Relationship of biodiversity to productivity in mowed and abandoned hay meadows of Ciucului Mountains

- Preliminary results -

Anna Mária Csergő, László Demeter

Introduction

Plant productivity (carbon uptake) has been used as one indicator of carbon sequestration (Catovsky et al. 2002), which is among the most important services provided to humans by natural ecosystems (Daily et al. 2000). Currently one of the biggest concerns in conservation is that loss of biodiversity triggers accelerated lost of healthy ecosystem functioning and therefore vital ecosystem services (Grime 1997). Consequently, the relationship between biodiversity and productivity is of high interest for grassland managers, yet the topic is still debated by ecologists (Tilman et al. 2001). One general models is the standing crop/species richness relationship ('hump-backed model') (Grime 1973), which states that species richness reaches a maximum at intermediate standing crop. Many studies have found patterns consistent with this model, whereas others have challenged it, as a result of inconclusive evidence issued from multi-site studies (Adler et al. 2011).

In the Carpathian Mountains, it is generally acknowledged that hay meadows are nutrient-poor, species-rich and have intermediate to low productivity (Bărbos 2007). It is also documented that traditional haymaking generates high plant species diversity, whereas abandonment decreases diversity of managed grasslands (Csergő et al., in prep.). However, much less is known about how abandonment of traditional land use affects the relationship between biodiversity and productivity in these grasslands. The purpose of our study was to investigate patterns of biodiversity and productivity in mowed versus abandoned hay meadows in Ciucului Mountains. We hypothesized that actively managed (mowed) meadows will have overall high species diversity and lower productivity, whereas abandoned meadows on the contrary will have lower diversity and higher productivity. We expected that a "hump-back" pattern would arise from the high microhabitat heterogeneity, which created a visible mosaic of productivity patterns. The

study constitutes part of a global meta-analysis of the effect of spatial scale on the relationship between species richness and plant biomass.

Methods

Study site

The study area is situated in the Ciucului Mountains, which belongs to the flysch zone of the Eastern Carpathians. The mountains have steep slopes and narrow valleys. Forest cover is relatively low because of human impact, representing about 50% of the area. A large area is covered by secondary grasslands. The annual average temperature is 6-7 C, and annual precipitation is 700-1000 mm. The climate is boreal-mountainous and average total annual precipitation ranges between 580-1200 mm (Kristó, 1994). According to the land owner, in 1990 a peak in the population dynamics of moles caused frequent disturbances all over the area.

The actively managed meadow was dominated by *Festuca nigrescens* and *Agrostis tenuis*. This type of temperate grassland is the most species rich in the Carpathian Mountains and develops under continuous management. One replicate was placed on the upper part of a slope, close to a ridge, had a slope angle of ~ 10 degrees and the exposure was E-NE. The site has been continuously mown by hand (scythe or recently hand mower) for decades, but sheep have transited the meadow at least once in a year (in spring and/or autumn). In 2011 the site was not mown, and in 2010 the site was moderately sheep grazed. The second replicate was situated closer to the middle part of a slope, the slope angle was ~ 25 degrees and the exposure was E. In 2011 and 2010 the site was not mown, and in 2010 it was moderately sheep grazed. The second management regime was a mountain hay meadow abandoned 9 years ago, with high dominance of *Brachypodium pinnatum* and small woody species. The first replicate had a slope angle of ~ 25 degrees and the exposure was E. There had been some larger shrubs in the plots, which were cleared in May 2012. The second replicate is situated closer to the lower part of a slope, had a slope angle of ~ 20 degrees and the exposure was E-SE.

Data collection

Two replicate study areas were delimited in both mowed and abandoned hay meadows. One replicate was a 10 x 10 metre grid, containing 100 1m^2 plots. For each plot, the

number of species was counted and identified. Live and dry (litter) above-ground biomass were then harvested separately, dried and weighed.

Data analysis

Mean species richness (number of species), live, dry and total biomass were calculated for each 10 x 10 metre grid and compared. Because sample plots were adjacent (spatially dependent), no statistical analyses were employed. To analyse the relationship between species richness and biomass, the number of species in each small plot was fitted against live, dry and total biomass using simple linear and non-linear regressions.

Results

Grids of the mowed meadows accumulated a number of 103 and 96 species, whereas grids of the abandoned meadows had a lower number of 84 and 87 species. Number of vascular plant species per 1 m^2 plot varied between 25 and 48 in mowed meadows and 15 and 39 in abandoned meadows. Mean number of species was the highest in the first mowed replicate (40.4±3.7) (mean±SD) and the lowest in the first abandoned replicate (23.8±4.0) (mean±SD), whereas no notable difference existed between the other mowed and abandoned replicates (Fig. 1a). Total plant biomass varied between 327 g/m^2 and 673 g/m^2 in the mowed meadows and 275 g/m^2 and 767 g/m^2 in the abandoned meadows. Mean total biomass was similar across sample grids (490-552 g/m^2), except the first abandoned replicate which had lower biomass (408 g/m^2) (Fig 1b). Live biomass showed a similar pattern. The amount of dry biomass (litter) was much lower in the first mowed replicate (Fig. 1d).

