Thaiszia - J. Bot., Košice, 19, Suppl. 1: 67-78, 2009 http://www.bz.upjs.sk/thaiszia

THAISZIA
JOURNAL OF
BOTANY

Vegetation, phytomass and seed bank of strictly protected hay-making *Molinion* meadows in Zemplén Mountains (Hungary) after restored management

PÉTER TÖRÖK[1], ILDIKÓ ARANY[2,3], MÁTYÁS PROMMER[4], ORSOLYA VALKÓ[1,3], ADRIEN BALOGH[3], ENIKŐ VIDA[1,3], BÉLA TÓTHMÉRÉSZ[1] & GÁBOR MATUS[3]

[1]Department of Ecology, Faculty of Science, University of Debrecen, Egyetem tér 1., P.O. Box 71, Debrecen H-4010

[2]CEEWEB Office, H-1021 Budapest, Kuruclesi út 11/a

[3]Department of Botany, Faculty of Science, University of Debrecen, Egyetem tér 1., P.O. Box 14, Debrecen H-4010

[4]WWF Hungary, H-1124 Budapest, Németvölgyi út 78/b; molinia@gmail.com

Török P., Arany I., Prommer M., Valkó O., Balogh A., Vida E., Tóthmérész B. & Matus G. (2009): Vegetation, phytomass and seed bank of strictly protected hay-making *Molinion* meadows in Zemplén Mountains (Hungary) after restored management. – Thaiszia – J. Bot. 19, Suppl. 1: 67-78. – ISSN 1210-0420.

Abstract: The outstandingly species-rich Gyertyán-kút meadow in the Zemplén Mountains (NE Hungary) was selected for a restoration study in 1993. The effect of annual summer cutting on species diversity and reproductive success was studied in abandoned *Junco-Molinion* stands. In two stands, pairs of 100-m^2 sized plots (cut, unmanaged) were surveyed in 2004. Species composition and number of flowering shoots were registered in 1-m^2 sized subplots (n=20 per stand). Aboveground phytomass samples (10×10cm, n=32) were harvested, dried and sorted as (i) dead, (ii) graminoid (Cyperaceae, Poaceae, Juncaceae) and (iii) herbaceous (dicots and herbaceous monocots). The seed bank was studied using the seedling emergence method.

Higher species number and a higher number of herbaceous and flowering herbaceous species were detected in cut plots. More of the frequent flowering herbaceous species had a higher number of flowering shoots in the cut plots than in the unmanaged ones (e.g. *Leontodon hispidus, Potentilla erecta, Plantago lanceolata, Stellaria graminea, Gladiolus imbricatus, Viola canina*). Graminoids, especially *Molinia* and *Deschampsia cespitosa*, showed higher reproductive success in unmanaged plots. Lower dead and graminoid phytomass were detected in cut stands. Reproductive performance and phytomass of *Molinia* was negatively correlated with reproductive performance of herbaceous species and with herbaceous species richness. *Juncus conglomeratus/effusus* species group formed the vast majority of the seed bank. *Molinia* had a significantly ($p<0.001$) more dense seed bank in the unmanaged plots. In contrast, most of the dominant herbaceous species had a more dense seed bank in the cut plots. A few species that were present in the vegetation lacked persistent seed banks or had sparse ones (e.g. *Succisa pratensis*, *Achillea ptarmica, Leontodon hispidus*).

Our results suggest that annual cutting is an appropriate tool to restore species richness of abandoned wet hay meadows and to maintain high flowering performance of meadow species by decreasing phytomass and diminishing the flowering success of *Molinia*.

Keywords: abandonment, *Molinia*, species richness, phytomass, seed bank, hay meadow.

Introduction

Economic changes during the second half of the 20th century altered land use practice in many parts of Europe, and these changes resulted in intensive migration to the urban centres. This caused cessation of traditional management of meadows (BAKKER 1989, STAMPFLI & ZEITER 1999). Abandonment of species-rich grasslands often resulted in the increasing dominance of a few species and the loss of subordinate ones (WILLEMS & BIK 1998). This decline in species richness from abandoned meadows and pastures was reported from different parts of Europe (BAKKER 1989, WILLEMS 1983**,** WELLS 1980).

