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EXTENSIVE USE OF SOWN MEADOWS – A TOOL FOR RESTORATION OF BOTANICAL DIVERSITY

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Abstract. The state of sown meadow communities of different intensity of management (intensive and extensive using) over the period of 10–14 years of running was evaluated at Graisupis Experimental Field Station, Lithuania. Comparison of study data on intensively and extensively used sown meadows enabled to ascertain that intensity of sown meadows succession depends upon the character of grassland management. The positive correlation between the number of vascular plant species and sown meadow age revealed that botanical diversity of species in extensively used grassland restores much faster ($r_E = 0{,}95$) than under intensive management conditions ($r_I = 0{,}59$).

Keywords: sown meadow, succession, extensive and intensive use, productivity, botanical diversity, restoration.

1. Introduction

Meadows in the forest zone are mostly synanthropic, i e they occur because of human impact upon the primary landscape (instead of cleared, burnt forests or reclaimed bogs) of course, with the exception of natural wetlands and flood meadows [1–3]. As the forests were cleared, grasslands were established under the influence of domestic stock by a process of natural recruitment of grasses and herbs from forest glades and wetlands. These grasszlands varied in their structure and floristic composition according to the prevailing ecological conditions and the intensity of management [2]. Under temperate climate conditions meadow ecosystems are unstable and considered as an intermediate stage of succession of plant communities. Communities of semi-natural meadows formed as a result of centuries-long traditions of land use, which determined the formation of meadow communities characterised by high species diversity of vascular plants. In the second half of the 20th century, however, intensification of agricultural activities (land reclamation, enlargement of arable land areas, excessive fertilisation) in Central and East Europe inevitably affected the whole natural environment. The changes unavoidably influenced meadow ecosystems, especially those valuable in ecological aspect but less important economically. The survival not only of natural (even flooded) but also semi-natural meadows and preservation of their biological diversity is threatened. Only at the end of the 20th century, as the status of land property and farming priorities was changed and the need for fodder decreased, the process of cultural grasslands naturalization and meadow restoration started: the structure of communities, productivity, economic value of grasslands change, and the diversity of plant species and even meadow communities increases [4].

Presently, investigations on communities of natural and sown meadows become particularly important. Researchers worldwide are engaged in the issues of meadow succession and restoration [3, 5–11]. For the research on the development of meadow communities, it is essential to monitor and evaluate the condition of the natural and sown meadows in Lithuania, predict their changes, leave the areas of the necessary size to ensure the preservation of biological diversity, and to choose an appropriate regime of their maintenance. As Lithuania has become a Member State of the EU, there appear new possibilities to preserve botanical diversity of the communities in the remaining natural and restoring semi-natural meadows. The financial assistance to farmers for well maintained meadows encourage them to take care, mow, and prevent the overgrowth with shrubs. Regarding the preservation of botanical diversity, extensive farming involving minimum financial expenditure, refusal or only minimal fertilization and mowing of the meadow at least once per season would be very efficient.

The aim of the investigation is to evaluate changes in the communities of naturalizing intensively and extensively used sown meadows and possibilities for restoration of botanical diversity.

2. Material and methods

The object of the study was intensively and extensively used sown mesophillous meadow communities undergoing the process of naturalization.

Methods. The status of intensively and extensively used sown meadow communities was evaluated in the

period of 2001–2005 (June–August) at the Experimental Field Station (EFS) of Graisupis (Kėdainiai district; N 55°19´–20´, E 23°49´–50´), representing the region of the Central Lithuanian Plain. To establish the station, a grassland mixture (27 kg/ha; *Festuca pratense*, *Dactylis glomerata*, *Poa pratensis*, *Phleum pratense*, *Lolium perenne*, *Trifolium* pratense, and T. repens) was sown into the arable field in 1991 [12]. Intensively used grassland is being fertilized, hay made and pastured every year, extensively used grassland is not fertilized, but it is undergoing yearly haymaking and rare pasturage. The grassland develops on plain landscape, the relief of which does not have strong influence on differences in ecological conditions of ecosystems, therefore, human activity and meteorological conditions in growth season are decisive factors.

Flora composition of the grasslands and aboveground phytomass (dry weight, g/m²) were registered in June (1st harvest), July (2nd harvest) and August (3rd harvest) on two experimental field sites (intensively and extensively used). On every experimental field site, three permanent study plots (100 m²) were singled out each divided into three trial plots of 1 m² in size (Fig 1).

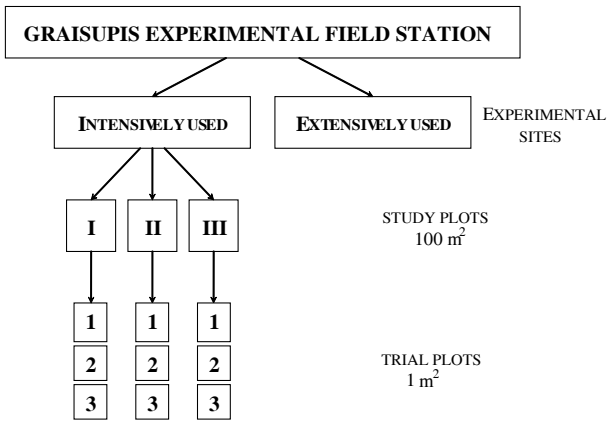

Fig 1. Scheme of Graisupis Experimental Field Station

Phytosociological relevés were made and aboveground phytomass was estimated in the same permanent places. Phytocenotic descriptions of sown meadow communities were performed applying the principles of vegetation research of French-Swiss (Zürich-Montpelier) school [13–14]. Abundance of species of sown meadow communities and herb layer coverage were evaluated according to J. Braun-Blanquet [13] scale on the study plots (100 m²). On individual experimental sites the frequency (%) of every vascular plant species was ascertained. Table 1 presents general data on sown meadow flora composition at Graisupis EFS. Nomenclature of plant species was applied following Z. Gudžinskas [15].

