

Ecosystem Services and Functions of Biodiversity in Grasslands

A. Weigelt¹, A. Vogel², M. Scherer-Lorenzen³

¹ Institute of Biology I, University of Leipzig

² Institute of Ecology, University of Jena

³ Faculty of Biology, University of Freiburg



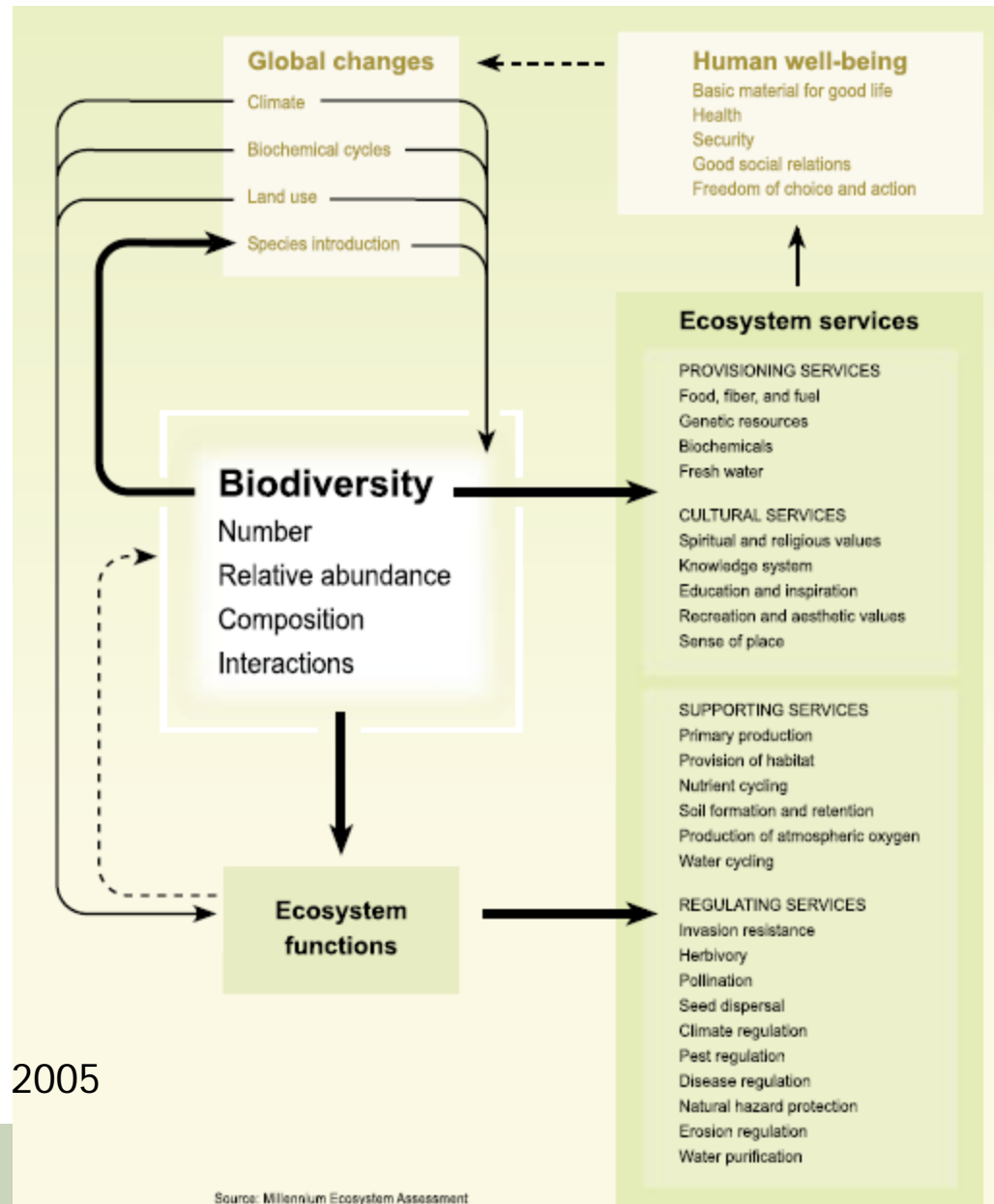
DFG

EGF 2010

Grassland Ecosystem Services

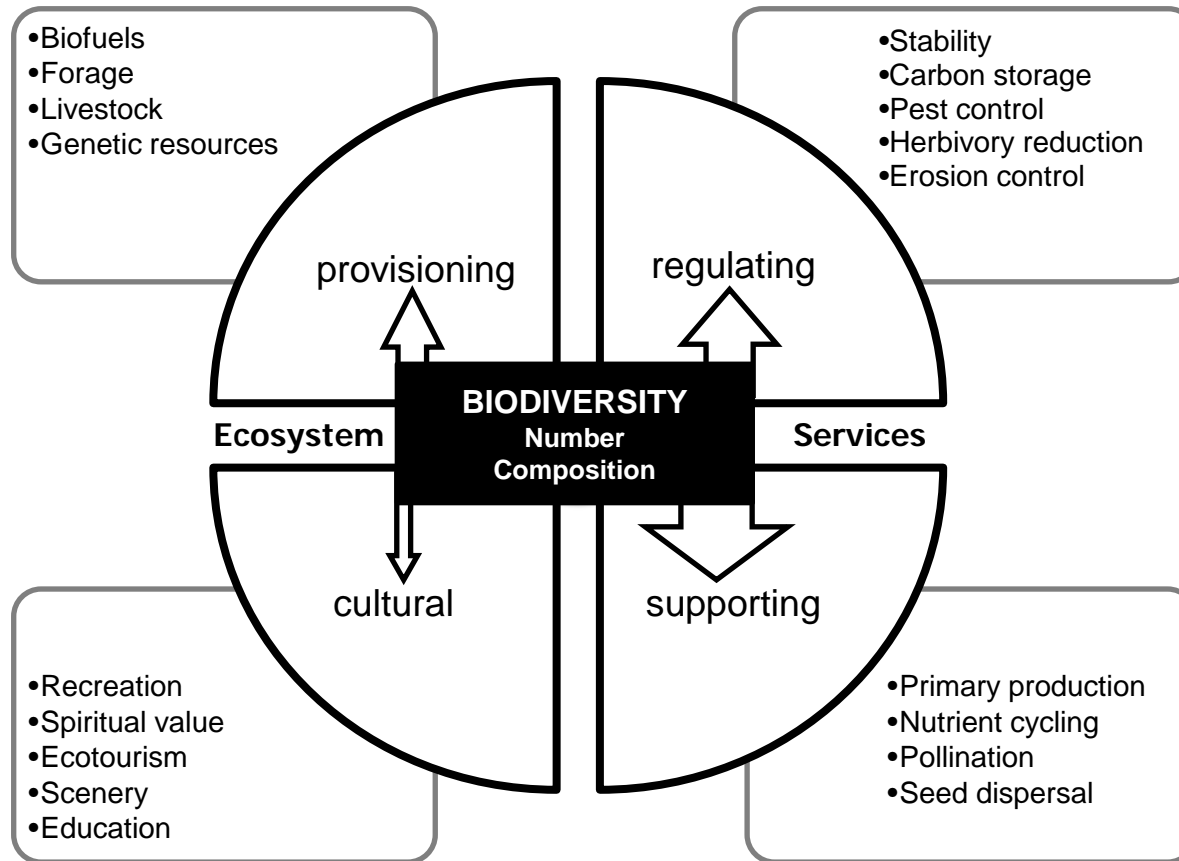
- **Provision services**
 - Food, forage, livestock, fibers, genetic resources, biofuel, biochemicals, medicines, pharmaceuticals, ornamental resources
- **Supportive functions and structures**
 - Nutrient-, carbon- and water cycling, net primary production, pollination, seed dispersal, habitat, soil formation
- **Regulating services**
 - CO₂ sequestration, climate regulation, soil retention, soil fertility, carbon storage, purification of water, watershed functions, pest- and disease control, reduction of herbivory, stability
- **Cultural services**
 - Ecotourism, recreation, scenery, religious value, science and education

