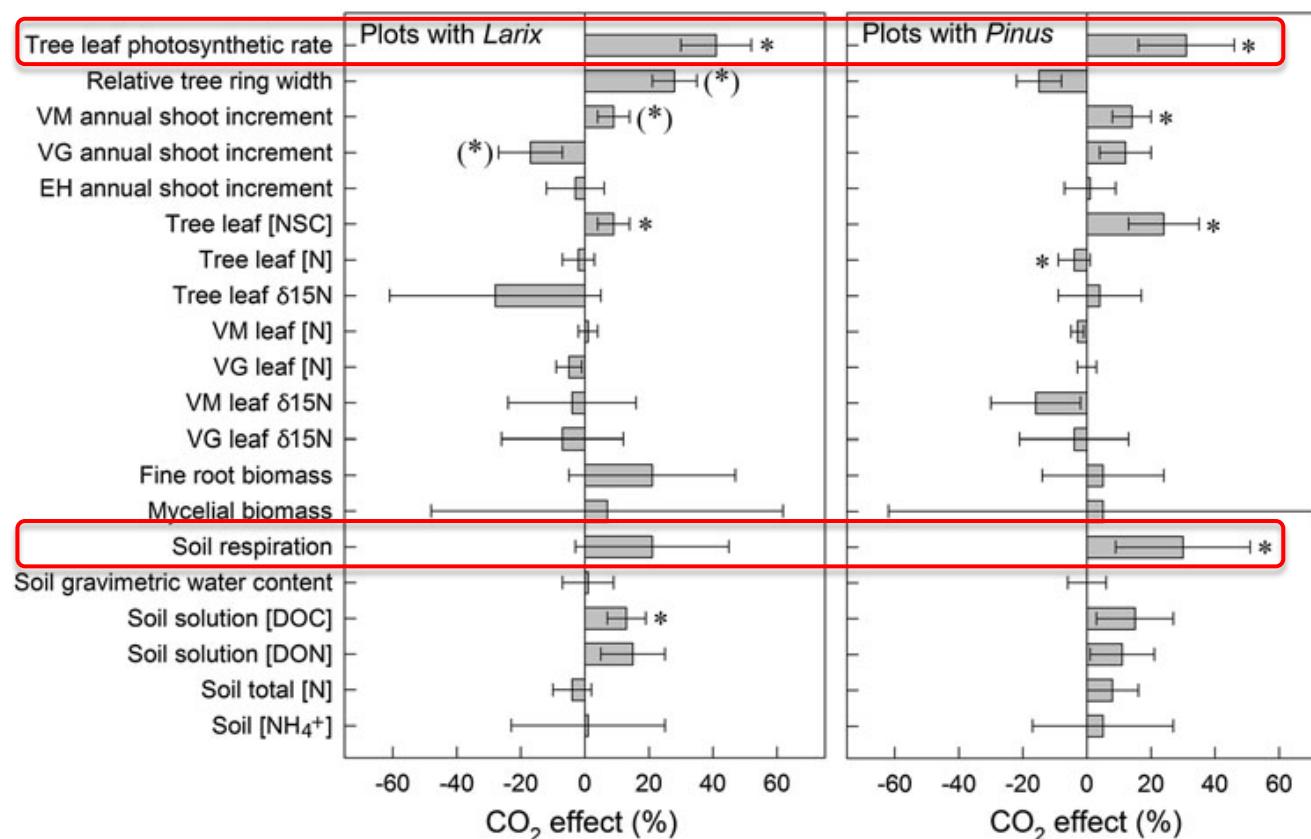
Curvuletum





Carbon dioxide

Tree line

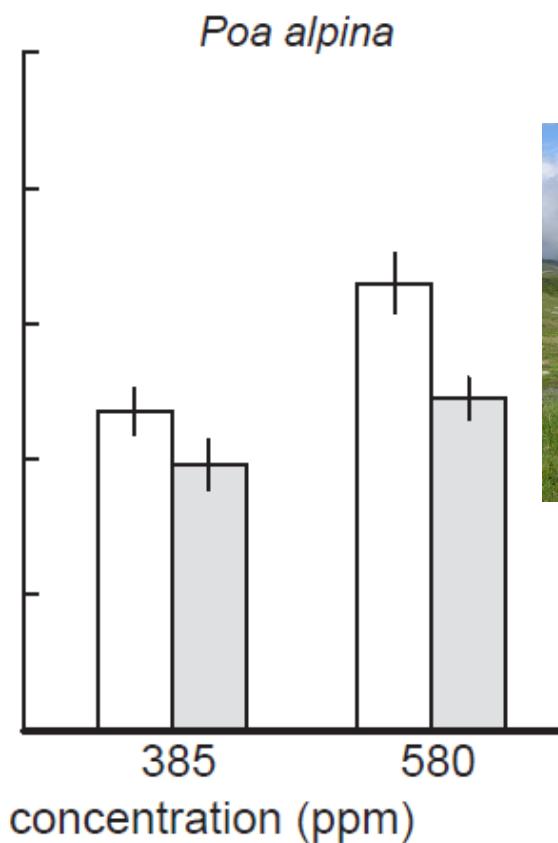
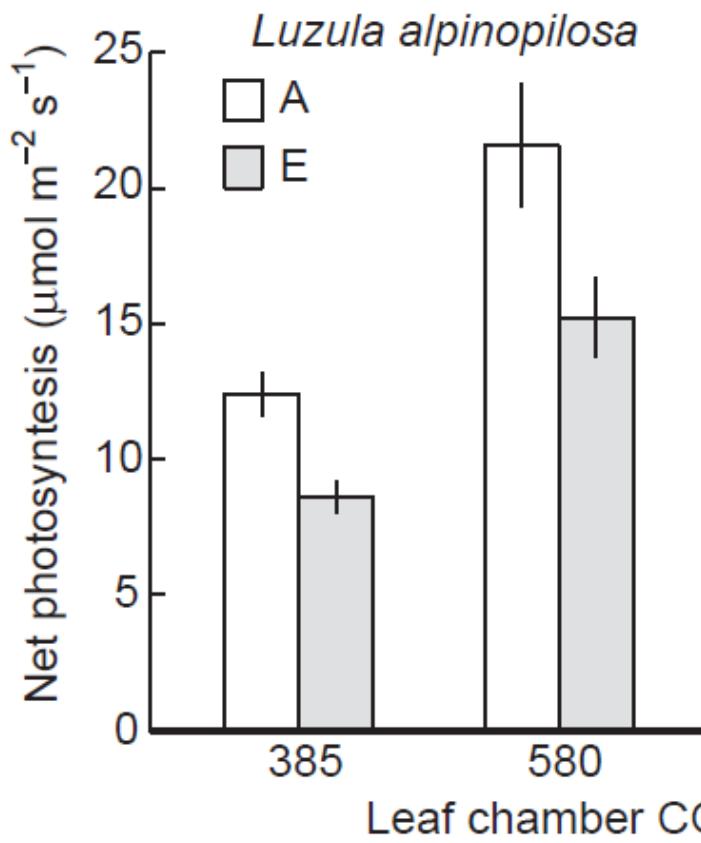


© Hättenschwiler

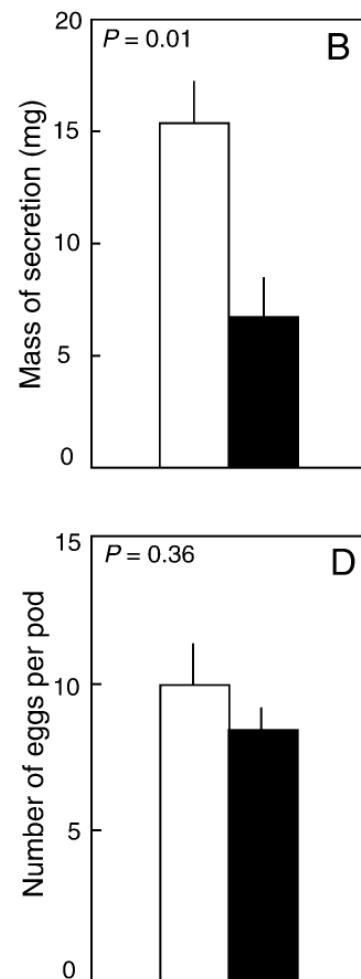
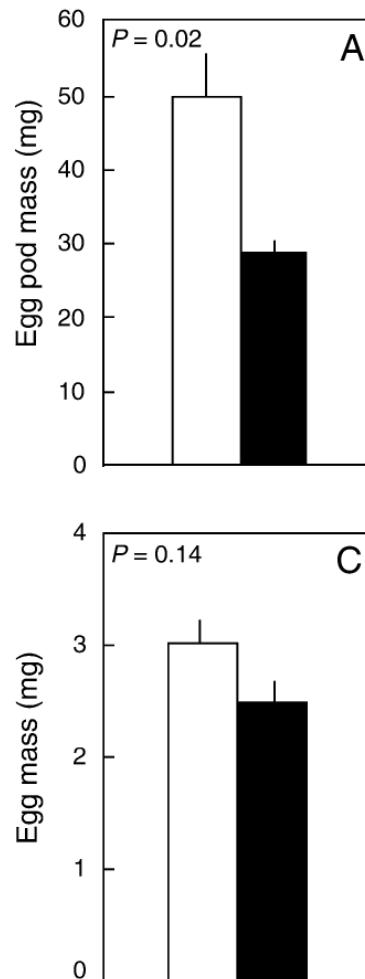


Carbon dioxide

Glacier forefield plants

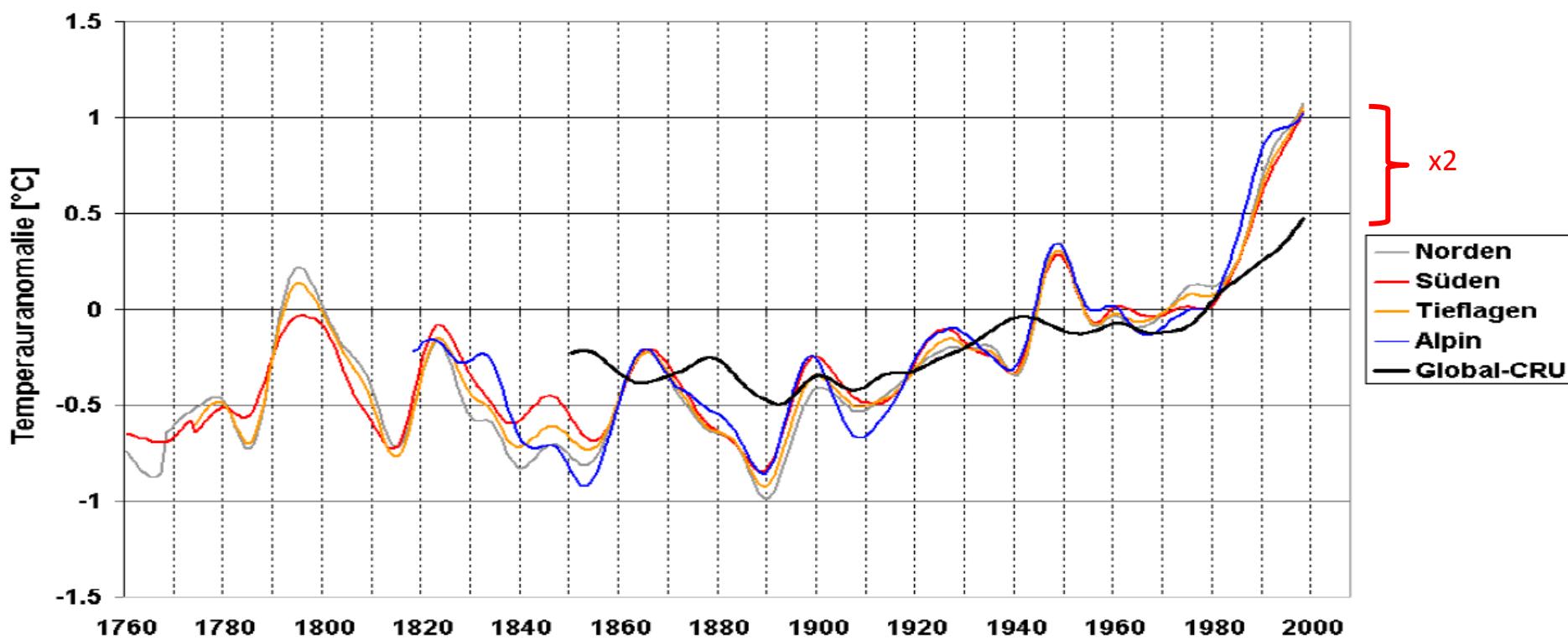


Carbon dioxide



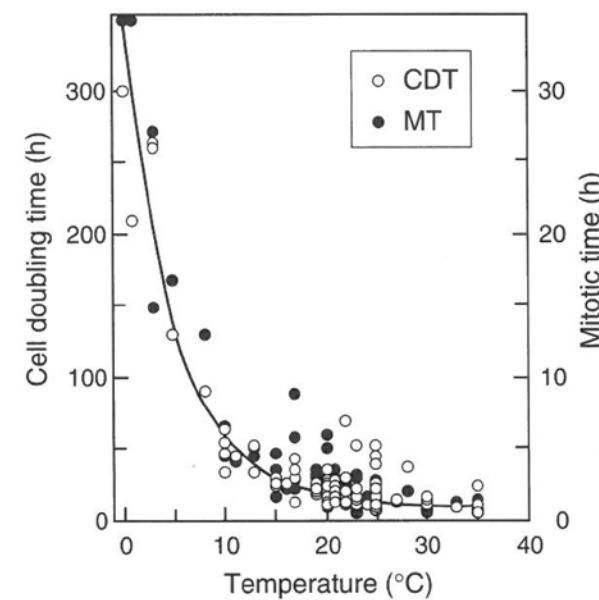


Temperature

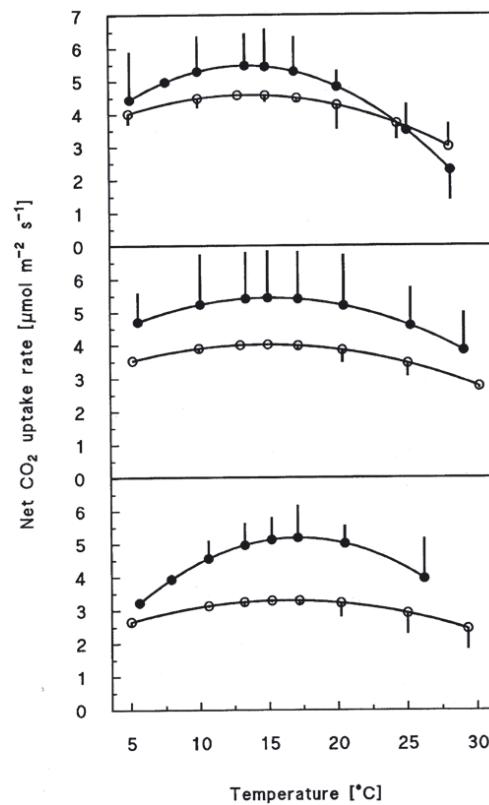




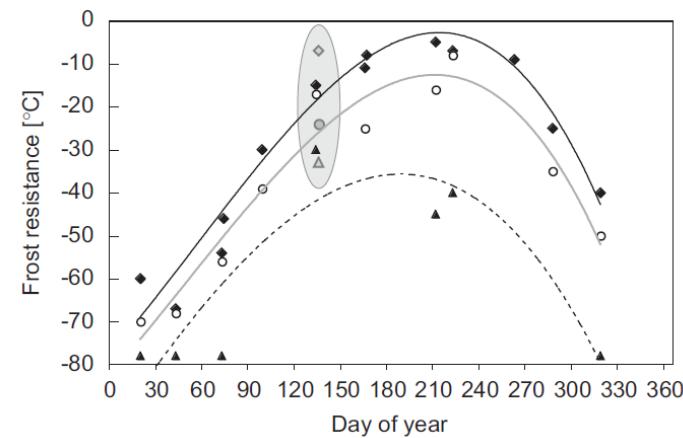
Temperature



Körner (2003) Alpine Plant Life



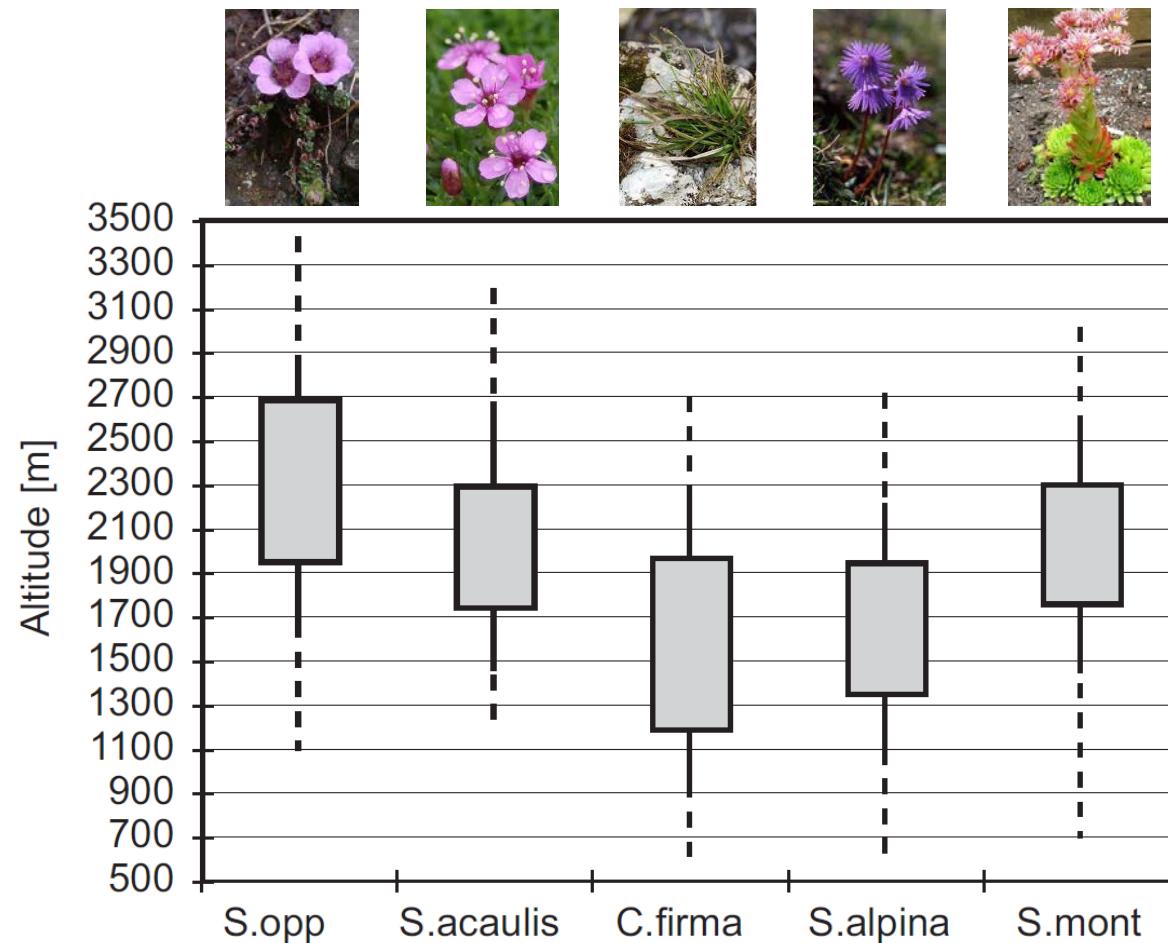
Wieser et al. (2010) Annals of Forest Science