Aboveground phytomass of meadow communities was ascertained according to the programme and methods of geobotanical investigations [16–17]. Three times per growth season (1st–3rd harvests) on each study plot the aboveground phytomass was determined on three typical (by flora composition and herb layer coverage) trial plots of 1 m² in size. The aboveground part, mown down to the soil level, was grouped into vascular plants (arranged into species), bryophytes and dead parts of plants. The sorted out sample was dried up and weighed, i e the specific weight of every grass species was indicated (Table 2). Economic value of the communities was indicated following the methods of A. Petkevičius and A. Stancevičius [18]. Ecological groups of vascular plants were presented by means of H. Ellenberg [19] scale.

Similarity of meadow communities was ascertained according to Sörensen coefficients: C_S – to compare communities according to flora composition of the recorded vascular plants, C_N – to compare communities according to aboveground phytomass of vascular plants [20].

The data were processed applying *Microsoft Excel* and *STATISTICA for Windows* software. Correlation coefficient (r) was used to figure interrelation of diverse features [21].

3. Natural conditions

According to physical and geographical division of Lithuania, the area of Graisupis EFS is situated on the Central Lithuanian Plain [21–22]. Graisupis EFS is located on the right side of the Nevėžis River basin between the rivulets Jaugila and Smilga. The area has been reclaimed intensively. Among natural perennial vegetation distribution ranges, only larger agricultural forest of Ąžuolaičiai (78,6 ha) and some small agricultural forests have survived. The agricultural area of the basin includes a continuous territory of arable land and sown meadows (the area of individual distribution ranges exceeds 200 ha). The landscape of undulating, ridged loamy plain prevails in this area. Soil forming rocks of morainic or limnoglacial origins occur, light loam with occasional sand threads dominates. Gleyic calcaric cambisols prevail at the EFS of Graisupis, like on the whole Central Lithuanian Plain because of carbon-bearing parent rocks (carbonates are washed out at a depth of 40–60 cm) [22–25].

4. Results

The condition of sown meadow communities of different intensity of management (intensive and extensive using) over the period of 10–14 years of running was evaluated (Figs 2, 3).

In an ***intensively used*** meadow, during five years of investigation, 39 vascular plant species were recorded; in separate years the number varied from 22 (in 2002) to 30 (in 2005). Among them 6 Poaceae (*Dactylis glomerata, Festuca pratensis, Lolium perenne, Phleum pratense, Poa pratensis, P. annua*), 3 *Fabaceae* (*Trifolium repens, T. pratense, T. hybridum*) and 30 species (*Taraxacum officinale, Leontodon autumnalis, Achillea millefolium, Alchemilla vulgaris, Capsella bursa-pastoris, Cerastium holosteoides, Cirsium arvense, C. vulgare, Matricaria discoidea, Plantago lanceolata, Potentilla anserina, Rumex crispus*, etc) of other families were identified; with an average reaching 13–20 species per 100 m² of study plots (Table 1, Figs 4, 5).

Grassland of high and very high economic value (8,0–9,1 points) is of average productivity – 720–1340 g/m² of aboveground phytomass (Table 2, Figs 6, 7).

Fig 2. Intensively used sown meadow communities

Fig 3. Extensively used sown meadow communities

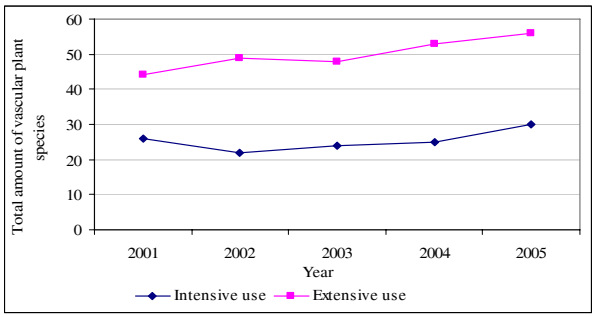

Fig 4. Total amount of vascular plants species in intensively and extensively used sown meadow communities, Graisupis EFS, Lithuania

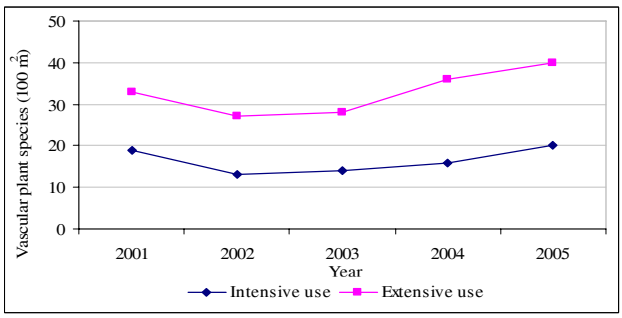

Fig 5. Amount og vascular plants species in intensively and extensively used sown meadow communities (100 m²), Graisupis EFS, Lithuania

