

The ecological consequences of biodiversity loss

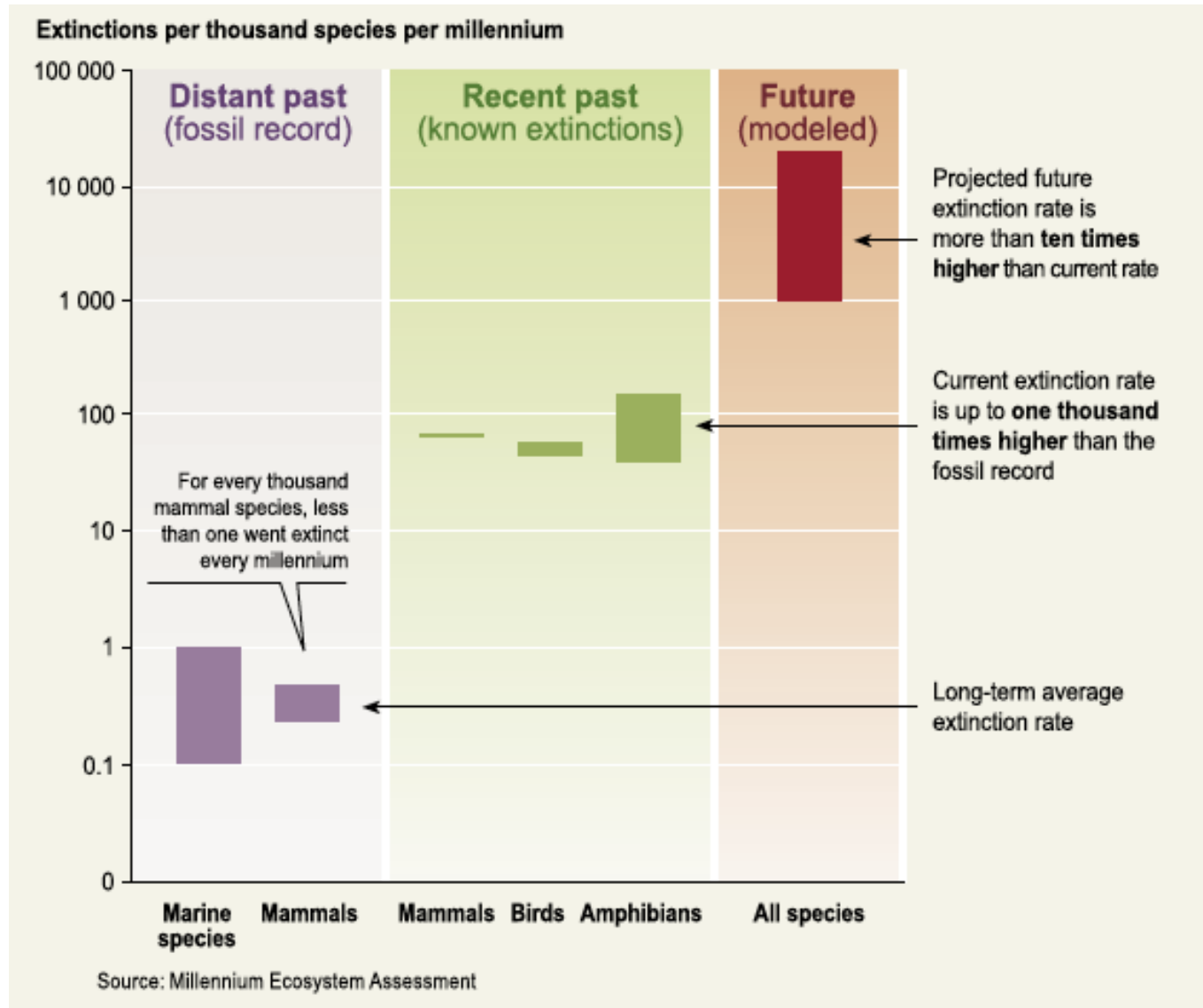
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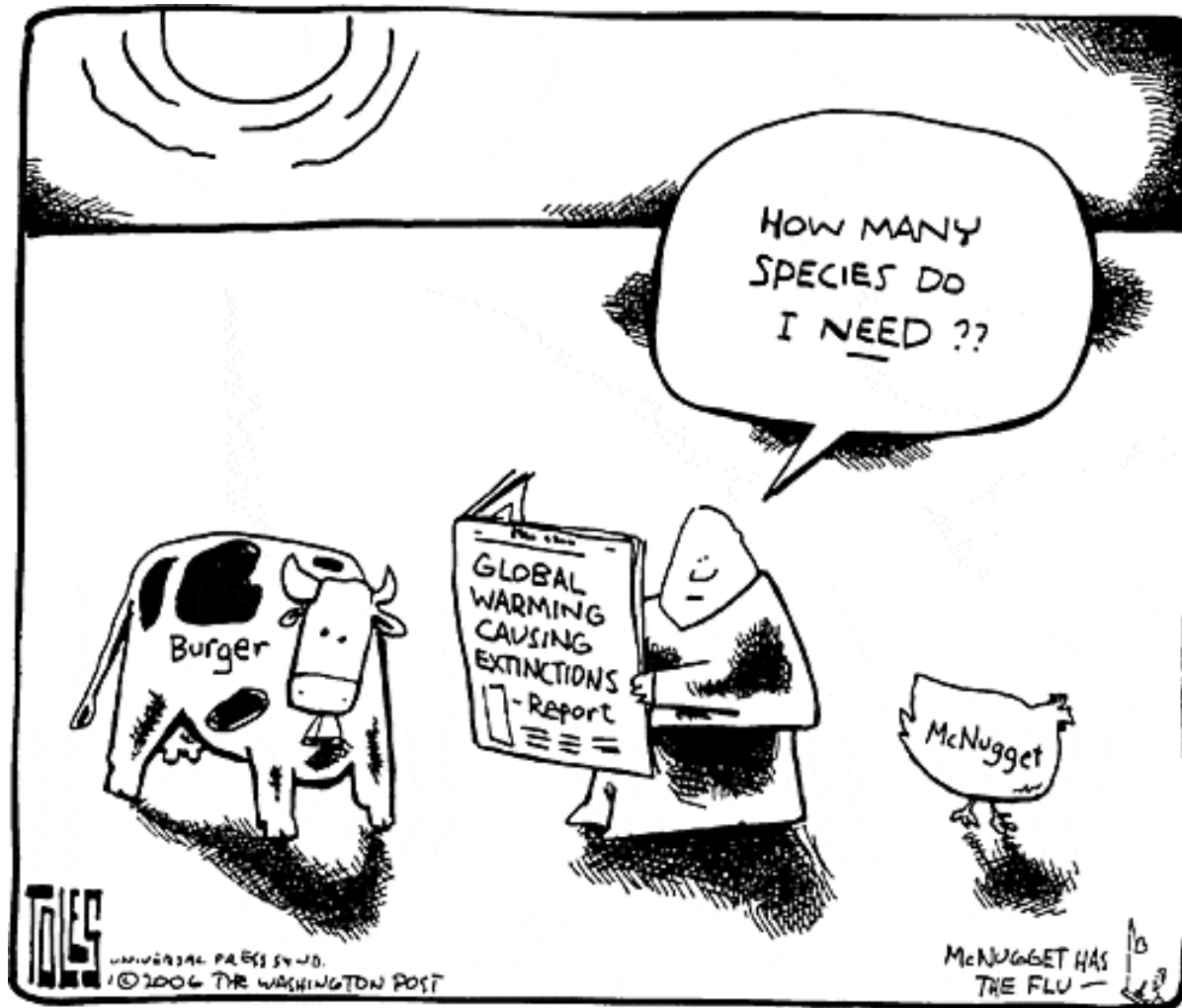
E-mail: michel.loreau@mcgill.ca