Ecosystem Services

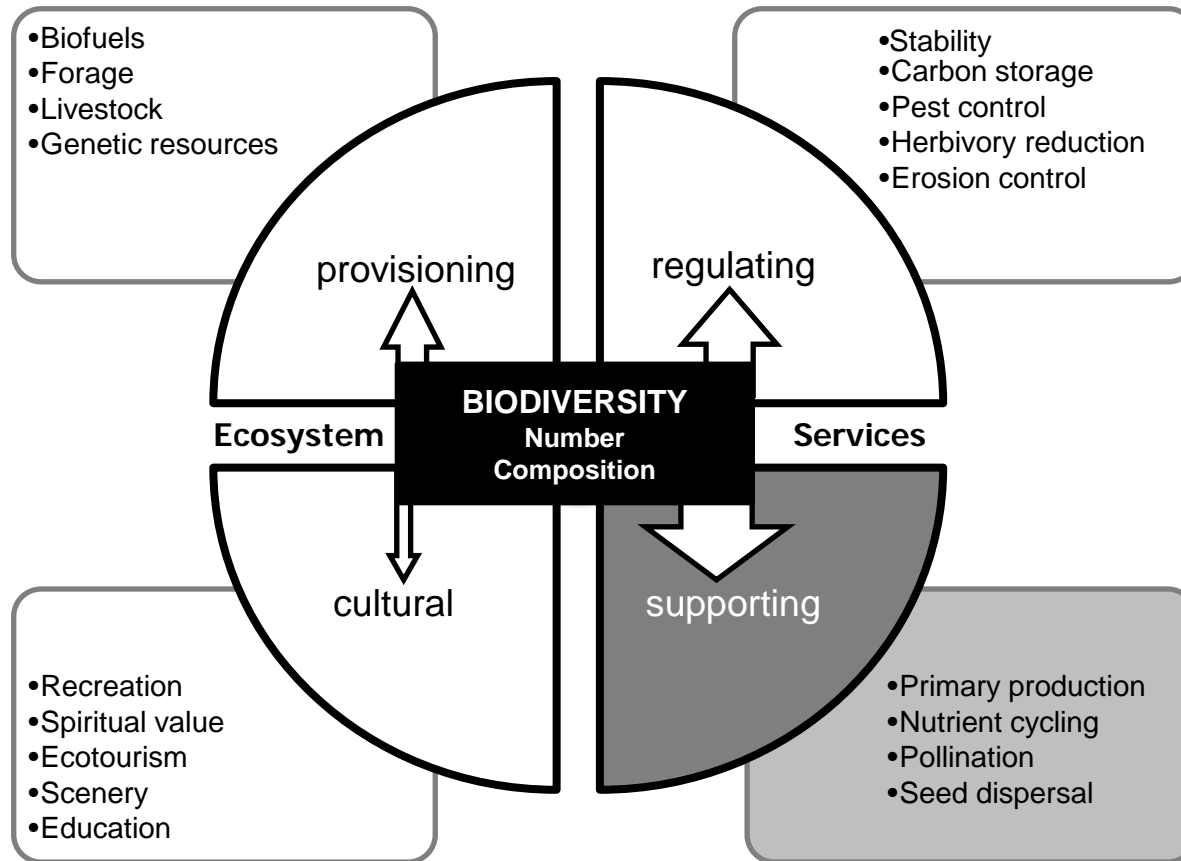


Millenium Ecosystem Assessment 2005

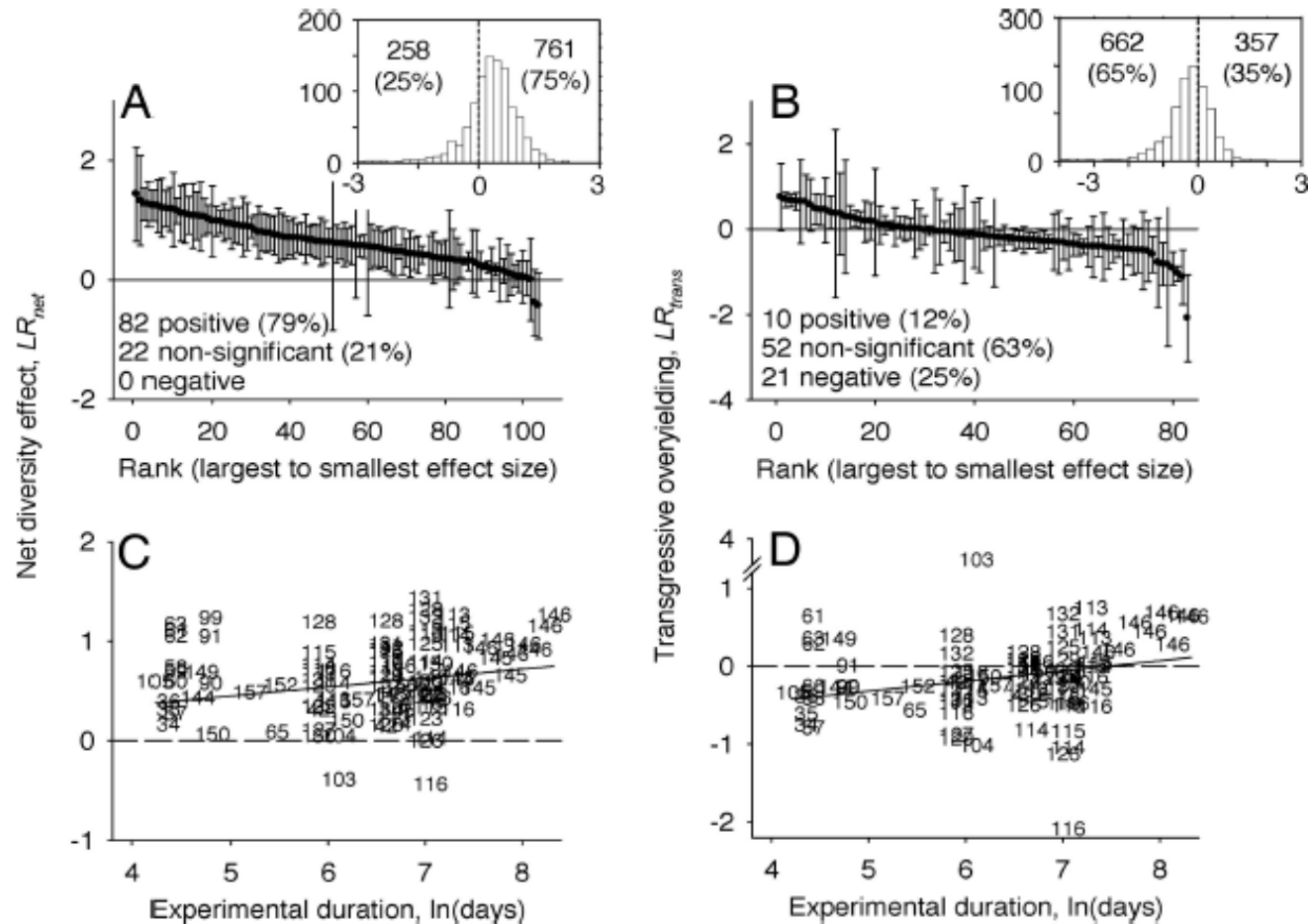
Grassland Ecosystem Services



Supporting services of biodiversity

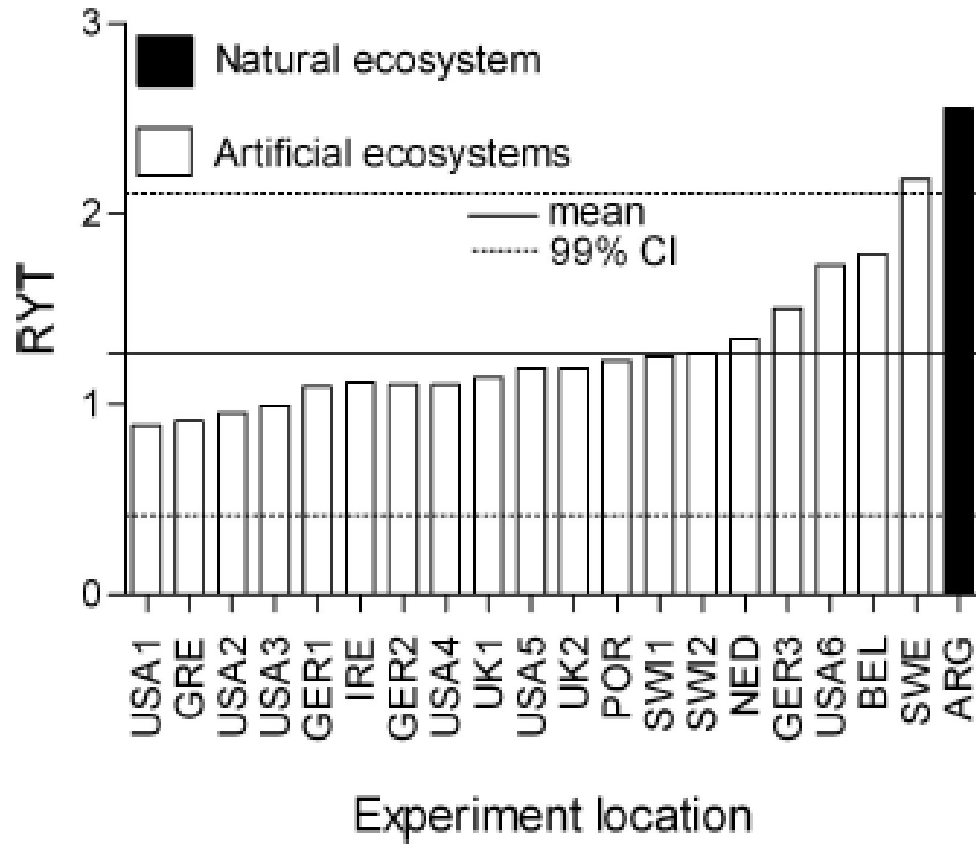


Primary production

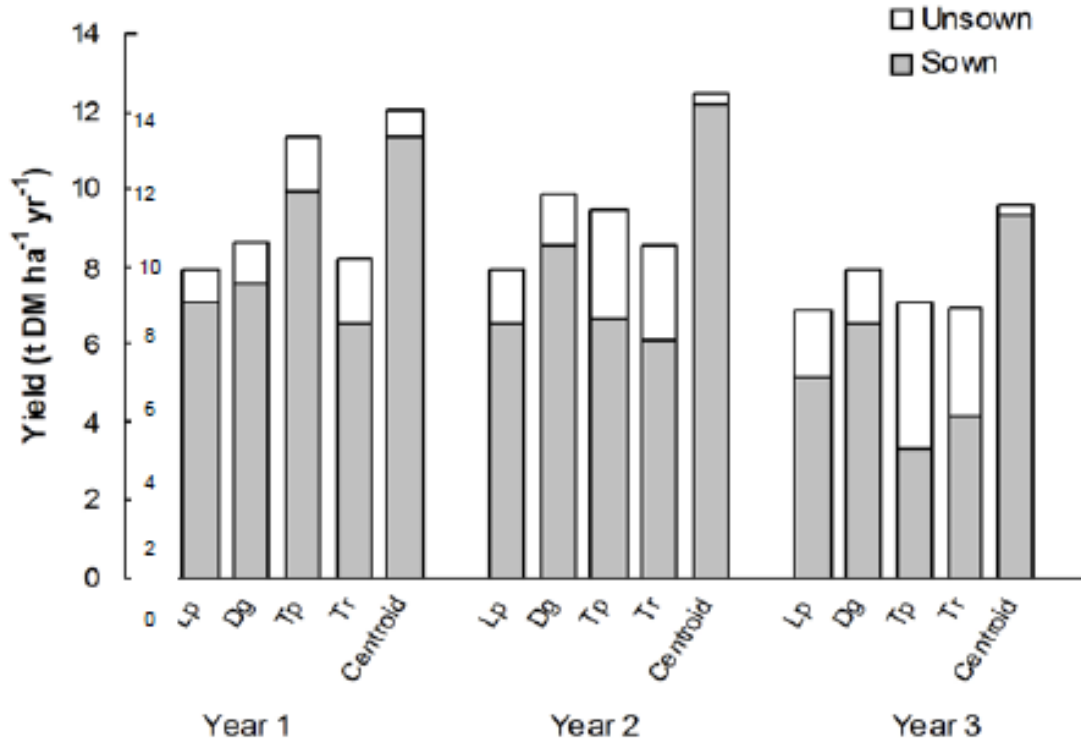


(44 studies, 41
grasslands)
Cardinale et al.
2006

Primary production



Primary production