The mountain hay meadows are often very species-rich with many endangered plant species. Therefore, it is important to restore and/or preserve these habitats. Traditional management practices are used to preserve species-rich mountain hay meadows in many regions of Europe. Well-designed and documented monitoring programmes are needed in a restoration experiment to test the appropriateness of management practices (MURPHY 1990, STAMPFLI 1992).

In 1993, a long-term restoration experiment was started in one of the largest hay meadows of Hungary. The aim of the study was to study the effect of annual cutting on the species richness, phytomass and seed bank of abandoned meadow stands.

Material and Methods

Study site

We studied the strictly protected; approximately 100-ha sized Gyertyán-kúti-rétek meadows, in the Zemplén Mountains (NE Hungary). This outstandingly species-rich meadow is situated at a height of 640-720-m a.s.l. on a plateau surrounded by forests. The upper soil level is acidic (pH_{KCl}=3.6-4.4) and is rich in humus (6.9-8.2%) and clay. The mean annual temperature is 7.5-8ºC. The mean annual precipitation is about 750-800-mm and the maximum amount of precipitation is in July-August (MATUS 1997).

According to SIMON (1977) the meadows in the Zemplén Mountains, including the Gyertyán-kúti-rétek, were created in the 17-18th century by the clear felling of oak woods (*Quercetum petreae-cerris* and *Querco petreae-Carpinetum*). Over the past 200-250 years the meadows were cut once a year, usually in July (PALÁDI-KOVÁCS 1979). Traditional management has gradually been abandoned since the 1960s.

Experimental design and sampling

In 1993 a long-term restoration experiment was started. To study the effect of annual cutting on species richness and flowering success in *Molinion* meadows a total of four 100m^2 permanent plots (at two sites with one cut and one unmanaged plot per site) were selected. The cut plots were mown by scythe once a year in the last week of July, and the hay was carried away. In all plots 20 permanent 1-m^2 subplots were marked. In these subplots the species lists and number of flowering shoots were recorded in July before cutting. Species nomenclature follows SIMON (2000).

In 2004, aboveground phytomass samples (10×10cm, 32 per plot) from close to the permanent subplots were harvested and dried to constant weight (25℃, 2 weeks). The dry samples were sorted as (i) dead, (ii) graminoid (Cyperaceae, Poaceae, Juncaceae) and (iii) herbaceous groups (dicots and herbaceous monocots) (TILMAN 1993, OBA et al. 2001, WAIDE et al. 1999). After sorting the phytomass weights were measured with 0.01g accuracy.

The seed bank was studied with the seedling emergence method. In each plot 30 soil samples were taken (4cm in diameter, 10cm in depth) after snowmelt in early April 2005. Two vertical segments (0-5cm, 5-10cm) were separated. Identical segments were pooled on the spot, to minimize sample variability. Pooled samples were treated with bulk reduction procedure (TER HEERDT et al. 1996). Vegetative organs were retained by washing over a coarse sieve (3.0mm mesh width) while seed-free fine soil components were removed on a 0.2mm mesh. Concentrated samples were spread in a maximum 3-4mm thick layer on trays, previously filled with 4cm of normal and 4cm of steam-sterilized potting soil.

Trays were illuminated with natural light in a greenhouse at Botanical Garden of Debrecen University. In the greenhouse, shaded with Rachel nets from early May to late August, temperature varied typically between 30ºC/18ºC in the day /

at night. In early July when no new seedlings emerged, watering was stopped and then the dried sample layers were crumbled. In late August watering was re-started and continued till late October. Seedlings were regularly counted, identified (CSAPODY 1968, MULLER 1978) and removed. Unidentified taxa were at least partly transplanted. Transplants of *Cyperaceae*, *Juncaceae* and *Poaceae* were mostly identified the following spring when flowering. Seed rain was monitored in sample-free control trays. Contaminant species e.g. greenhouse weeds (*Oxalis corniculata*, *Cymbalaria muralis*) were excluded from analyses.

Data processing

The mean of species richness (i.e. number of species per subplot), number of flowering shoots and phytomass weights were compared by Mann-Whitney U-test. The relationship between species richness and the various phytomass components were studied using Spearman rank correlation test (DYTHAM 2003).