Larcher et al. (2010) Flora

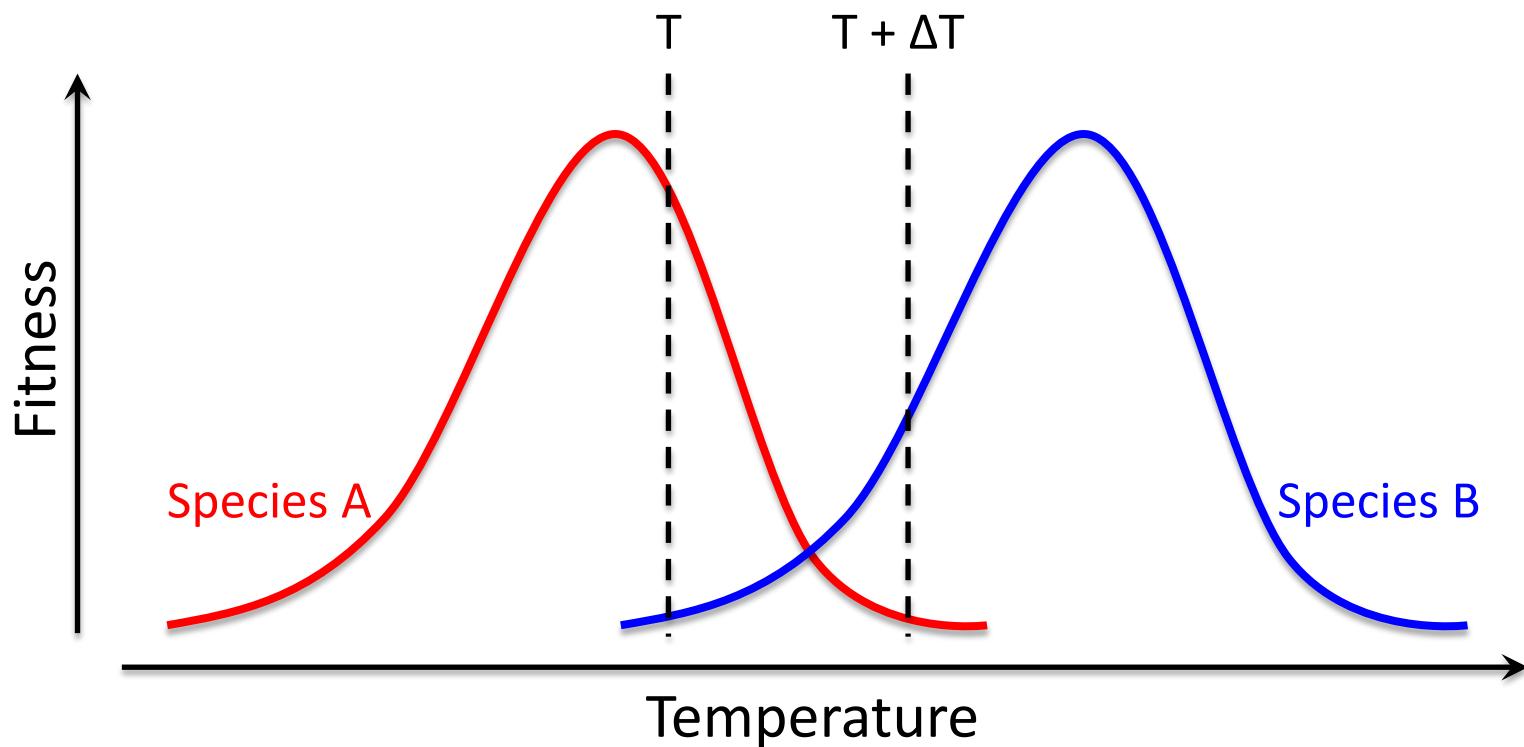


Temperature



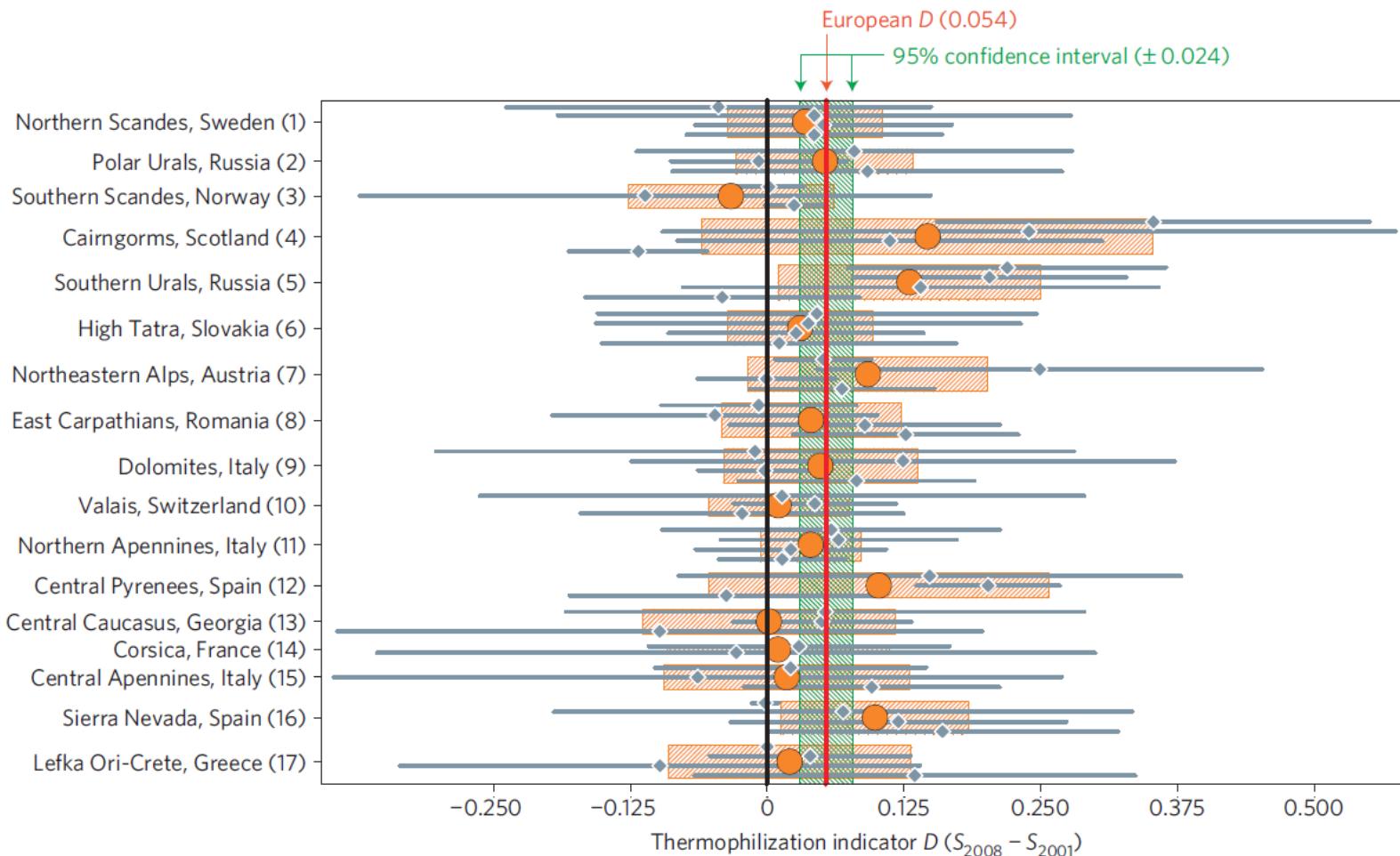


Temperature



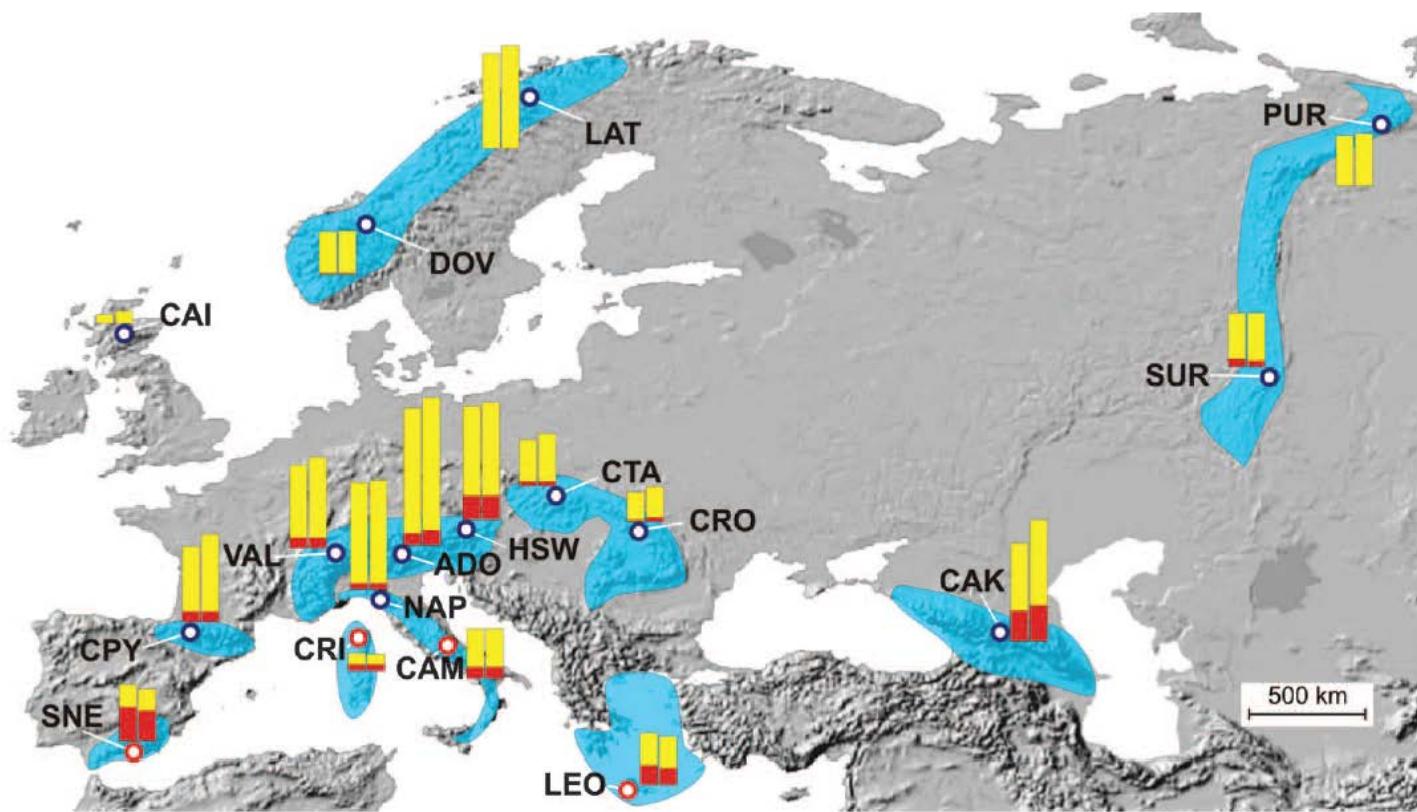


Temperature



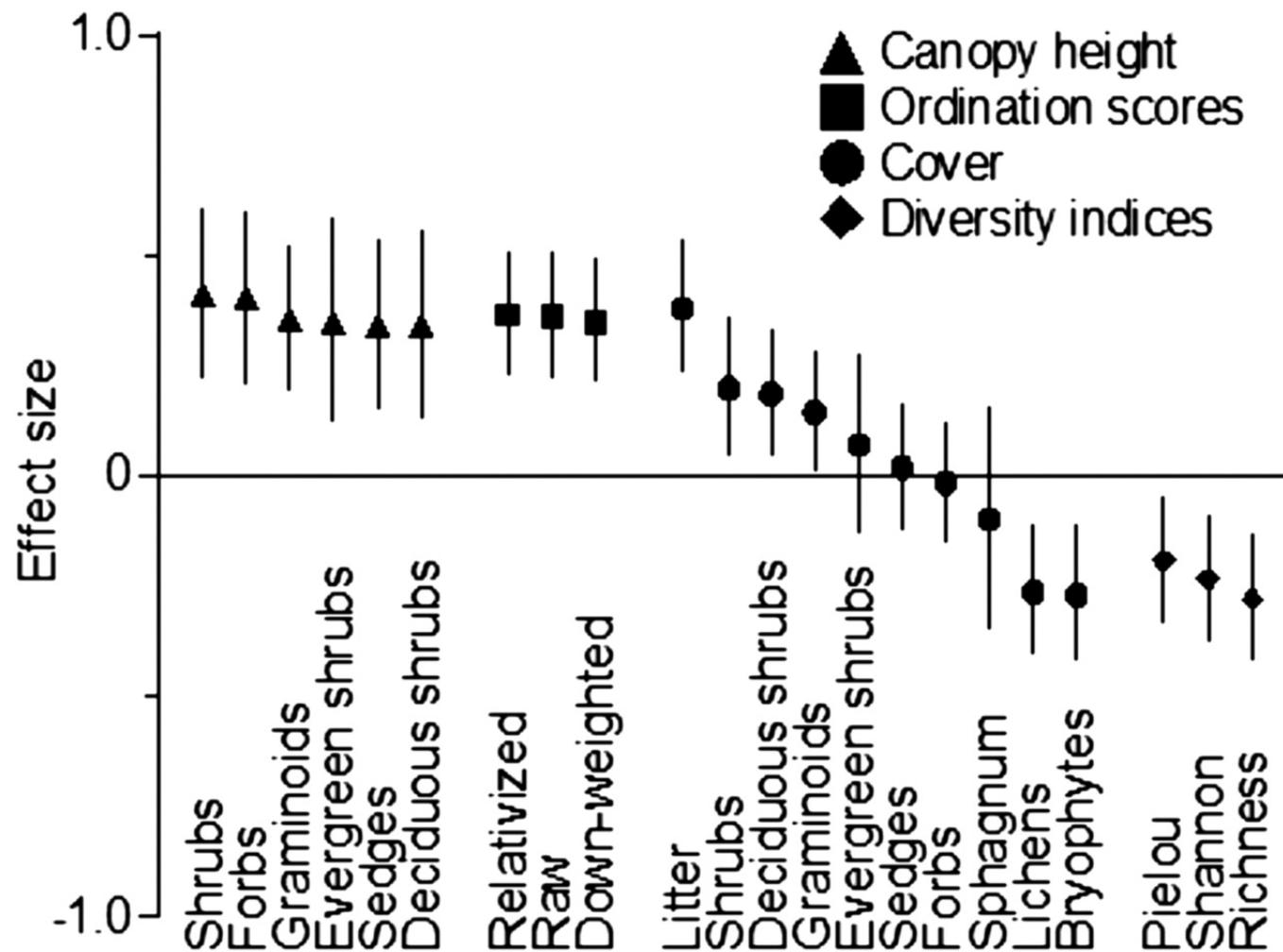


Temperature





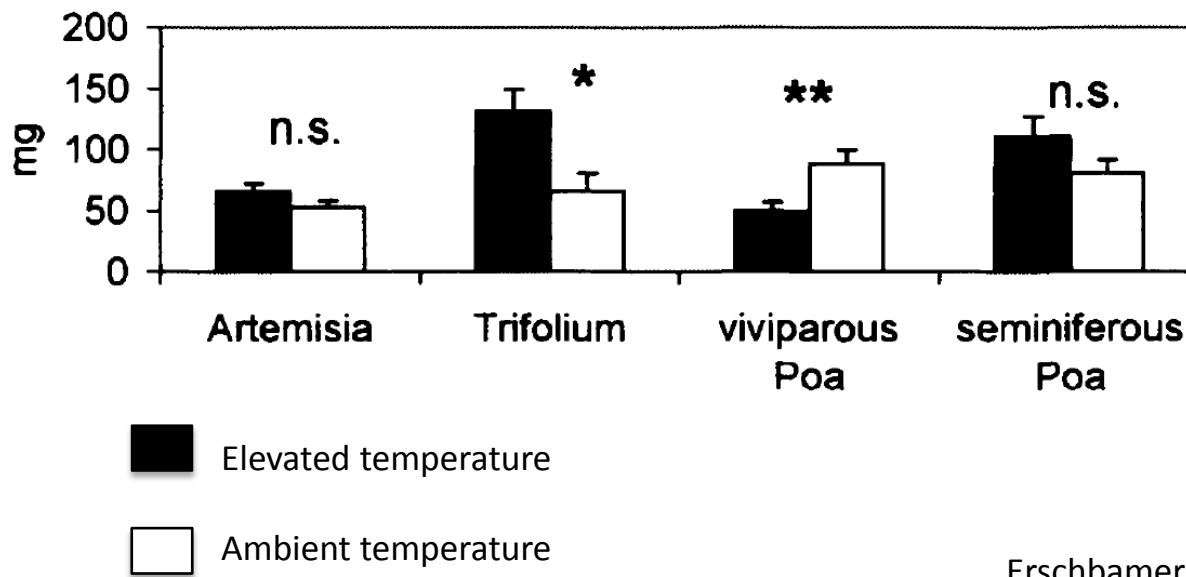
Temperature





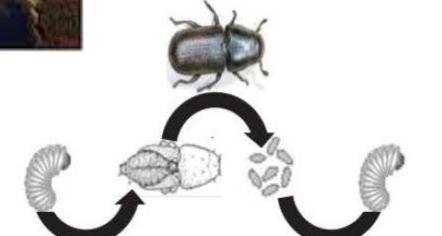
Temperature

Glacier forefield plant species





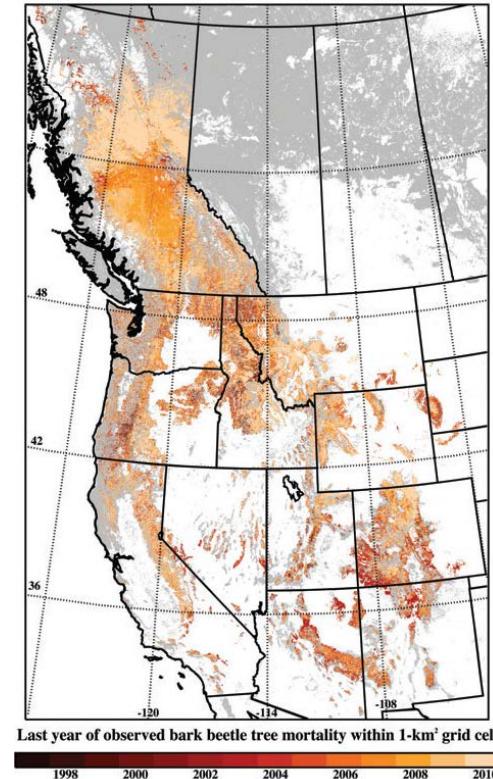
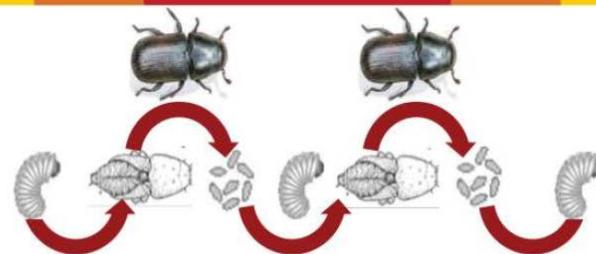