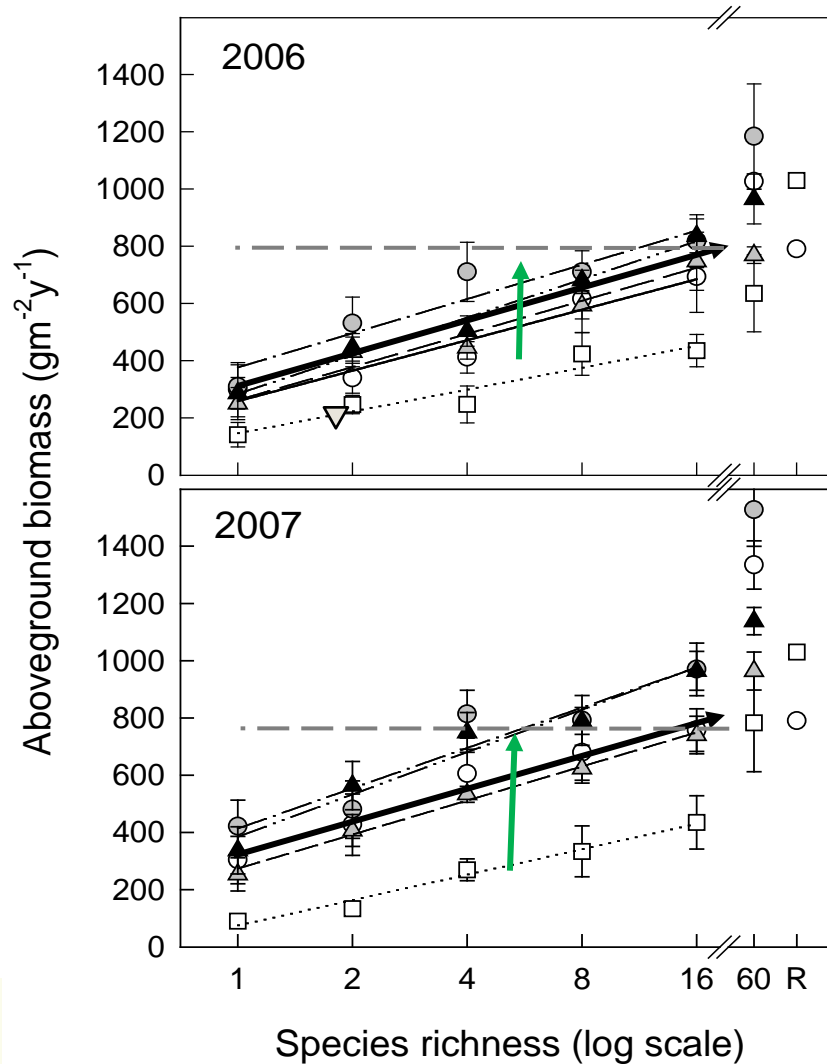
Lüscher et al. 2008

Kirwan et al. 2007

Bullock et al. 2009

Frankow-Lindberg et al. 2009

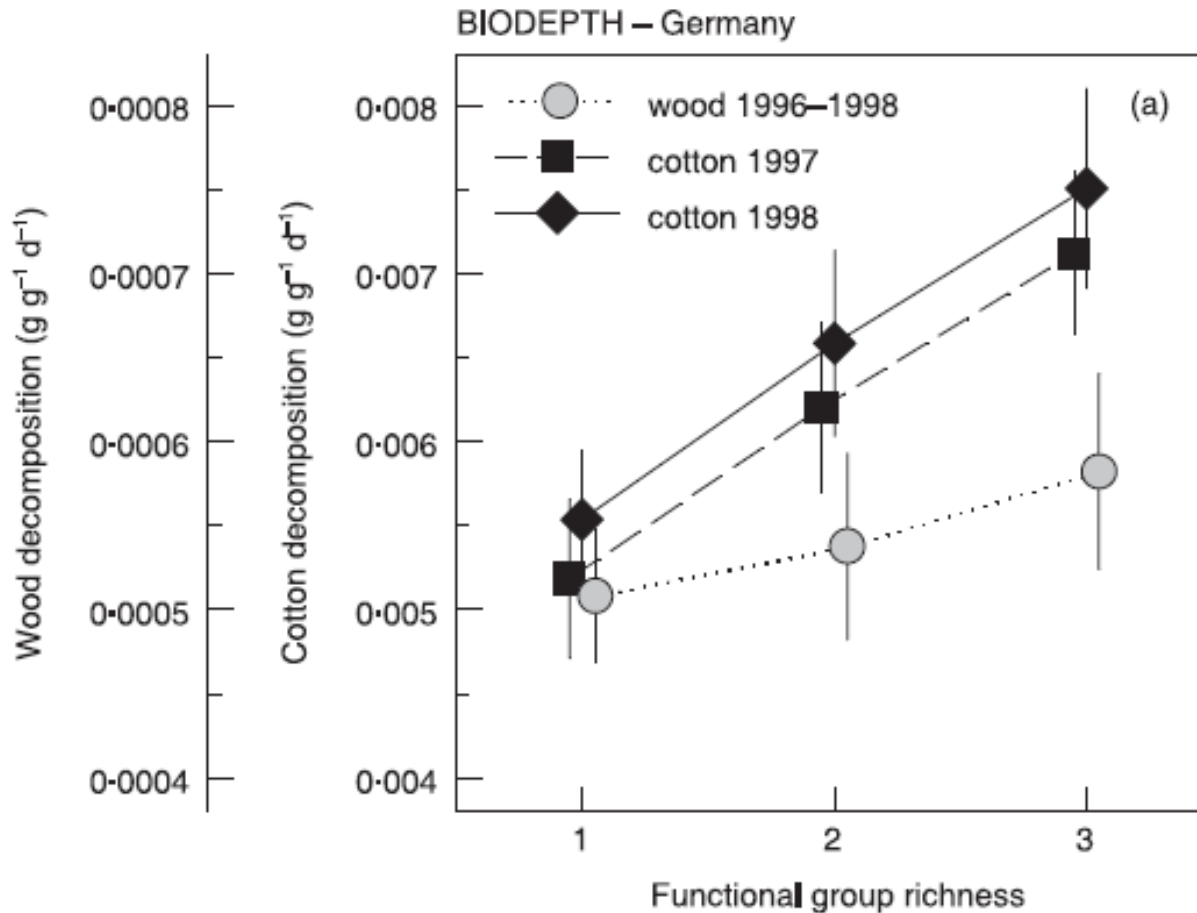
Primary production



Species richness: 450 (490) $\text{g m}^{-2} \text{y}^{-2}$
 Management: 315 (440) $\text{g m}^{-2} \text{y}^{-2}$

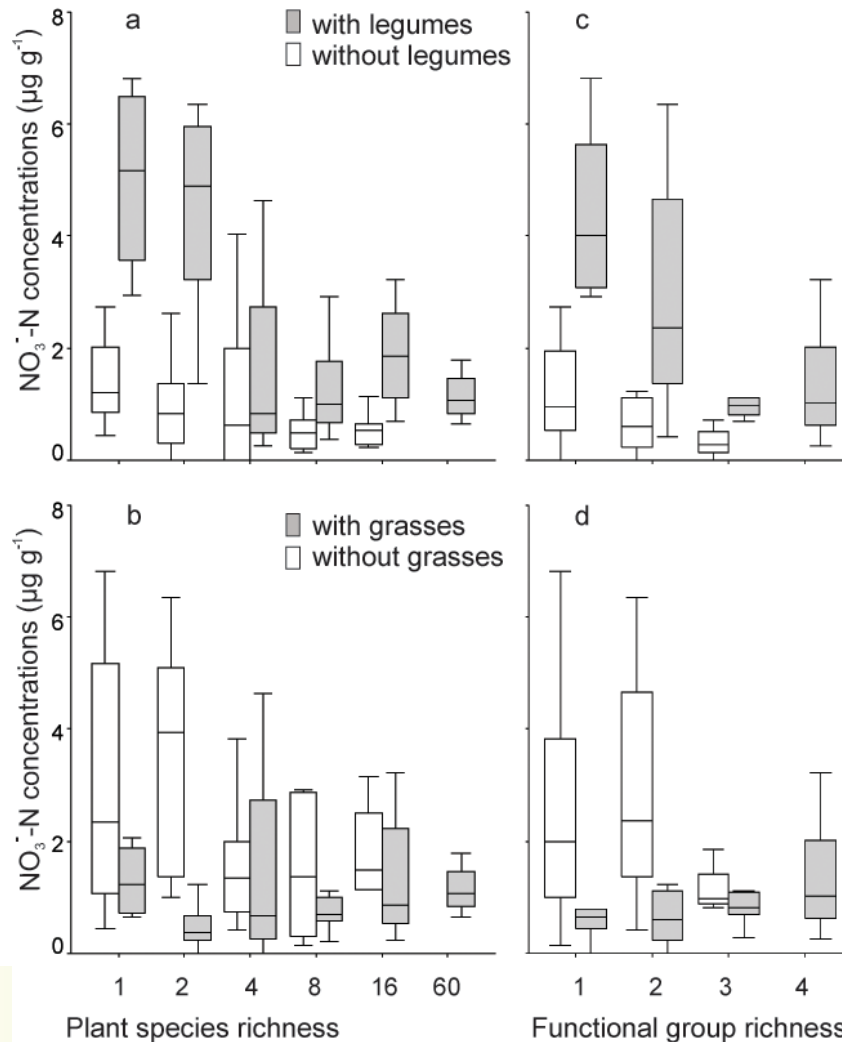
Weigelt et al. 2009
 Nyfeler et al. 2009