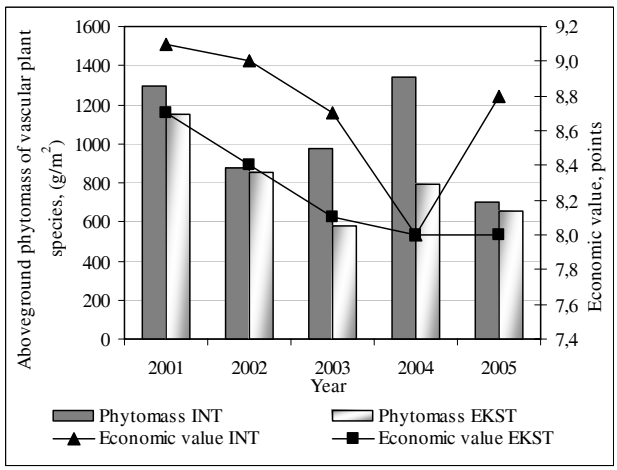

Fig 6. Phytomass (dry weight, g/m²) of vascular plants species and economic value (points) of grasslands in intensively and extensively used sown meadow communities, Graisupis EFS, Lithuania

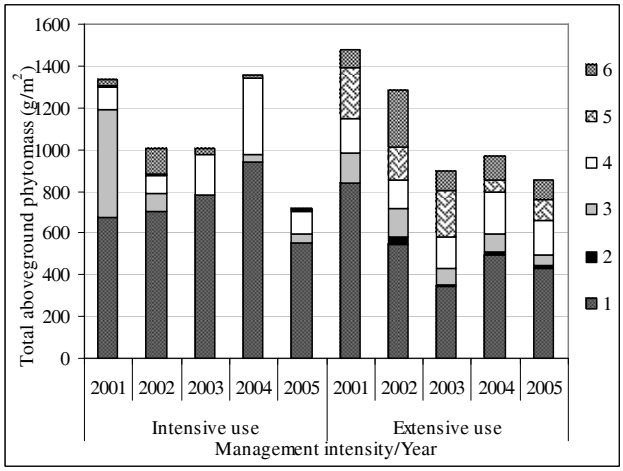

Fig 7. Phytomass (dry weight, g/m²) of the aboveground part of sown meadow communities, Graisupis EFS, Lithuania: 1 – *Poaceae*; 2 – *Cyperaceae* and *Juncaceae*; 3 – *Fabaceae*; 4 – other species; 5 – bryophytes, 6 – dead parts of plants

Intensive use of the grassland predetermines low amount of bryophytes (up to 1,4 %) and dead parts of plants (0,8–12,0 %) in the total aboveground phytomass (Table 3, Fig 7). An annual tendency towards decline of the total aboveground phyto-mass (r_I = –0,53) and phytomass of vascular plants (r_E = –0,42) was noticed (Table 4).

Low diversity of vascular plants is due to intensive meadow use. It confirms the opinion of B. H. Green [2] that botanical diversity of productive meadows restores much slower. In annually fertilized grasslands, the sown species consistent with the existing ecological conditions are more competitive; they get enough nutritious substances; therefore, plants of these species suppress

Table 1. Sown meadow composition and frequency (%) of vascular plants species in intensively and extensively used sown meadow communities, Graisupis Experimental Field Station, Kėdainiai district, Lithuania, June–August 2001–2005