Temperature



Univoltine (historical)

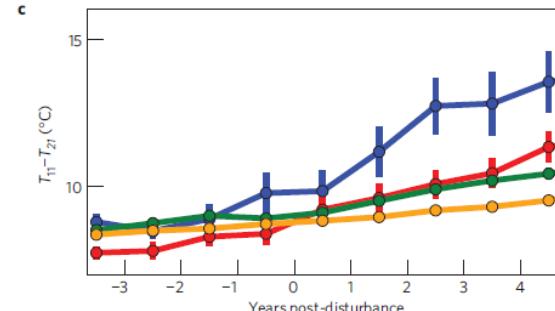
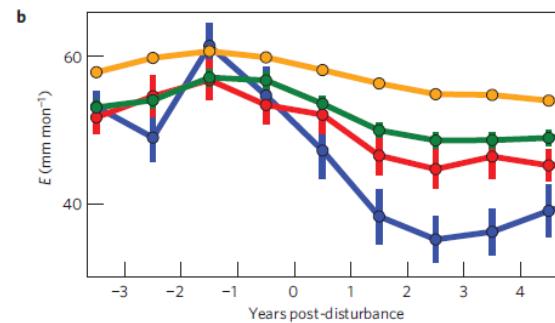
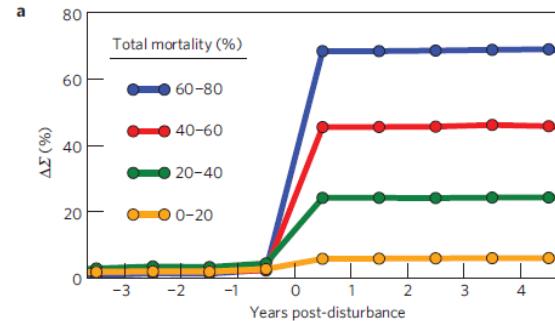
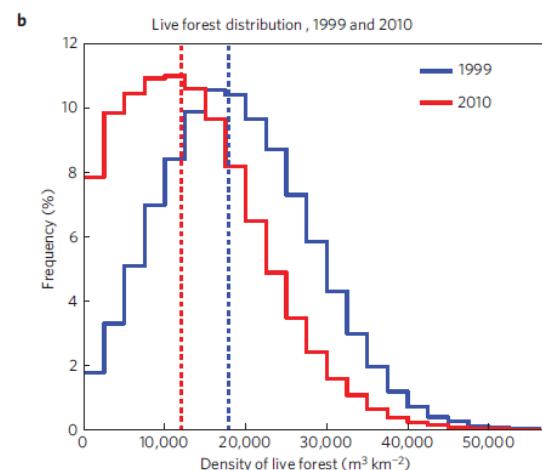
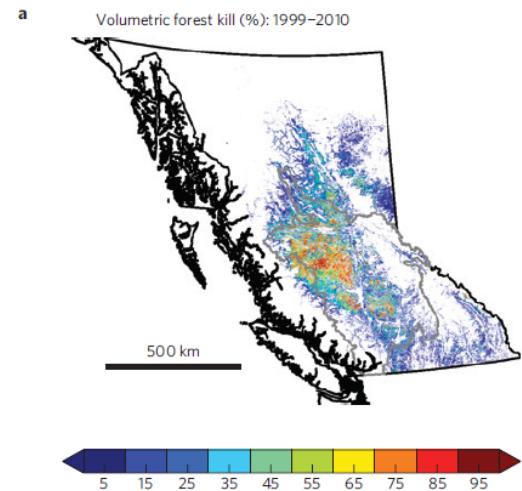


Bivoltine (recent)



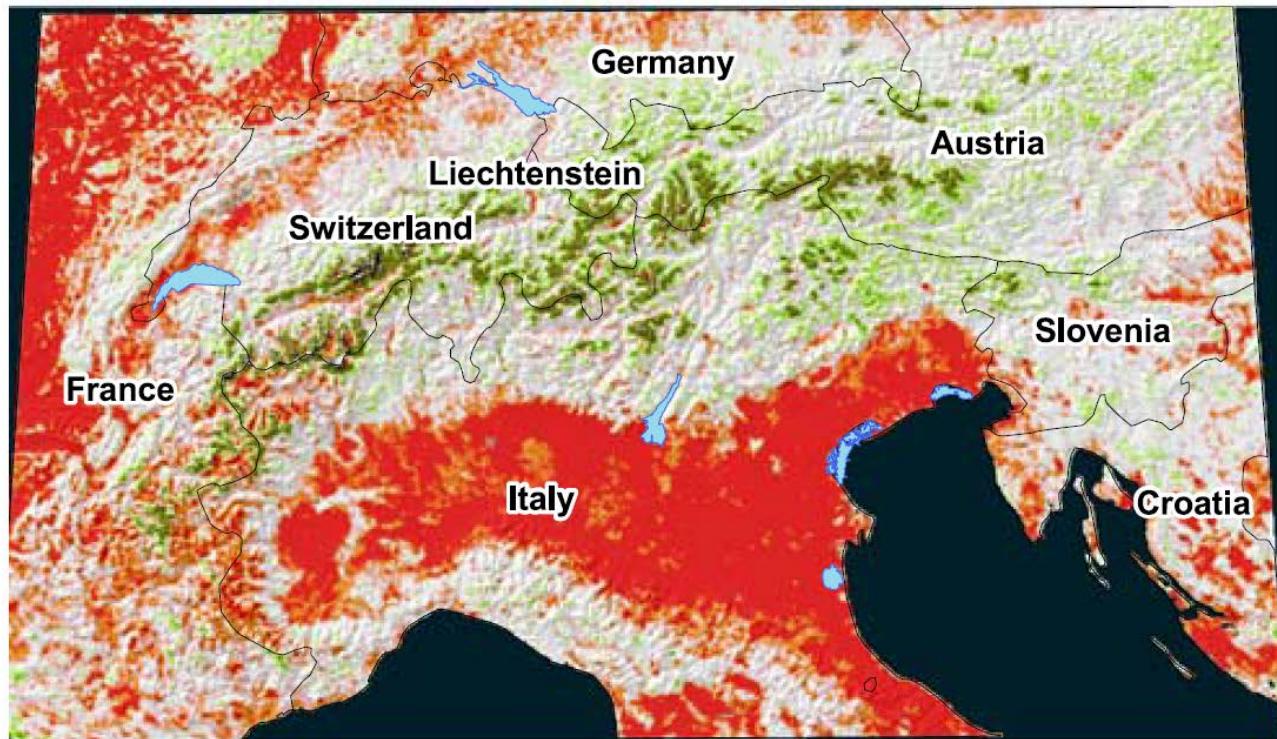


Temperature

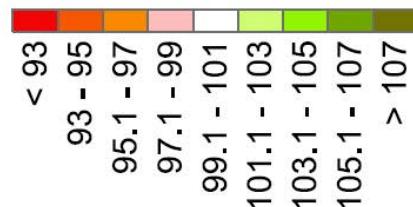




Temperature

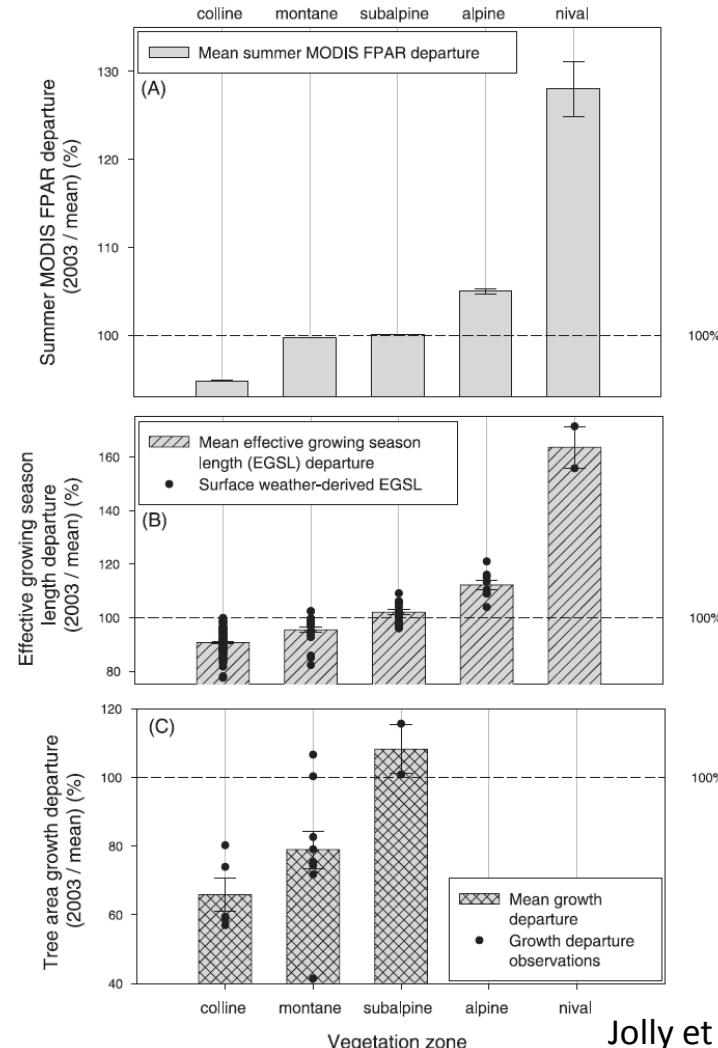


MODIS Summer FPAR relative to mean (%)