Results

Species composition and flowering success

In the investigated 80 subplots 23 graminoid and 84 herbaceous species were detected. In the cut plots 23 graminoid and 68 herbaceous species, while in the unmanaged plots 21 graminoid and 70 herbaceous species were present. Altogether 23 species were considered as abundant in flowering shoots (>50 flowering shoots for graminoid, >25 flowering shoots for herbaceous species, Tab. 1). Out of the 16 abundant flowering herbaceous species eight species were more frequent in cut plots than in unmanaged ones. Only one herbaceous species (*Serratula tinctoria*) proved more frequent in the unmanaged plots. Out of the seven frequent graminoid species only one was more frequent in unmanaged plots, and three species were indifferent.

Significantly higher species richness ($p<0.01$), herbaceous species number ($p<0.001$) and flowering herbaceous species number ($p<0.001$) were detected in the cut plots (Fig. 1.). *Molinia* and the other graminoids had significantly higher flowering success ($p<0.001$) in the unmanaged plots (Fig. 2.). The flowering success of *Molinia* showed a negative correlation (r = -0.70, $p<0.01$) with that of herbaceous species, and a negative correlation (r = -0.65, $p<0.01$) with the herbaceous species richness.

Phytomass

In the unmanaged plots significantly higher graminoid ($p<0.01$) and dead phytomass ($p<0.001$) were sampled. No significant differences were found between the cut and unmanaged herbaceous phytomass (Fig. 3). The herbaceous species richness correlated negatively with dead (N=128, r=-0.64 and $p<0.001$) and the graminoid (N=128, r=-0.53 and $p<0.001$) phytomass, respectively. The graminoid phytomass showed a weak negative correlation with the herbaceous phytomass (N=128, r=-0.26 and $p<0.001$). The graminoid phytomass without *Molinia* was positively correlated with the herbaceous species richness (N=128, r=0.35 and p<0.001) and negatively with the phytomass of *Molinia* (N=128, r=-0.46 and p<0.001).

Seed bank

More than 12,000 seedlings emerged, and about 1,600 seedlings were transplanted. Total seed densities in the upper 10 cm soil layers varied from 64,000 to 94,000 seeds/m^2. Both the highest and the lowest seed densities were found in the unmanaged plots. Altogether 32 species had more than 10 seedlings (Tab. 2). *Juncus conglomeratus/effusus* species group formed the vast majority of the seed bank (62-86% of the total seed bank). Most seed bank species were present also in the vegetation. *Molinia* had a significantly (p<0.001) more dense seed bank in the unmanaged plots, and most of the dominant herbaceous species had a more dense seed bank in the cut plots. A few of the species present in the vegetation had at most sparse seed banks (e.g. *Achillea ptarmica, Leontodon hispidus, Succisa pratensis*). In contrast, some taxa rare in the vegetation had dense seed banks (*Juncus conglomeratus*/*effusus*). Some further sedges and rushes were detected exclusively in the seed bank (*Carex pilulifera*, *C. flava*, *Juncus bufonius*, *J. tenuis*).

Discussion

Species richness, flowering success and seed bank

At the beginning of the experiment (1993) no significant differences were detected between the plots to be cut and those to be left unmanaged. In 1998 the species richness (p<0.001), the number of flowering species (p<0.05) and that of flowering shoots (p<0.01) were already significantly higher in the cut plots. In 2004 the managed plots had even higher species richness, herbaceous and flowering herbaceous species numbers.

After 12 years of management the species richness and the number of flowering shoots turned out to be significantly higher in the managed plots, as was also shown in other studies by HUHTA et al. (2001), LOSVIK (1999), BAKKER et al. (1980) and BABA (2004). In contrast the flowering success of *Molinia* has significantly decreased in the cut plots.

The cut plots showed an increase in frequency of graminoids (without *Molinia*) and herbaceous species from 1993 to 2004. The frequency of most herbaceous and graminoid species (14 frequent herbaceous and 8 graminoid species) was significantly higher in cut plots than in the unmanaged ones in 2004. Only a few species (e.g. *Myosotis palustris*, *Lysimachia vulgaris*, *Hypericum maculatum*) became rare after 12 years of management. The possible explanation for the differences in the species frequencies between the cut and the unmanaged plots could be a higher specific sensitivity to cutting, or the altered competitive environment.

We found that restored management resulted in an increased seed density of many of the herbaceous species. In the managed plots most of the dominant flowering herbaceous species had greater seed densities, whereas the density for the dominant *Molinia* was significantly lower. Similar results were shown by BAKKER et al. (1997), BEKKER et al. (1997) and TOUZARD et al. (2002). Due to sparse seed banks no statistically clear tendency was revealed for a number of species.

