Conservation effects on the botanical composition of grass swards in the hilly soils of West Lithuania

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ABSTRACT

Four conservation methods were compared on grassland unused for 30 years: 1. control (unused grassland); 2. one cut, herbage mass was spread for mulch; 3. one cut, herbage mass was removed; 4. two cuts, herbage mass were removed. Experiments were carried out during 1996–2000 at the Kaltinenai Research Station of the Lithuanian Institute of Agriculture in a hilly region of the Zemaiciai Uplands of West Lithuania, on a hilltop and hill slope. During the experimental period an increase in the number of shoots of each botanical group (grasses, legumes and forbs) were identified in all treatments. The highest increase in the total number of grass shoots was characteristic of the controlled treatment on both parts of the hill. At the end of the conservation period, 38 herb species were identified in the trial. Treatments 1 and 2 were richer in floristic diversity (27–33 species) compared with treatments 3 and 4 (20–25 species). The treatments on the hill slope had a more diverse species composition than those on the hilltop. During the grassland conservation period the content of legumes in the herbage mass increased from 0 to 27.7% in the swards where cut herbage was removed.

Keywords: grassland conservation; botanical composition; species diversity; number of shoots

A high proportion of arable land in Lithuania is in forage cropping, including temporary grassland (44.4% of the crop area). In the current challenging situation of agricultural reform, many agricultural producers either lack financial means or are still unable to use all their land profitably. On the other hand, current EU agricultural policy aims to counteract overproduction by imposing quotas on livestock number and milk output and changes in agricultural policy have moved away from a production-oriented direction towards encouraging countryside amenity and wildlife conservation (Fisher et al. 1996). During the conservation period of the temporarily unused grasslands it is important not only to maintain but also improve soil fertility, to keep the landscape intact and rich in floral biodiversity. Environmental and site conditions, including geomorphology, slope, aspect, soil types, human impacts and management, seed sources and existing vegetation, determine plant species success on a site. On natural grasslands extensive use affects biodiversity (Baars 2002). However, some experimental evidence suggests that the frequency of sward cutting contributes to species diversity (Šantrůček et al. 2002, Ziliotto et al. 2002). When the sward is cut frequently, short species fill in the thinning-out sward. In rarely cut swards tall grasses gradually become dominant. The date at which the hay crop is cut is an important factor in controlling which species are able to set seed (Nösberger and Rodriguez 1996, Smith et al. 1996). Early (14 June) or late (1 September) cutting dates or a lack of aftermath grazing encourage competitive grass species, increasing the yield and reducing plant species diversity (Smith et al. 1996). The presented studies were carried out both at the community and individual species levels and aimed to identify changes in botanical composition in swards conserved by different methods.

MATERIAL AND METHODS

The trial was carried out from 1996–2001 on a meadow unused for 30 years at the Kaltinenai Research Station of the Lithuanian Institute of Agriculture. This is in West Lithuania s undulating region of the southern-central Zemaiciai Upland (55°36′N, 22°28′E) at 160–170 m altitude, with the west-facing slope having a mean inclination of 12°. Local soils are sandy clay loam Dystric Albeluvisols.

The experimental design included the following treatments on both parts of the hill using a randomized split-plot design, with four replicates of the 25 m^2 plots: 1. control (unused grassland), 2. one cut for mulch (the crop is cut and left in situ), 3. one

cut with removing the cut mass, 4. two cuts with removing the cut mass. No organic or inorganic fertilizers or lime were applied to the plots. The mean organic matter content in the Ah horizon (0–20 cm depth) on the hilltop was 23.9 g/kg and on the hill slope 21.2 g/kg, available P 129 and 80 mg/kg, K 214 and 133 mg/kg and pH_{KCl} 6.0 and 5.4, respectively (n = four samples).