The relationship between biomass and species richness is shown in Fig 2. In mowed meadows no significant diversity-productivity relationship existed, whereas in abandoned meadows linear models described best the diversity-productivity relationship. Although singificant, these effects were very small (Fig. 2). In the first abandoned site, diversity increased with increasing live and total biomass. In contrast, in the second abandoned site, diversity decreased with increasing live, dry and total biomass.

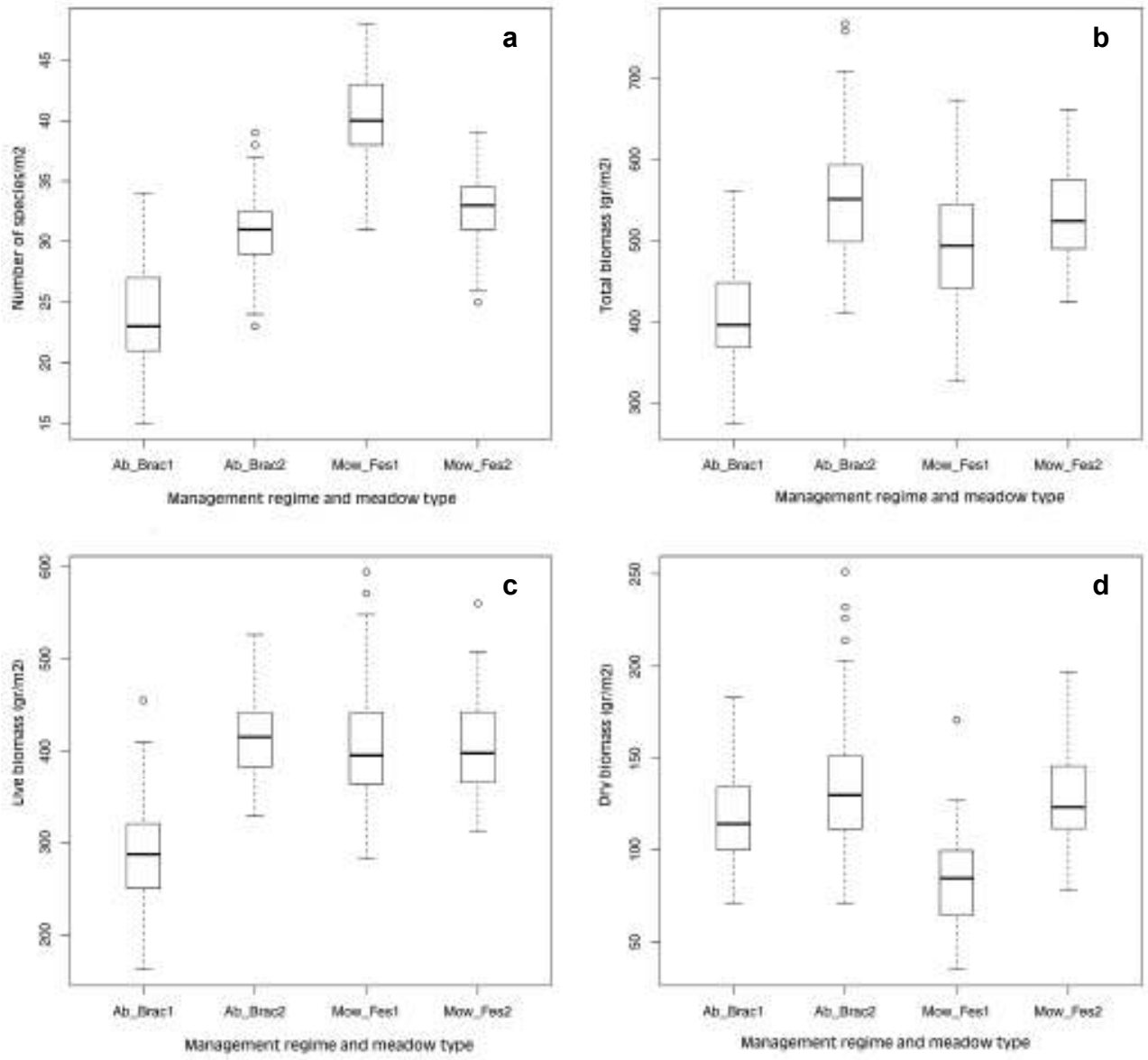

Fig. 1 Box diagrams (median and quartiles) of species richness (**a**), total- (**b**), live- (**c**) and dry- (**d**) biomass for different management regimes (Ab=abandoned meadows, Mow=mowed meadows, Fes=community dominated by *Festuca rubra* & *Agrostis tenuis*, Brac= community dominated by *Brachypodium pinnatum*)