Phytomass and species richness

No statistically significant differences were detected between the phytomass weights in the cut and the unmanaged plots in 1993. By 1998 the amount of dead phytomass was already significantly lower (p<0.001) in the cut plots. In 2004 the total phytomass, the amount of the graminoid and the dead phytomass were also significantly lower in the managed plots. That is to say that cutting and litter removal reduced the amount of graminoid and dead phytomass.

Many studies indicate that, in temperate grasslands, the aboveground phytomass is negatively correlated with the plant species richness (GRIME 1990, HUSTON 1979, WHEELER & GILLER 1982, WAIDE et al. 1999). A similar phenomenon was observed in our study.

Dead and graminoid phytomass were also found to be negatively correlated with the flowering success and species richness of herbaceous plants (JENSEN & MEYER 2001, WHEELER & SHAW 1991). It is widely accepted, that regular mowing decreases the living (especially graminoid) aboveground phytomass (JENSEN & MEYER 2001, RYSER et al. 1995), and also reduces the accumulation of dead phytomass (RYSER et al. 1995, HUHTA et al. 2001). Regular cutting reduces shoot competition and shading (ZOBEL et al. 1996), and so light availability on the ground improves (BOBBINK et al. 1989). The better light conditions support the survival of young seedlings (TILMAN 1993). Cutting also has a positive effect on the germination and survival of herbaceous plants (OVERBECK et al. 2003), which results in greater species richness and flowering success.

Our results clearly indicate that the traditional management, i.e. annual midsummer cutting, is an effective way to decrease the amount of dead material and the phytomass of graminoids (especially that of *Molinia*). Therefore, it is an appropriate tool to restore and maintain species richness and flowering diversity of wet meadows but successful restoration can also depend on the quality of the local species pool (e.g. seed availability). Similar predictions have been made in studies from similarly managed extensive grasslands (ZOBEL et al. 1996, KULL & ZOBEL 1991, STAMPFLI et al. 1994, STAMPFLI & ZEITER 1999).

Acknowledgements

We are indebted to Péter Hulják, István Rimán, Zoltán Mikecz, Orsolya Kiss, Tamás Zsólyomi, for their help in fieldwork. Thanks are due to the staff of Debrecen University Botanical Garden for providing facilities. The financial support of the Ministry of Education to the first author, of the Ministry of Environment and Water (Fellowship of Environmental Sciences) to the first and second author, and the Békésy Postdoctoral Fellowship (Ministry of Education) to the last author is gratefully acknowledged.

References

BABA W. (2004): The species composition and dynamics in well-preserved and restored calcareous xerothermic grasslands (South Poland). In: Biologia 59: 447-456.

BAKKER J. P., DEKKER M. & DEVRIES Y. (1980): The effect of different management practices on a grassland community and the resulting fate of seedlings. In: Acta Bot. Neerl. 29: 469-482.

BAKKER J. P. (1989): Nature Management by Grazing and Cutting. Kluwer Academic Publishers. - Dodrecht, Boston, London, p. 401.

BAKKER J. P., BAKKER E. S., ROSÉN E. & VERWEIJ, G. L. (1997): The soil seed bank of undisturbed and disturbed dry limestone grassland on Öland (Sweden). In: Z. Ökologie u. Naturschutz 6: 9-18.

BEKKER R. M., VERWEIJ G. L., SMITH R. E. N., REINE R., BAKKER J. P. & SCHNEIDER S. (1997): Soil seed banks in European grasslands: Does land use affect regeneration perspectives? In: J. Appl. Ecol. 34: 1293-1310.

BOBBINK R., DEN DUBBELDEN K. & WILLEMS J. H. (1989): Seasonal dynamics of phytomass and nutrients in chalk grassland. In: Oikos 55: 216-224.

CSAPODY V. (1968): Keimlingsbestimmungsbuch der Dikotyledonen. Akadémiai Kiadó – Budapest, p. 286.

DYTHAM C. (2003): Choosing and Using Statistics. A Biologist's Guide. Blackwell Scientific Publications. – Oxford, London, Edinburgh, p. 248.

GRIME J. P. (1990): Mechanisms promoting floristic diversity in calcareous grassland. – In: HILLIER S. H., WALTON D. W. H. & WELLS D. A. (ed.): Calcareous Grasslands: ecology and management. Bluntisham Books. – Bluntisham, p. 51-56.