The first cut (treatments 2, 3 and 4) was taken at the inflorescence emergence stage of the dominant grasses. Cutting dates were 20 June 1996, 19 June and 9 August 1997, 8 June and 10 August 1998, 7 June and 26 July 1999, and 19 June and 18 August 2000. A MF-70 plot harvester was used, leaving cut and unchopped herbage in the swaths and stubble height was 0.04–0.05 m. A sample of 400 g cut herbage from each harvested plot of each treatment was taken for botanical analysis. This sample was separated by hand, when appropriate, into four groups: 1. the most common grass species (*Dactylis glomerata* L., *Poa pratensis* L., *Phleum pratense* L., and *Festuca pratensis* Huds.), 2. legumes (including *Trifolium pratense* L., *Lathyrus pratensis* L., and *Vicia sepium* L.), 3. forbs and minor grasses, and 4. dead herbs. Each group from the sample and each species of groups 1 and 2 were weighed separately and oven-dried to give botanical composition on a dry matter basis. The remaining cut mass from treatments 3 and 4 was raked and removed from the plots. Botanical composition in the control was identified at the same time as the other treatments. Herbage samples for analysis from the control treatment were taken from the marked protection plots (0.5 × 0.5 m). Assessment of the abundance of the individual species of herbaceous plants was performed visually in spring before the first cut.

In the springs of trial establishment and the last year of the conservation period (17 April 2000) the number of shoots, i.e. the number of vegetative components of herbaceous plants (grass tillers, branches of stem and rosettes of other herbs), was counted in two marked places within each plot (0.2 × 0.2 m) on both parts of the hill. The number of these components was re-calculated into units per m^2.

The weather conditions during the experimental period were typical of west Lithuania's region with alternating droughty and wet periods during the growing season: the mean annual precipitation of 1996–2000 was 723 mm and mean annual temperature was 6.3°C. The years 1996 and 2000 were adverse for herbage growth. August 1996 and September 2000 were exceptionally dry with precipitation 8–10 times less than the mean amount.

RESULTS

Abandoned meadows in Lithuania are usually characterized by the dominance of several herbaceous species. At the beginning of the experiment grasses were the main components of the sward in all treatments. The contribution of a number of grass tillers per m^2 to the total number of vegetative components of herbaceous plants was high: 81–93% in the treatments on the hilltop and 58–79% on the hills slope (Figure 1). No legume shoots were identified on the hilltop, and in all the treatments arranged on the hills slope was as few as two legume shoots per m^2 or 4–6.7% to the total number. The share of the number of rosettes or stems of forbs in the total number of shoots varied within the range 7–19% on the hilltop and 17–24% on the hills slope. During the years of conservation the number of herb shoots increased and the distribution of separate groups in the treatments changed. The main tendency was a decreased share of grass and an increase in legume components in the total amount of vegetative components (tillers, stems and/or rosettes) of herbs. Depending on the conservation method, the share of legume shoots on both parts of the hill was major in treatments 3 and 4 (with removal of cut herbage). The contribution of forb shoots and rosettes visibly decreased in these treatments.

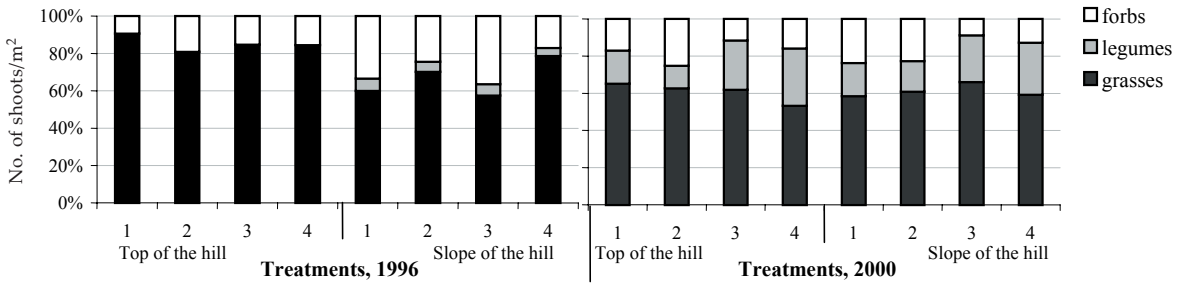

Figure 1. The percentage of number of vegetative components (shoots) per m^2 of each group of herbs as a proportion of the total