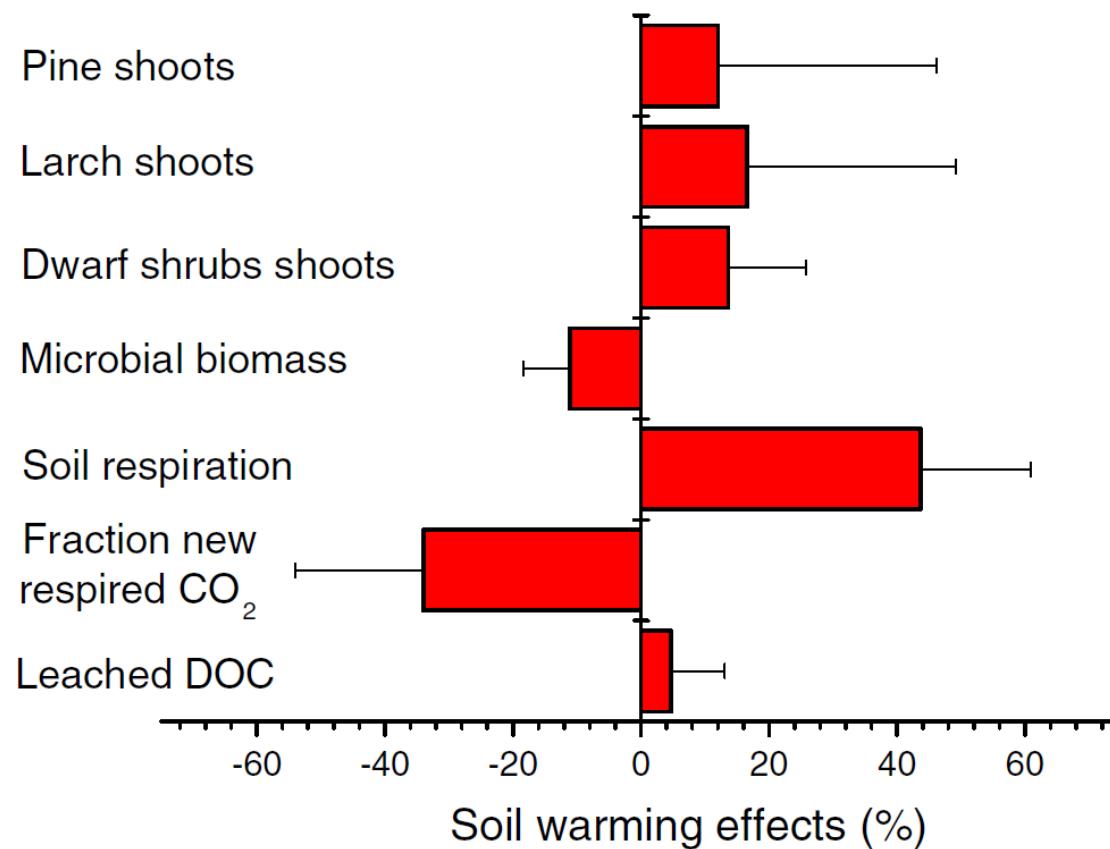
Temperature





Temperature

Treeline





Temperature

Snow cover

8 March 2006



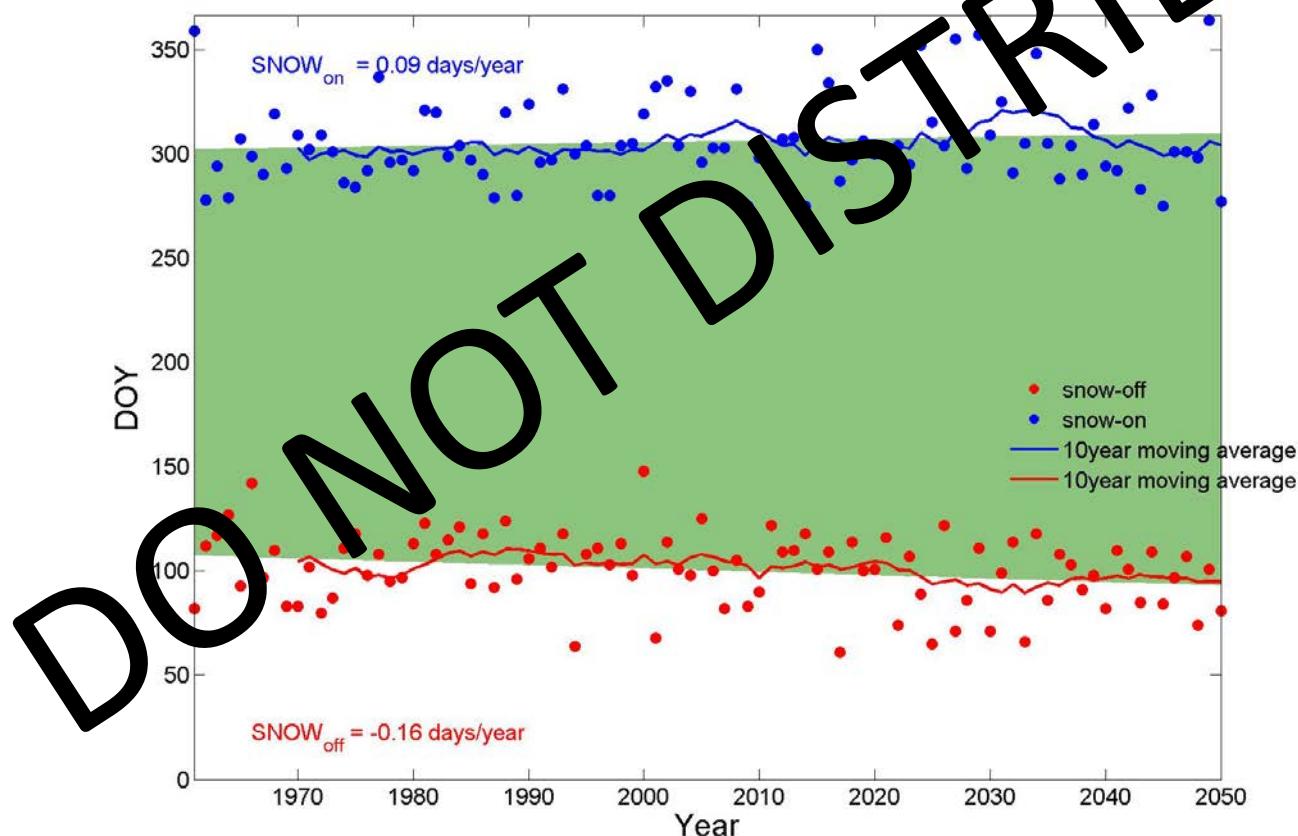
13 March 2007





Temperature

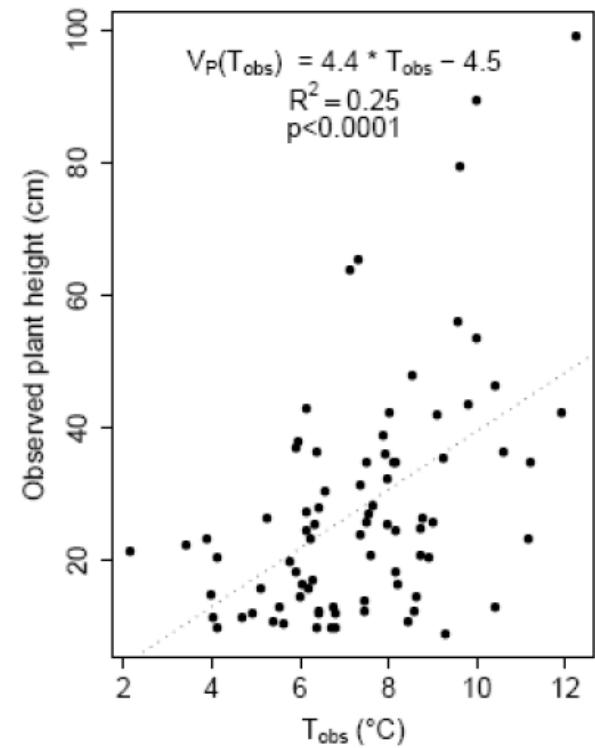
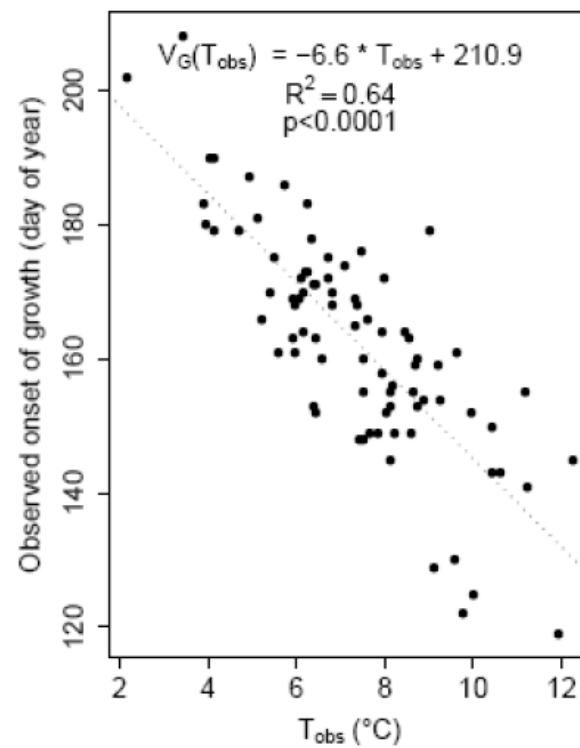
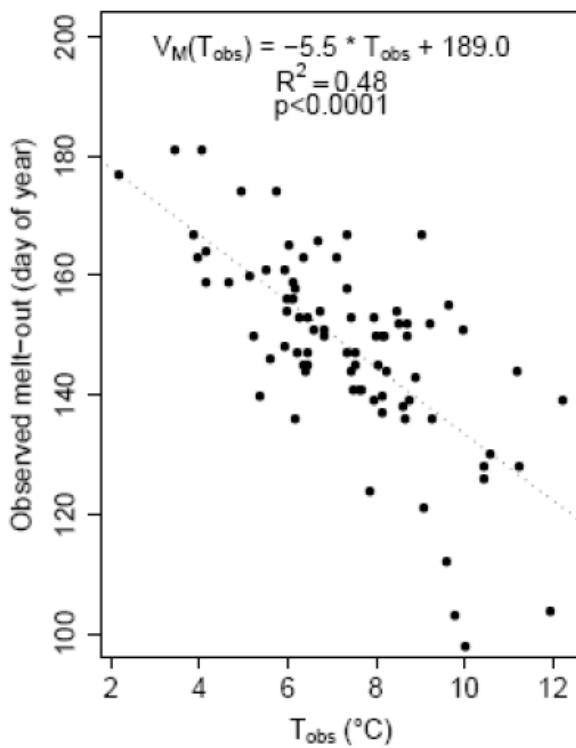
Snow cover





Temperature

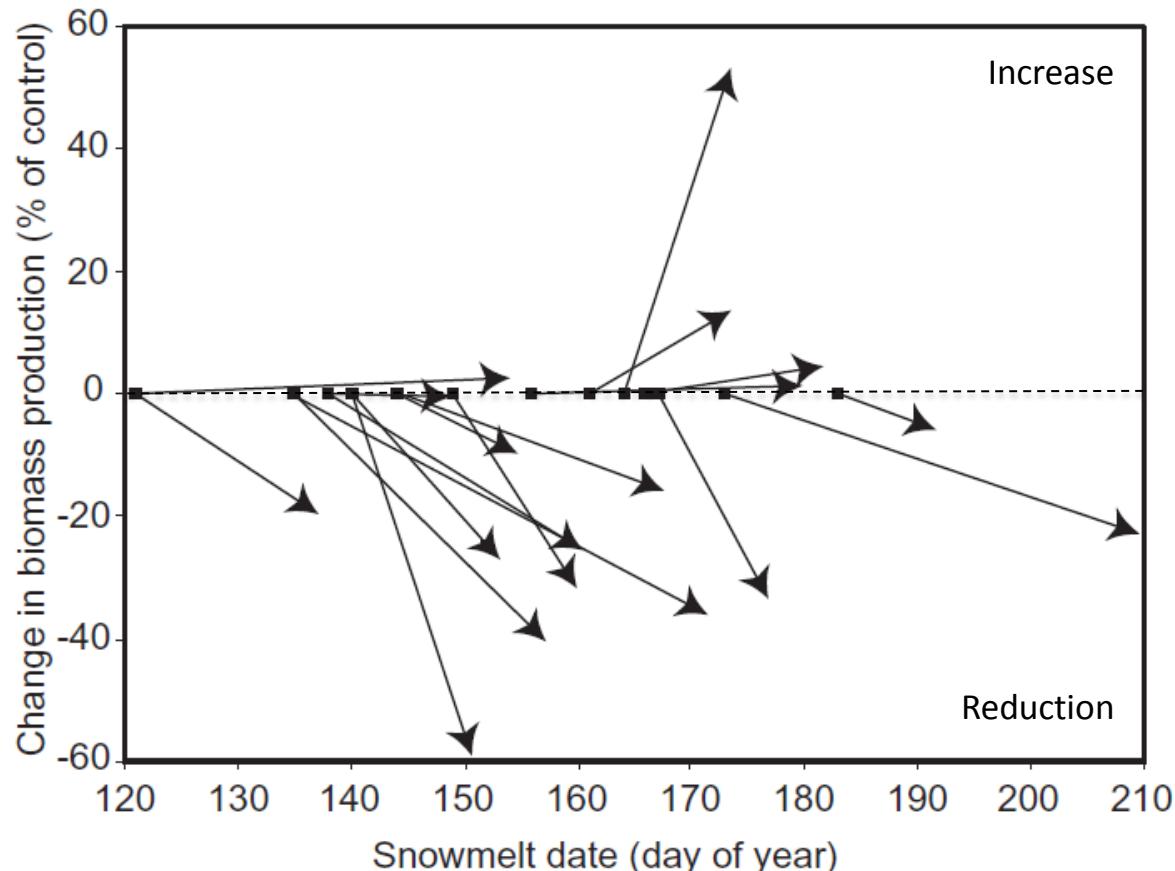
Snow melt and biomass production





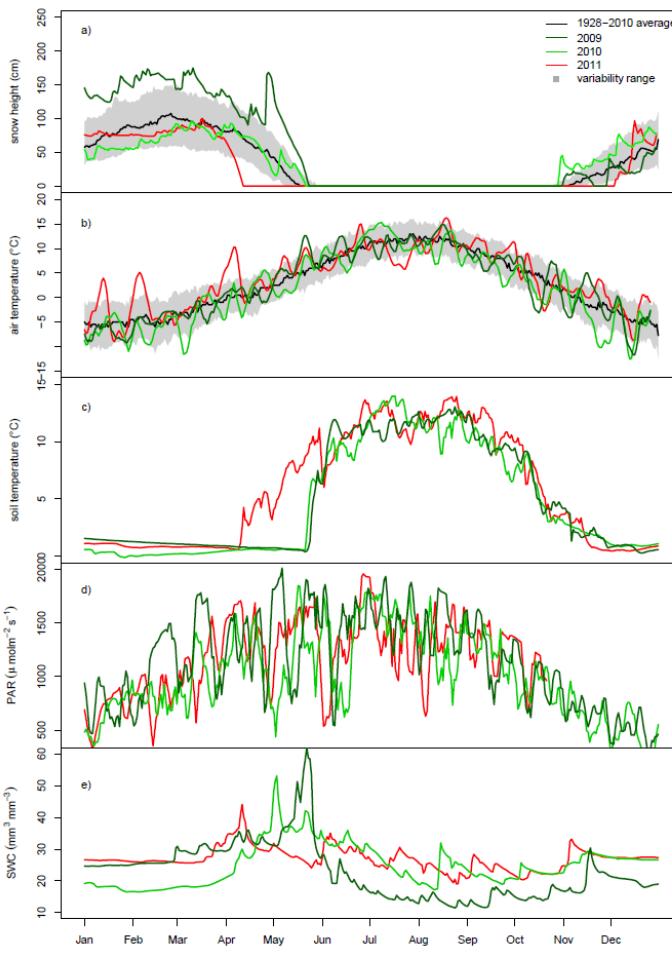
Temperature

Snow melt and biomass production

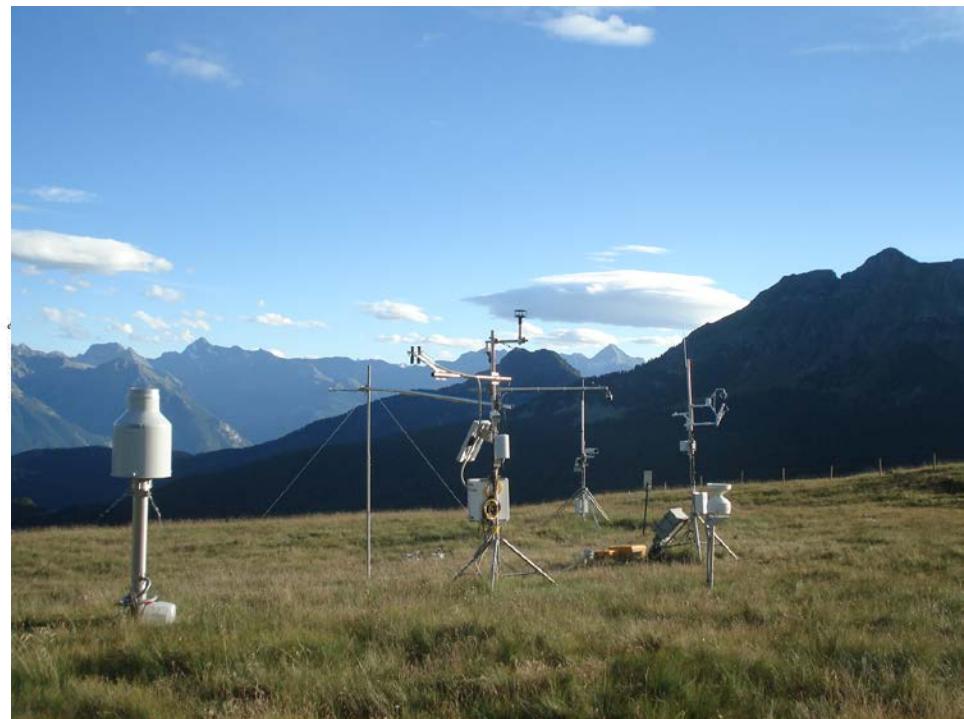




Temperature

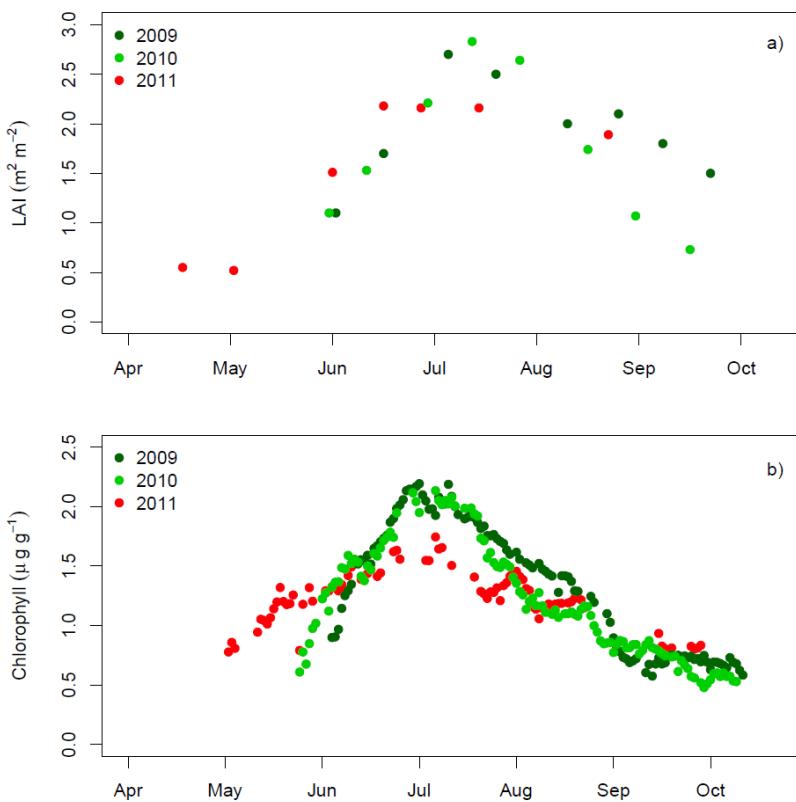


Snow melt and biogeochemical cycles

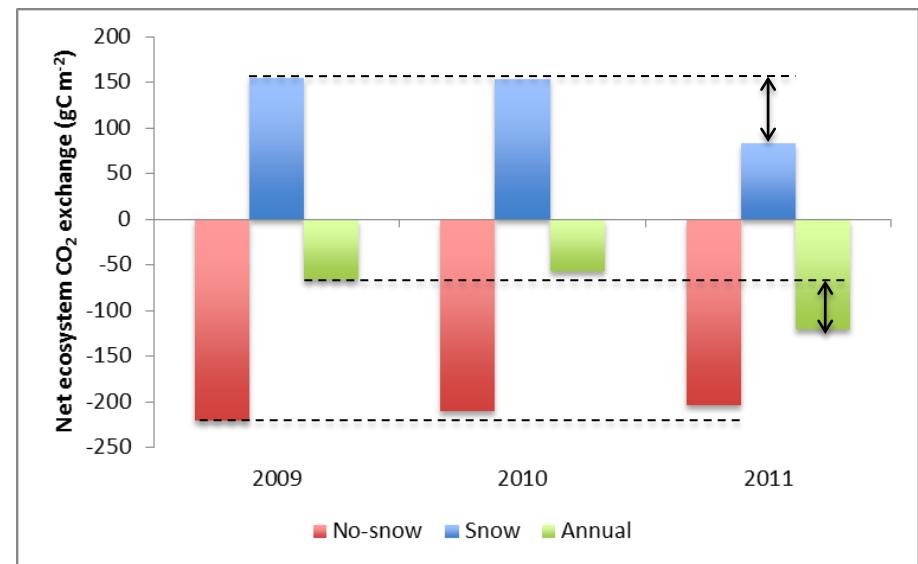




Temperature



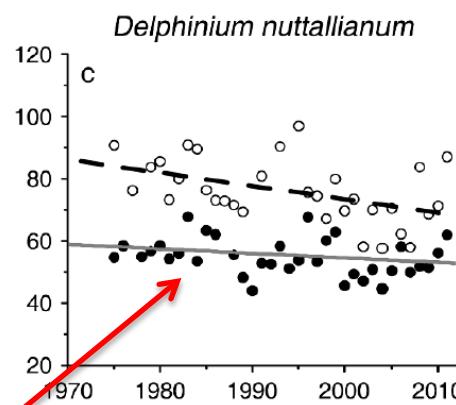
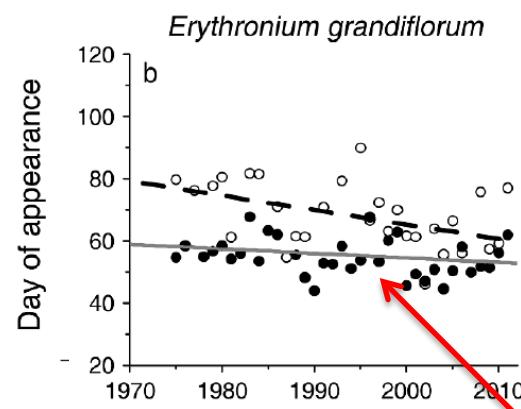
Snow melt and biogeochemical cycles