Plant nutrient concentration - litter decomposition



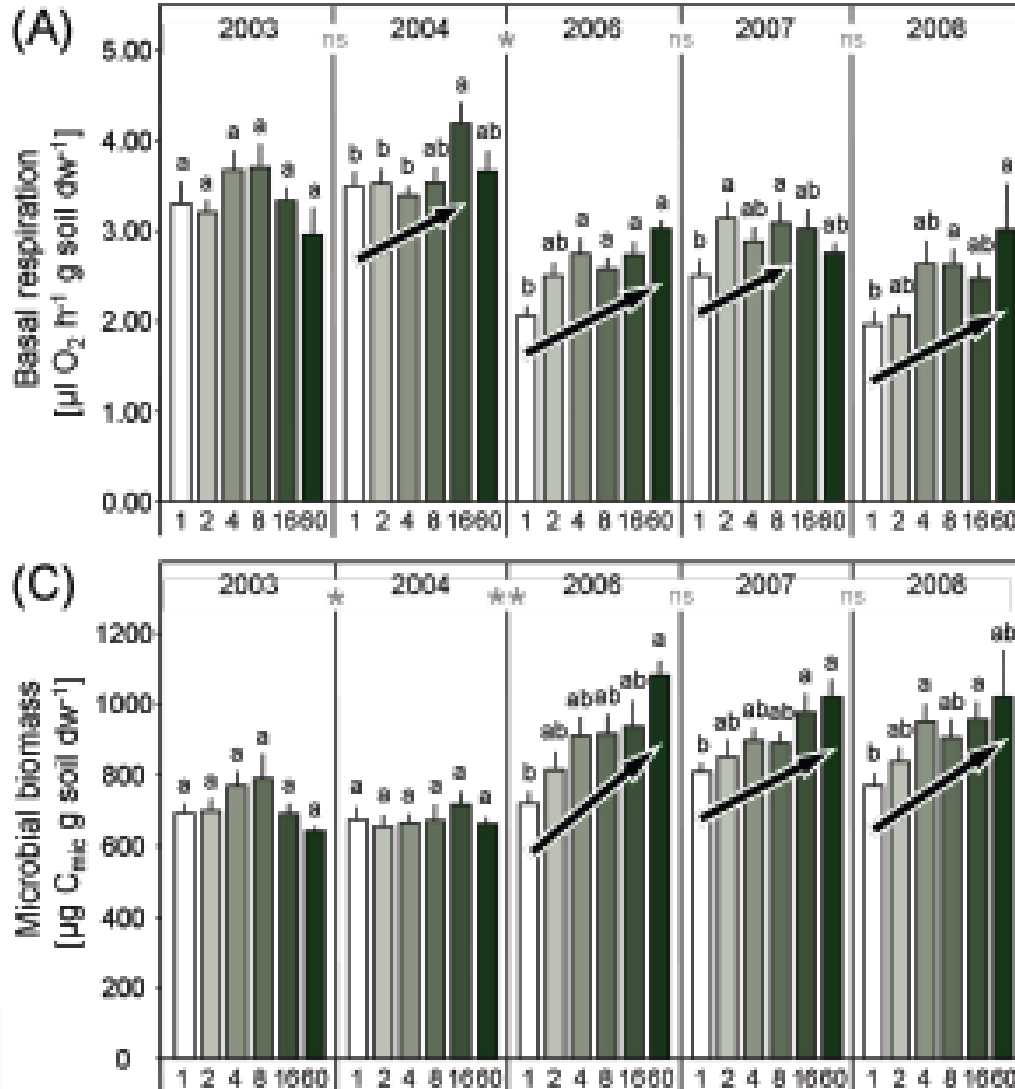
Scherer-Lorenzen 2008
 Tilman et al. 1997
 Hector et al. 2000
 Spehn et al. 2002
 Dybzinski et al. 2008
 Fargione et al. 2007
 Fornara et al. 2009
 BUT: Knops et al. 2001

Soil nutrient concentration and microbial activity



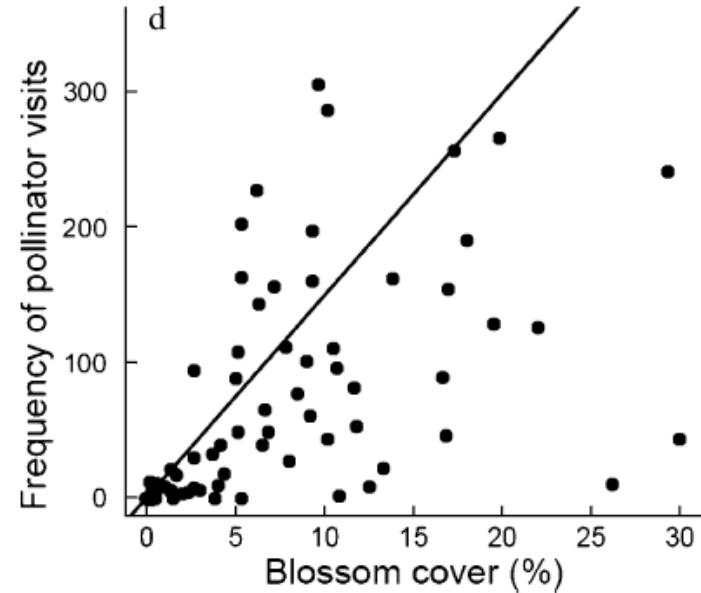
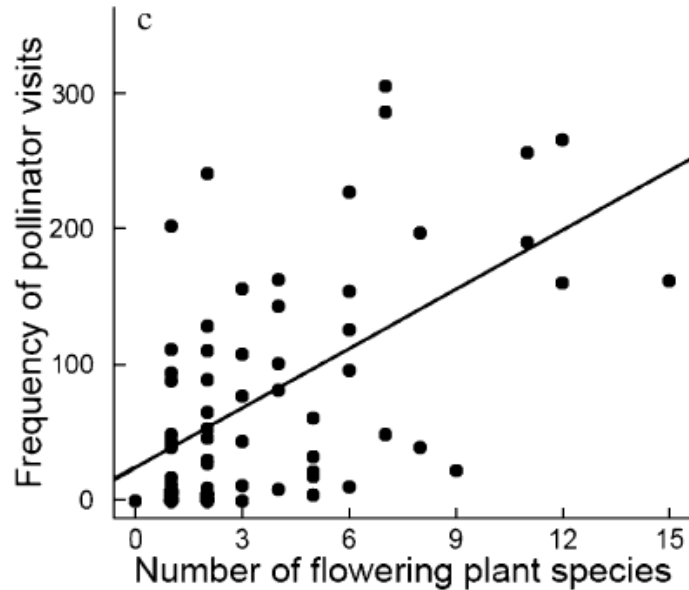
Oelmann et al. 2007
 Hooper & Vitousek 1997
 Tilman et al. 1996
 Van der Heijden et al. 1998
 BUT: Symstad et al. 1998