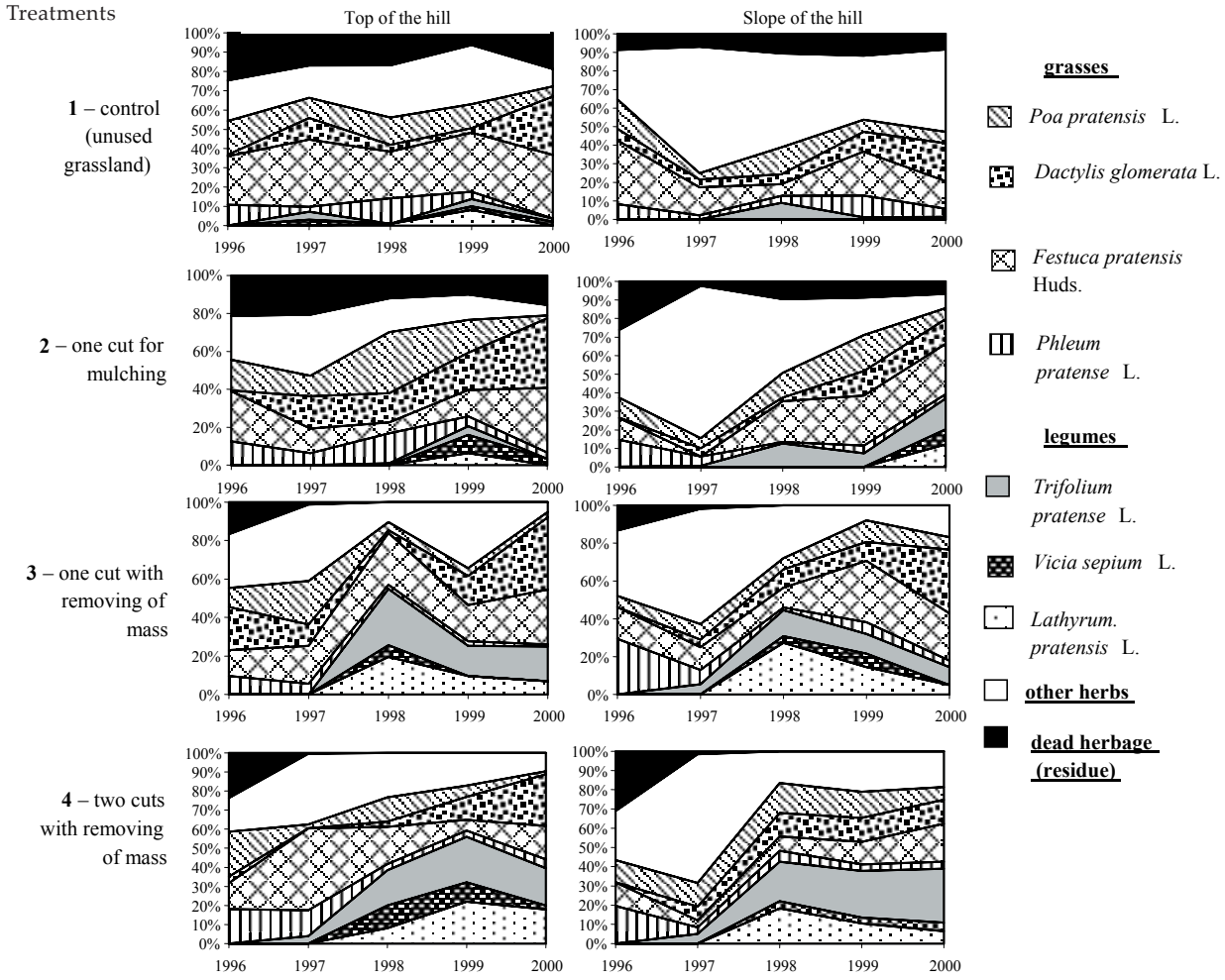

Figure 2. Botanical composition of herbage mass

During the whole experimental period no bare non-vegetated spaces were identified, either on the hilltop or hills slope. Even in unused plots (control) with some dead herbage, some grass grew underneath, though the tillers were not luxuriant. Visually, moss content was lower in the plots of the treatments, which included removing cut herbage.