Heading for a global biodiversity crisis

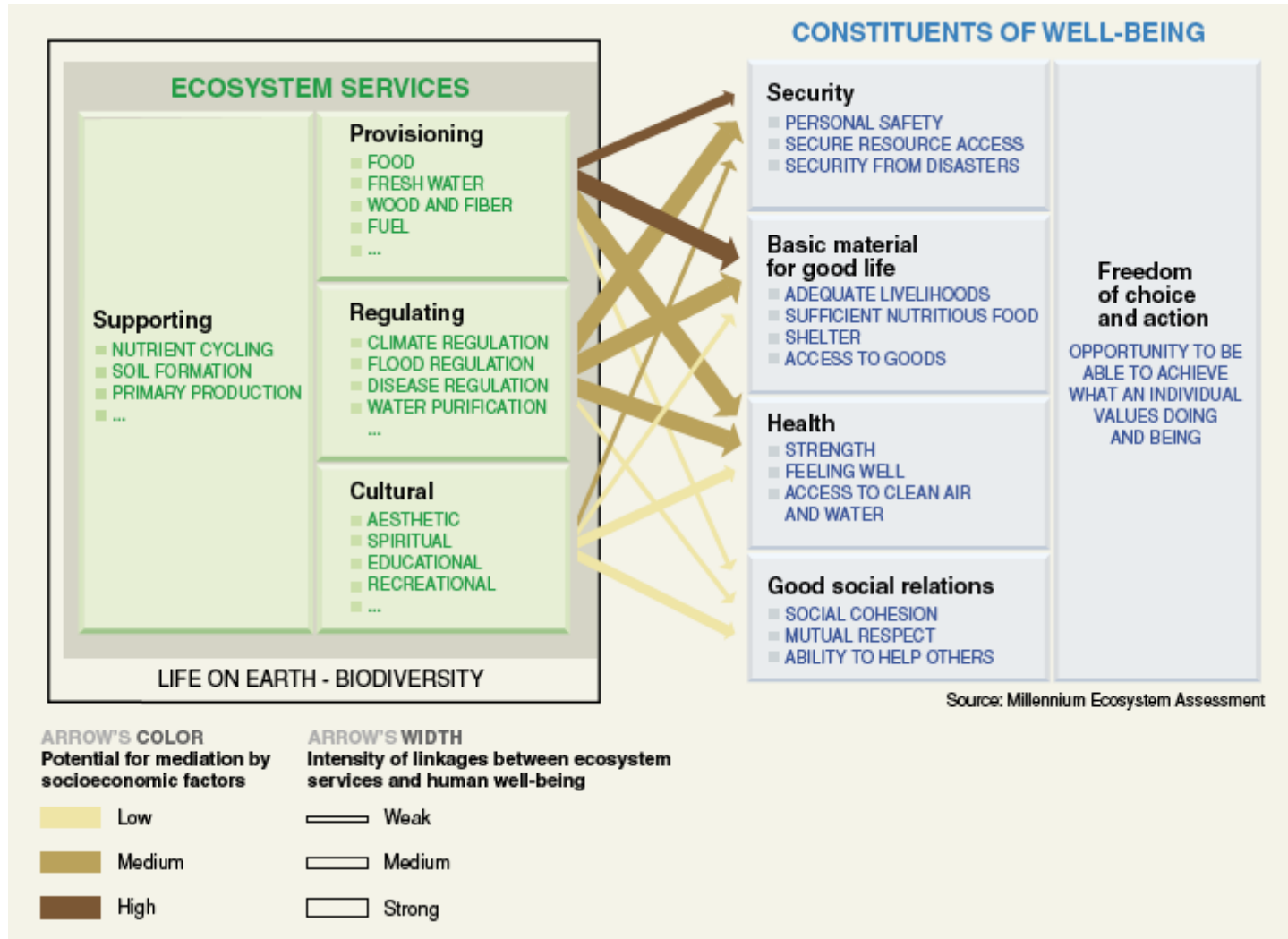


Why does biodiversity matter?



1-13-06

Biodiversity, ecosystem functioning, and human wellbeing



Importance of “vertical” diversity



Removal of sea otters



Population explosion of sea urchins



Overgrazing of kelp



- Extinction of other species living in kelp
- Increased wave action, coastal erosion and storm damage
- Evolution of chemical defences in kelp

But what is the ecological significance of “horizontal” diversity?

Separation between community ecology (biodiversity) and ecosystem ecology (ecosystem functioning, management)

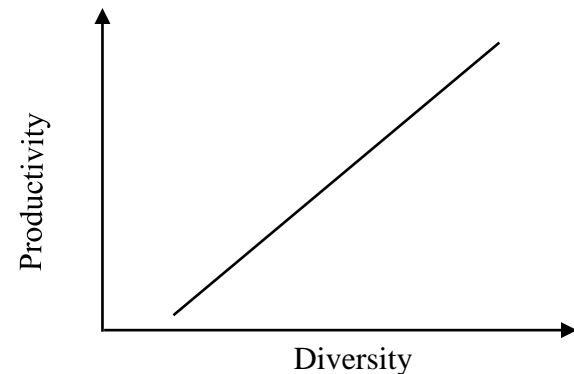
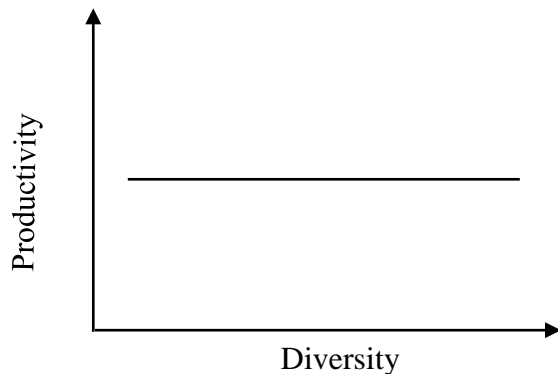
Neutral theory

Functional
redundancy

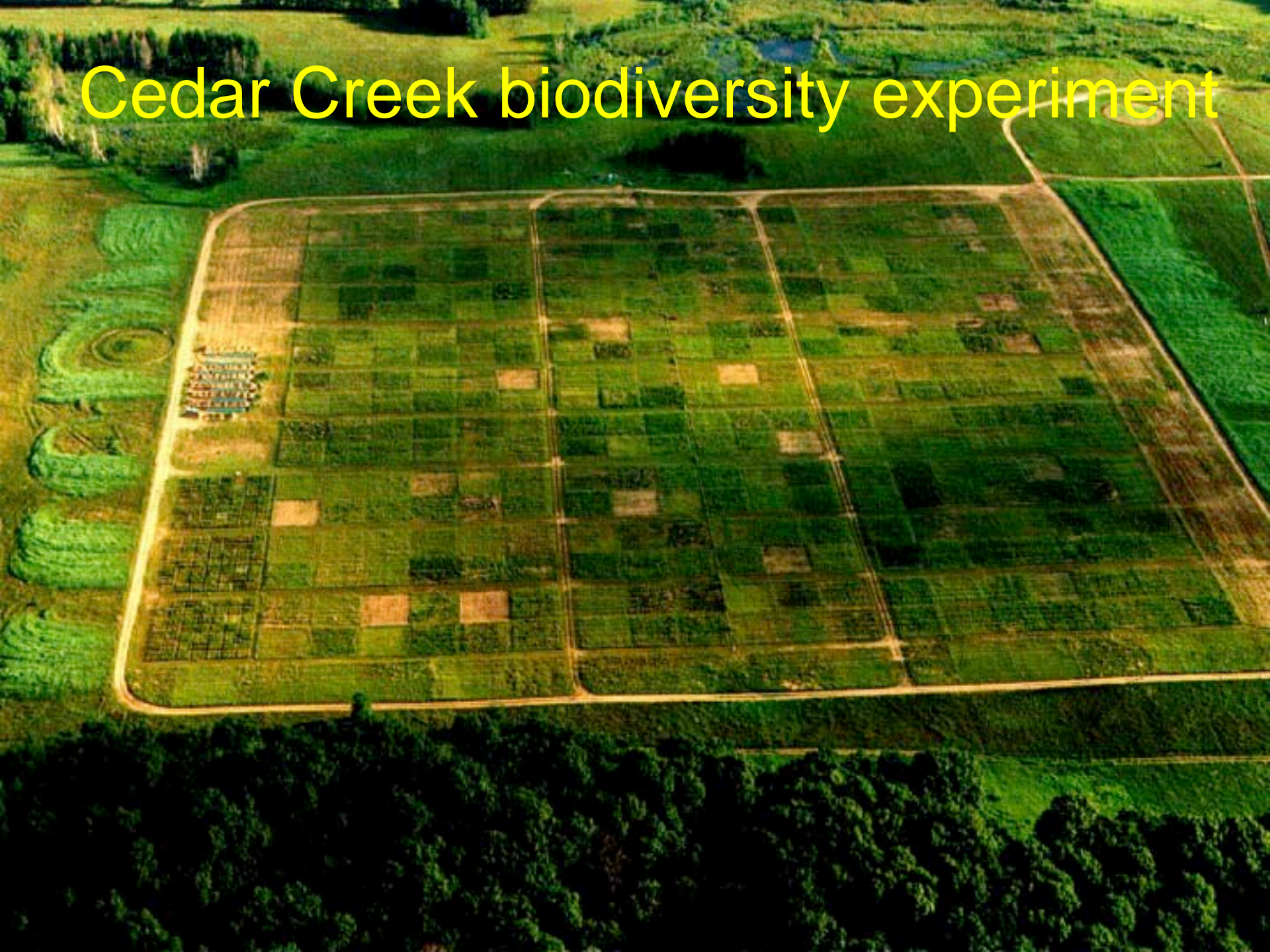


Niche theory

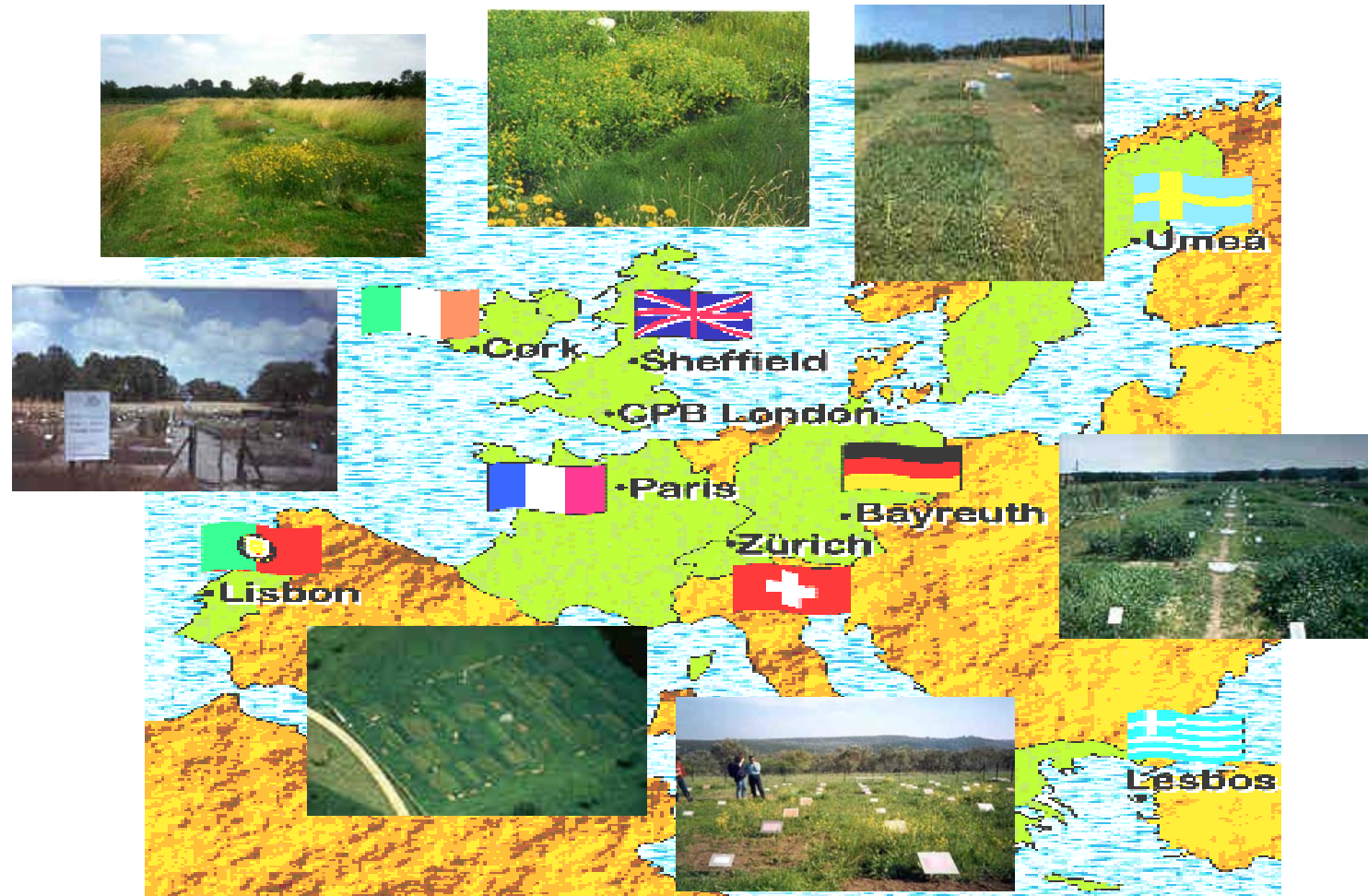
Functional
complementarity



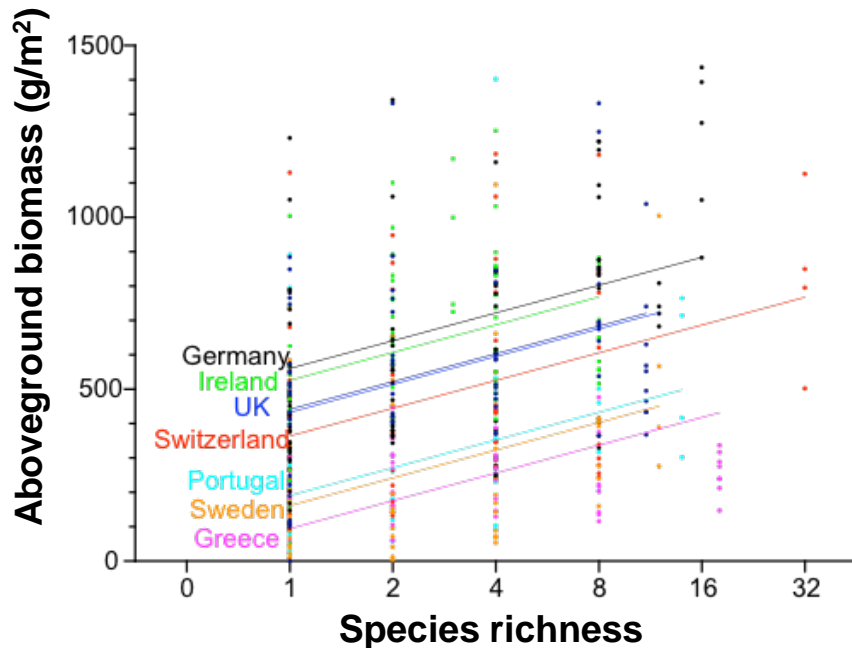
Cedar Creek biodiversity experiment



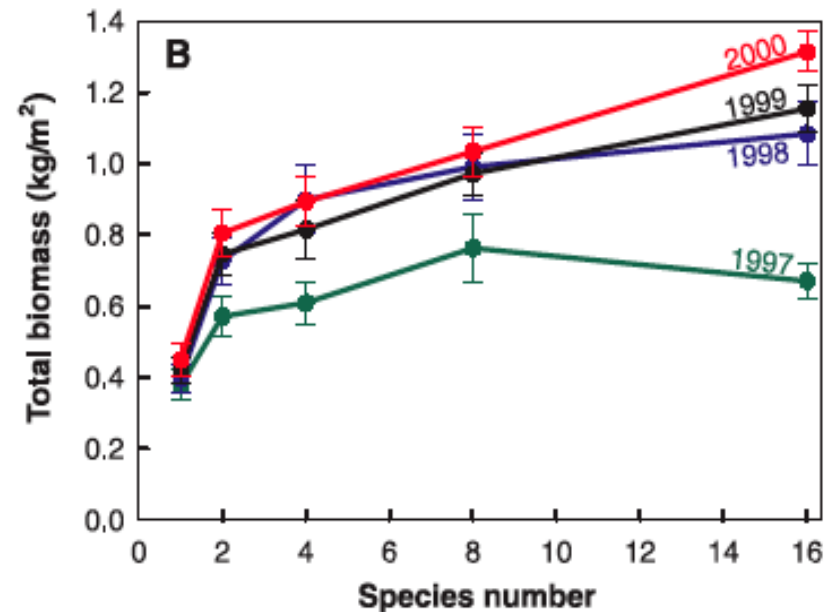
BIODEPTH biodiversity experiment



Species diversity increases plant biomass production in grasslands

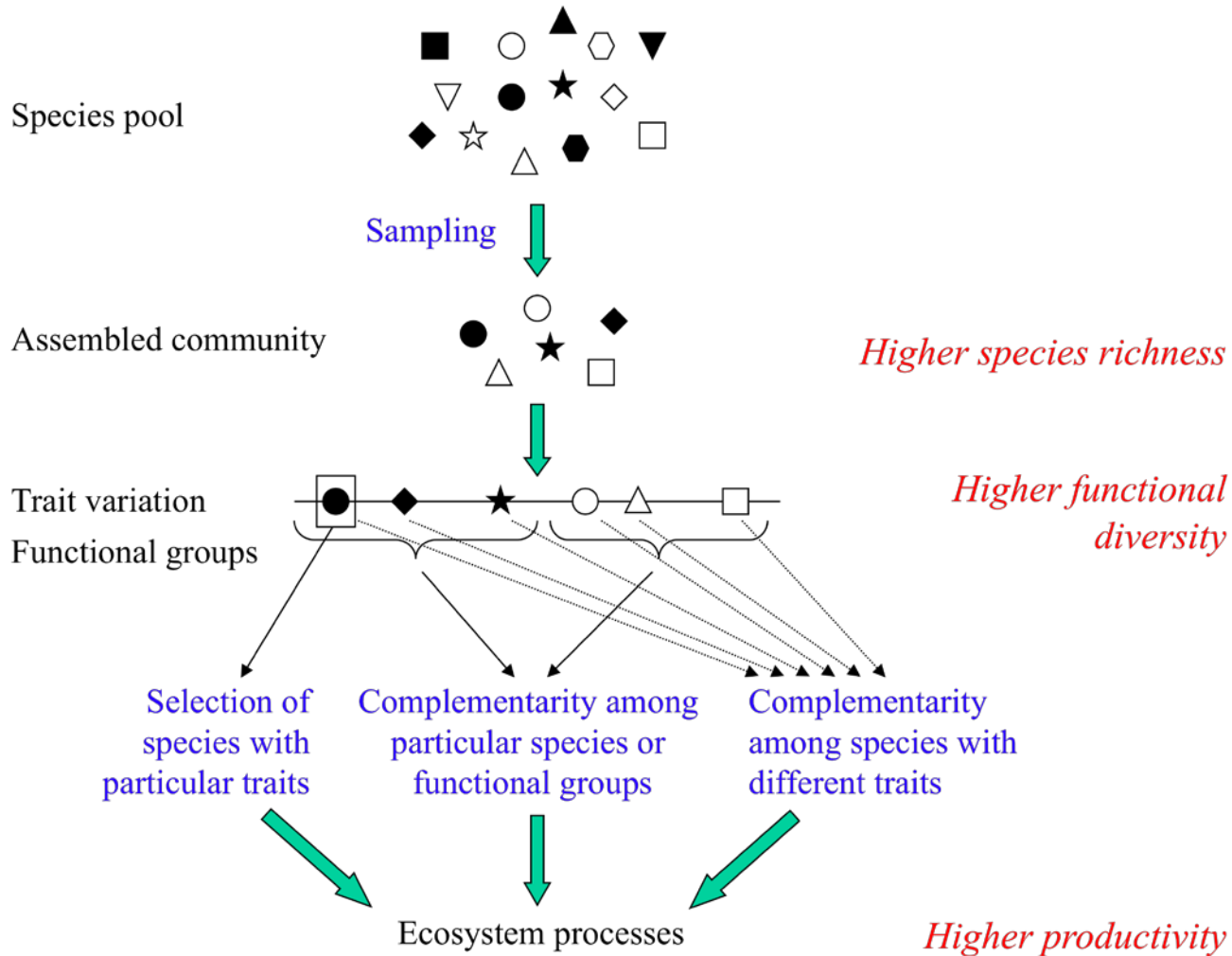


Hector et al., *Science* 286: 1123–1127 (1999)



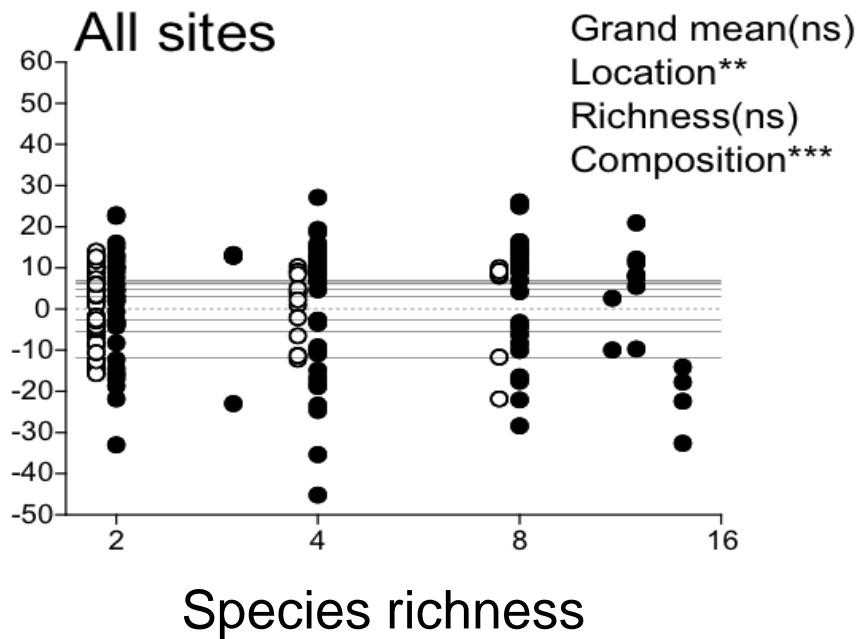
Tilman et al., *Science* 294: 843–845 (2001)

The controversy over mechanisms

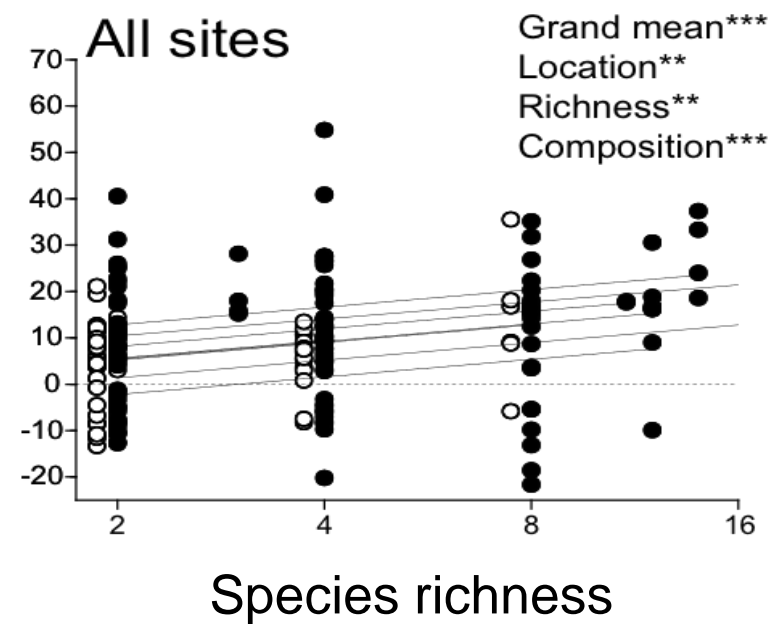


Biodiversity effects on plant biomass production in BIODEPTH

Selection effect ($g^{1/2}/m$)

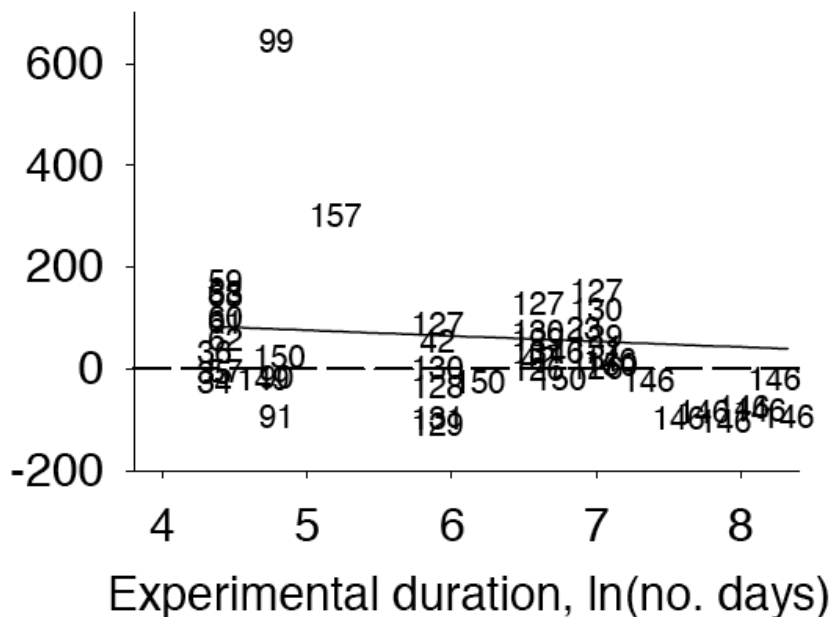


Complementarity effect ($g^{1/2}/m$)

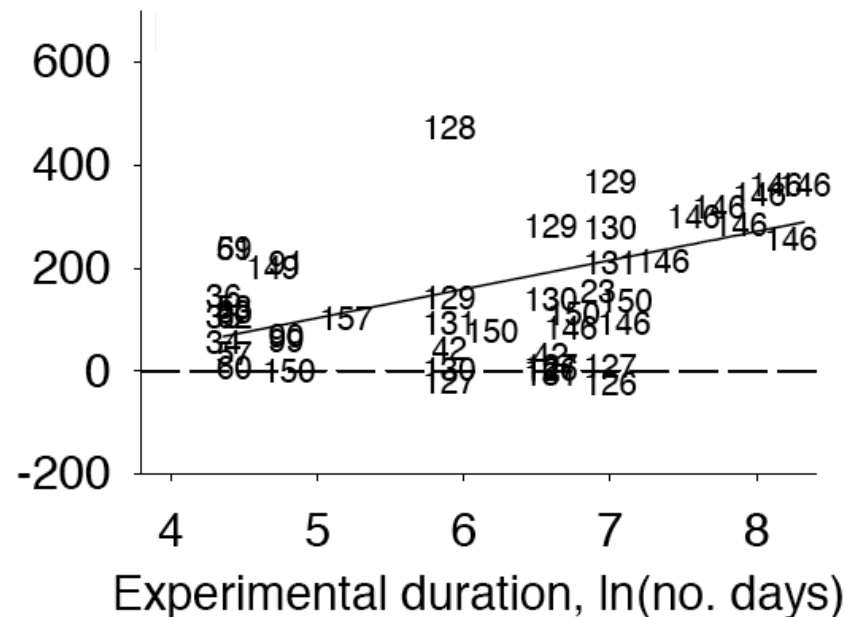


Biodiversity effects on plant biomass production: A meta-analysis

Selection effect (g/m^2)



Complementarity effect (g/m^2)



The results of biodiversity experiments support niche theory

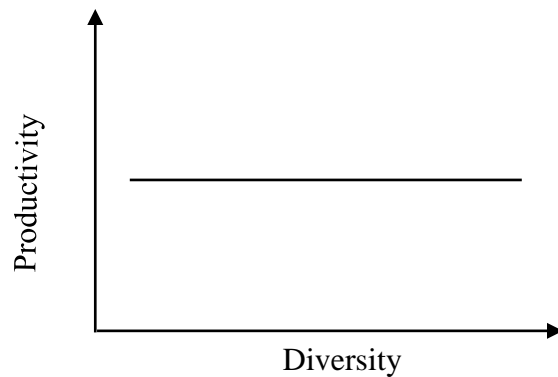
Neutral theory

Functional
redundancy

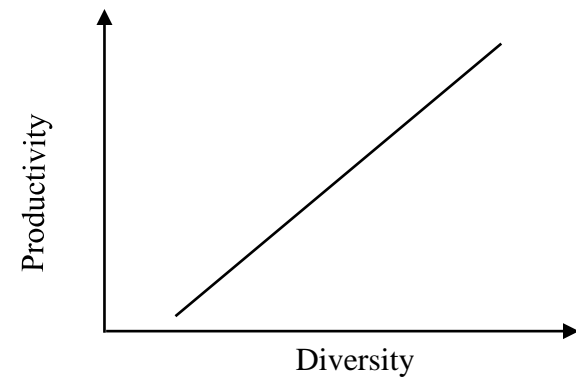


Niche theory

Functional
complementarity

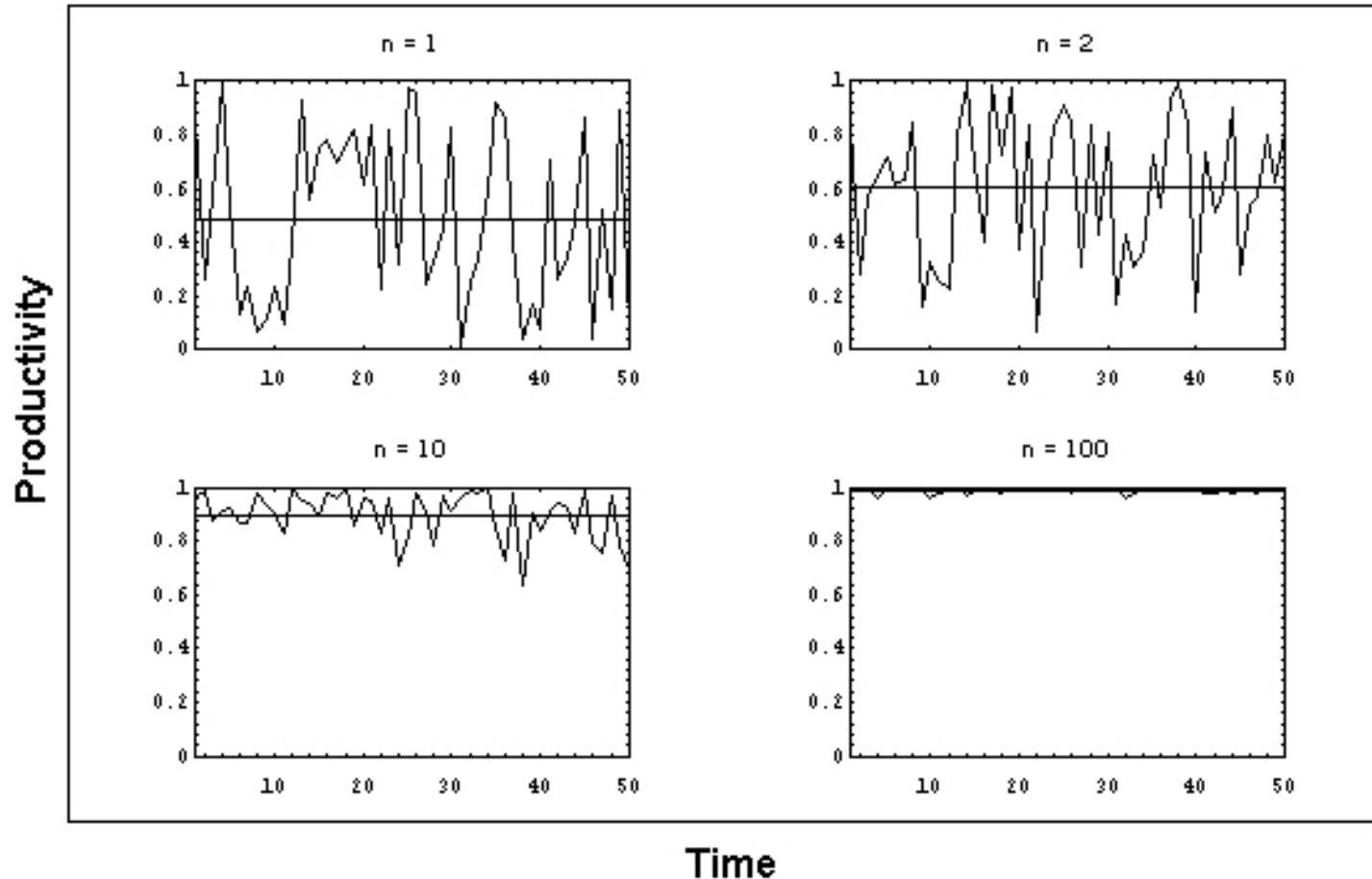


~~No net biodiversity effect
No complementarity effect
No selection effect~~

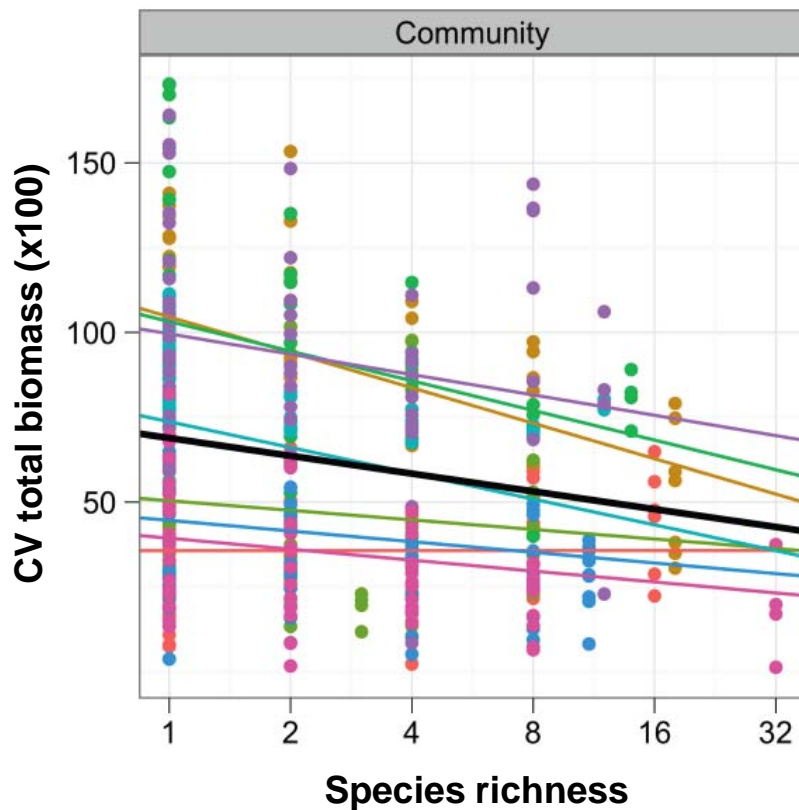


Positive net biodiversity effect
Positive complementarity effect
Variable selection effect

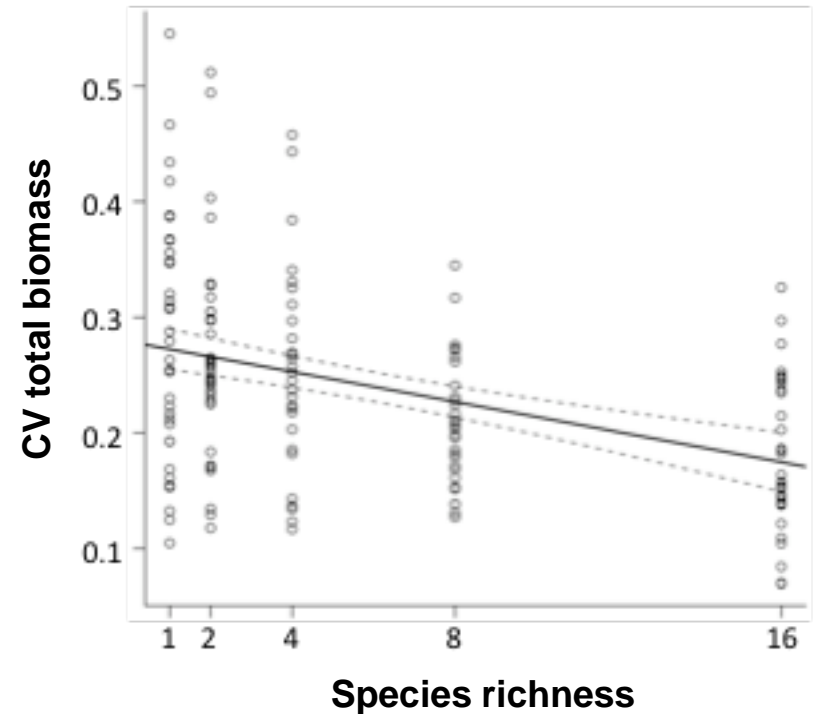
Biodiversity and ecosystem stability: The insurance hypothesis



Species diversity stabilises plant biomass production in grasslands

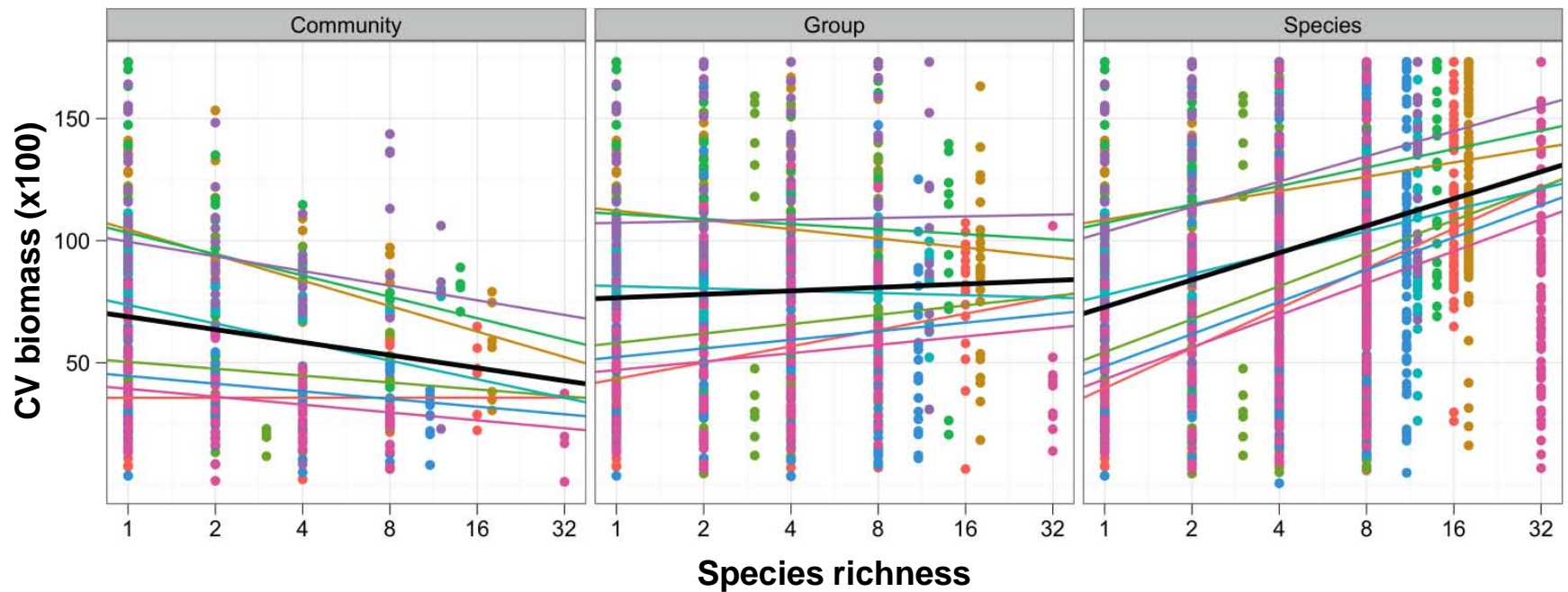


Hector et al., *Ecology* 441: 629–632 (2010)



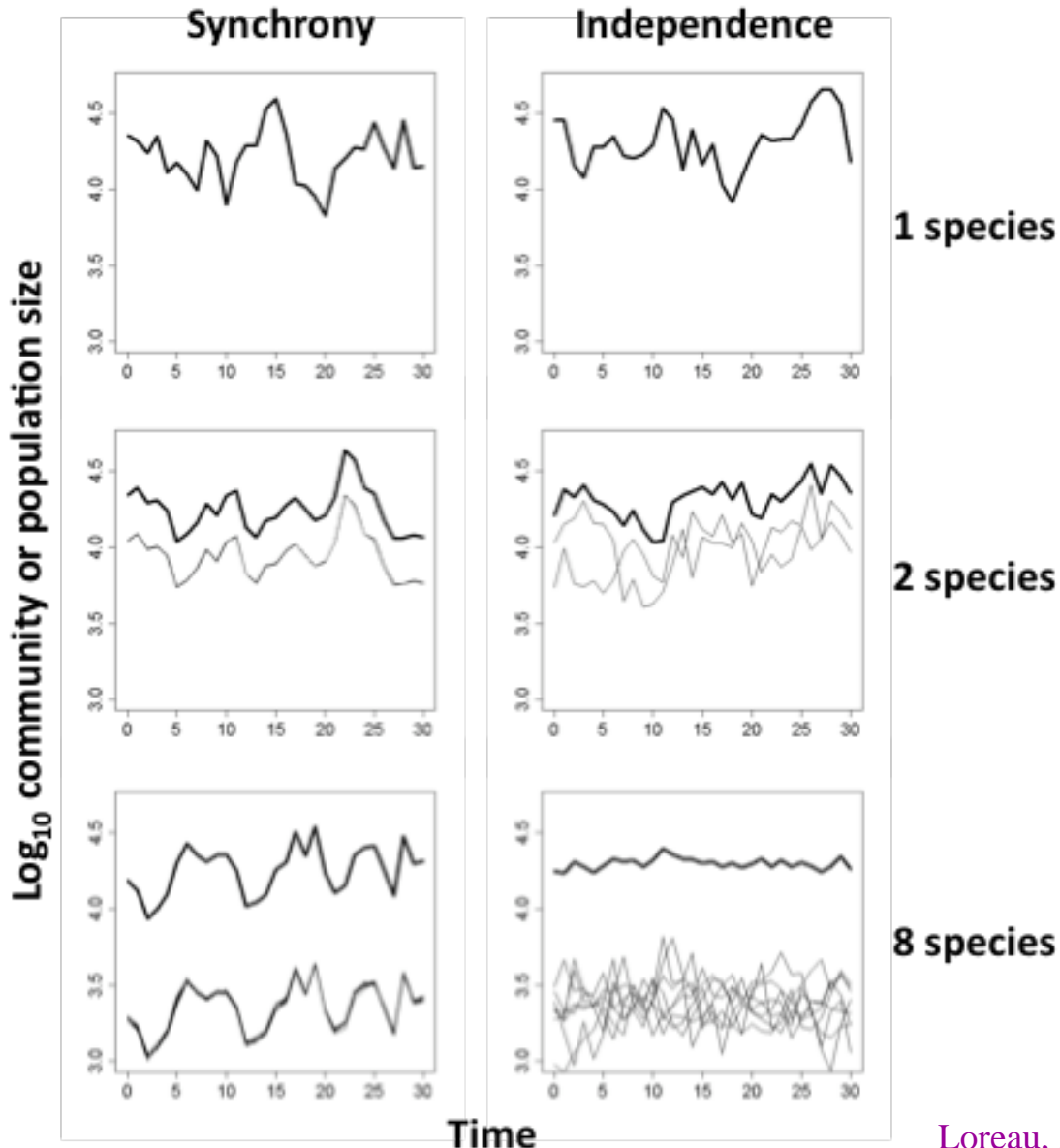
Based on Tilman et al., *Nature* 441: 629–632 (2006)

Population vs. ecosystem stability in grassland plants



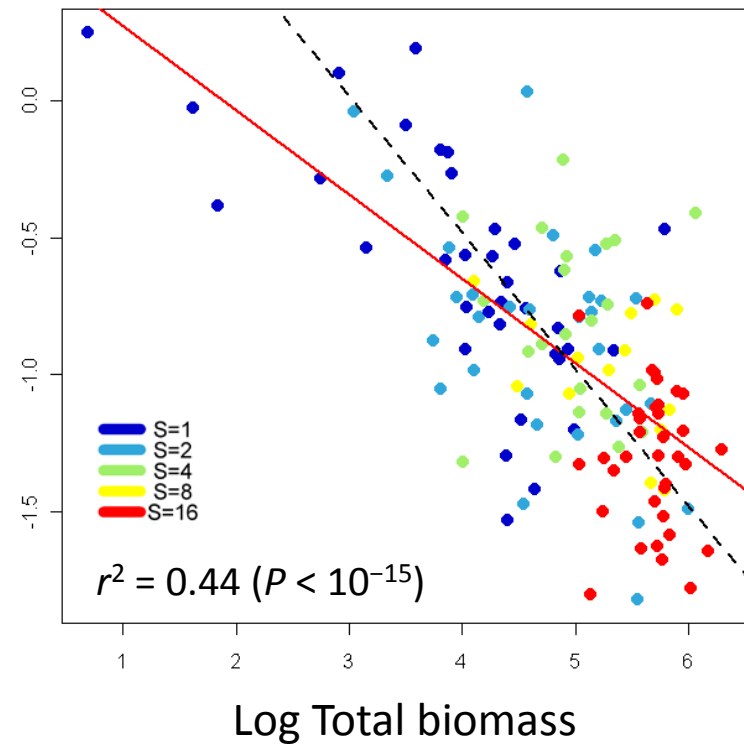
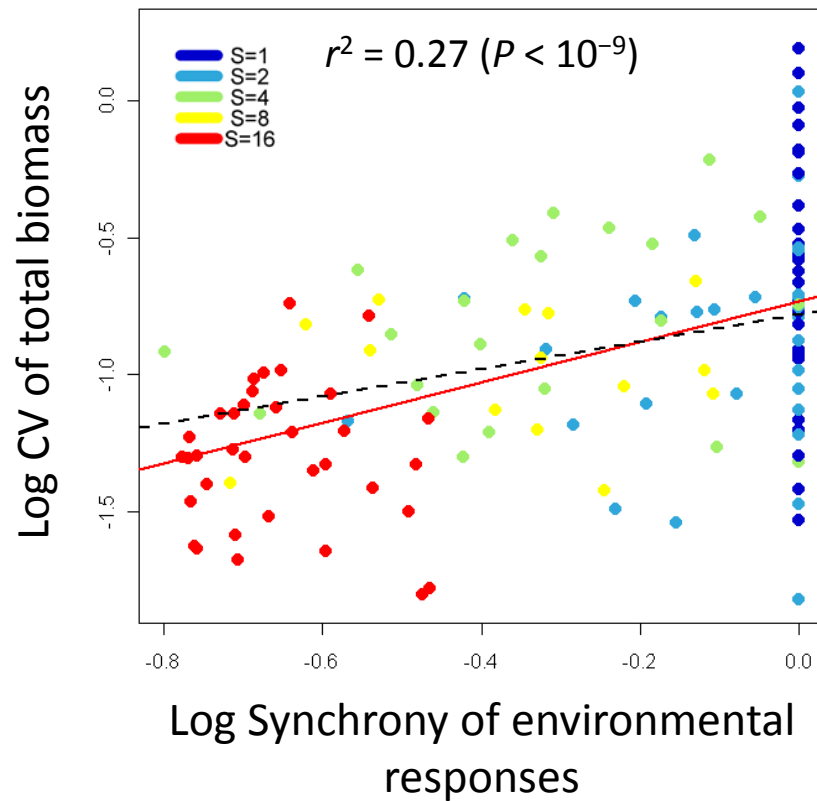
The whole is the sum of its parts, but it obeys different rules

Biodiversity as insurance: Mechanisms in theory

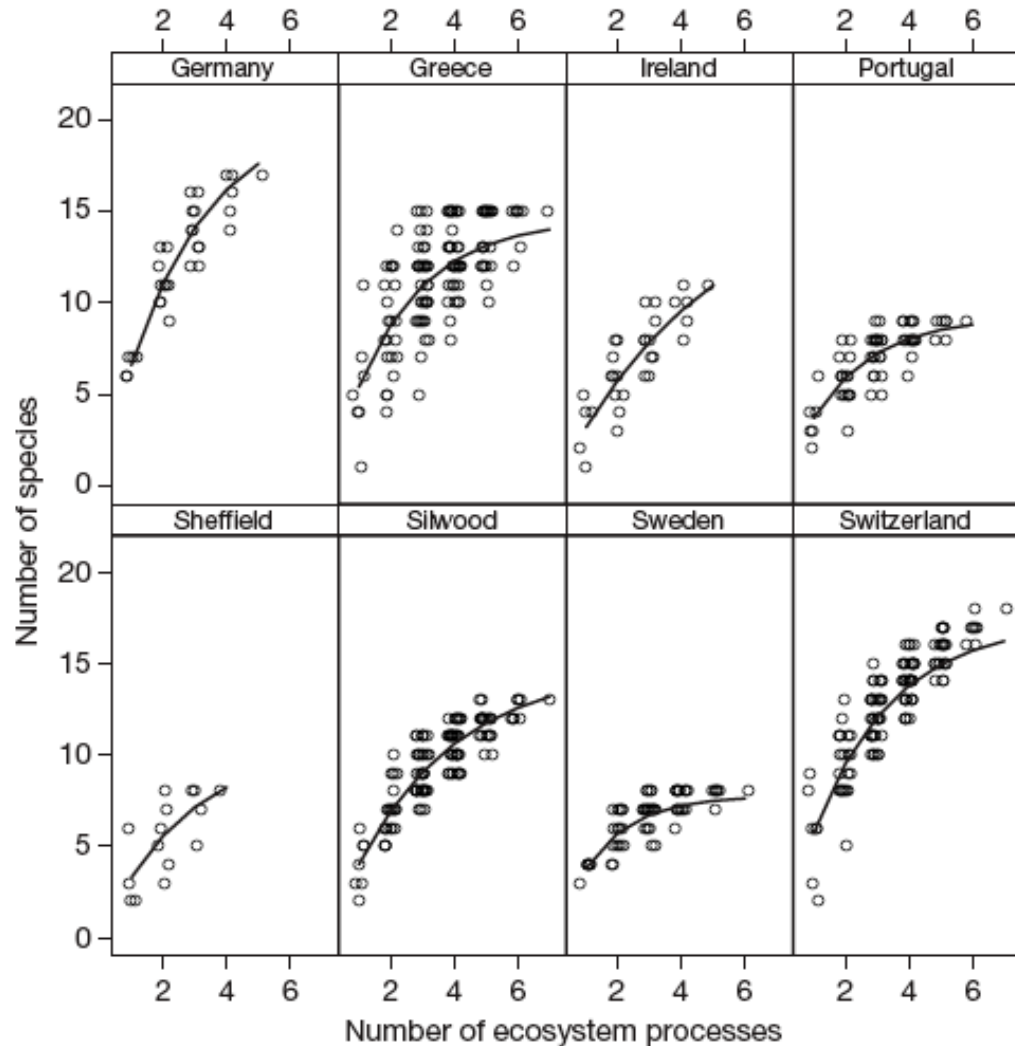


1. Asynchrony of species environmental responses (= temporal complementarity)
2. Increase in total biomass because of functional complementarity

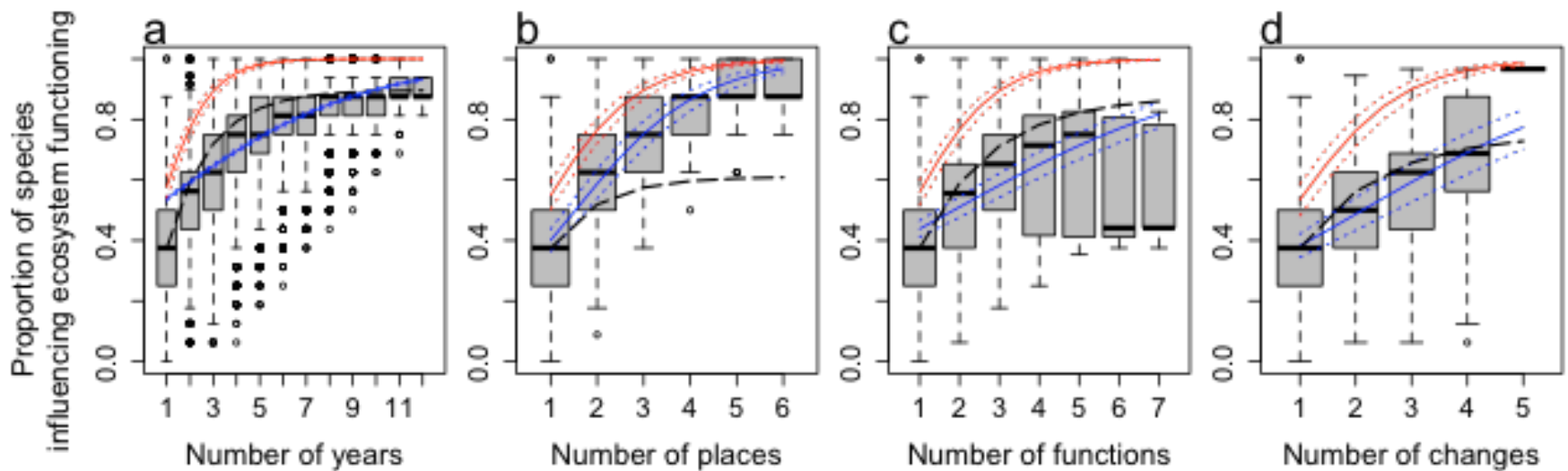
Biodiversity as insurance: Mechanisms in the Cedar Creek experiment



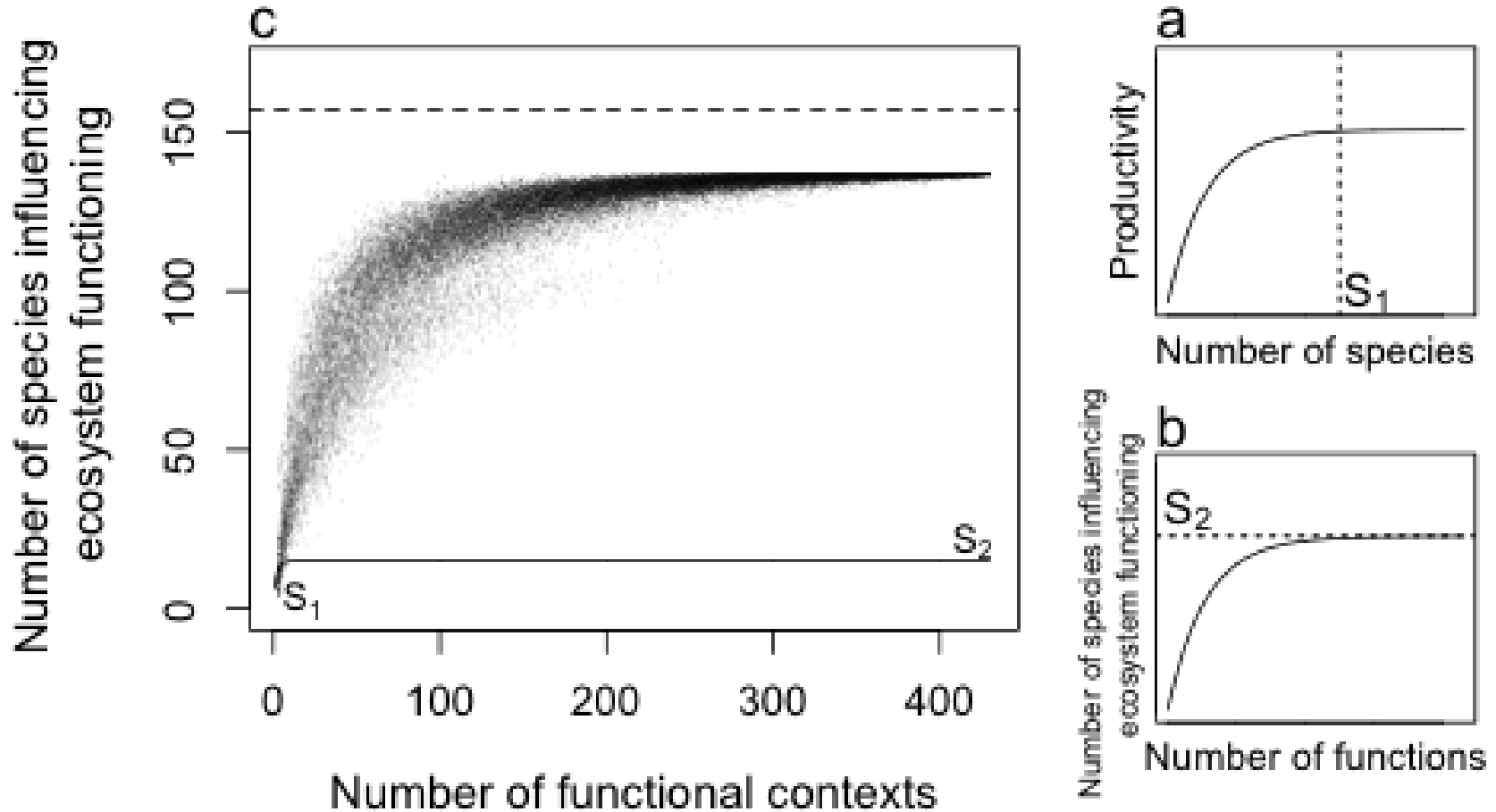
Biodiversity and ecosystem multifunctionality in BIODEPTH



Biodiversity and ecosystem multifunctionality in grasslands



Biodiversity and ecosystem multifunctionality in grasslands



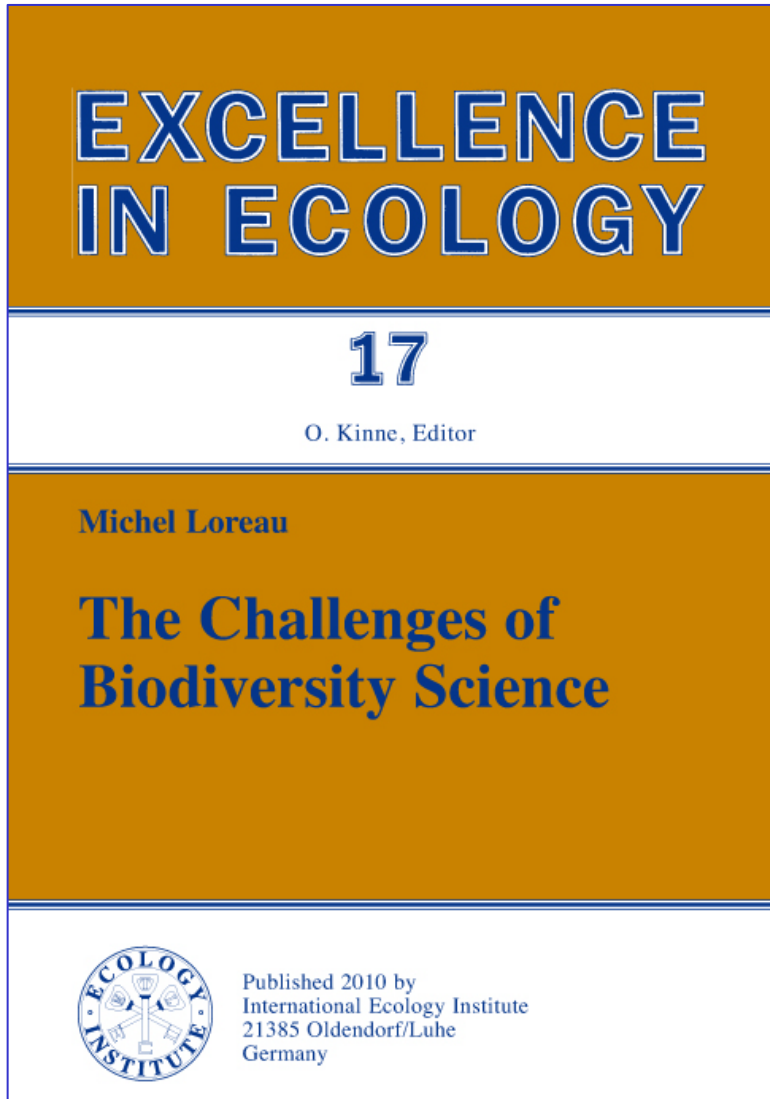
Conclusions

- Biodiversity loss has significant impacts on ecosystem functioning, in particular:
 - Horizontal diversity enhances resource use and biomass production through functional complementarity between species
 - Horizontal diversity stabilises ecosystem properties through a combination of temporal and functional complementarity between species

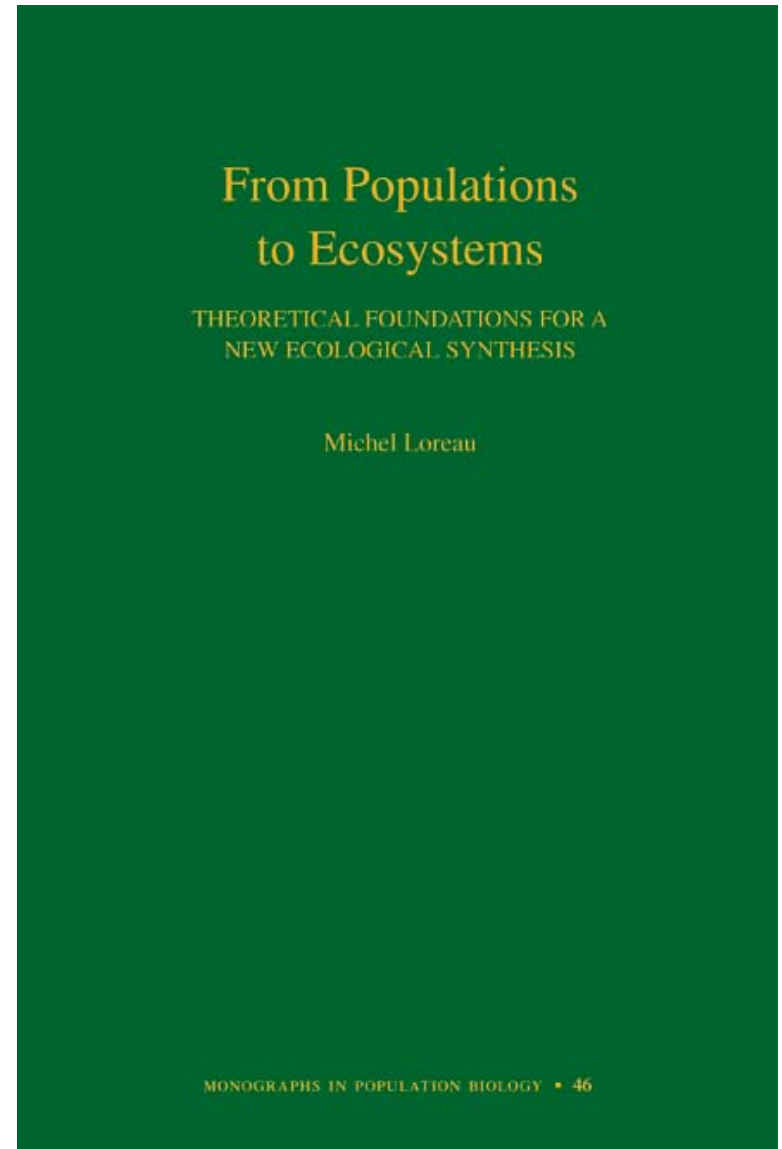
Conclusions

- The ecological consequences of biodiversity loss have been vastly underestimated because of the traditional focus on small scales and single ecosystem processes
- Most grassland species play a significant role in ecosystem functioning when variability across space, time, functions, and environmental drivers is taken into account
- Biodiversity loss is likely to strongly affect the provision of ecosystem services and is, therefore, a serious threat to human wellbeing and sustainable development

If you want to know more...



<http://www.int-res.com/book-series/excellence-in-ecology-books/ee17/>



Princeton University Press (2010)