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THE INFLUENCE OF AGRI-ENVIRONMENTAL MEASURES BASED GRASSLAND MANAGEMENT ON GRASSLAND PLANT COMMUNITIES

Summary of doctoral dissertation
Biomedical Sciences, Ecology and Environmental Sciences (03 B)

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AURELIJA LOŽYTĖ

AGRARINĖS APLINKOSAUGOS PRIEMONĖMIS PAREMTŲ TVARKYMO METODŲ ĮTAKA PIEVŲ AUGALŲ BENDRIJOMS

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CONTENTS

INTRODUCTION

Relevance of the study. Territorially agriculture is the most demanding human economic activity affecting the biological diversity locally, regionally, and globally. Agrarian landscape, formed due to the interaction of natural processes and human activities, is an anthropogenised landscape that maintained the main natural features (Aleknavičius, Valčiukienė, 2011). Grassland habitats, characterized by large biological diversity, is an important element of agrarian landscape, whose natural potential helps to ensure the efficiency of natural systems and functional diversity of natural environment as well as maintains its resistance, adaptability, and renewability (Pakalnis, Venckus, 2012).

Grassland habitats play a multifunctional role in the formation of landscape. Grassland is important not only for maintenance of biological diversity, it also prevent the erosion of soil (Jankowska-Huflejt, 2006) and contribute to the reduction of greenhouse gas emissions (Conant et al., 2001); grassland biomass can be used as the source of energy (Heinsoo et al., 2010; Kryževičiene et al., 2005); grassland reduces heavy metal pollution of soil (Tomaškin, 2007) and prevents biogenic pollution of surface waters, since its dense system of plants' roots does not only protect the soil from a mechanical impact and washing out, but also retains chemical substances that resolve in water and migrate in soil (Balevičienė et al., 1998). Natural regulation of floods is one of the most important ecological functions performed by flooded grasslands (Honigová et al., 2012). Though the aesthetical value of landscape is a subjective matter (Pakalnis, Venckus, 2012), independently from aesthetical evaluation, it might be maintained that grassland performs an important function as the source of aesthetic and spiritual thoughts. Recreational value of grassland is not of minor importance too (Starczewski et al., 2009). Spending their free time in a grassland people can monitor natural environment, hunt, collect medicinal plants, or perform other activities (Honigová et al., 2012). Grasslands are also extremely important for the agriculture – they are farming lands making a great influence on the development of stockbreeding (Balevičienė et al., 1998). Grass forages are economical, and grass fed stock produces naturally clean and healthy products (Vasiliauskiene et al., 2007). Plants are the main elements of biocoenosis structure in grassland, influencing living conditions of other grassland

communities. There are about 550 species of plants in Lithuanian grasslands (Balevičienė, 2000). The formation of grassland plant communities are greatly affected by anthropogenic factors. According to Kavaliauskas P. (2011), actual situation of the biocomponent of countryside depends on a human factor.

Changing agricultural policy in Lithuania and Europe more and more often negates the importance of intensive primary production and highlights the role of agricultural activities on solving environmental problems related to the preservation of biological diversity. Aiming to successfully implement biological diversity policies of the European Union (EU), financial support measures, helping to solve the problem of decreasing biological diversity, were developed. In Lithuania, seemingly as in the most of EU countries, the preservation of biological diversity in agriculture is performed according to rural development programmes (Mierauskas, 2012). Rural Development Programme for Lithuania 2007–2013 (RDP), corresponding to strategic rural development guidelines, sets measures to prevent biological diversity of grassland too. The purpose of agri-environmental measures is to reduce negative anthropogenic effect on grassland plant communities and preserve valuable biological diversity, combining farming and environmental needs. The implementation of agri-environmental measures is supported by financial instruments, thus it is important to evaluate the influence of such measures on grassland plant communities.

The main objective of this research. Having researched the differences of grassland plant diversity and economic value, influenced by different intensity economic activities, evaluate the efficiency of regulated, EU agri-environmental measures based, grassland management methods in small farming sector of Lithuania.

The research was aimed at:

1. Evaluating the differences of plant species' composition conditioned by biological diversity favourable economic activities, compulsory for getting agri-environmental payments, in grassland researched.
2. Evaluating the distribution of grassland plant species among the ecological groups.
3. Defining and evaluating the differences of economic value conditioned by biological diversity favourable economic activities supported by agri-environmental measures in grassland researched.

4. Evaluating the efficiency of currently applied agri-environmental measures aimed at the preservation grassland plant diversity.

5. Suggesting criteria for more efficient agri-environmental protection and targeted implementation of agri-environmental payments in new funding period aiming to preserve grassland plant diversity.

Scientific novelty. Up to now, field studies were not used for the purpose to prove the significance of financial allocations, assessing the influence of financial support according to the rural development programmes of the EU on the preservation of grassland biological diversity in Lithuania. The paper evaluates the efficiency of regulated agri-environmental measures aimed at the preservation of biological diversity of natural and semi-natural grassland of Lithuania using field trials and handful (De Vries) method.

Practical significance. The research results are relevant for planning agri-environmental measures for Rural Development Programme for Lithuanian 2014–2020, defining such activities that are important for the preservation of biological diversity of agrarian landscape in Lithuania. The research results, presented in the paper, are important for setting requirements of biological diversity favourable economic activities aiming to preserve certain grassland plant species and habitats.