Experimental sites		**Intensive use (I)**					**Extensive use (E)**				
Year		**2001**	**2002**	**2003**	**2004**	**2005**	**2001**	**2002**	**2003**	**2004**	**2005**
Total number of relevés		9	9	9	9	9	9	9	9	9	9
Coverage (%)	**herb layer**	70	60	65	90	90	60	65	70	65	60
	bryophyte layer	30	10	10	5	5	90	90	90	85	80
Average number of species		19	13	14	16	20	33	27	28	36	40
Total number of species		26	22	24	25	30	44	49	48	53	56
1		**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Achillea millefolium		100	100	100	100	100	100	75	83	100	100
Aegopodium podagraria		.	.	.	.	.	.	.	.	.	22
Agrostis capillaris		.	.	.	.		.	.	.	.	44
Ajuga reptans		.	.	.	.	.	.	8	.	.	.
Alchemilla vulgaris		.	17	8	11	44	42	33	50	67	89
Alnus incana		.	.	.	.	.	92	75	8	44	.
Angelica sylvestris		.	.	.	.	.	.	25	.	.	.
Anthemis arvensis		.	.	.	.	.	.	.	.	.	.
Anthoxanthum odoratum		.	.	.	.	.	67	33	50	78	89
Anthriscus sylvestris		.	.	.	.	33	8	33	.	22	22
Arctium lappa		25	.	.	.	11	.	.	.	.	.
Artemisia vulgaris		.	.	.	22	22	.	17	.	.	.
Barbarea vulgaris		17	.	.	.	.	.	.	.	.	.
Campanula patula		.	.	.	.	.	33	42	67	100	89
Capsella bursa-pastoris		67	33	75	100	89	.	.	.	.	.
Carex hirta		.	.	.	.	.	42	83	50	56	100
Carex panicea		.	.	.	.	.	.	17	25	44	67
Centaurea jacea		.	.	.	.	.	.	17	.	.	.
Centaurium erythraea		.	.	.	.	.	92	58	67	100	89
Cerastium holosteoides		67	58	17	67	100	92	.	25	67	78
Chenopodium album		.	.	8	.	.	.	.	.	.	.
Cirsium arvense		83	75	33	56	100	100	100	75	33	67
Cirsium palustre		.	.	.	.	.	.	.	.	11	56
Cirsium rivulare		.	.	.	.	.	25	8	33	44	33
Cirsium vulgare		33	33	33	11	100	25	25	17	89	44
Convolvulus arvensis		.	.	.	.	.	.	.	8	.	.
Dactylis glomerata		100	100	100	100	100	100	100	100	100	100
Deschampsia cespitosa		.	.	.	.	.	100	100	100	100	100
Equisetum arvense		.	.	.	.	.	67	33	.	.	.
Erygeron acris		.	.	.	.	.	.	.	.	.	.
Euphrasia rostkoviana		17	.	.	.	.	.	.	.	.	.
Festuca pratensis		100	100	100	100	100	100	100	100	100	100
Festuca rubra		.	.	.	.	.	.	.	.	.	78
Fragaria vesca		.	.	.	.	.	.	.	.	.	.
Galium mollugo		.	.	.	.	.	.	.	17	22	.
Galium uliginosum		.	.	.	.	.	.	.	.	44	.
Geum rivale		.	.	.	.	.	33	33	25	67	100
Glechoma hederacea		42	.	.	11	33	83	33	83	56	100
Heracleum sibiricum		.	.	.	.	.	.	.	.	.	11
Hypericum maculatum		.	.	.	.	.	100	100	75	100	100
Hypericum perforatum		.	.	.	.	.	.	.	.	.	.
Juncus conglomeratus		.	.	.	.	.	58	58	42	56	56
Lathyrus pratensis		.	.	.	.	.	100	100	100	100	100
Leontodon autumnalis		67	58	17	22	44	58	67	42	56	67
Leontodon hispidus		.	.	.	.	.	.	.	.	11	.
Leucanthemum vulgare		.	.	.	.	.	92	58	33	78	78
Lolium perenne		100	100	100	100	100	.	.	.	.	.
Lotus corniculatus		.	.	.	.	.	67	58	33	67	100
Luzula multiflora		.	.	.	.	.	75	75	67	100	100
Lychnis flos-cuculi		.	.	.	.	.	83	75	83	100	100
Lysimachia nummularia		.	.	.	11	.	100	92	100	100	100

Table 1 (continued)

1	2	3	4	5	6	7	8	9	10	11
Matricaria discoidea	.	83	50	67	78	8	.	.	.	.
Medicago lupulina	.	.	.	.	.	.	8	50	33	.
Medicago sativa	.	.	.	.	.	.	.	.	.	.
Mentha arvensis	.	.	.	.	.	17	.	17	22	44
Myosotis arvensis	.	.	.	.	.	.	.	.	.	.
Myosotis scorpioides	.	.	.	.	.	83	33	8	33	33
Odontites vulgaris	.	.	.	.	.	.	25	17	56	44
Peucedanum palustre	.	.	.	.	.	.	.	.	.	44
Phleum pratense	17	67	100	100	100	100	100	100	100	100
Pilosella officinarum	.	.	.	.	.	.	.	.	.	.
Pimpinella saxifraga	.	.	.	.	.	25	.	.	11	.
Plantago lanceolata	100	.	17	.	11	.	.	.	.	.
Plantago major	67	.	25	11	22	.	.	25	.	11
Poa annua	83	58	92	100	100	.	.	.	.	.
Poa pratensis	100	100	100	100	100	100	100	100	100	100
Polygonum aviculare	.	.	33	.	.	.	.	.	.	.
Potentilla anserina	58	.	.	44	33	100	100	100	100	100
Prunella vulgaris	.	.	.	.	.	.	42	17	33	56
Ranunculus acris	.	.	.	.	.	83	58	33	67	89
Ranunculus repens	.	33	.	.	56	100	100	75	67	100
Raphanus raphanistrum	17	17	.	.	.	.	.	.	.	.
Rumex acetosa	.	.	.	.	22	42	8	33	67	44
Rumex confertus	83	17	33	.	.	.	.	.	.	.
Rumex crispus	83	83	8	100	100	83	58	58	67	56
Salex sp.	.	.	.	.	.	.	.	.	.	44
Sanguisorba officinalis	.	.	.	.	.	.	.	.	.	11
Senecio jacobaea	.	.	.	.	.	.	.	.	56	.
Sonchus arvensis	.	.	.	.	.	.	.	.	.	.
Stellaria graminea	.	17	.	.	.	.	.	.	56	56
Tanacetum vulgare	.	.	.	.	.	.	.	.	.	22
Taraxacum officinale	100	100	100	100	100	100	100	100	100	100
Trifolium hybridum	.	.	.	44	67	83	75	100	33	89
Trifolium pratense	100	100	100	78	100	50	33	100	100	78
Trifolium repens	100	75	100	100	100	92	75	100	100	100
Tripleurospermum perforatum	50	.	.	.	.	.	.	.	.	.
Tussilago farfara	.	.	.	.	.	.	.	.	.	.
Urtica dioica	.	.	.	.	.	.	8	.	.	.
Veronica chamaedrys	.	.	.	.	22	92	75	67	100	67
Veronica serpyllifolia	.	.	.	.	.	.	.	.	.	33
Vicia angustifolia	.	.	.	.	.	.	.	58	78	100
Vicia cracca	.	.	.	.	.	100	100	100	100	100
Viola arvensis	.	.	8	22	33	.	.	.	.	.

the development of slower growing and less demanding plants. Consequently, fertilizers increase the productivity of grassland but impede the restoration of botanical diversity. According to M. H. Losvik [26] and A. P. Huhta [27], species diversity of vascular plants is strongly related with a negative balance of nutrients in plant habitats. Rather large amounts of nutritious substances are removed while mowing (dry aboveground phytomass is taken away from the meadow) or grazing. The deficiency of nutrients in the habitats of non-fertilized meadows inhibits the growth of sown plants and increases possibilities for new species to establish and botanical diversity to increase.

In ***extensively used*** meadows a considerably higher species diversity of vascular plants was recorded. During the investigation, 71 species of vascular plants were registered; an average number of species per study plot was 27–40. Among them 8 *Poaceae* (*Dactylis glomerata*, *Deschampsia cespitosa*, *Festuca pratensis*, *F. rubra*, *Phleum pratense*, *Poa pratensis*, *Anthoxanthum odoratum*, *Agrostis capillaris*), 2 *Cyperaceae* (*Carex hirta*, *C. panicea*) and *Juncaceae* (*Juncus conglomeratus*, *Luzula multiflora*), 8 *Fabaceae* (*Lathyrus pratensis*, *Lotus corniculatus*, *Medicago lupulina*, *Trifolium hybridum*, *T. pratense*, *T. repens*, *Vicia angustifolia*, *V. cracca*) and 51 species of other families were determined (Table 1, Figs 4, 5). Close proximity of forest and minimum farming activities induced quicker succession of the sown grassland than in the case of intensive farming. In the grassland besides valuable and economically important fodder species unvaluable but ecologically significant species, the indicators of meadow naturalization (e g *Agrostis capillaris*, *Anthoxanthum odoratum*, *Carex hirta*, *C. panicea*, *Cirsium rivulare*, *Deschampsia cespitosa*,

Table 2. Aboveground phytomass of vascular plants (dry weight mass; g/m^2; %) in intensive and extensive use of sown meadow communities, Graisupis Experimental Field Station, Kėdainiai district, Lithuania, June–August 2001–2005

Experimental sites	**Intensive use**										**Extensive use**									
Year	**2001**		**2002**		**2003**		**2004**		**2005**		**2001**		**2002**		**2003**		**2004**		**2005**	
Phytomass	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Agrostis capillaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.4	0.4
Anthoxanthum odoratum	.	.	.	.	.	.	.	.	.	.	1.9	0.2	.	.	1.3	0.2	0.7	0.1	.	.
Dactylis glomerata	138.2	10.6	112.0	12.8	57.2	5.9	57.6	4.3	73.8	10.5	24.5	2.1	20.3	2.4	3.5	0.6	1.8	0.2	1.7	0.3
Deschampsia cespitosa	.	.	.	.	.	.	.	.	.	.	13.8	1.2	.	.	2.6	0.4	0.4	0.1	.	.
Elytrigia repens	.	.	.	.	.	.	2.8	0.2	.	.	.	.	.	.	.	.	.	.	.	.
Festuca pratensis	118.2	9.1	106.9	12.2	29.9	3.1	108.4	8.1	33.7	4.8	34.0	3.0	37.3	4.4	9.1	1.6	18.0	2.3	2.3	0.3
Lolium perenne	240.5	18.5	223.5	25.5	22.7	2.3	365.0	27.1	136.5	19.5	.	.	.	.	.	.	.	.	.	.
Phleum pratense	.	.	0.9	0.1	0.3	0.0	26.5	2.0	.	.	99.3	8.7	120.2	14.0	44.0	7.6	46.6	5.9	2.3	0.4
Poa annua	16.5	1.3	7.0	0.8	.	.	19.2	1.4	1.6	0.2	.	.	.	.	.	.	.	.	.	.
Poa pratensis	162.2	12.5	250.8	28.6	669.9	68.8	360.0	26.8	309.2	44.2	662.8	57.8	367.6	42.8	287.4	49.8	427.7	53.9	425.3	64.5
***Poaceae* Σ**	**675.6**	**52.0**	**701.1**	**80.0**	**780.0**	**80.1**	**939.5**	**69.9**	**554.8**	**79.2**	**836.3**	**73.0**	**545.4**	**63.6**	**347.9**	**60.2**	**495.2**	**62.5**	**434.0**	**65.9**
Carex hirta	.	.	.	.	.	.	.	.	.	.	2.4	0.2	1.0	0.1	0.6	0.1	0.9	0.1	.	.
Carex panicea	.	.	.	.	.	.	.	.	.	.	.	.	23.7	2.8	1.4	0.2	.	.	.	.
Juncus conglomeratus	.	.	.	.	.	.	.	.	.	.	.	.	6.9	0.8	0.3	0.1	0.1	0.0	1.1	0.2
Luzula multiflora	.	.	.	.	.	.	.	.	.	.	0.3	0.0	1.7	0.2	2.8	0.5	16.6	2.1	11.6	1.8
***Cyperaceae &Juncaceae* Σ**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.7**	**0.2**	**33.3**	**3.9**	**5.1**	**0.9**	**17.6**	**2.2**	**12.7**	**2.0**
Lathyrus pratense	.	.	.	.	.	.	.	.	.	.	107.0	9.3	125.0	14.6	45.7	8.0	13.9	1.8	42.1	6.4
Lotus corniculatus	.	.	.	.	.	.	.	.	.	.	1.7	0.1	.	.	.	.	3.3	0.4	.	.
Trifolium pratense	119.4	9.2	65.3	7.5	1.6	0.2	1.0	0.1	2.0	0.3	1.5	0.1	4.1	0.5	.	.	2.3	0.3	.	.
Trifolium repens	396.6	30.5	25.7	2.9	1.0	0.1	37.5	2.8	37.7	5.4	14.7	1.3	0.1	0.0	0.8	0.1	54.0	6.8	0.5	0.1
Vicia angustifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.7	0.5	0.8	0.1	0.3	0.0
Vicia cracca	.	.	.	.	.	.	.	.	.	.	19.4	1.7	8.5	1.0	25.5	4.4	11.0	1.4	7.2	1.1
***Fabaceae* Σ**	**516.0**	**39.7**	**91.0**	**10.4**	**2.6**	**0.3**	**38.5**	**2.9**	**39.7**	**5.7**	**144.3**	**12.5**	**137.7**	**16.1**	**74.7**	**13.0**	**85.3**	**10.8**	**50.1**	**7.6**
Achillea millefolium	.	.	17.2	2.0	.	.	.	.	3.7	0.5	1.4	0.1	2.0	0.2	1.8	0.3	2.8	0.4	0.4	0.1
Alchemilla vulgaris	.	.	.	.	.	.	.	.	0.6	0.1		.	.	.	.	.	.	.	.	.
Angelica sylvestris	.	.	.	.	.	.	.	.	.	.	.	.	0.3	0.0	.	.	.	.	.	.
Anthriscus sylvestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.2	0.1	0.9	0.1	.	.
Campanula patula	.	.	.	.	.	.	.	.	.	.	0.1	0.0	.	.	1.5	0.2	.	.	0.3	0.0
Capsella bursa-pastoris	2.2	0.2	.	.	.	.	14.0	1.0	0.3	0.0		.	.	.	.	.	.	.	.	.
Centaurium erythraea	.	.	.	.	.	.	.	.	.	.	33.8	2.9	0.4	0.1	3.8	0.6	0.3	0.0	0.4	0.1
Cerastium holosteoides	39.4	3.0	2.2	0.2	.	.	.	.	4.4	0.6	1.3	0.1	.	.	.	.	3.5	0.4	1.3	0.2
Cirsium arvense	1.7	0.1	.	.	.	.	.	.	.	.	6.5	0.6	6.0	0.7	0.4	0.1	3.4	0.4	1.8	0.3
Equisetum arvense	.	.	.	.	.	.	.	.	.	.	0.1	0.0	0.3	0.0	.	.	.	.	.	.
Euphrasia roskoviana	0.3	0.0	0.5	0.1	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.

Table 2 (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Geum rivale	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3.7	0.5	0.2	0.0
Glechoma hederacea	.	.	0.2	0.0	.	.	.	.	.	.	1.0	0.1	.	.	0.1	0.0	3.9	0.5	0.1	0.0
Hypericum maculatum	.	.	.	.	.	.	.	.	.	.	2.6	0.2	.	.	.	.	.	.	.	.
Hypericum perforatum	.	.	.	.	.	.	.	.	.	.	.	.	3.5	0.4	.	.	0.5	0.1	0.3	0.0
Leontadon autumnalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3.2	0.4	17.2	2.6
Leucanthemum vulgare	.	.	.	.	.	.	.	.	.	.	0.5	0.0	.	.	0.8	0.1	3.1	0.4	3.9	0.6
Lychnis flos-cuculi	.	.	.	.	.	.	.	.	.	.	1.9	0.2	3.7	0.4	1.5	0.3	35.9	4.5	21.5	3.3
Lysimachia nummularia	.	.	.	.	.	.	.	.	.	.	19.4	1.7	4.5	0.5	1.1	0.2	1.8	0.2	11.2	1.7
Matricaria discoidea	0.2	0.0	.	.	1.4	0.1	.	.	.	.		.	.	.	.	.	.	.	.	.
Mentha arvensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.2	0.0	.	.
Myosotis scorpioides	.	.	.	.	.	.	.	.	.	.	0.2	0.0	.	.	0.1	0.0	0.1	0.0	.	.
Odontites vulgaris	.	.	.	.	.	.	.	.	.	.	.	.	0.1	0.0	0.4	0.1	0.8	0.1	1.1	0.2
Peucedanum palustre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	0.2
Plantago major	3.5	0.3	.	.	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.
Potentilla anserina	.	.	.	.	.	.	.	.	0.1	0.0	1.6	0.1	4.0	0.5	3.0	0.5	13.1	1.7	13.9	2.1
Prunella vulgaris	.	.	.	.	.	.	.	.	.	.	.	.	0.6	0.1	.	.	4.4	0.6	0.5	0.1
Ranunculus auricomus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3.0	0.5	3.0	0.4	3.4	0.5
Ranunculus repens	.	.	.	.	.	.	.	.	.	.	15.0	1.3	40.2	4.7	1.1	0.2	2.2	0.3	0.2	0.0
Rumex acetosa	.	.	.	.	.	.	.	.	.	.	.	.	0.1	0.0	0.1	0.0	.	.	.	.
Rumex crispus	0.4	0.0	.	.	.	.	.	.	.	.	2.1	0.2	1.2	0.2	2.0	0.3	.	.	.	.
Stellaria graminea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.7	0.1	.	.	1.6	0.2
Taraxacum officinale	59.4	4.7	64.0	7.3	190.4	19.5	351.4	26.2	96.6	13.9	77.8	6.8	73.4	8.6	127.5	22.1	106.5	13.3	78.3	11.9
Veronica chamaedrys	.	.	.	.	.	.	.	.	0.1	0.0	0.5	0.0	.	.	1.1	0.2	1.6	0.2	2.6	0.4
Other species Σ	**107.1**	**8.3**	**84.1**	**9.6**	**191.8**	**19.6**	**365.4**	**27.2**	**105.8**	**15.1**	**165.8**	**14.3**	**140.3**	**16.4**	**150.2**	**25.9**	**194.9**	**24.5**	**161.3**	**24.5**
Total	**1298.7**	**100.0**	**876.2**	**100.0**	**974.4**	**100.0**	**1343.4**	**100.0**	**700.3**	**100.0**	**1149.1**	**100.0**	**856.7**	**100.0**	**577.9**	**100.0**	**793.0**	**100.0**	**658.1**	**100.0**

Table 3. Total aboveground phytomass (dry weight mass; g/m^2; %) in intensively and extensively used sown meadow communities, Graisupis Experimental Field Station, Kėdainiai district, Lithuania, June–August 2001–2005

Experimental sites	**Intensive use**										**Extensive use**									
Year	**2001**		**2002**		**2003**		**2004**		**2005**		**2001**		**2002**		**2003**		**2004**		**2005**	
Phytomass	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%
Vascular plant	1298.7	97.1	876.2	87.3	974.4	96.8	1343.4	99.3	700.3	97.8	1149.1	77.8	856.7	66.6	577.9	64.7	793.0	81.7	658.1	77.2
Bryophytes	3.6	0.3	6.7	0.7	0.0	0.0	0.0	0.0	10.0	1.4	244.4	16.6	152.3	11.8	228.1	25.5	59.7	6.1	106.0	12.4
Dead parts of plants	34.4	2.6	120.5	12.0	32.0	3.2	9.3	0.7	5.6	0.8	83.2	5.6	277.5	21.6	87.5	9.8	119.0	12.2	88.6	10.4
Total	**1336.7**	**100.0**	**1003.4**	**100.0**	**1006.4**	**100.0**	**1352.7**	**100.0**	**715.9**	**100.0**	**1476.7**	**100.0**	**1286.5**	**100.0**	**893.5**	**100.0**	**971.7**	**100.0**	**852.7**	**100.0**

Table 4. Changes in variables of sown meadow quality (by correlation analysis; *r* – correlation coefficient; character of management: *I* – intensive use, *E* – extensive use), Graisupis EFS, Kėdainiai district, Lithuania, 2001–2005

Variables		Character of management	
x	***y***	r_I	r_E
Number of vascular plants species	Age of sown meadows	0,59	0,95
Aboveground phytomass of vascular plants (g/m²)	Age of sown meadows	–0,42	–0,75
Aboveground phytomass of vascular plants (g/m²)	Number of vascular plants species	–0,27	–0,63
Total aboveground phytomass (g/m²)	Age of sown meadows	–0,53	–0,91
Total aboveground phytomass (g/m²)	Number of vascular plants species	–0,40	–0,77
Economic value of grassland	Age of sown meadows	–0,59	–0,93
Economic value of grassland	Number of vascular plants species	–0,01	–0,85

Geum rivale, *Glechoma hederaceae*, *Hypericum maculatum*, *Juncus conglomeratus*, *Leucanthemum vulgare*, *Lotus corniculatus*, *Luzula multiflora*, *Lychnis flos-cuculi*, *Lysimachia nummularia*, *Mentha arvensis*, *Myosotis scorpioides*, *Pimpinella saxifraga*, *Potentilla anserina*, *Ranunculus acris, R. repens*, *Vicia angustifolia*, etc), are also abundant; their constancy is rather high. Bryophyte coverage reaches 80–90 %. The grassland is formed of constantly and abundantly growing mesophytic plants (*Dactylis glomerata*, *Festuca pratensis*, *Phleum pratense*, *Poa pratensis*, *Lathyrus pratensis*, *Taraxacum officinale*).

Grassland of high and very high economic value (8,0–8,7 points) is of average productivity – 850–1480 g/m² of aboveground phytomass (Figs 6, 7). Extensive use of the grassland conditioned rather large amount of bryophytes (6,1–25,6 %) and dead parts of plants (5,6–21,6 %) (Table 3, Fig 7). During five years of investigation, distinct annual tendency towards the reduction of the total aboveground phytomass (r_E = –0,91) and vascular plant phytomass (r_E = –0,75) was observed (Table 4).