HUHTA A. P., RAUTIO P., TUOMI J. & LAINE K. (2001): Restoration mowing on an abandoned semi-natural meadow: Short-term and predicted long-term effects. In: Journal of Vegetation Science 12: 677-686.

HUSTON M. (1979): A general hypothesis of species diversity. In: American Naturalist 113: 81-101.

JENSEN K. & MEYER C. (2001): Effects of light competition and litter on the performance of *Viola palustris* and on species composition and diversity of an abandoned fen meadow. In: Plant Ecology 155: 169-181.

KULL K. & ZOBEL M. (1991): High species richness in an Estonian wooded meadow. In: Journal of Vegetation Science 2: 711-714.

LOSVIK M. H. (1999): Plant species diversity in an old, traditionally managed hay meadow compared to abandoned hay meadows in southwest Norway. In: Nordic Journal of Botany 19: 473-487.

MATUS G. (1997): Florisztikai kutatások a zempléni Gyertyánkúti-réteken. [Floristic research in the Gyertyánkúti-rétek meadows]. In: Kitaibelia 2: 313-316.

MULLER F. M. (1978): Seedlings of the North-Western European Lowland. A flora of seedlings. Dr. W. Junk B. V. Publishers. The Hague, Boston.

MURPHY D. D. (1990): Conservation biology and scientific method. In: Conservation Biology 4: 203-204.

OBA G., VETAAS O. R. & STENSETH N. C. (2001): Relationships between biomass and plant species richness in arid-zone grazing lands. In: Journal of Applied Ecology 38: 836-845.

OVERBECK G., KIEHL K. & ABS C. (2003): Seedling recruitment of *Succisella inflexa* in fen meadows: Importance of seed and microsite availability. In: Applied Vegetaion Science 6: 97-104.
PALÁDI-KOVÁCS A. (1979): A magyar parasztság rétgazdálkodása. [Meadow management of the Hungarian peasantry]. Akadémiai Kiadó. Budapest.
RYSER P., LANGENAUER R. & GIGON A. (1995): Species richness and vegetation structure in a limestone grassland after 15 years management with 6 biomass removal regimes. In: Folia Geobotanica & Phytotaxonomica 30: 157-167.
SIMON T. (1977): A Zempléni-hegység északi részének védendő flórakülönlegességeiről. [Floristic curiosities of the northern region of Zemplén Mountains to be protected]. In: Abstracta Botanica 5: 57-63.
SIMON T. (2000): A magyarországi edényes flóra határozója. [Vascular Flora of Hungary]. Nemzeti Tankönyvkiadó. Budapest.
STAMPFLI A & ZEITER M. (1999): Plant species decline due to abandonment of meadows cannot easily be reversed by mowing. A case study from the Southern Alps. In: Journal of Vegetation Science 10: 151-164.
STAMPFLI A. (1992): Effects of mowing and removing litter on reproductive shoot modules of some plant species in abandoned meadows of Monte San Giorgio. In: Botanica Helvetica 102: 85-92.
STAMPFLI A., GUGGISBERG F., BERLI S. & PESTALOZZI H. (1994): The abandoned *Danthonia alpina* – grassland on Monte San Giorgio: Evidence of floristic changes and suggested management practices. In: LOTTER A. F. & AMMANN B. (ed.): Festschrift Gerhard Lang, Dissertationes Botanicae 234: 59-78.
TERHEERDT G. N. J., VERWEIJ G. L., BEKKER R. M. & BAKKER J. P. (1996): An improved method for seed bank analysis: seedling emergence after removing the soil by sieving. In: Funct. Ecol. 10: 144-151.
TILMAN D. (1993): Species richness of experimental productivity gradients: how important is colonisation limitation? In: Ecology 74: 2179-2191.
TOUZARD B., AMIAUD B., LANGLOIS E., LEMAUVIEL S. & CLÉMENT B. (2002): The relationship between soil seed bank, aboveground vegetation and disturbances in an eutrophic alluvial wetland of Western France. In: Flora 197: 175-185.
WAIDE R. B., WILLIG M. R., STEINER C. F., MITTELBACH G., GOUGH L., DODSON S. I., JULAY G. P. & PARMENTER R. (1999): The relationship between productivity and species richness. In: Annu. Rev. Ecol. Syst. 30: 257-300.
WELLS T. C. E. (1980): Management options for lowland grassland – In: Rorison I. H. & Hunt R. (ed.): Amenity grassland. An ecological perspective, p. 175-195. Wiley & Sons, Chichester.
WHEELER B. D. & GILLER K. E. (1982): Species richness of herbaceous fen vegetation in Broadland, Norfolk in relation to the quantity of above-ground plant material. In: Journal of Ecology 70: 179-200.
WHEELER B. D. & SHAW S. C. (1991): Above-ground crop mass and species richness of the principal types of herbaceous rich-fen vegetation of lowland England and Wales. In: Journal of Ecology 79: 285-301.
WILLEMS J. H. & BIK L. P. M. (1998): Restoration of high species density in calcareous grassland: the role of seed rain and soil seed bank. In: Applied Vegetation Science 1: 91-100.
WILLEMS J. H. (1983): Species composition and above ground phytomass in chalk grassland with different management. In: Vegetatio 52: 171-180
ZOBEL M., SUURKASK M. ROSÉN E. & PÄRTEL M. (1996): The dynamics of species richness in an experimentally restored calcareous grassland. In: Journal of Vegetation Science 7: 203-210.