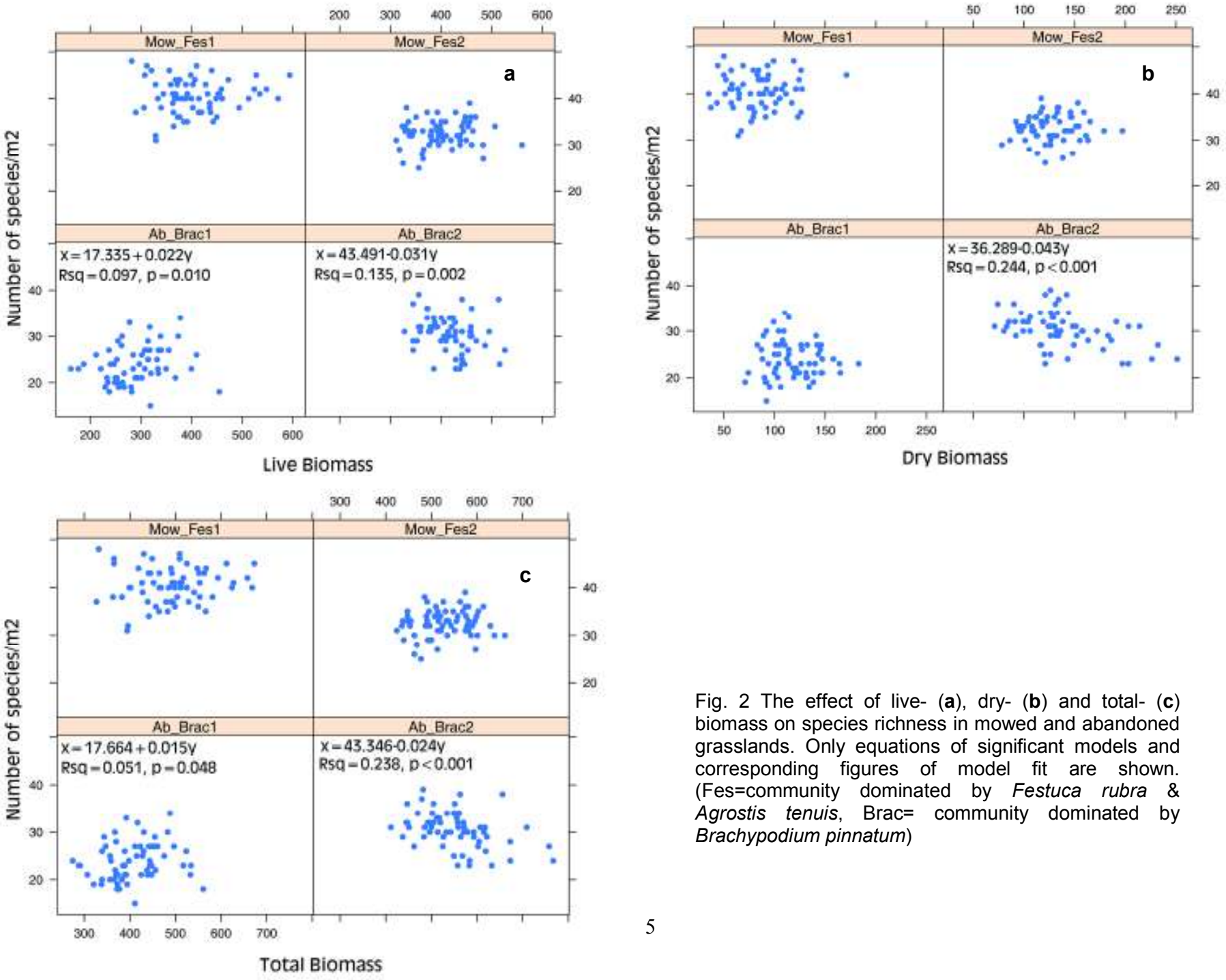

Fig. 2 The effect of live- (**a**), dry- (**b**) and total- (**c**) biomass on species richness in mowed and abandoned grasslands. Only equations of significant models and corresponding figures of model fit are shown. (Fes=community dominated by *Festuca rubra* & *Agrostis tenuis*, Brac= community dominated by *Brachypodium pinnatum*)

Discussion and conclusion

We report here a rather high variability of diversity and productivity patterns in our study area. Nonetheless, some mowed meadows cumulated the highest, and some abandoned meadows, the lowest diversity, and thus we align to current views of diversity loss with abandonment (Losvik, 1999). Contrary to our initial hypothesis, the biodiversity-productivity relationship was not “hump-backed” at the individual study sites. This would have suggested that the availability of limiting resources or disturbance and plant competition are both critical and alternating determinants of diversity in hay meadows (Grime 1979). Instead, single factors might have a stronger effect. For example, the lack of relationship in mowed meadows might arise from very frequent disturbances caused by vole activity. A positive relationship at the first abandoned site is very likely due to the invasion of grassland by woody species and drastic decrease of diversity. Other studies have found that primary productivity of grassland ecosystems is positively related to plant species diversity (Roy 2001). At the second abandoned site, species diversity might be limited by interspecific competition from the fast-growing *B. pinnatum*, a stress-tolerator competitor which progressively increases abundance following abandonment. This situation is typical to high productivity communities (e.g. Wilson and Keddy 1986).
At this point we believe that more refined analyses are needed in order to draw definite conclusions about the patterns of diversity-productivity in our system. As our analyses progress, we will be able to disentangle the processes that lay behind the high variability of responses in mowed versus abandoned grasslands.

References

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