Temperature

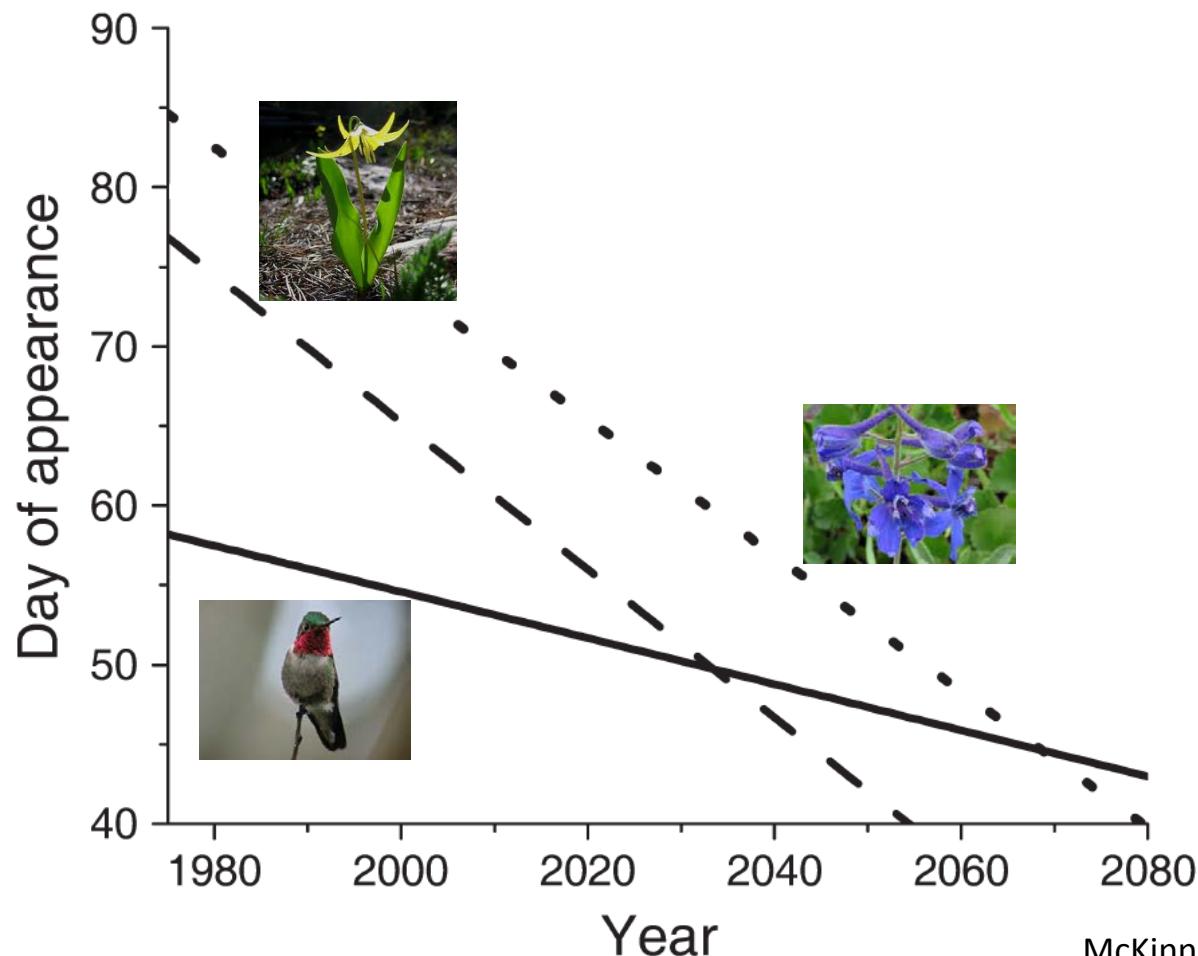
Snow melt and phenology





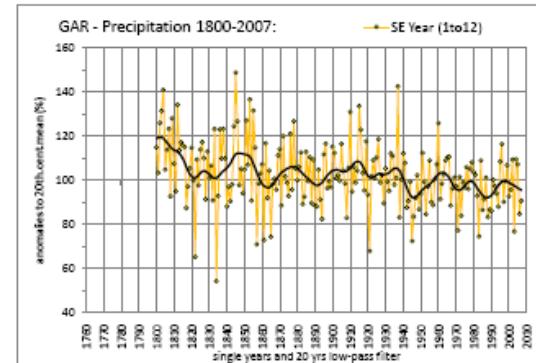
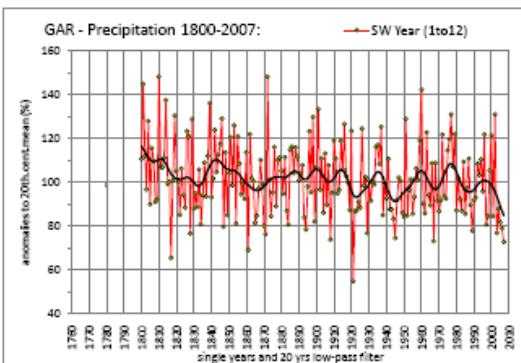
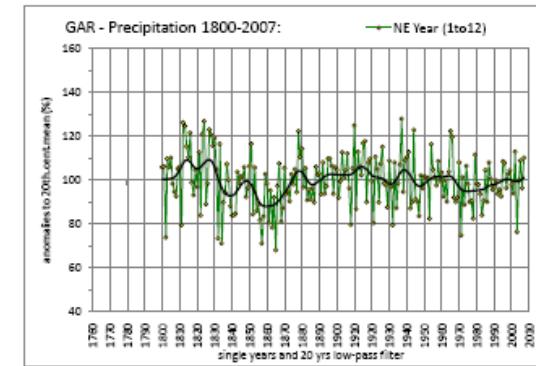
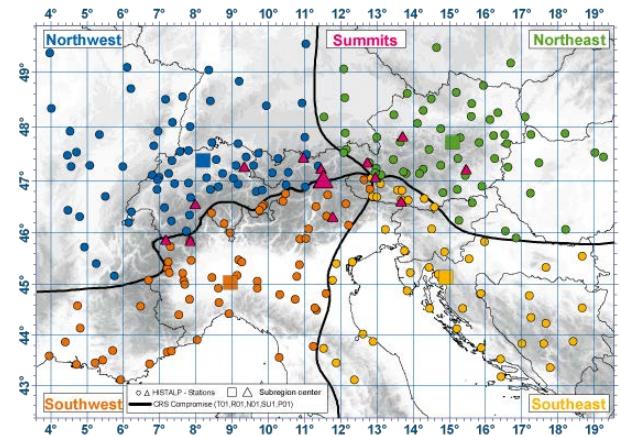
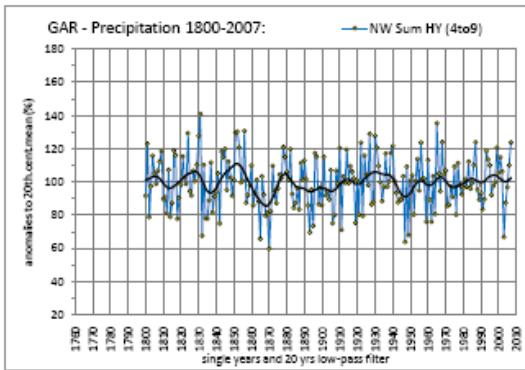
Temperature

Snow melt and phenology





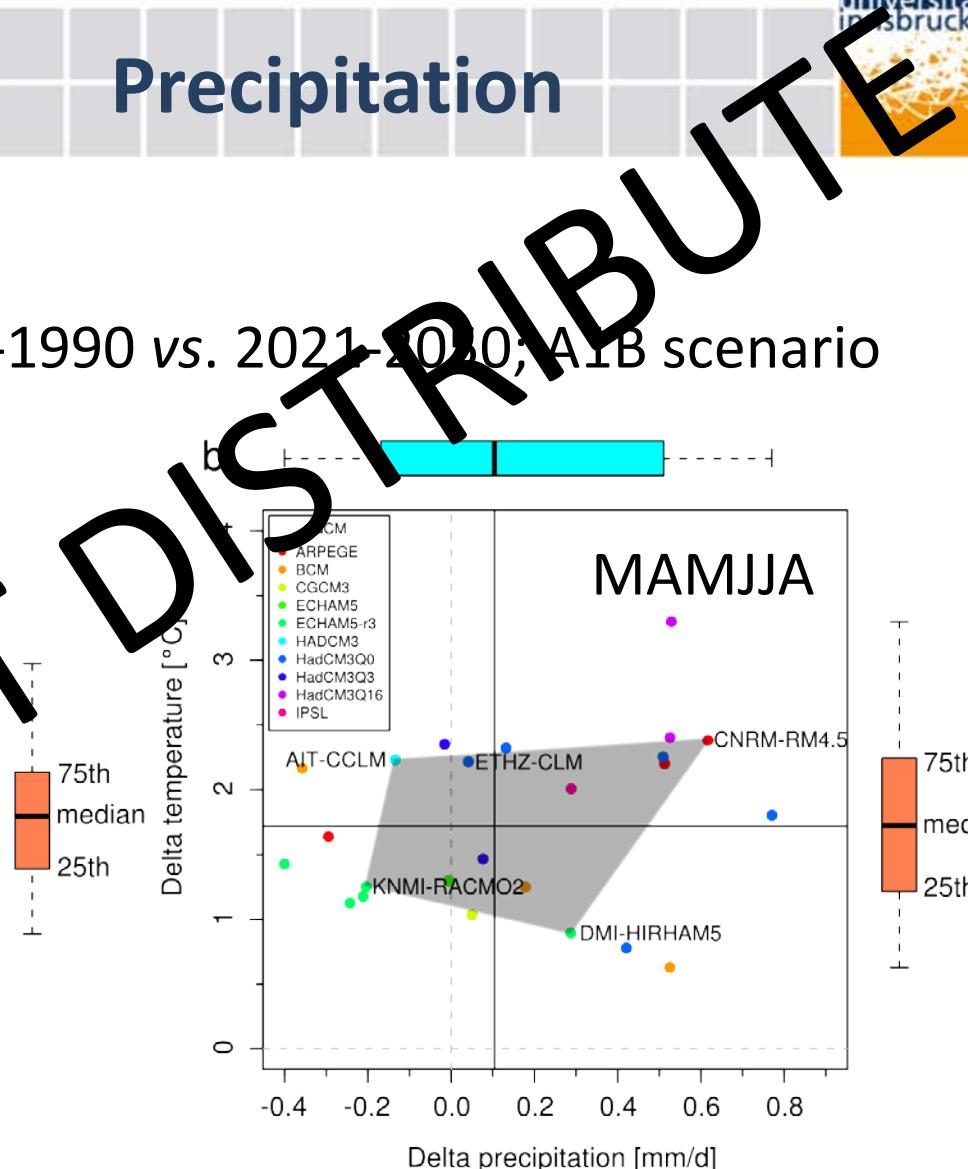
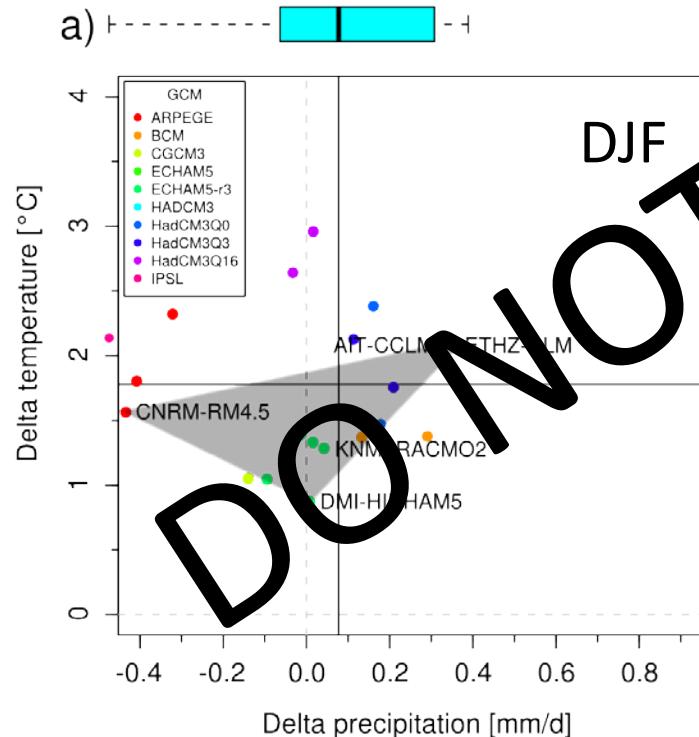
Precipitation

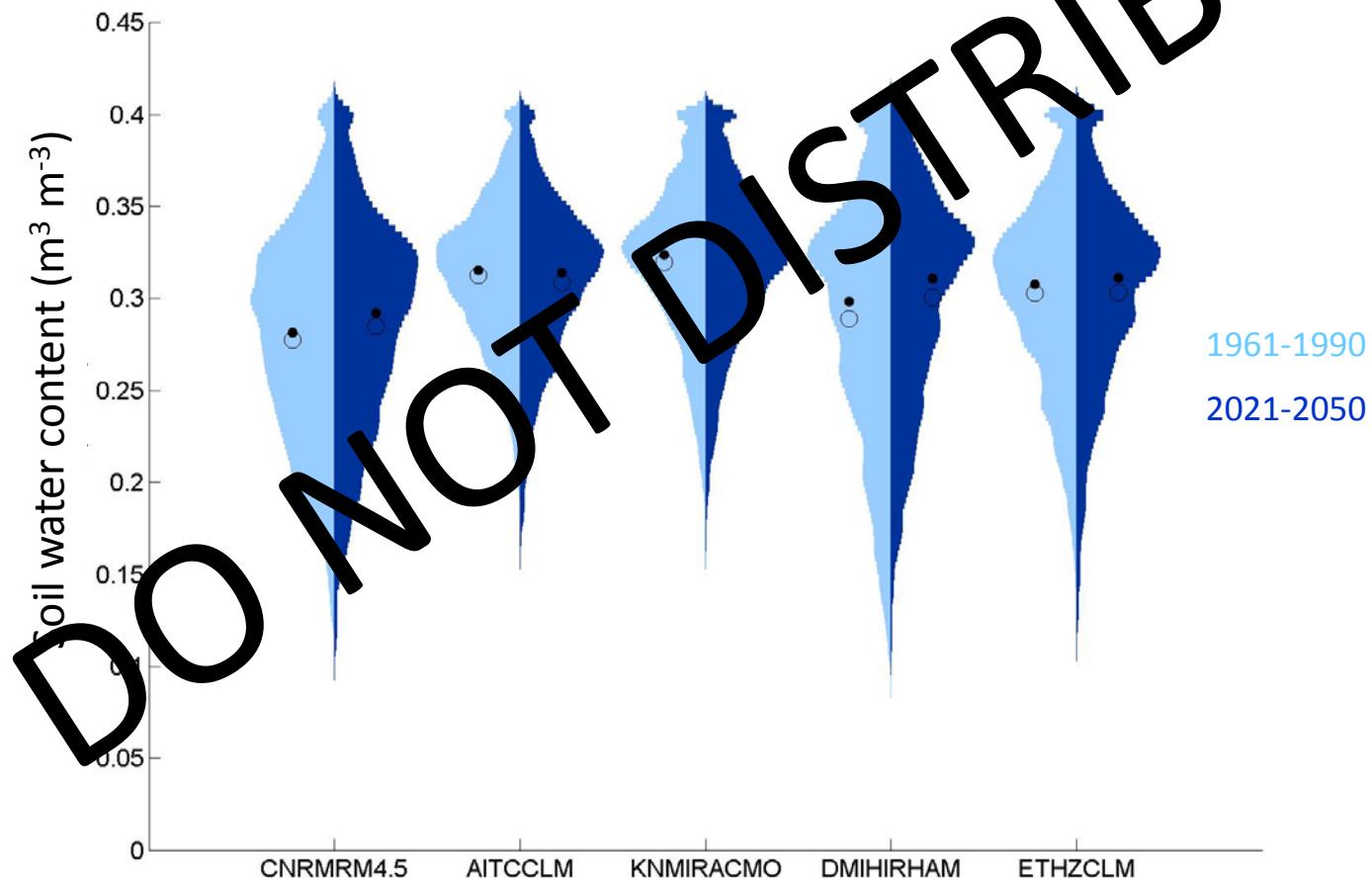




Precipitation

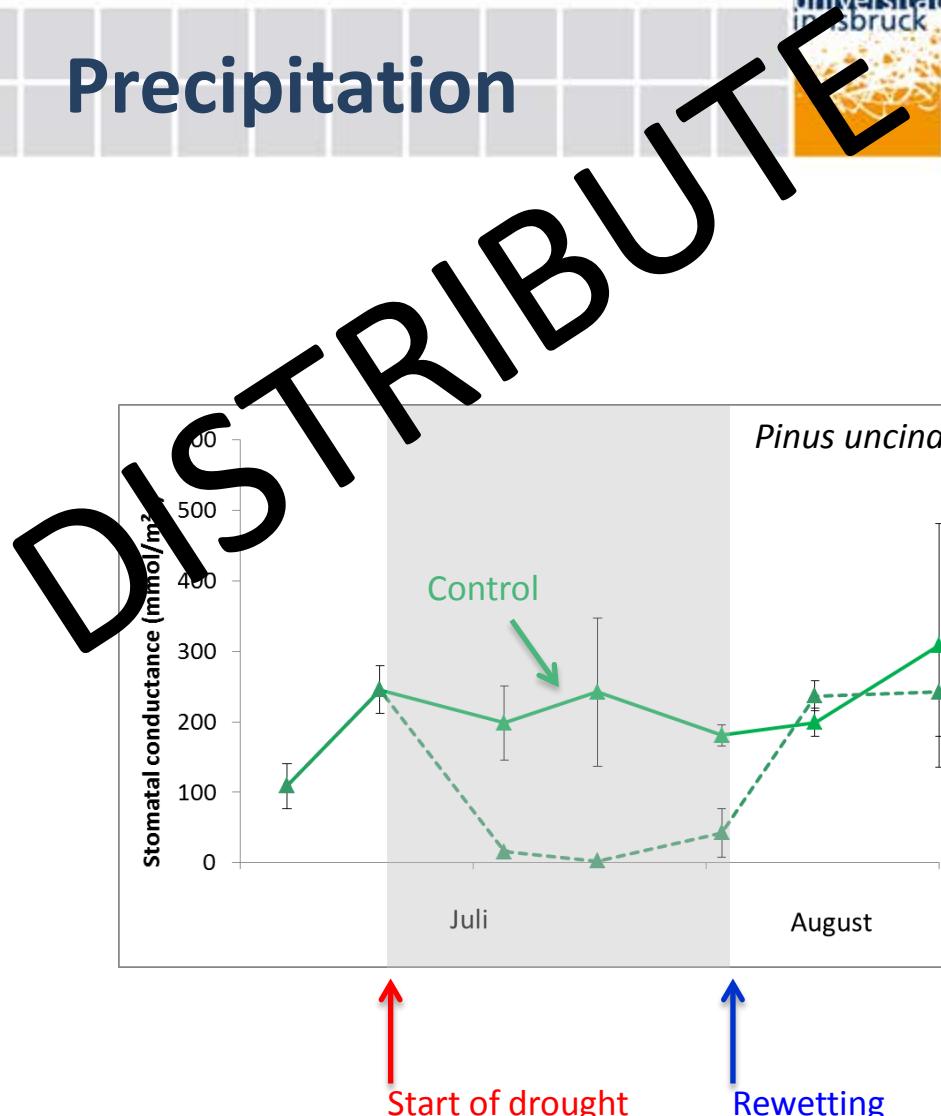
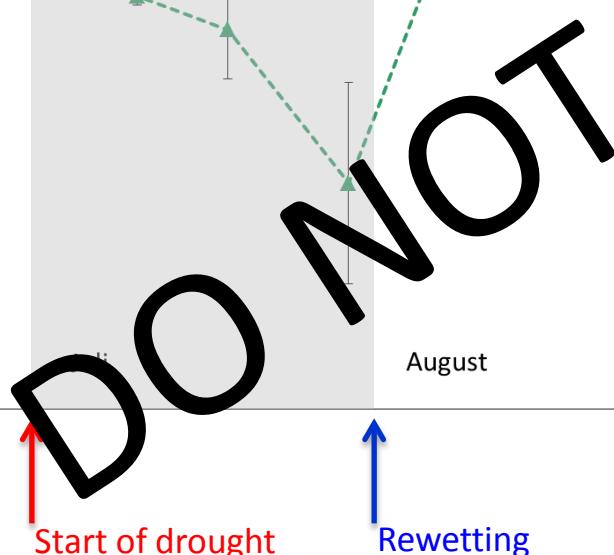
Spatial domain: Tyrol; 1961-1990 vs. 2021-2050; A1B scenario





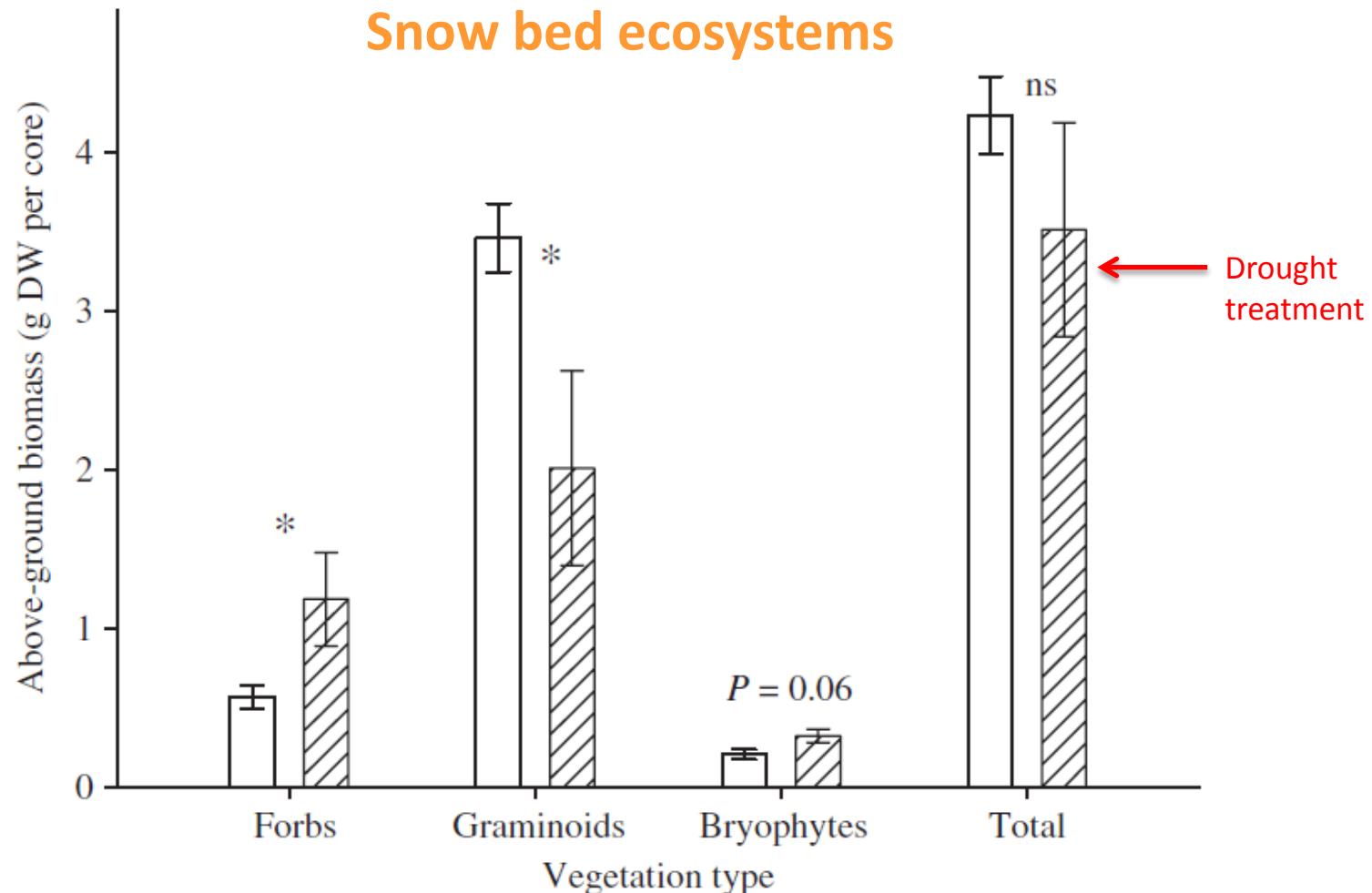


Precipitation



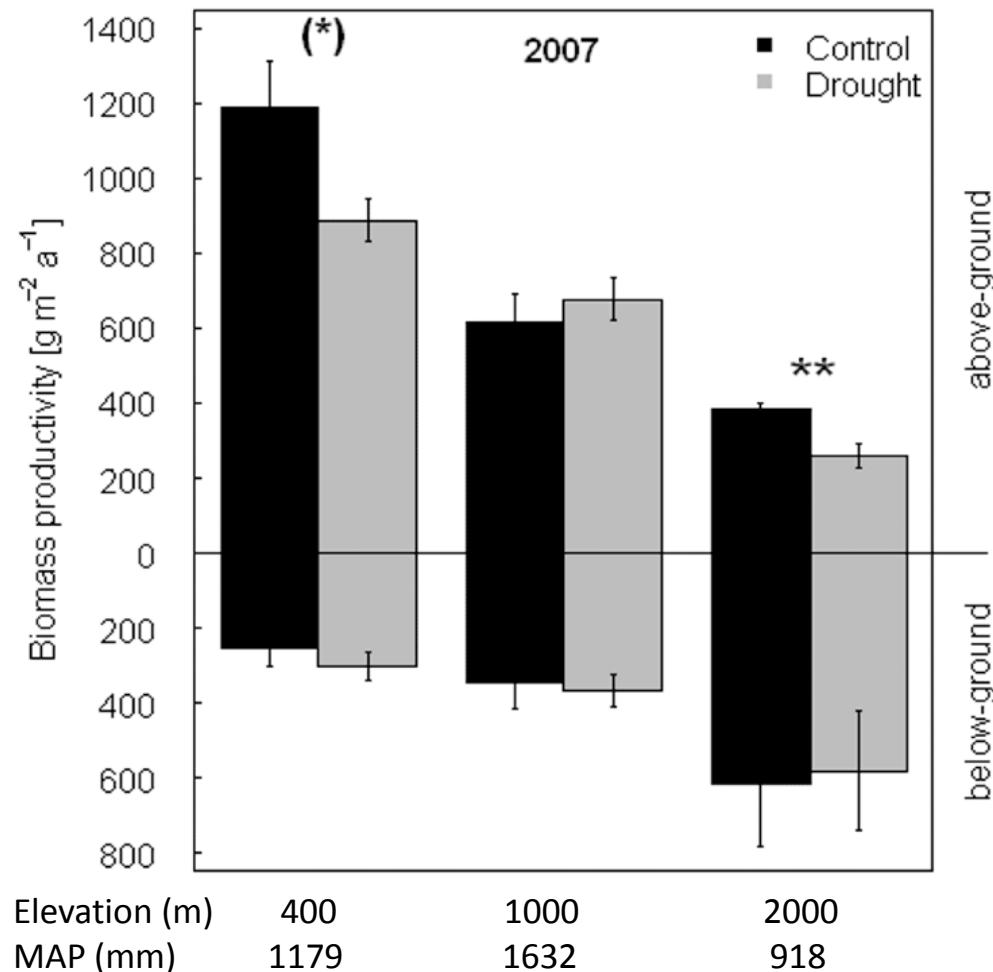


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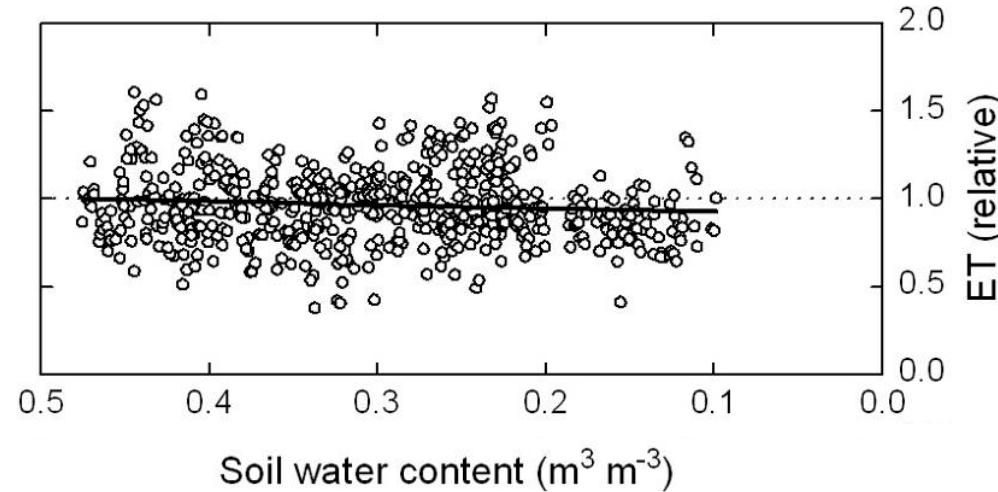