Tab. 1. Total number of flowering shoots of frequent flowering species in the 20 subplots in 2004 (>50 flowering shoots for graminoid, >25 flowering shoots for herbaceous species). Species were arranged in an alphabetical order as herbaceous first then graminoids. Herbaceous and graminoid species are separated with a dashed line.

Species	Site I.		Site II.	
	cut	unmanaged	cut	unmanaged
More frequent in the cut plots				
Centaurea jacea	2	1	55	24
Gladiolus imbricatus	8	5	34	4
Leontodon hispidus	0	0	430	2
Plantago lanceolata	27	0	26	0
Potentilla erecta	68	47	111	85
Stellaria graminea	38	1	194	171
Thymus pulegioides	0	0	52	9
Viola canina	105	6	82	31
Agrostis canina et *tenuis*	60	0	156	135
Briza media	7	0	69	16
Festuca ovina	57	0	42	4
More frequent in the unmanaged plots				
Serratula tinctoria	3	7	18	27
Molinia coerulea	859	1494	297	1190
Indifferent species				
Achilea millefolium	4	6	36	2
Cruciata glabra	12	1	31	62
Galium verum	2	2	4	25
Prunella vulgaris	31	0	60	61
Sanguisorba officinalis	52	10	13	20
Selinum carvifolia	53	7	22	84
Succisa pratensis	17	2	26	43
Brachypodium pinnatum	1	3	102	0
Carex pallescens	8	6	8	88
Luzula multiflora	32	6	47	54

Tab. 2. Number of emerged seedlings of frequent species (each seedling detected corresponds to 26.53 seeds/m^2). Species were arranged in an alphabetical order as herbaceous first then graminoids. Herbaceous and graminoid species are separated with a dashed line.

Species (n > 10 seedlings)	Site I.		Site II.	
	cut	unmanaged	cut	unmanaged
More frequent in the cut plots				
Campanula patula	5,439	3,794	5,943	5,518
Lychnis flos-cuculi	637	292	1,273	186
Lysimachia nummularia	424	0	80	0
Myosotis palustris	796	769	1,884	663
Ranunculus acris	106	80	53	0
Veronica officinalis	159	0	159	27
Veronica serpyllifolia	531	106	318	80
Juncus bufonius	557	133	27	0
Agrostis canina et *tenuis*	690	424	2,998	27
More frequent in the unmanaged plots				
Betula pendula	371	424	106	371
Potentilla erecta	212	318	159	292
Typha angustifolia	27	80	27	80
Carex panicea	159	212	53	292
Deschampsia cespitosa	159	1,008	0	0
Molinia coerulea agg.	133	2,122	0	1,486
Indifferent species				
Ajuga reptans	80	106	106	27
Conyza canadensis	27	239	27	0
Hypericum maculatum	478	424	27	159
Leucanthemum vulgare	186	53	27	80
Ranunculus repens	345	0	0	27
Stellaria graminea	1,061	1,273	345	106
Veronica chamaedrys	743	133	27	27
Viola canina	663	663	133	133
Calamagrostis epigeios	80	212	27	0
Carex nigra	133	0	0	0
Carex ovalis	239	106	27	106
Carex pallescens	1,353	1,300	663	982
Carex sp.	318	265	212	478
Carex tomentosa	133	239	0	0
Juncus articulatus	6,553	1,247	1,194	2,547
Juncus conglomeratus/effusus	59,427	76,804	74,523	49,107
Luzula multiflora	557	451	822	982

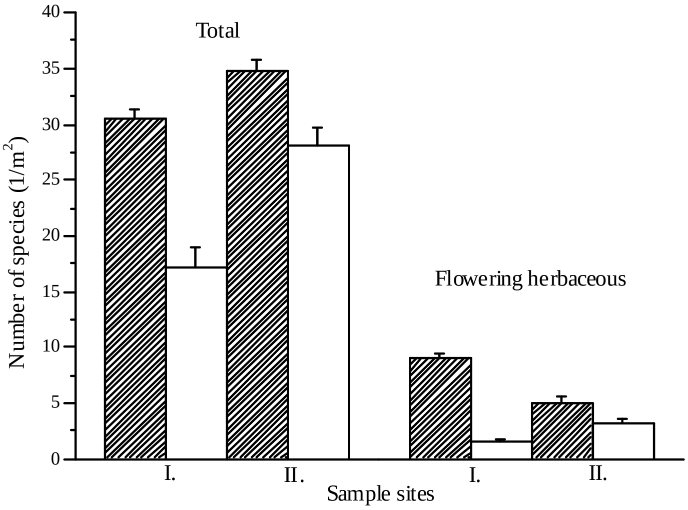

Fig. 1. Total species richness and number of flowering herbaceous species in 2004 (means with SE). Cut plots: , unmanaged plots: .

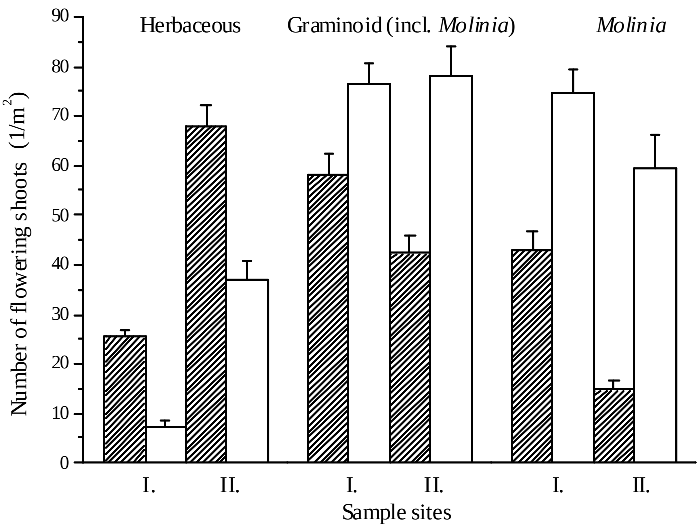

Fig. 2. Flowering shoot numbers of herbaceous and graminoid groups, and flowering shoot numbers of Molinia in 2004 (mean with SE). For column indications see Fig 1.

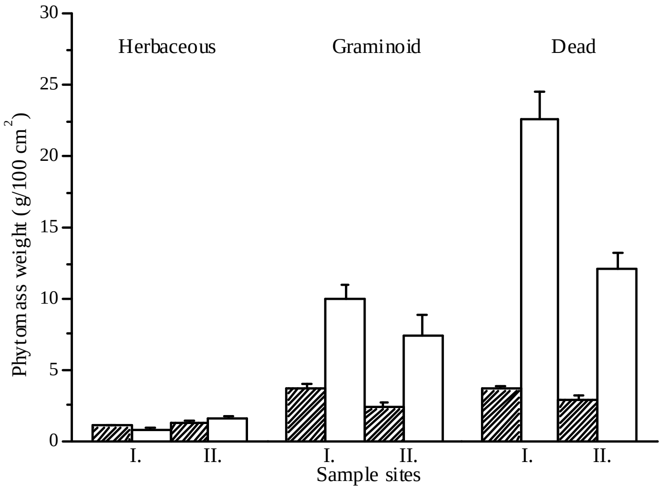

Fig. 3. Phytomass weights of herbaceous, graminoid and dead phytomass groups in 2004 (mean values with SE). For column indications see Fig 1.