Soil nutrient concentration and soil biota activity

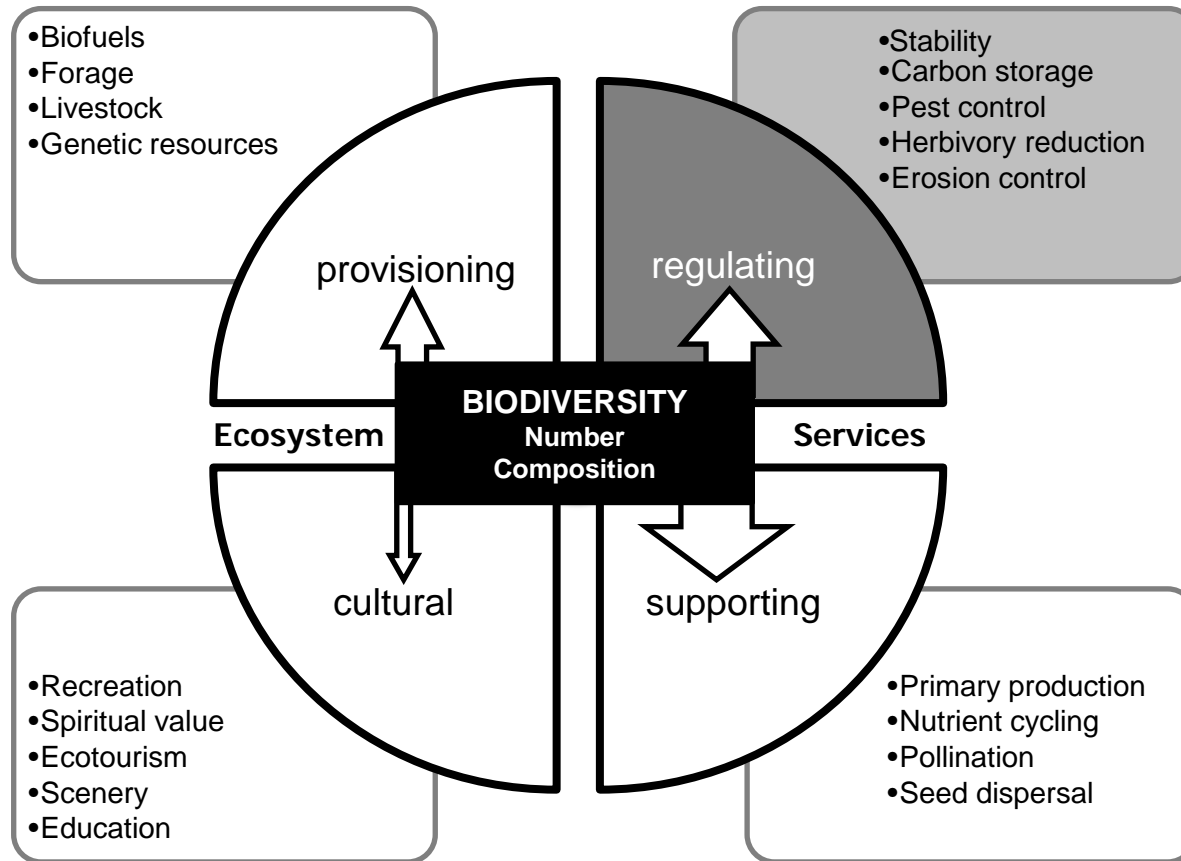


Eisenhauer et al. 2010
 Van Eekeren et al. 2009
 Partly: Zak et al. 2003

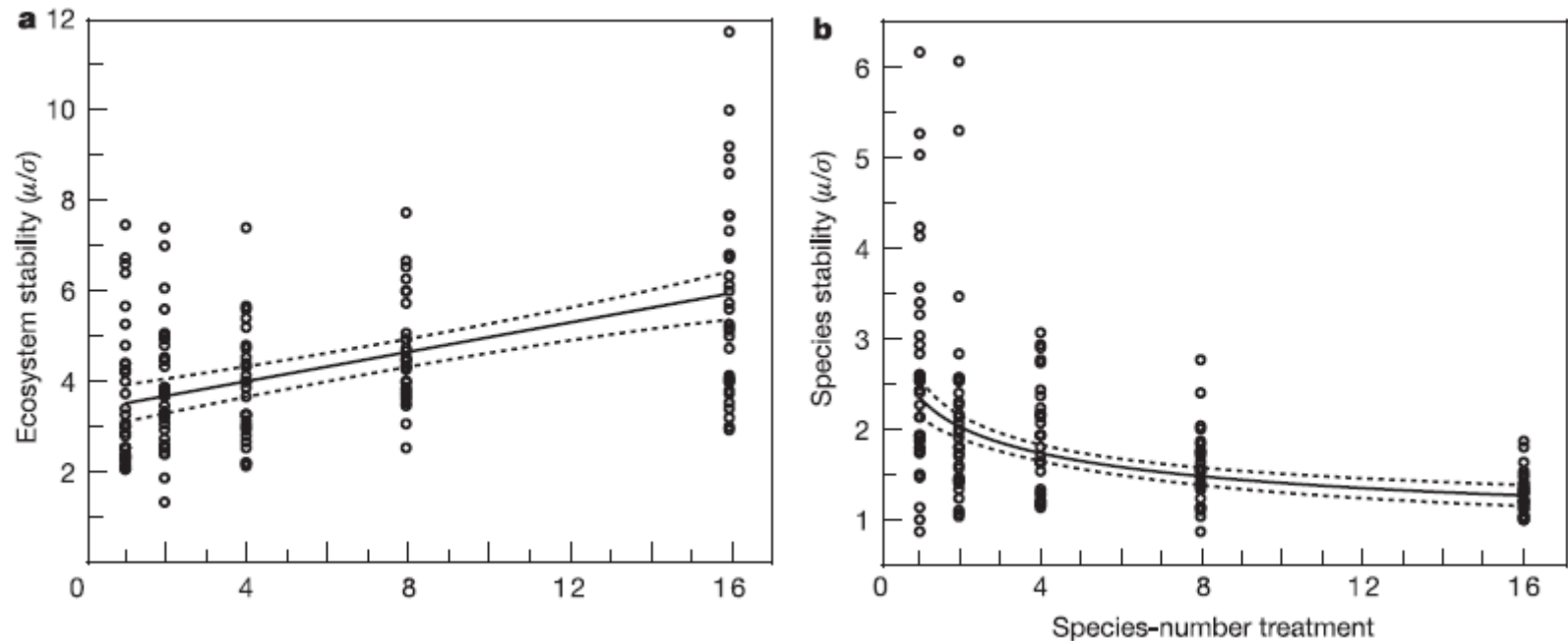
Pollination



Regulating services of Biodiversity



Stability of primary production



Stability over time:

Tilman et al. 2006

Isbell et al. 2009

Stability within one field:

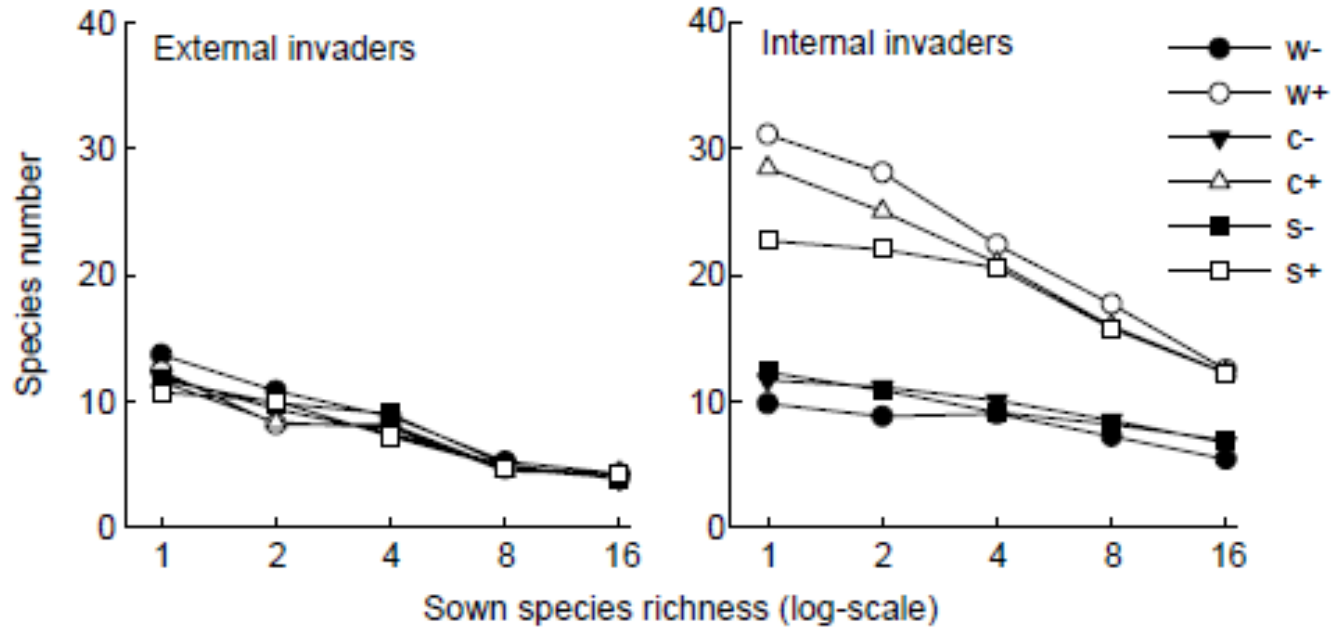
Weigelt et al. 2008

Stability as economic value:

Koellner & Schmitz 2006

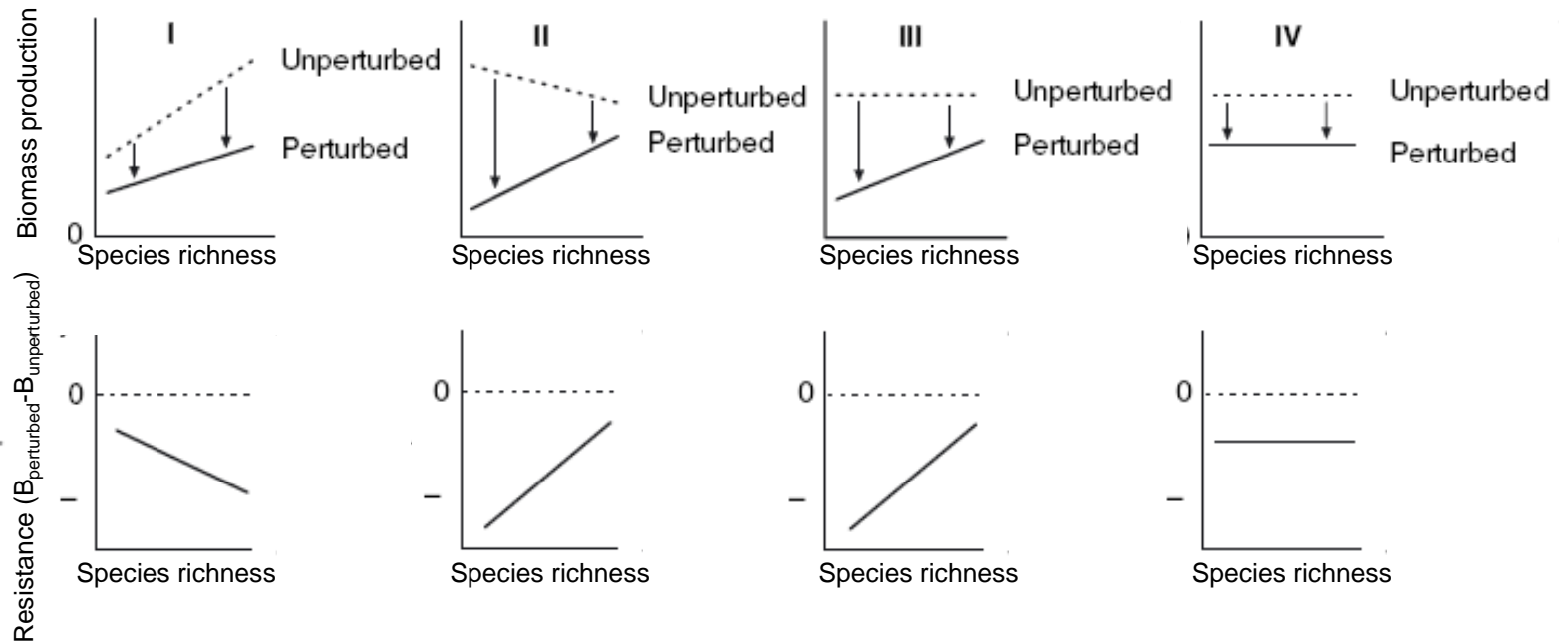
Baumgartner 2007

Invasion resistance



Roscher et al. 2009 a,b,c
 Joshi et al. 2000
 Tracy & Sanderson 2004
 Lanta & Leps 2008
 Maron & Marler 2008
 Frankow-Lindberg et al. 2009