Precipitation



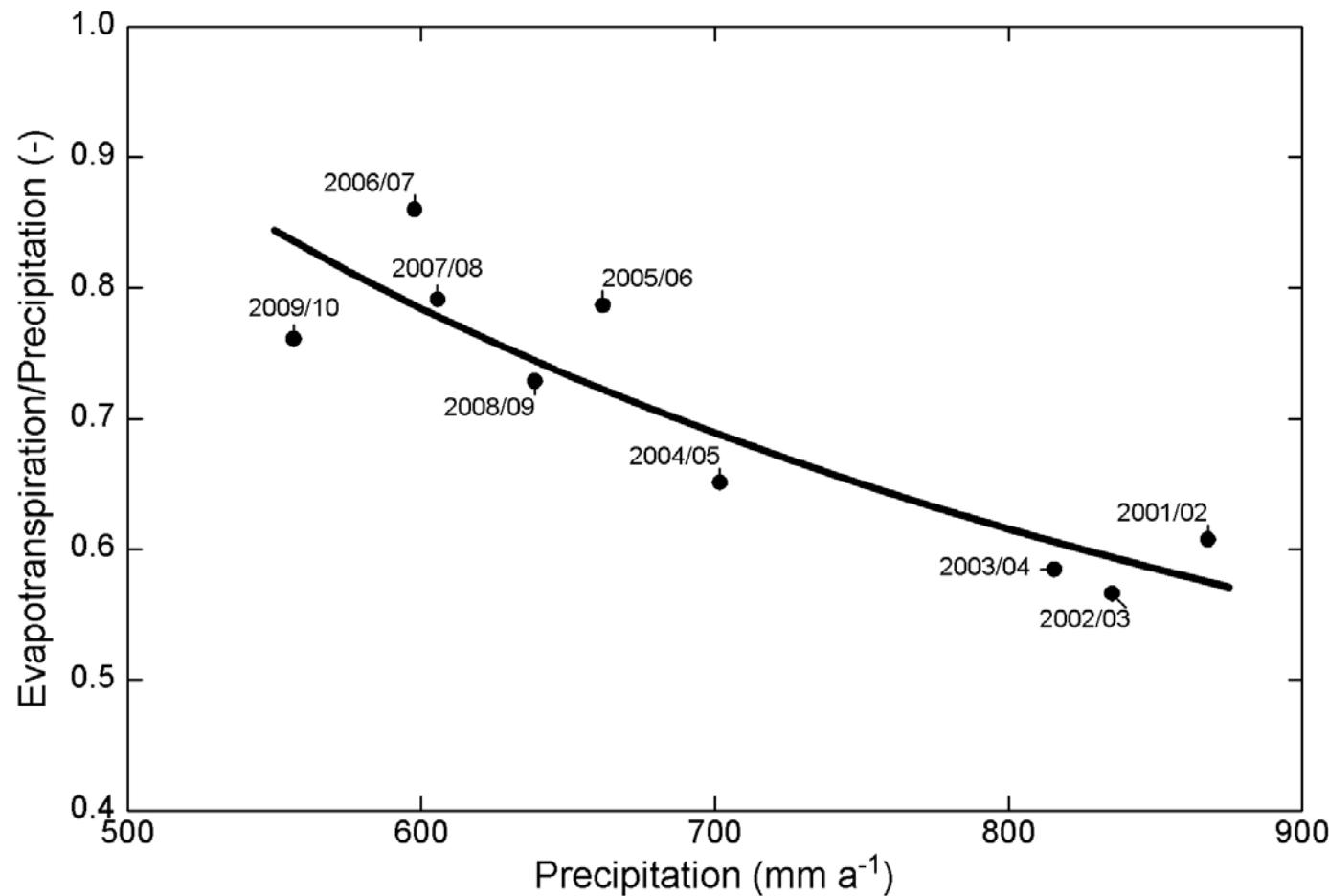


Precipitation



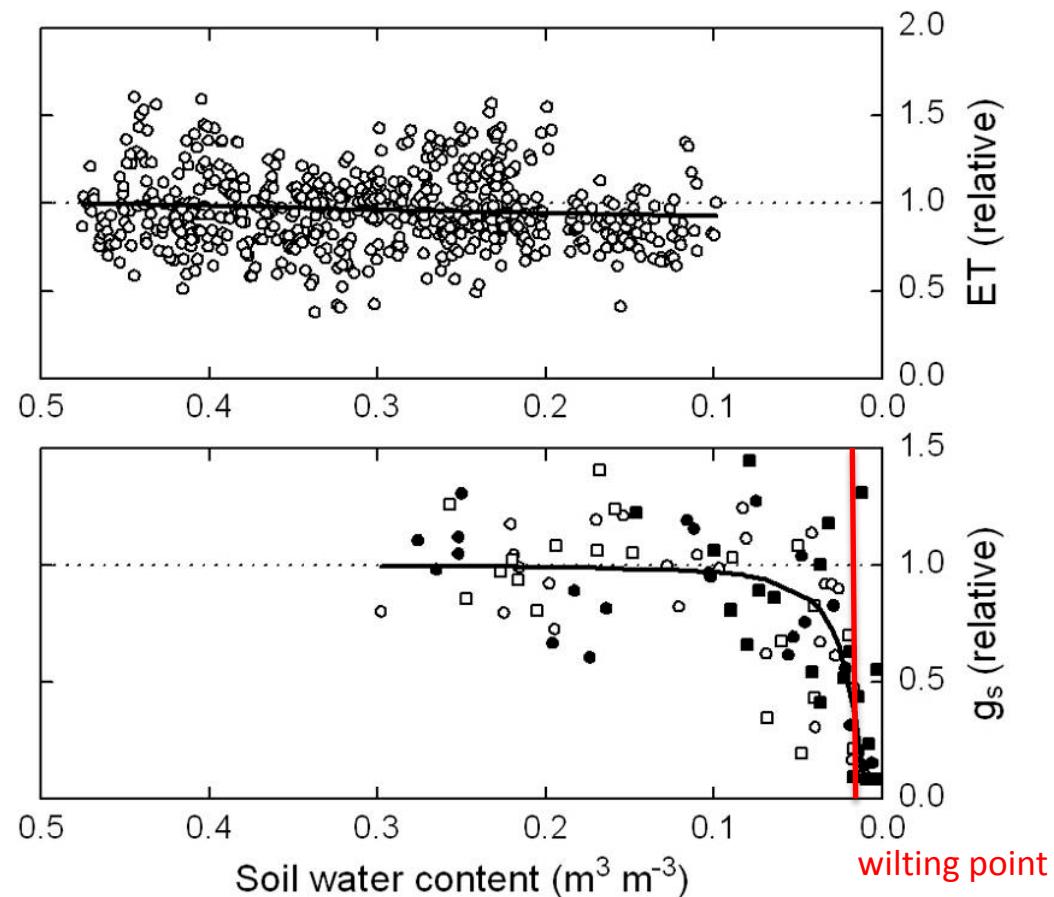


Precipitation



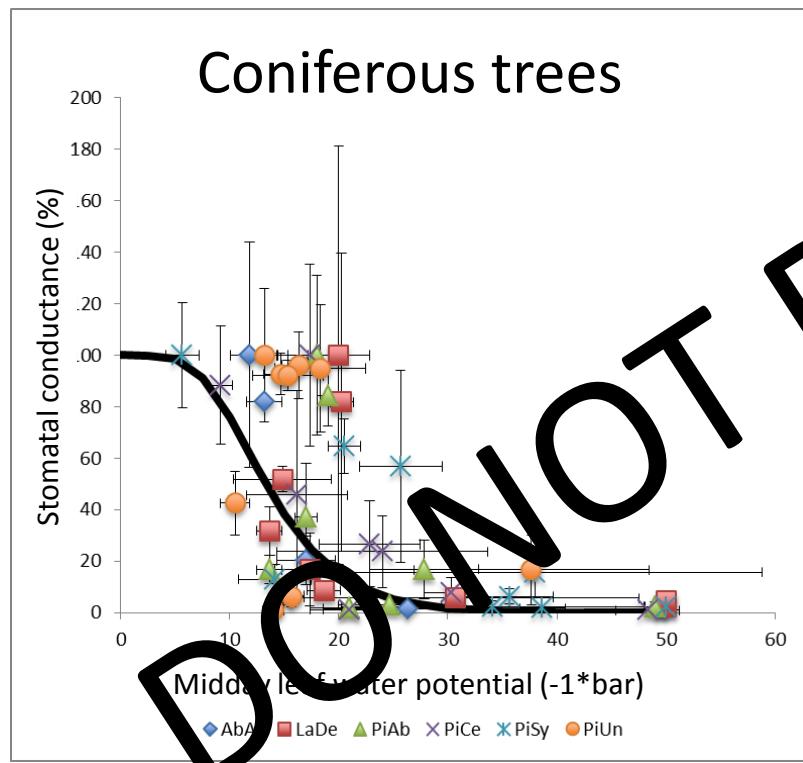


Precipitation

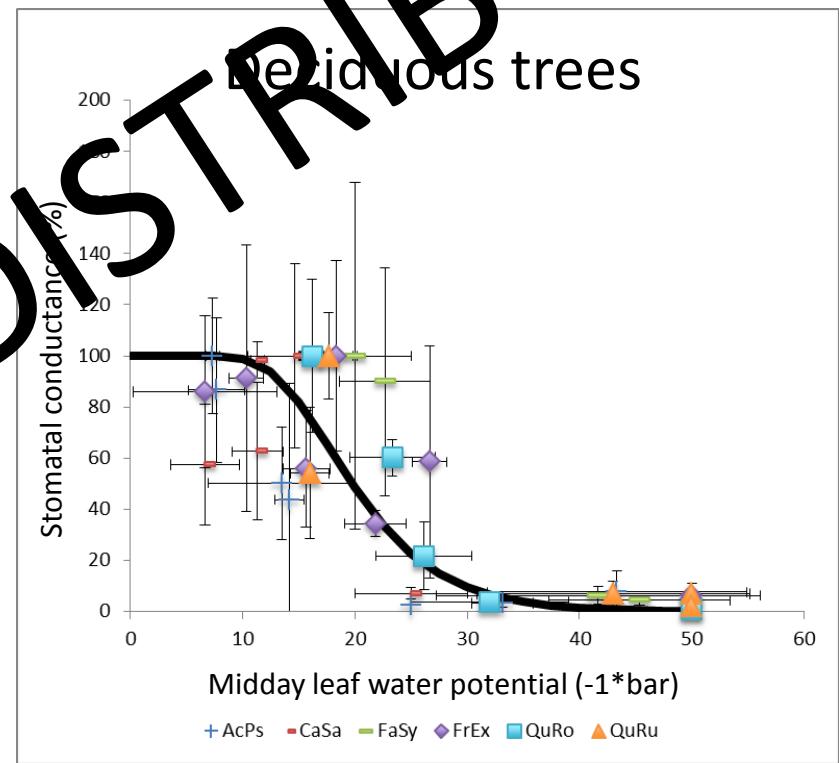




Precipitation



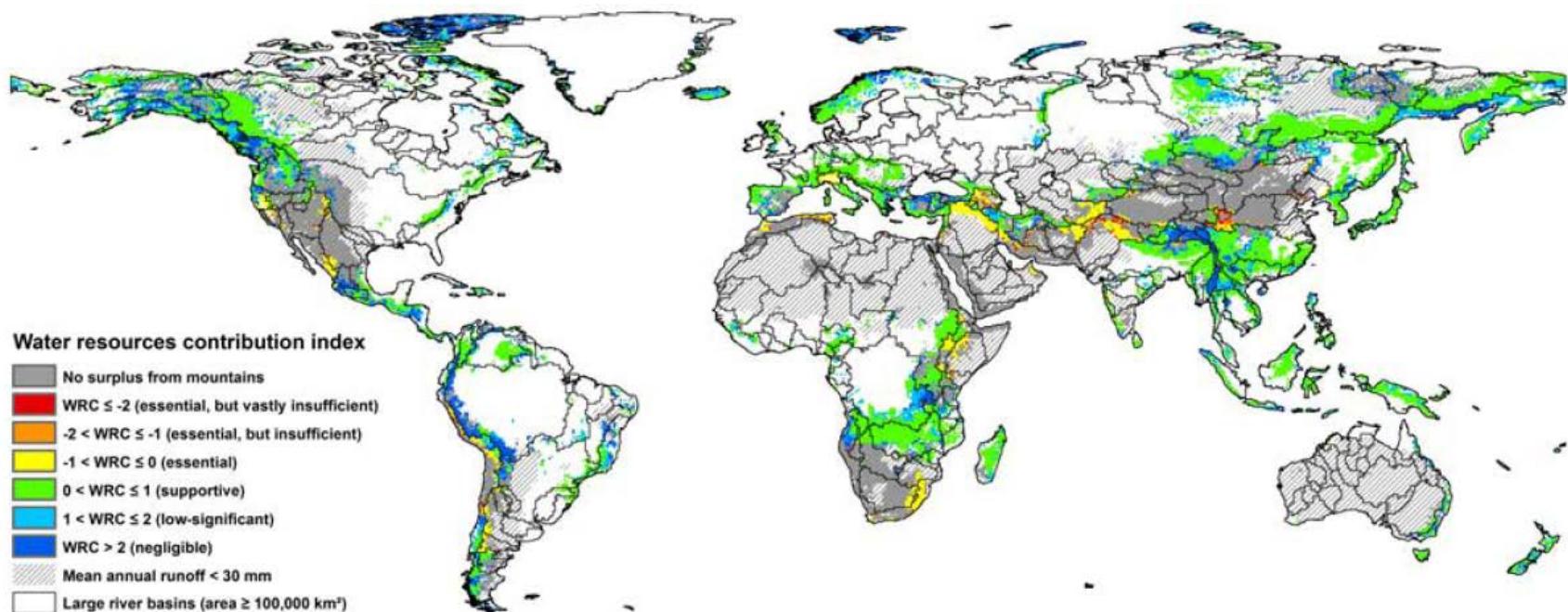
DONOT DISTRIBUTE





Precipitation

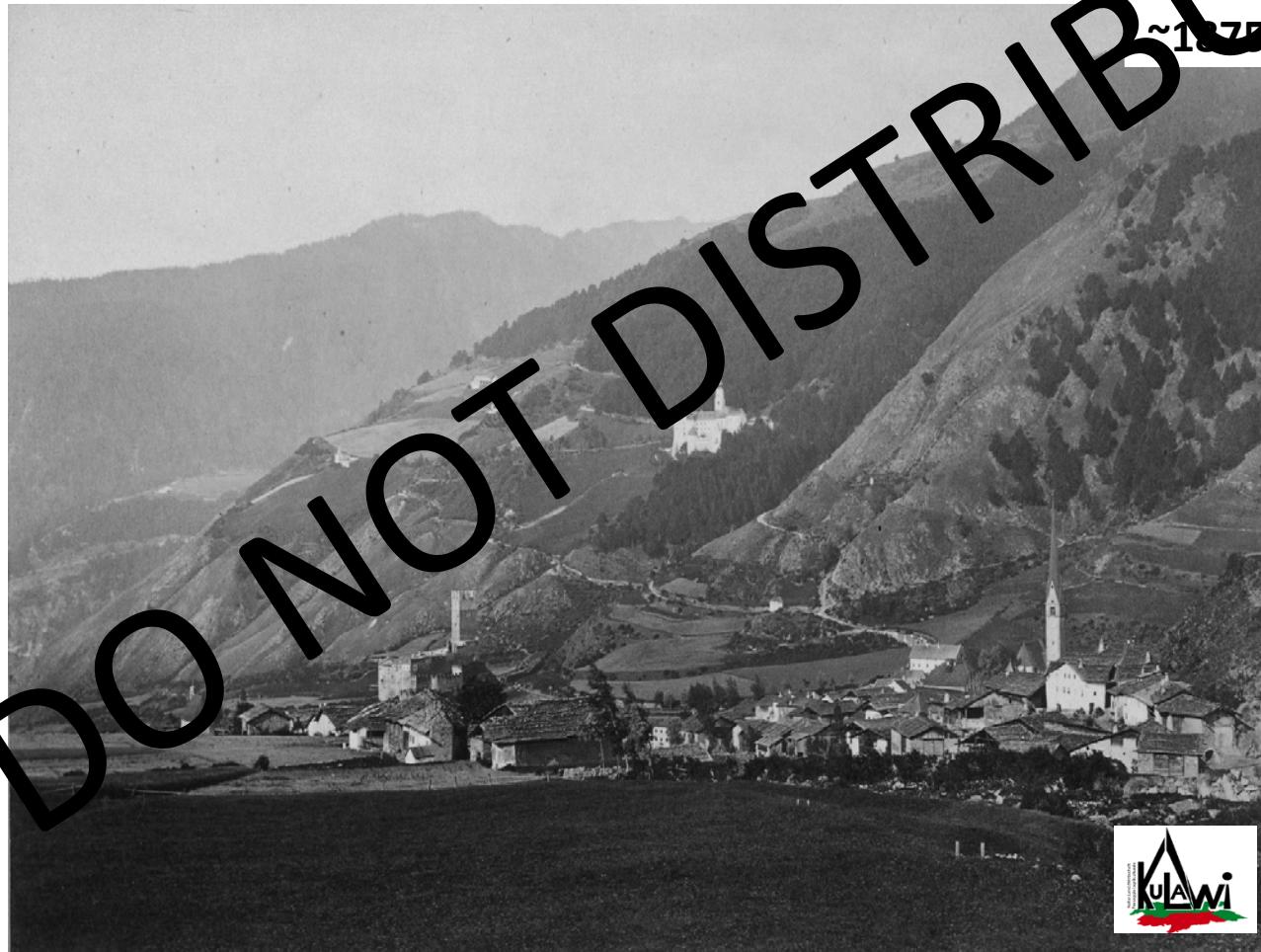
$$\text{PPT} - \text{ET} \approx \text{Runoff}$$





Land-use change

DO NOT DISTRIBUTE





Land-use change

2010

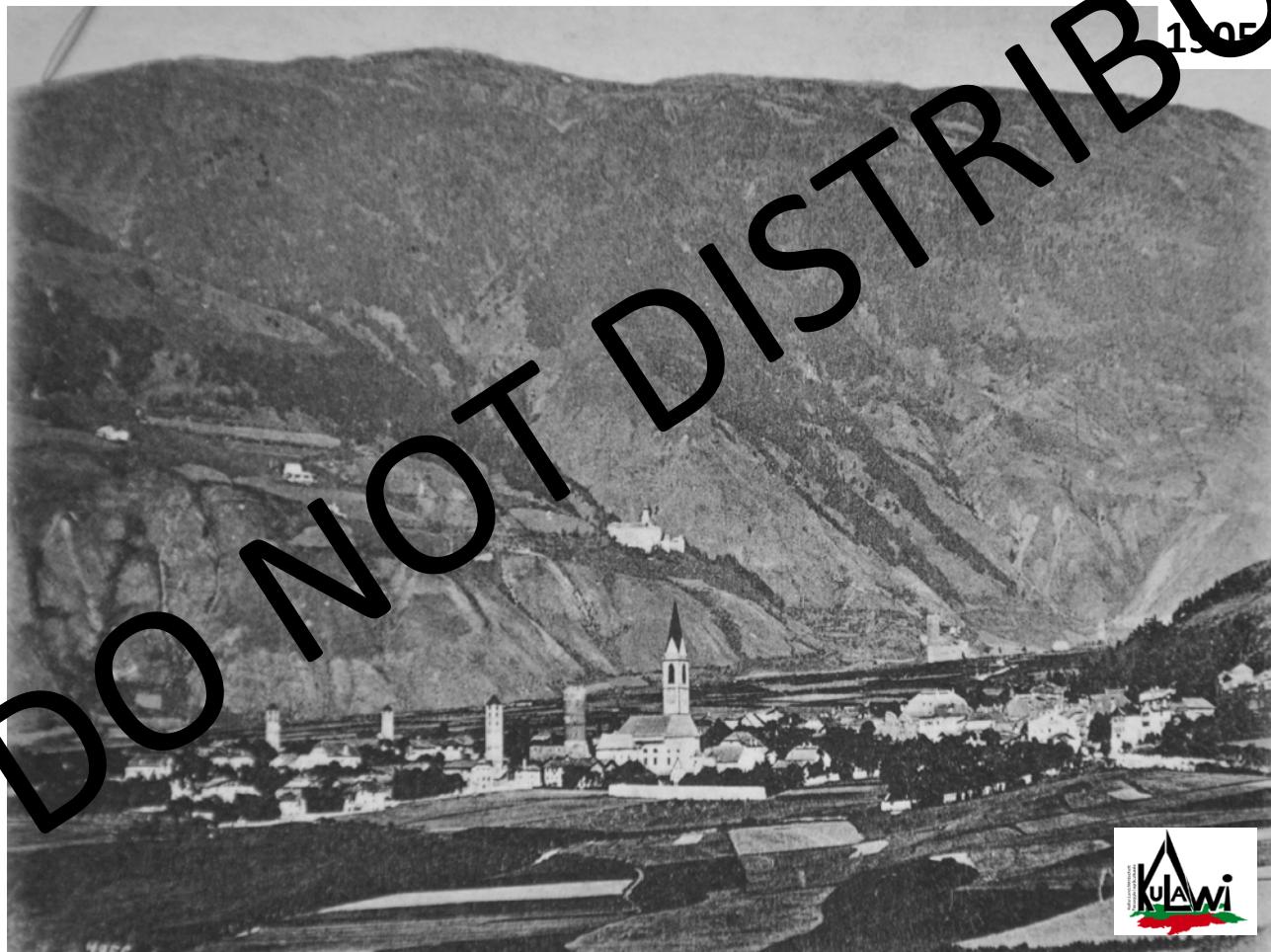


Photographs courtesy Erich Tasser (EURAC)



Land-use change

DO NOT DISTRIBUTE



Photographs courtesy Erich Tasser (EURAC)



Land-use change

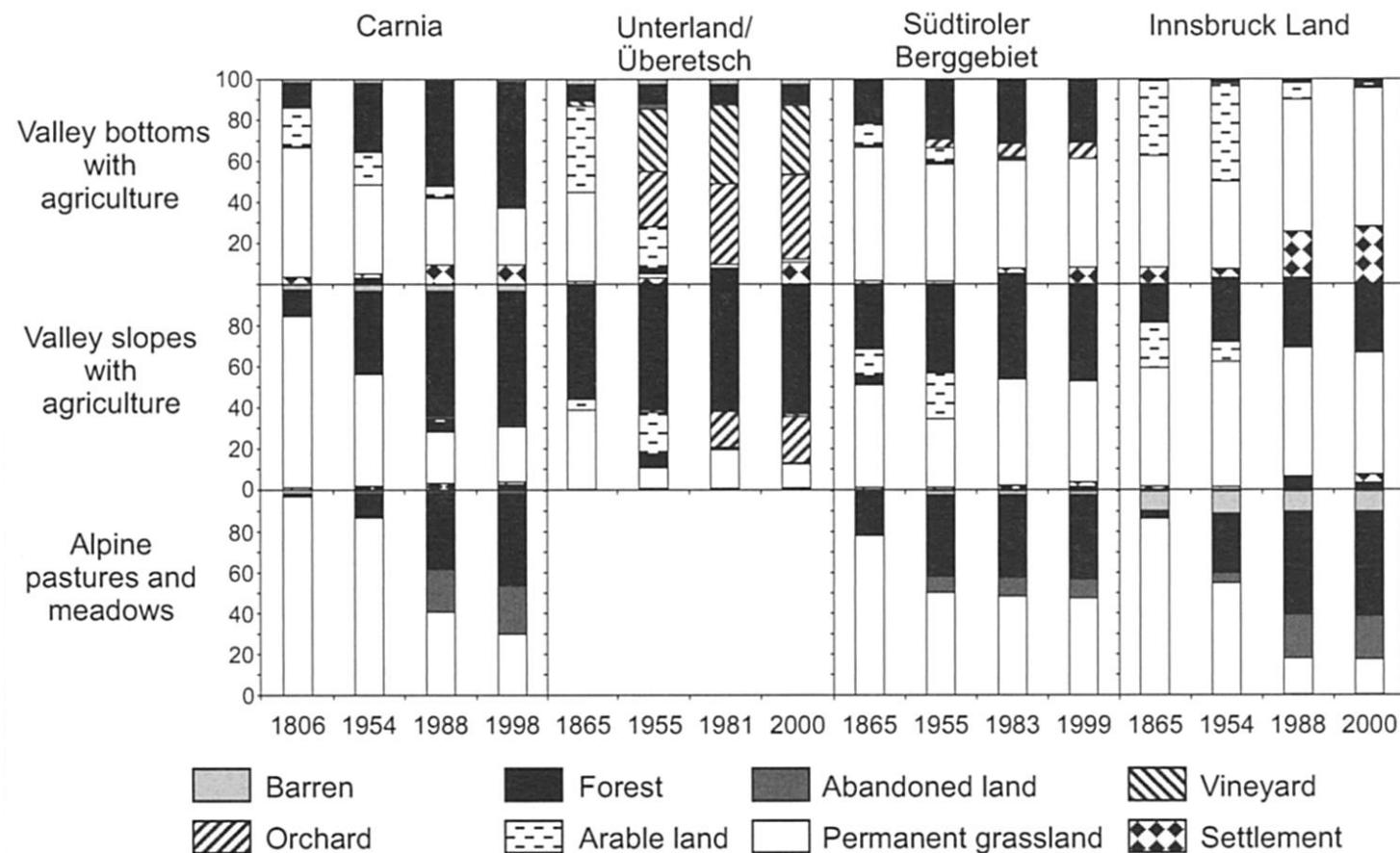
2010



Photographs courtesy Erich Tasser (EURAC)