Defended statements:

1. The differences in the composition of plant species in plant communities of traditionally managed grassland and that of biological diversity favourable farming are minor.

2. Biological diversity favourable farming does not reduce economic value of grassland, thus farmers and other landowners should not be less motivated to apply agri-environmental measures in lands managed by them.

3. Currently applied agri-environmental measures, aimed at the preservation of biological diversity of grassland, are not efficient enough, aiming to increase plant diversity of semi-natural grassland.

Doctoral dissertation contents. Original doctoral dissertation (in Lithuanian) contains the following parts: List of abbreviations, Introduction, Literature review, Research object, materials and methods, Results and discussion, Conclusions and recommendations, List of publications, Acknowledgments, Reference list, and

Appendix. The dissertation is written in the Lithuanian language and consists of 195 pages, 21 tables, and 79 figures. Reference list contains 131 reference sources.

LITERATURE REVIEW

This chapter presents the review of information on the concept of grassland, grassland classification, changes of grassland areas in Lithuania, main economic and ecological functions of grassland, the influence of such anthropogenic factors as draining, fertilising, undersowing, intensive haying and pasturing, and abandonment on grassland plant communities, found in scientific literature. Also, the information on the implementation of agri-environmental measures aimed at the preservation of biological diversity of grasslands in Lithuania.

RESEARCH OBJECT, MATERIALS AND METHODS

Selection of research places

The research material was collected in four places of Telsiai district (Ryskenai and Zarenai elderships). The research places were selected using the information of National Paying Agency under the Ministry of Agriculture, taking into account the indicatory features of cropping and agricultural land, i.e. crop code 5PT-1, which indicates the grassland managed in accordance with the requirements of the activity "Natural and semi-natural grassland management". Based on the above mentioned indicatory feature and using mathematical statistical processing programs (submitting the application to the database of declared land areas) Telsiai district grassland managed in accordance with the requirements of the abovementioned activities was researched. Random survey of holders of the abovementioned grassland allowed to select four grassland areas managed in accordance with the requirements of the activity "Natural and semi-natural grassland management" (1 ha each). Aiming to evaluate the differences of botanical diversity, influenced by regulated agri-environmental measures based grassland management methods, grassland areas managed in compliance with the requirements of the activity "Natural and semi-natural grassland management" were researched in comparison to grassland areas managed not in compliance with the abovementioned requirements (located next to them). Each of four research places consists of two differently managed grassland areas (Fig. 1). Each research place was

named according to the village site where the research data was collected: 1) Saušilis I; 2) Saušilis II; 3) Lauko Soda; 4) Užminijai.

In large area, it is hard to describe plants precisely and in detail, thus the researchers selected and precisely measured the model plots where they analysed the plants and delivered general conclusions from the information collected (Dagys, 1980). In each grassland area, the researcher studied a model plot of 100 m^2 where the diversity of plant species visually corresponded to that of the grassland researched. Eight model plots were researched in total. Map references of the site were defined using the GNSS receiver Trimble R4.

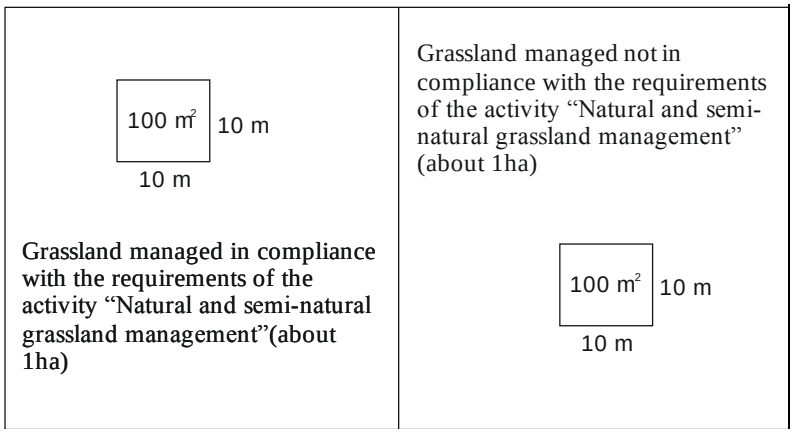

Fig. 1. The layout of one research place.

Description of the research places

Physical-geographical conditions. According to physical-geographical layout of Lithuania, the research places belong to Kurso – Zemaiciu geomorphologic area, Centre Zemaitija Highland region (Basalykas, 1965), or according to Kavaliauskas (1982) – Zemaiciu Island Moraine Highland geomorphologic area Centre Zemaitija North Moraine Hillland region (Galvydytė, Kavaliauskas, 2003). According to botanical geographical layout of Lithuania, the research places belong to Central European province, Baltic sub-province, Zemaiciai Highland Sprucewood and Low-lying Wetland region (Balevičienė, 2011).

Meteorological conditions. According to climatic layout of Lithuania, Ryskenai and Zarenai elderships belong to Zemaiciai region, Zemaiciu Highland sub-region. The territory can be characterised by the following climatic characteristics: average annual temperature is 6.0 – 6.3 °C, average precipitation is 800 – 820 mm (Bukantis, