Plant diversity does not enhance ecosystem functioning in montane grasslands

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Introduction

Rapid loss of biodiversity is one of the main environmental issues that is presently discussed at the global scale. While research documenting the loss of species diversity is starting to be well established, the consequences of species extinctions for ecosystem functioning such as productivity are poorly understood.

First results from studies in experimental grasslands have shown a positive relationship of plant biodiversity and aboveground productivity (for a summary see Loreau et al., 2001). Three independent theories were suggested to explain the observed patterns:

1. **Niche Complementary**
   Different species occupy different ecological niches with respect to resource acquisition. An increase in species number thus leads to more efficient resource use and increased productivity.
2. **Facilitation**
   Biodiversity enhances the performance of ecosystems through positive species interactions.
3. **Selection Effect**
   Ecosystems that include many species have a higher probability of containing a highly productive species which leads to increased productivity.

Although recent theoretical papers suggest niche complementary as the dominant effect of biodiversity on ecosystem functioning in experimental grasslands, no clear experimental evidence has been provided yet.

Objectives

First studies on biodiversity and ecosystem functioning were conducted in experimental grasslands that consisted of very low species numbers (1,2,4,8). Since such low species numbers are rarely found in natural grasslands, there is a strong need to test the patterns observed in these experiments in natural ecosystems. Therefore we investigate the effects of plant biodiversity on ecosystem functioning in natural montane grasslands in central Germany. Specifically we focus on the effect of biodiversity on various aspects of the carbon cycle to determine:

- the effect of plant diversity on productivity in natural montane grasslands.
- if there is a relationship between plant species richness and soil respiration.
- if niche complementary enhances ecosystem functioning in ecosystems with natural diversity levels.

Fig.1.: Montane grasslands in the Thuringian Schiefergebirge, Germany with high (a) and low (b) plant diversity.

Results

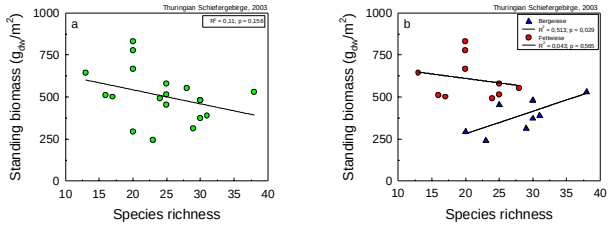

Fig.2.: Plant species richness shows no constant effect on productivity in montane grasslands. In Fig. 2a data are analyzed across two different grassland types. In Fig. 2b data are separated by grassland type. Biomass was harvested twice a year (June and September 2003).

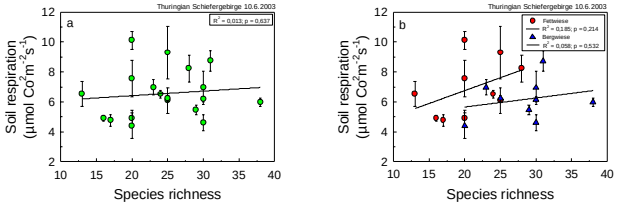

Fig.3.: Plant species richness shows no significant effect on soil respiration in montane grasslands. In Fig. 3a data are analyzed across two different grassland types. In Fig. 3b data are separated by grassland type.

Conclusion

- Plant species richness shows no constant effect on productivity in montane grasslands.
- Plant species richness shows no significant effect on soil respiration in montane grasslands.
- Since no constant effect of plant species richness on the observed ecosystem functions was determined, we suggest that the niche complementary effect can only be observed in ecosystems with very low diversities such as experimental grasslands. In ecosystems with "natural" diversity levels, empty niches will be occupied by the remaining species (Fig.4c).

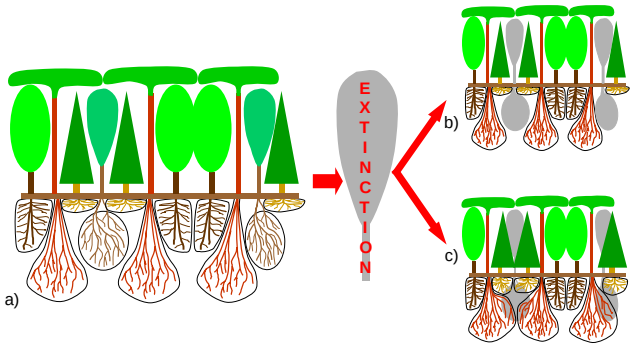

Fig.4.: Different species occupy different ecological niches in an ecosystem (a). The theory of niche complementary suggests that ecological niches remain empty when species go extinct (b). Our data suggest that empty niches are occupied by the remaining species and thus – given a minimum number of species – there is no effect of biodiversity on ecosystem functioning.

Methods

19 grasslands of two different plant community types (Geranio-Trisetetum alopecuretosum ("Fettwiese") and Geranio-Trisetetum nardetosum ("Bergwiese")) were investigated in the Thuringian Schiefergebirge/Frankenwald in central Germany. Grasslands were selected to be similar in their management regime (cutting, no grazing and no fertilization) and their abiotic factors (nutrient status, geographic position) but differed in their plant diversity levels. The 19 grasslands covered a diversity gradient from 14 to 37 plant species.

Aboveground biomass was harvested in late June and early September 2003 (n = 8*0.125 m^2). Soil respiration was measures using a Licor 6400-9 8 times a year. Only data of one campain are shown (16.6.03).

Outlook

In order to fully understand the effect of plant diversity on ecosystem functioning we will experimentally test the niche complementary hypothesis. We will characterize ecological niches that plants occupy with respect to resource acquisition using stable isotope techniques. We will than compare the determined niches of individual species across ecosystems with different diversity levels and thus determine whether niche occupancy for a species remains the same independently of the diversity level of the ecosystem (Fig. 4b) or if the investigated species are able to occupy empty niches (Fig. 4c).

References

Loreau, M. et al., 2001, Biodiversity and ecosystem functioning: Current knowledge and future challenges. Science Vol 294, p 804.

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