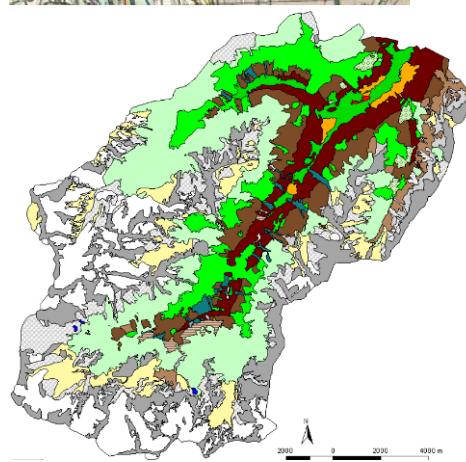
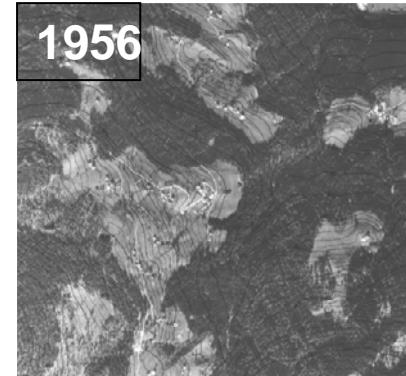
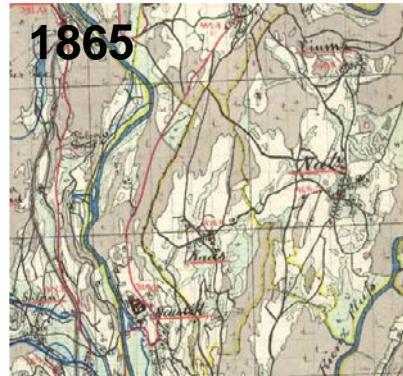


Land-use change

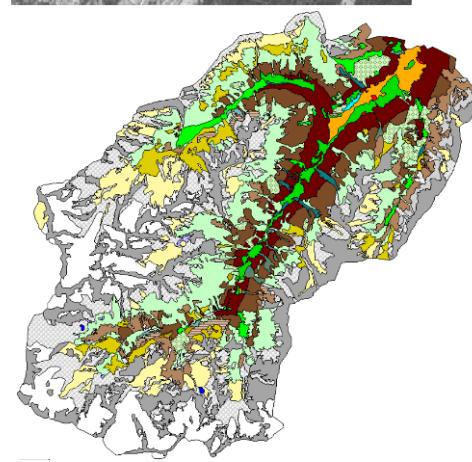




Land-use change



Lebensräume	
See	Laubwald
Hochmoor	Laub-Nadel-Mischwald
Kies- und Schotterbank	Gletscher, oder permanentes Schneefeld
Latschengebüsche	Saurer Felslebensraum des Hochgebirges
Nadelwald der subalpinen Stufe	Basischer Felslebensraum des Hochgebirges
Nadelwald der montanen Stufe	Saurer Felslebensraum der planaren bis subalpinen Stufe
Gehölzbestände auf Felsflur	Basischer Felslebensraum der planaren bis subalpinen Stufe
Grünerlengebüsch	Natürliche, saure alpine Rasen
Naß- und Feuchtwälder	Natürliche, basische alpine Rasen
Mischbestand: Feuchtwald-Nadelwald	Verstrauchte saure Wiesen und Weiden

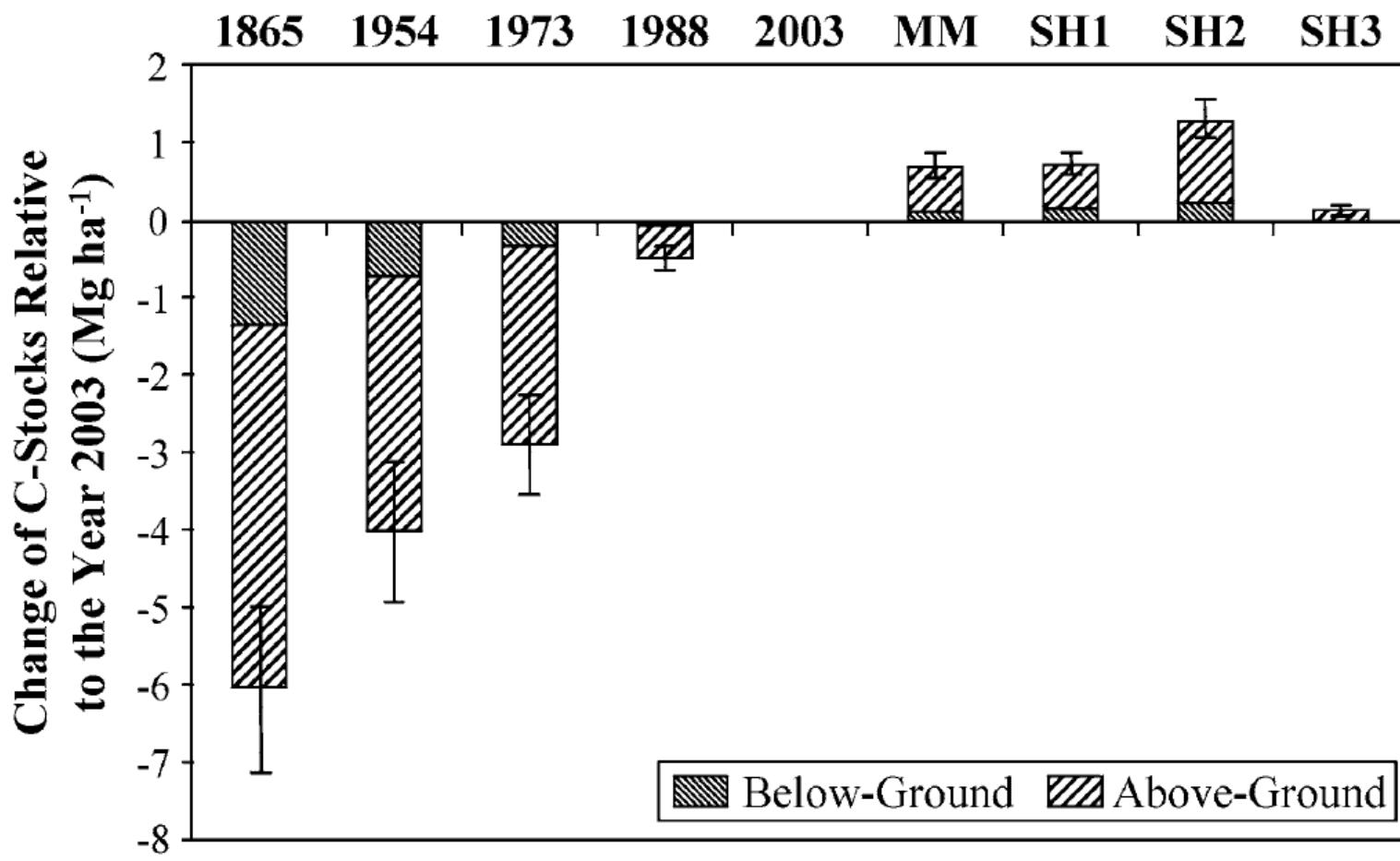


Verstrauchte basisch Wiesen und Weiden
Verbuschtes Kulturland
Extensiv genutztes Grasland auf saurem Boden
Extensiv genutztes Grasland auf basischem Boden
Mäßig intensiv bewirtschaftetes Grünland
Intensiv genutztes Wirtschaftsgrünland
Ackerflächen
Lärchwiese/-weide
Siedlungsraum
Parkplätze



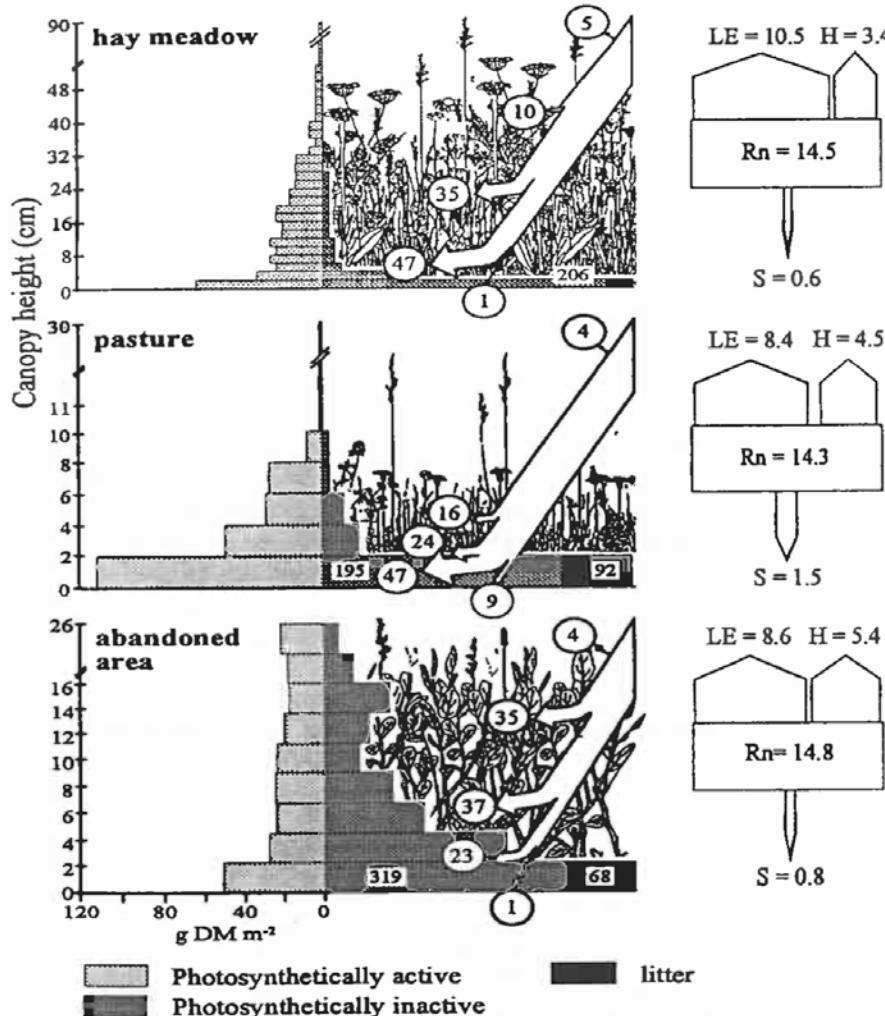
Land-use change

2018





Land-use change



$$\beta = 0.33, \lambda E = 0.72 R_n$$

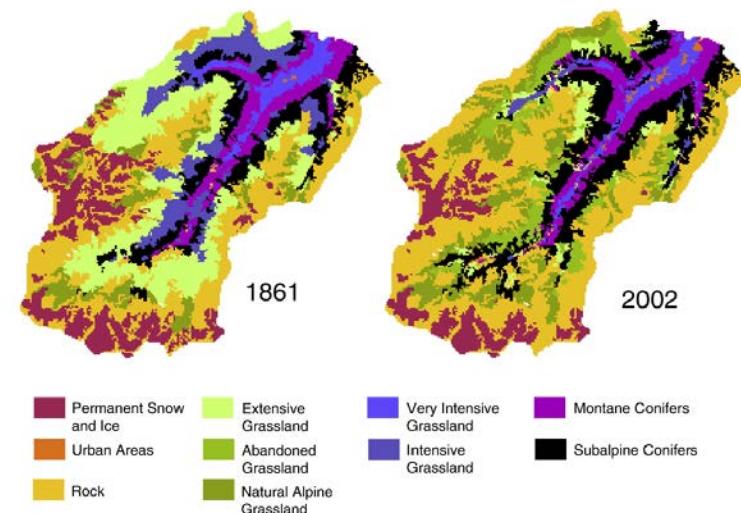
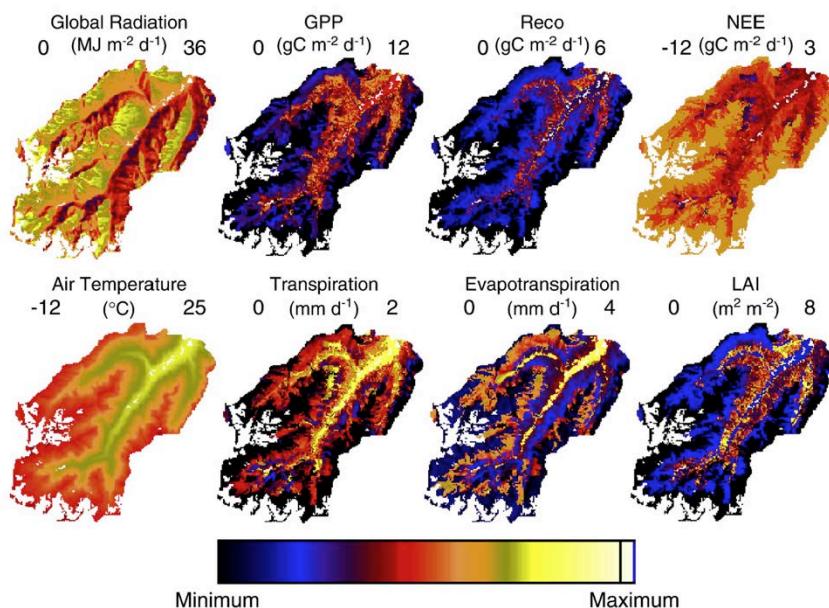
$$\beta = 0.54, \lambda E = 0.59 R_n$$

$$\beta = 0.63, \lambda E = 0.58 R_n$$



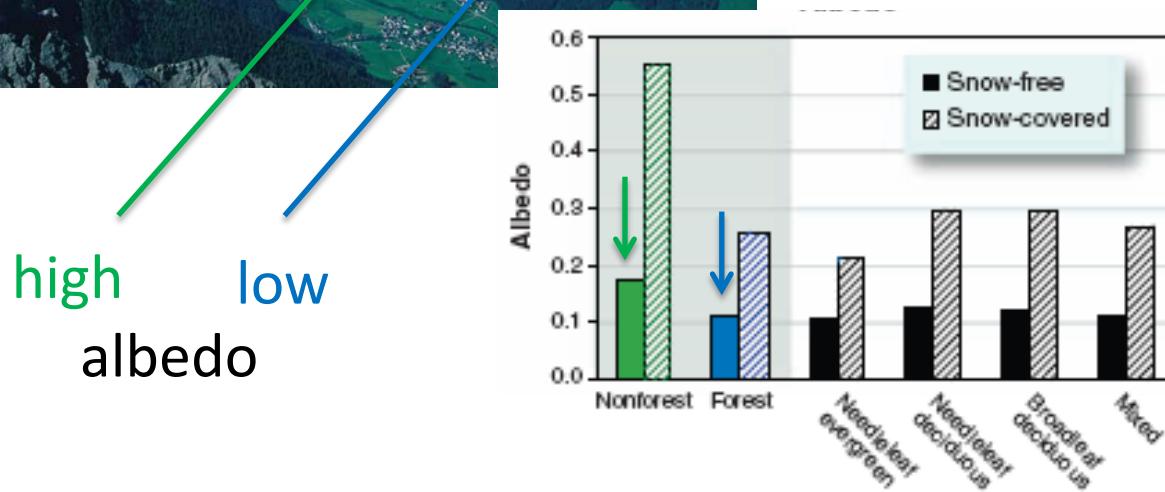
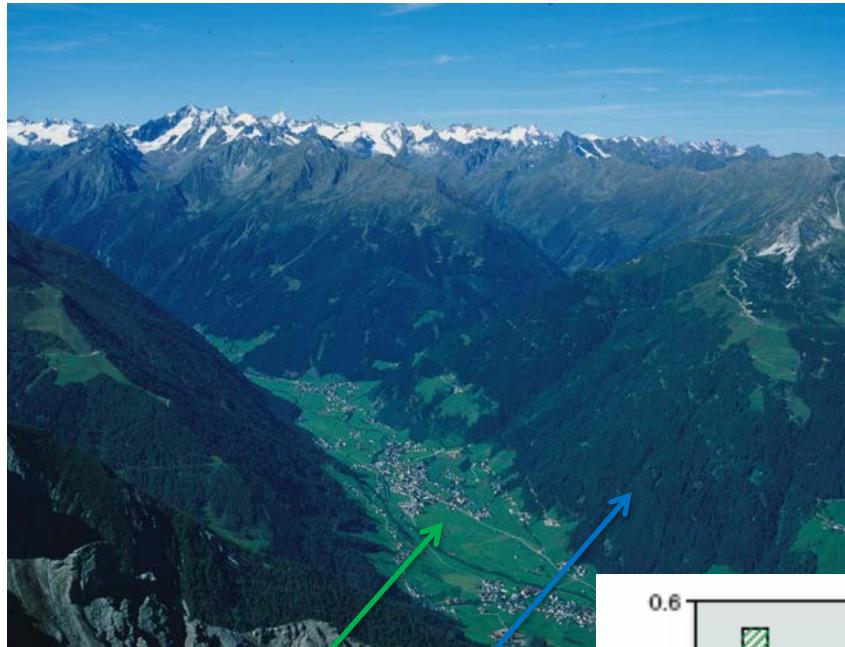
Land-use change

17% reduction in ET





Land-use change



Bonan (2008) Science



Conclusions

- **Global change has winners and losers**
- **Global change is multi-factorial – our experiments need to be so too**
- **Climate change x Land-use change interaction**
- **Climate change: means vs. extremes**
- **Ecosystem response to Global change is non-linear (regime shifts, switches, tipping points, ...)**
- **Global change surprises: watch out for the “unknown unknowns”**

Grazie per la vostra attenzione!



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