Drought resistance



Pfisterer & Schmid 2002
De Boek et al. 2008
Van Ruijven et al. 2010

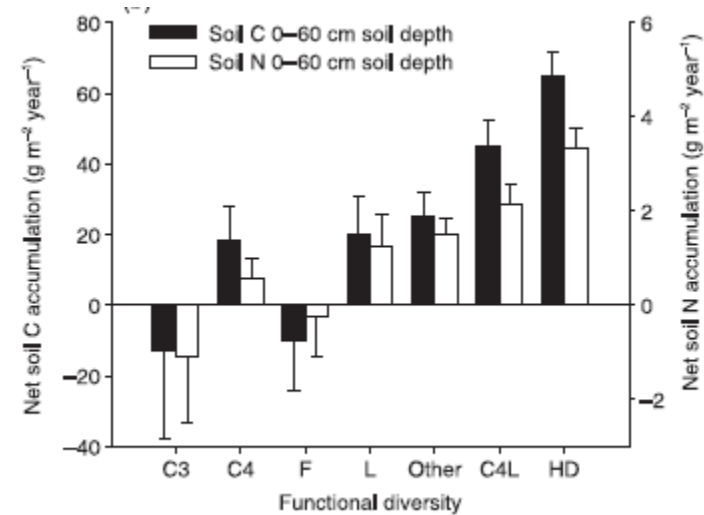
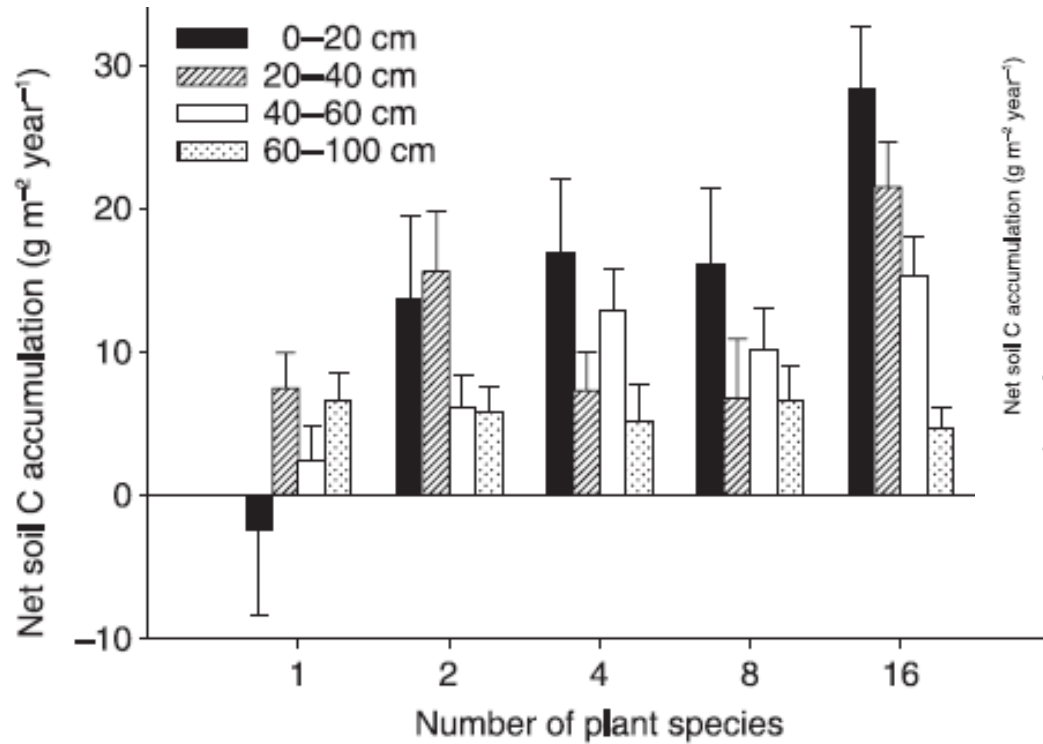
Tilman 1996

Mulder et al 2001

Wang et al.2007
Kahmen et al 2005

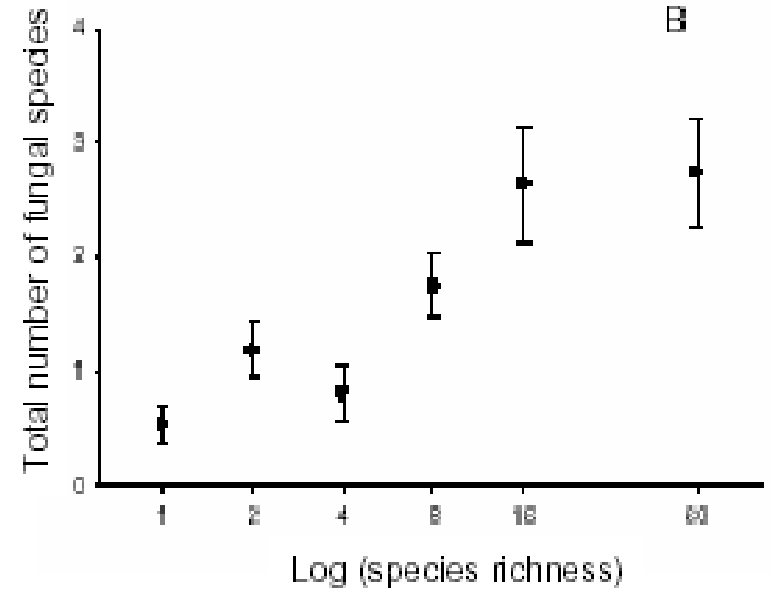
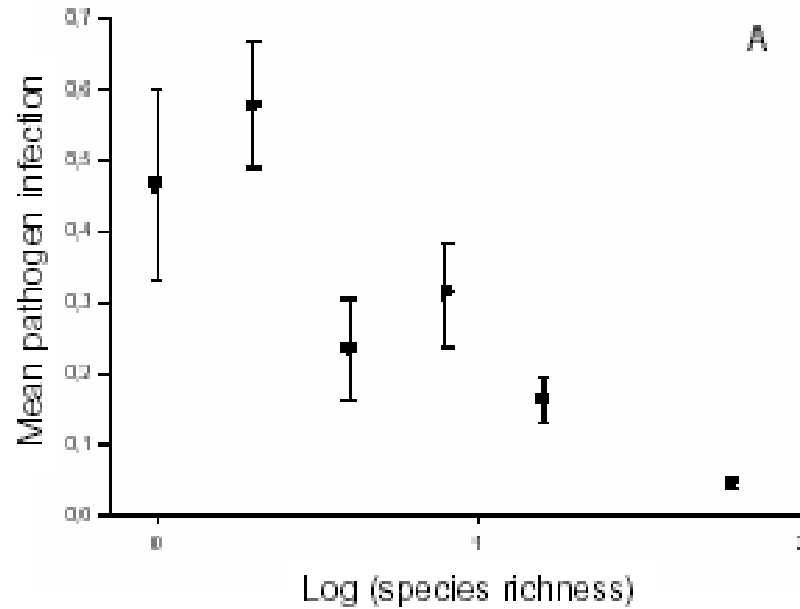
Reindeer grazing (-): Olofson 2006

Carbon storage



Fornara & Tilman 2008
 Steinbeiss et al. 2008
 Dias et al. 2010
 BUT: Johnson et al. 2008

Pest control

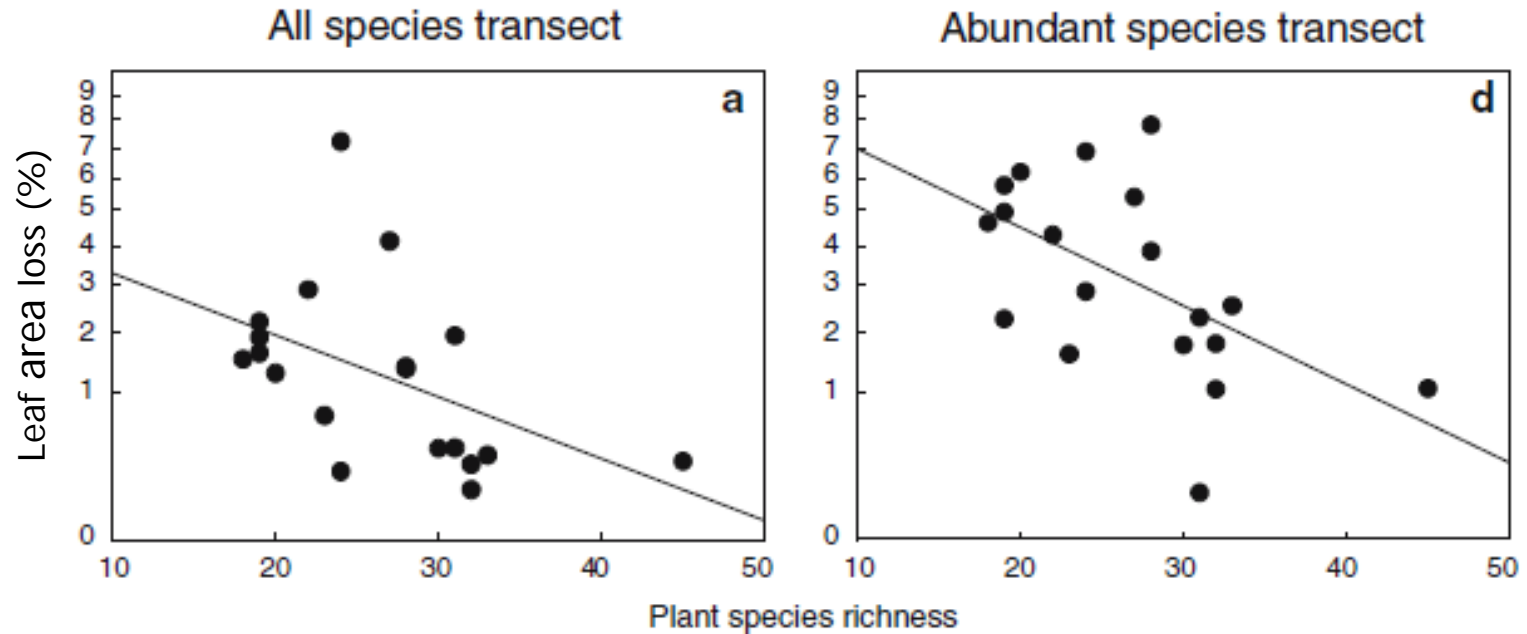


Rottstock, Kummer, Fischer (2010) in prep.
Knops et al. 1999
Mitchell et al. 2002