Comparison of the data on botanical diversity and aboveground phytomass weight of intensively and extensively used sown meadows revealed that the character of grassland management influenced the intensity of the succession. During five years of investigation, in extensively used sown meadows a considerably higher number of vascular plant species (71 species) was identified comparing with intensively used grasslands (39 species). A low number (23 species) of vascular plant species, inventoried in both extensively and intensively used grasslands (Table 1), determined a low value of Sörensen coefficient (C_S = 0,42). It proves that the investigated meadows undergo different succession stages. The determined positive correlation between the number of vascular plant species and the age of sown meadows (r_E = 0,95; r_I = 0,59) demonstrated that in extensively used grassland the species diversity restored considerably quicker than in intensive used ones (Table 4).

Modified quantitative Sörensen coefficient values obtained by the comparison of grasslands of a different character of management according to the aboveground phytomass produced by plants of each species confirm the impact exerted by the meadow management upon the grassland condition. The coefficient shows that in 2001, i e on the 10th year of running, the composition of the aboveground phytomass of the compared grasslands clearly differed (C_N = 0,24). On the 14th year of running, however, steady settled *Poa pratensis* and *Taraxacum officinale* plants producing 44,2 % and 13,8 % (intensive use), 64,5 % and 11,9 % (extensive use) of aboveground phytomass of vascular plants (Table 2), respectively, conditioned stronger similarity of the compared grasslands (C_N = 0,58).

Negative correlation determined between aboveground phytomass of vascular plants and the age of sown meadows (r_I = –0,42; r_E = –0,75) shows that productivity of meadows of both management types has a tendency to decline; it is particularly evident in the case of extensive use conditions. Analogous relationship is observed regarding an economic value of the grassland and its age (year of meadow use, r_I = –0,59; r_E = –0,93) as well as the number of vascular plant species (r_E = –0,85) in extensively used meadow areas (Table 4).

5. Conclusions

1. Intensity of sown meadows succession depends upon the character of grassland management. Positive correlation between the number of vascular plant species and sown meadow age (r_E = 0,95; r_I = 0,59) revealed that botanical diversity in extensively used grassland restores much faster than under intensive farming conditions.

2. Fertilization of meadow sustains productivity of grassland but impedes the restoration of botanical diversity. In highly productive meadows the restoration of botanical diversity is markedly slower. In grasslands fertilized every year, the sown species consistent with the existing ecological conditions are more competitive; they get enough nutrients, and, therefore, suppress slower growing and less demanding plants.

3. Restoration of semi-natural meadow ecosystems (especially under conditions of extensive use) by naturalization of sown meadows involves exceptional advantages in comparison with other meadow restoration methods being comparatively cheap, undemanding for large investments and labour expenditures. The approach does not demand complete suspension of economic activity and meadow exploitation and reduces possibility for unwanted plant species to establish.

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EKSTENSYVUSIS SĖTŲJŲ PIEVŲ NAUDOJIMAS BOTANINEI ĮVAIROVEI ATKURTI

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Santrauka

Skirtingo naudojimo pobūdžio (intensyviojo ir ekstensyviojo) sėtųjų pievų augmenijos bendrijų būklė įvertinta ištyrus 10–14 metų naudotų pievų mezofilinus žolynus (Graisupio stotyje, Kėdainių r.). Palyginus intensyviai ir ekstensyviai naudojamų sėtųjų pievų tyrimų duomenis galima teigti, kad žolynų naudojimo pobūdis turi įtakos pievų sukcesijos intensyvumui. Nustatyta teigiama induočių augalų rūšių skaičiaus ir sėtųjų pievų amžiaus koreliacija leidžia teigti, kad ekstensyviai naudojamame žolyne botaninė rūšių įvairovė atsikuria žymiai greičiau (r_E = 0,95) nei intensyviojo ūkininkavimo sąlygomis (r_I = 0,59). Mažas vienodų induočių augalų rūšių, inventorizuotų skirtingo naudojimo žolynuose, kiekis (23 rūšys) lėmė nedidelę Sörensen koeficiento reikšmę (C_S = 0,42), patvirtinančią, kad tirtos pievos yra skirtingų sukcesijos stadijų.

Prasminiai žodžiai: sėtosios pievos, sukcesija, intensyvusis ir ekstensyvusis naudojimas, produktyvumas, botaninės įvairovės atsikūrimas.

ЭКСТЕНСИВНОЕ ПОЛЬЗОВАНИЕ СЕЯНЫХ ЛУГОВ КАК ВОЗМОЖНОСТЬ ВОССТАНОВЛЕНИЯ БОТАНИЧЕСКОГО РАЗНООБРАЗИЯ

Ю. Сенджикайте, Р. Пакальнис

Резюме

Исследовано состояние интенсивно и экстенсивно пользуемых мезофильных сеяных лугов (10–14-е годы пользования; стационар Грайсупис, Литва). Сравнение результатов исследования сеяных лугов различной интенсивности пользования позволяет утверждать, что характер пользования травостоев оказывает влияние на интенсивность сукцессий лугов. Установленная положительная корреляция количества видов сосудистых растений и возраста сеяного луга показывает, что в экстенсивно используемом травостое ботаническое разнообразие восстанавливается значительно быстрее (r_E = 0,95), чем в условиях интенсивного хозяйствования (r_I = 0,59). Сравнительно небольшое количество общих видов сосудистых растений (23 вида) в травостоях различной интенсивности пользования определило небольшое значение коэффициента Sörensen (C_S = 0,42), подтверждающее наличие различных стадий сукцессий исследованных лугов.

Ключевые слова: сеяные луга, сукцессия, интенсивное и экстенсивное пользование, продуктивность, восстановление ботанического разнообразия.

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