The dynamics of the sward alternation during their conservation period was assessed by estimating botanical composition of the herbage mass. Botanical composition of swards varied in relation to seasonal weather conditions, conservation method and section of the hill. At the beginning of the conservation experiment many grass species were found on both parts of the hill, of which *Festuca pratensis* Huds., *Poa pratensis* L. and *Phleum pratense* L. were dominant. Their contribution, together with *Dactylis glomerata* L., to total dry matter yield on both parts of the hill was 37.0–68.4% (Figure 2). There were no legumes in the hilltop yield, while on the hills slope, in the swards of treatments 1 and 2 the content of legumes was only 0.2–4.3%. The share of other species mass in the dry matter of the sward yields varied from 21.1 to 36.6% and the amount of dead herbage was 3.8–26.2% of the total herbage dry matter.

In the second year of conservation small amounts of legumes were still found in the swards, depending on the treatment, the swards contained 0–8.6% legumes, mostly red clover. The content of common grasses in the dry matter yield of the hilltop remained virtually unchanged (47.1–59.0%) compared with the first year of conservation. Only 1.2–5.2% of dead herbage was found in the dry matter herbage mass of treatments 3 and 4, in the other treatments 17.0–20.7%. The content of forbs and minor grasses (61.1–82.8% of dry matter yield) increased in all swards on the hills slope, there was found an especially high number of dandelions, ground-elder and hemlock. In the third and fifth years of conservation the contribution of cocksfoot and meadow fescue to the total herbage yield increased, while the content of timothy and smooth-stalked meadow grass declined. In the third year of the swards most frequent treatments,

Table 1. Correlations between botanical groups in dry matter of herbage mass during 1996–2000

Pairs of botanical groups (X-Y)	Treatments				Total for treatments
	1	2	3	4	
Hilltop					
Legumes – grasses	–0.35 nl	–0.10 nl	–0.58 nl	–0.90*l	–0.70**l
Legumes – forbs, minor grasses	0.35 nl	–0.40 nl	–0.63 nl	–0.51 nl	–0.32 nl
Grasses – forbs, minor grasses	–0.95**l	–0.84 nl	–0.18 nl	0.29 nl	–0.30 nl
Hillslope					
Legumes – grasses	–0.10 nl	0.42 nl	–0.24 nl	0.43 nl	0.07 nl
Legumes – forbs, minor grasses	–0.18 nl	–0.68 nl	–0.52 nl	–0.66 nl	–0.61**l
Grasses – forbs, minor grasses	–0.96**l	–0.90*l	–0.68 n	–0.96**l	–0.76**l

Significant at *$P < 0.05$ and **$P < 0.01$ probability levels; l = linear, nl = non-linear correlation, $n = 5$ for treatment, $n = 20$ for total

especially on the slope, were characterized by increased legume content, especially in the swards cut once or twice with removing the herbage. In these treatments practically all-dead herbage decayed and has not been found in the herbage yield since the 3rd experimental year. At the end of the trial the highest share of dry matter mass of forbs and minor grasses (other herbs in Figure 2) was identified in the control on the hills slope. On the hilltop in the fifth year of the investigation cocksfoot accounted for 27–37.5% of the total mass dry matter, a lower content of cocksfoot (12.3–20.4%) was identified on the hills slope, and only in treatment 3 cocksfoot accounted for 33.7%. In all treatments the contents of timothy and smooth-stalked meadow grass were low at 1.6–6.8 and 0–4.4%, respectively. The content of red clover on both parts of the hill was 0–28.0%, meadow vetchling 0–17.8% and bush vetch 0–8.1%.

The strength of correlation between the botanical groups of herbage in dry matter of herbage yield depended on the method of sward conservation and treatment location on the hill. In the hills slope treatments of dominant grasses competed with forbs and minor grasses. Negative and significant correlations between these groups of herbs was characteristic of all the treatments there, except the 3rd (Table 1). However, on the hilltop a strong correlation between the groups of these herbs was identified only in the control treatment. Competition tended to decline in relation to the strength of the human factor in the swards under conservation: the negative correlation in the treatment cut twice turned into a positive one. In the latter treatment legumes competed with grasses. The correlation between pairs of botanical groups X and Y was $r = –0.90$ ($n = 5$, $P < 0.05$, X-Y pairs of botanical groups was legumes – grasses).

Over 30 plant species were identified on the hilltop and hill slope before trial establishment. The following species were dominant: smooth-stalked meadow-grass (*Poa pratensis* L.), creeping bentgrass (*Agrostis stolonifera* L.), sweet vernal grass (*Anthoxanthum odoratum* L.), meadow fescue (*Festuca pratensis* Huds.), tufted hair-grass [*Deschampsia cespitosa* (L.) P. Beauv.], hedge bedstraw (*Galium album* Mill.), caraway (*Carum carvi* L.), hemlock (*Conium maculatum* L.), oxeye daisy (*Leucanthemum vulgare* Lamk.), ground elder (*Aegopodium podagraria* L.), cocksfoot (*Dactylis glomerata* L.) and quaking-grass (*Briza media* L.). In the first year of conservation when the swards were cut for mulch and the herbage mass was removed once or twice, no significant differences were determined in the swards. The species composition of the swards that formed at the end of the conservation trial is presented in Table 2.

The species composition of plants slightly changed within the whole experimental area: in total 38 plant species were found in the trial. In cut swards (treatments 2–4) the contents of dandelion (*Taraxacum officinale* F.H. Wigg.) and ladies mantle (*Alchemilla vulgaris* L.) were higher than in the control treatment. In addition, dandelion and ladies mantle, quitch-grass, red fescue, germander speedwell, tufted hair-grass, winter-cress, caraway, hedge bedstraw and meadow buttercup were found in varying amounts in all experimental treatments. The hill slope was more favourable for the establishment of *Umbelliferae* (*Apiaceae*) family plants (ecologically invasive perennial forbs such as *Aegopodium podagraria* L. and *Selinum carvifolia* L. or poisonous *Conium maculatum* L.), whereas the representative of this family *Angelica montana* Brot. was found only in the treatments where the herbage mass was not removed from the field, i.e. in treatments 1 and 2,

Table 2. Herb species composition at the end of the sward conservation period (2000)

Plant species	Treatments on the hilltop				Treatments on the hillslope			
	1	2	3	4	1	2	3	4
Grasses – *Poaceae*								
Agrostis alba L.	+	–+	–	–	++	+	–+	–+
Alopecurus pratensis L.	–	–	–	–	+	–	–+	–
Anthoxanthum odoratum L.	++	–+	–	–	++	+	–+	–+
Briza media L.	+	–+	–	–	+	–+	–	
Dactylis glomerata L.	++	++	++	++	++	++	++	++
Deschampsia cespitosa (L.) P. Beauv.	++	+	–+	–+	++	+	+	+
Elytrigia repens (L.) Nevski	++	++	+	+	++	++	++	++
Festuca pratensis Huds.	++	++	++	++	++	++	++	++
Festuca rubra L.	+	+	+	+	+	+	+	+
Phleum pratense L.	–+	+	–+	+	+	–+	+	+
Poa pratensis L.	+	+	+	+	+	+	+	+
Total number of grass species	10	10	7	7	11	10	10	9
Legumes – *Fabaceae*								
Lathyrus pratensis L.	–+	–+	+	+	–+	+	+	+
Trifolium pratense L.	–	–+	+	++	–+	–+	+	++
Vicia sepium L.	–+	+	+	+	–+	+	+	+
Number of legume species	2	3	3	3	3	3	3	3
Forbs – *Asteraceae*								
Centaurea scabiosa L.	–+	–	–	–	+	+	–	–+
Cirsium arvense Scop.	+	–+	–	–	–+	–	–+	–
Hieracium echioides Lumn.	–	–	–+	–	+	–+	–	–
Leucanthemum vulgare Lam.	+	–	–	–	+	–+	–	–
Taraxacum officinale FH. Wigg.	–+	+	++	++	–+	+	++	+
Apiaceae (*Umbelliferae*)								
Aegopodium podagraria L.	–	–	–	–	+	+	+	+
Angelica montana Brot.	–+	–+	–	–+	–+	–+	–	–+
Anthriscus sylvestris (L.) Hoffm.	–	–+	–	–	–	–+	–	–+
Carum carvi L.	+	+	–+	–+	+	+	–+	–
Conium maculatum L.	–	–	–	–	–+	+	++	++
Selinum carvifolia L.	+	–+	–	–	+	+	–+	–+
Rosaceae								
Alchemilla pratensis Schmidt.	+	++	++	++	+	+	++	+
Geum urbanum L.	–+	–+	–	–	–+	–+	–	–
Potentilla recta L.	–+	+	–+	–	+	+	–	–
Other families: *Brassicaceae, Campanulaceae, Rubiaceae, Plantaginaceae, Ranunculaceae, Polygonaceae, Urticaceae, Scrophulariaceae*								
Barbarea vulgaris R.Br.	–+	–+	–+	–+	–	–	–+	–+
Campanula persicifolia L.	–+	–+	–	–	–+	–+	–+	–
Galium album Mill.	–+	–	–	–	–+	–+	–	–
Plantago lanceolata L.	–	–	–+	–+	–	–	–+	–+
Ranunculus acris L.	–+	–+	–+	+	–+	–+	–+	–+
Rumex crispus L.	–	–	–+	–+	–	–	–+	–
Rumex obtusifolius L.	–+	–+	+	–+	–+	–+	–+	–+
Urtica dioica L.	–	–	–+	–	–	–	–	–
Verbascum thapsus L.	–+	–	–	–	–+	–	–	–
Veronica chamaedrys L.	–+	–+	–+	–+	–+	–+	–+	–+
Total number of forbs species	17	14	12	10	19	18	14	13
Total number of species	29	27	22	20	33	31	27	25

++ many, + frequent, –+ rare, – not found

irrespective of location on the hill. Quaking-grass completely disappeared in the swards that were cut once and twice and the herbage mass removed. The hill slope treatments had greater biodiversity than the respective hilltop treatments. Comparison of sward conservation methods suggests that control treatments had the most diverse vegetation, while the least species diversity after five experimental years was identified in treatments 3–4, where the cut herbage mass was removed from the plots.

DISCUSSION

The results clearly demonstrate that the botanical composition of swards differed between conservation methods and the location of plots on the hill. When the sward was cut once or twice and the herbage mass removed the botanical composition of swards became more diverse. The legume content increased in these treatments on both the hilltop and hill slope. Legume content increased with cutting frequency, which accords with the experimental evidence of Gaisler (2002) and Ziliotto et al. (2002). The prevalence of cocksfoot and its competitive superiority in all the tested treatments was determined by the fact that cocksfoot flowers earlier than most grass species in Lithuania (usually mid-May). An especially great abundance of this grass species was characteristic of the year 2000 and can be related with the peculiarities of meteorological conditions in 1999 when March was warm and vegetative growth of herbs started early. As a result, *Dactylis glomerata* was able to ripen seed and spread evenly in treatments 3–4.

Most interactions in communities are normally perceived as negative. The impacts of competition are well known, and we are interested in studying competition as it affects the regeneration processes in grassy vegetation. Results and the significant correlation between the dry matter yields of forbs (together with minor grass species) and grass suggested that there were direct competitive effects between these sward components, especially in treatments on the hill slope. Such competitive interactions between groups of these herbs were noted in experiments evaluating the suitability of grass species for sowing in a mixture with forbs (Fisher et al. 1996).

The richer phytodiversity on the hill slope can be explained by transport of herbage seeds from the hilltop by wind or rain. In contrast to the experimental evidence of Šantrůček et al. (2002), our findings suggest that the control had the richest species diversity. This may be explained by a more severe climate of Lithuania than the Czech Republic, where a field trial was established on arable Chernozems, due to which not all herbs were able to ripen seed in cut treatments. Early cutting prevents flowers and plants from setting seed and regenerating (Nösberger and Rodriguez 1996). Regardless of this, the treatments where the cut herbage mass was removed, were not characterized by greater species diversity. These swards were of a higher quality in terms of the botanical ratio of groups of herbs and made the landscape more aesthetic compared with the control treatment. Moreover, soil fertility is an important factor. Using grass leys for set-aside could prove a viable soil conservation technique (Fullen 1998). When the conditions for agricultural production have improved, it will be possible to reuse temporarily conserved land for intensive cropping. After conservation, the fields were cultivated and applied with NPK. The highest winter wheat or herbage yields were obtained in untreated conservation (control) plots or the swards cut for mulch. Organic matter and potassium contents in the soil under the swards of the control and the second treatment were significantly higher than those of the swards where the cut herbage mass was removed (Zableckienė et al. 2003). This includes accumulation of organic matter decomposition products of the continuously unused sward (treatment 1) or cut herbage left on the field (treatment 2) and thickening of organic matter with a concomitant increase in moisture retention. It can be concluded that the method of conservation of swards should depend on the purpose for which it is intended (i.e. to enrich the swards with plant species, to improve the landscape or soil agrochemical properties).

Acknowledgements

The authors would like to thank Dr. V. Žemaitis, former head of LIA Department of Grassland Husbandry for his benevolent advice on the trial establishment issues. We thank an anonymous referee for his thoughtful comments, Dr. M.A. Fullen from the University of Wolverhampton, UK for his valuable advice and help in revising our paper.

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Received on November 14, 2003

ABSTRAKT

Vliv konzervace travních porostů ve vyšších polohách západní Litvy na botanické složení

Na travním porostu, nesklízeném 30 let, byly porovnávány čtyři metody konzervace: 1. kontrola (nesklízený porost), 2. jedna seč (travní hmota rozprostřena na ploše jako mulč), 3. jedna seč (travní hmota odklizena), 4. dvě seče (travní hmota odklizena). Pokusy byly vedeny v letech 1996–2000 na Kaltinenaiské výzkumné stanici Litevského ústavu zemědělského ve vyšších polohách Zemaiciaiské vrchoviny v západní Litvě, na vrcholu kopce a na svahu. V průběhu pokusného období bylo u všech pokusných variant stanoveno zvýšení počtu výhonů u každé botanické skupiny (trávy, jeteloviny, byliny). Nejvyšší zvýšení celkového počtu odnoží trav bylo charakteristické u kontrolní varianty jak na vrcholu kopce, tak na svahu. Na konci období konzervace bylo v pokusech stanoveno 38 bylin. Varianty 1 a 2 byly bohatší ve floristickém složení (27–33 druhů) ve srovnání s variantami 3 a 4 (20–25 druhů). Ošetření na svahu byla druhově bohatší než na vrcholu kopce. Během období konzervace se zastoupení leguminóz v travní hmotě z porostů, u nichž byla posečená hmota odklízena, zvýšilo z 0 na 27%.

Klíčová slova: konzervace travních porostů; botanické složení; druhová diverzita; počet výhonů

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