Pest control

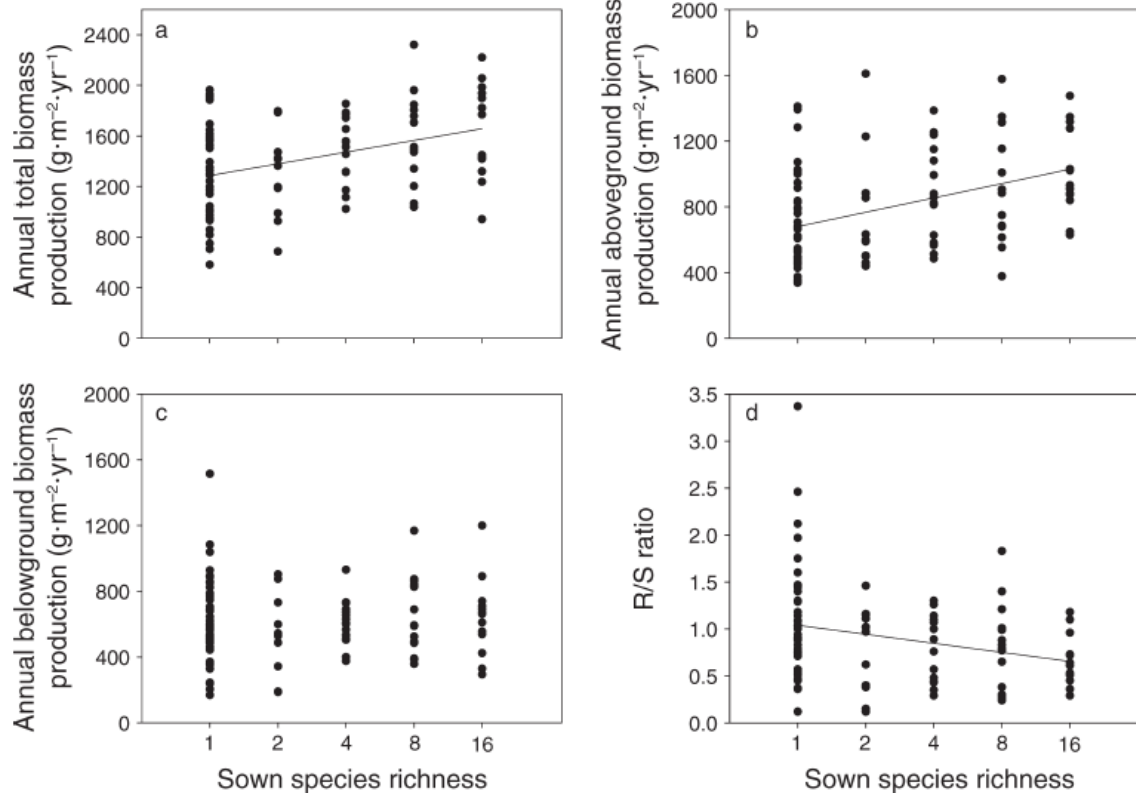
reduced				neutral				increased			
reference	score	effect size	type	reference	score	effect size	type	reference	score	effect size	type
Basedow (1990)	1	0.05, 0.07	d	Galecka (1966)	1	n.d.	d	Östman <i>et al.</i> (2001a)	0.5	n.d.	r
Den Belder <i>et al.</i> (2002)	1	n.d.	d	Holland & Fahrig (2000)	1	n.d.	d	Roschewitz <i>et al.</i> (2005)	1	1.4	d
Östman <i>et al.</i> (2001a)	0.5	0.6	e	Klug <i>et al.</i> (2003)	1	n.d.	d	—	—	—	—
Thies & Tschardt (1999)	1	0.6	c	Thies <i>et al.</i> (2005)	1	n.d.	d	—	—	—	—
Thies <i>et al.</i> (2003)	1	0.6	c	—	—	—	—	—	—	—	—
total	4.5				4				1.5		
percentage	45.0%				40.0%				15.0%		

Herbivory reduction



Unsicker et al. 2006, 2010
Montoya et al. 2003
Lanta 2007
Petermann et al. 2010
Partly: Scherber et al. 2006
Partly: Pfisterer et al. 2002

Erosion control – root and mycorrhiza abundance



No: Bessler et al. 2009

No: He et al. 2002

Van der Heijden et al. 1998

Mulder et al. 2002

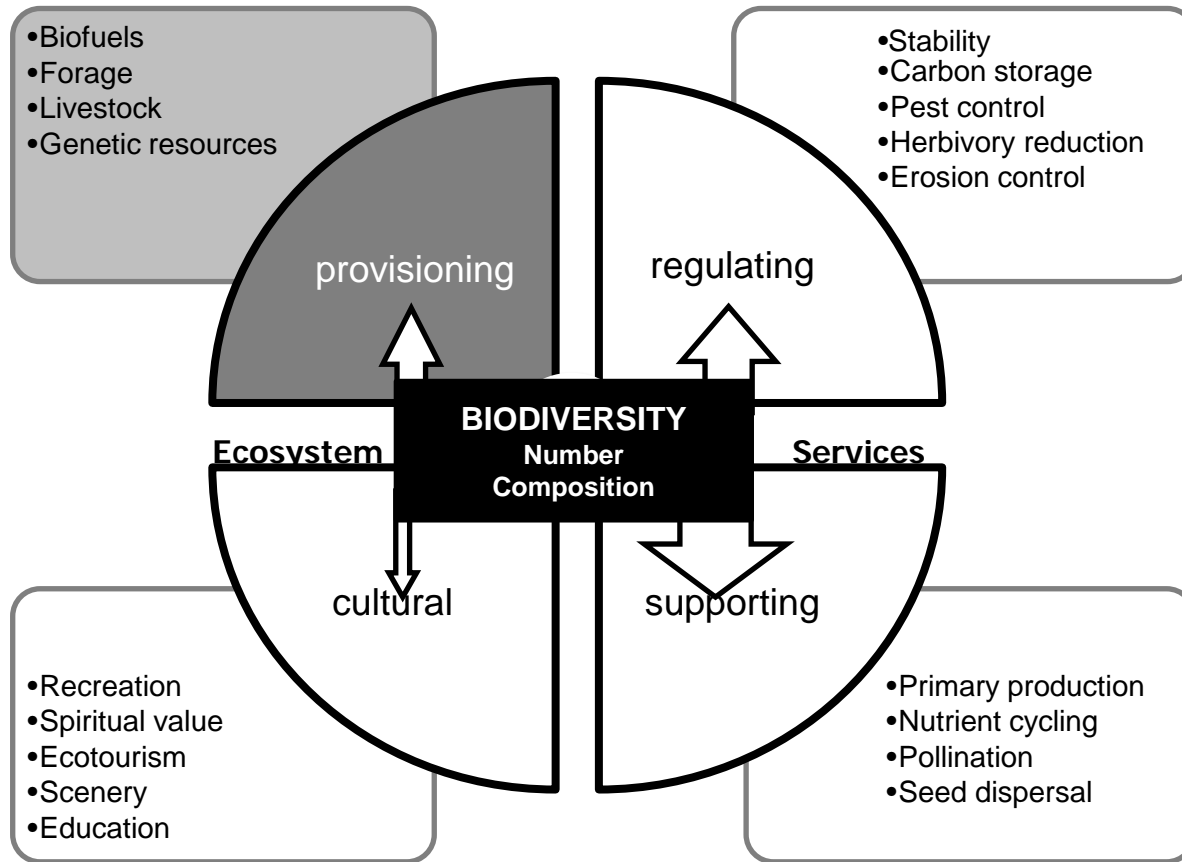
He et al. 2003

Scherer-Lorenzen et al. 2003

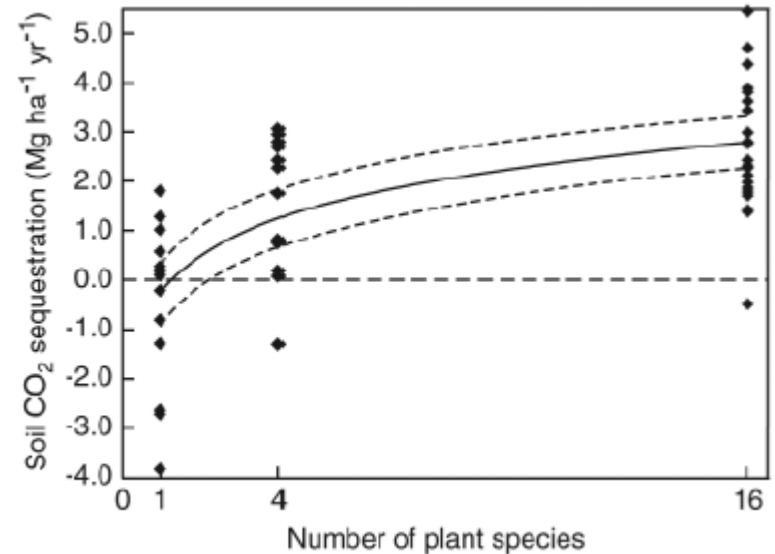
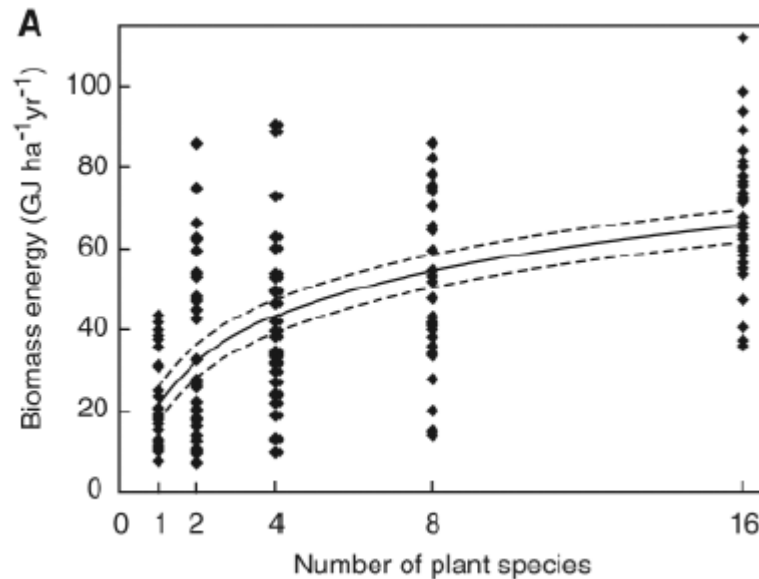
Burrows & Pfleger 2002

Van der Heijden et al. 1998

Provisioning services of Biodiversity



Biofuels



Talks: J. Murphy; F. Richter et al.

Poster: L. Bühle et al. ; F. Richter & M. Wachendorf ; U. Sölter et al.; B. Wienforth et al.; N. Svoboda et al.; K. Schmalzer et al.; A. Techow et al.; V. Tilvikienė et al.; B. Tonn et al.

Tilman et al. 2006

BUT:

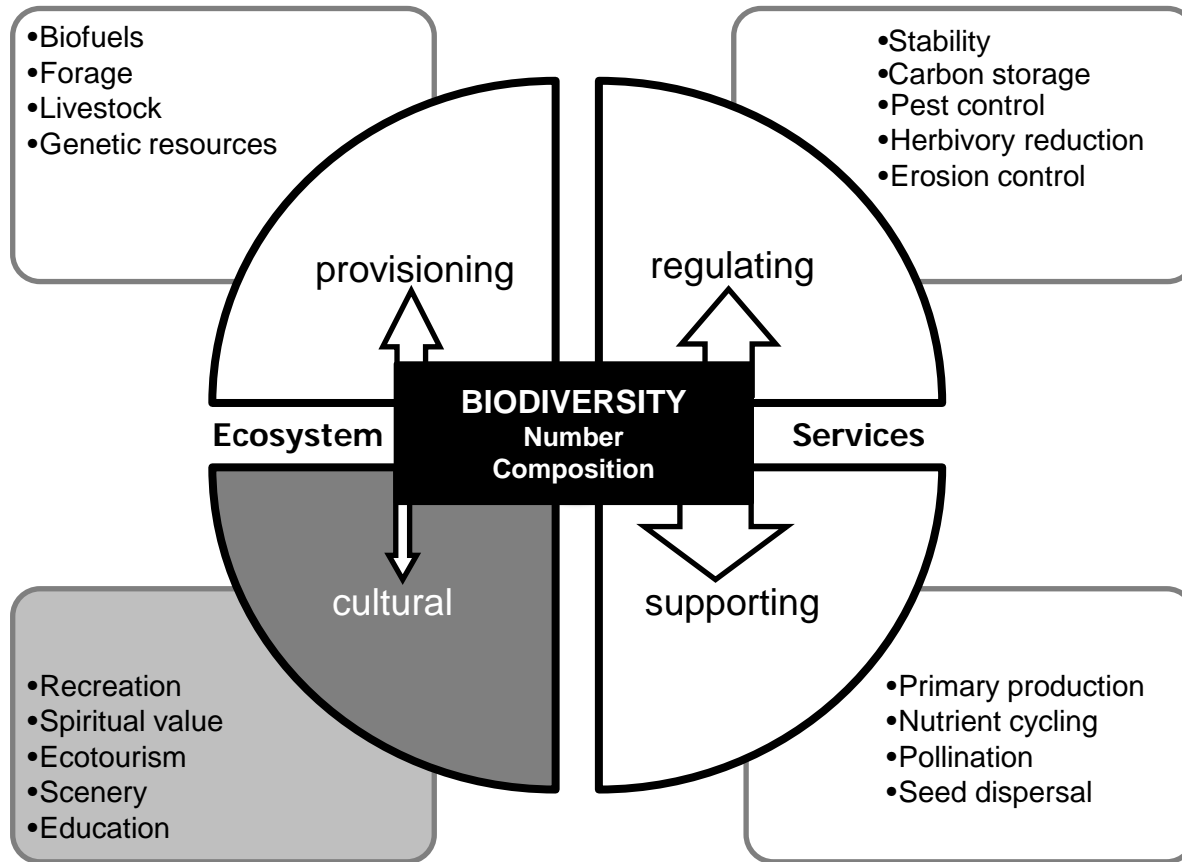
Ruselle et al. 2007

Ceotto et al. 2008

Fornara et al. 2008

De Haan et al. 2010

Cultural services of Biodiversity



Cultural services

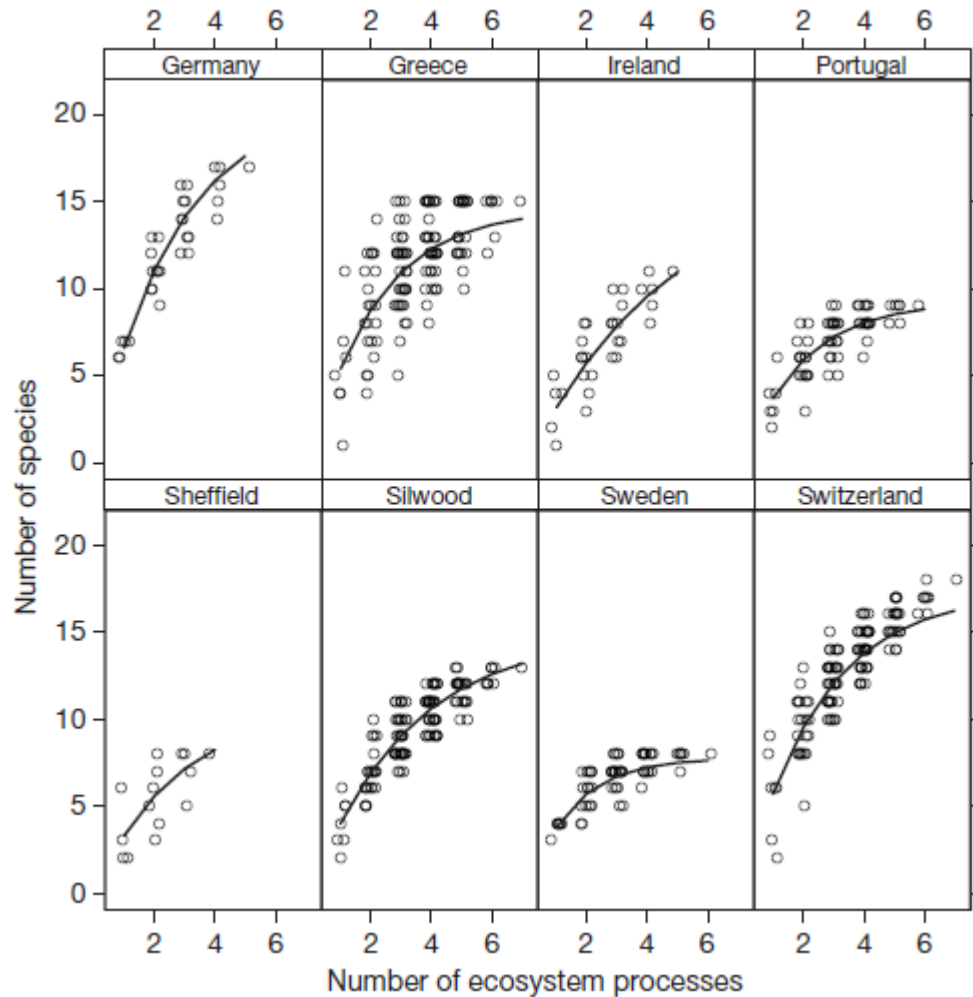
- **Scenery/Ecotourism**

- People's aesthetic appreciation increased with true species richness. Communities consisting of the same number of species were appreciated more when their evenness was high. Plant diversity in itself is attractive to humans (Lindemann-Matthies et al. 2010).

- **Education**

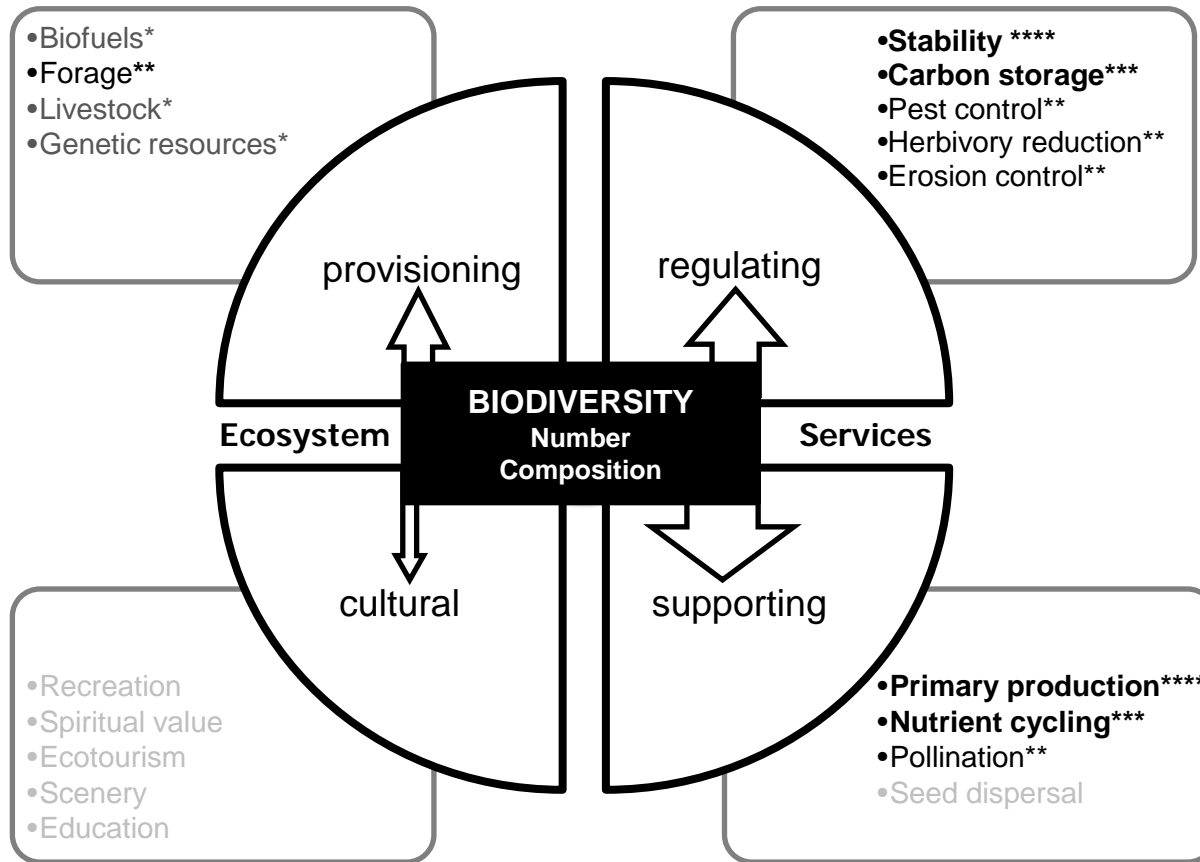
- First steps within the BIOTA and BIOLOG projects funded by the BMBF (http://www.biolog-veranstaltung.de/pdf/heimann_ua_schulprojekt_biolog.pdf, Scarano 2007)

Multiple functions



Hector & Bagchi 2007
Zavaleta et al. 2010

Grassland Ecosystem Services



Conclusions

- Grassland biodiversity affects supporting and regulating services as primary productivity, nutrient cycling, stability and carbon storage.
- The effect of managed grasslands on provisioning services as biofuel, forage, livestock and genetic resources is well studied in agricultural sciences, but the effects of diversity on these processes still need increasing attention.
- The effect of grassland biodiversity on cultural services has so far largely been neglected.
- Most dramatic changes in ecosystem services are likely to come from altered functional compositions and from the loss of locally abundant species rather than from the loss of already rare species.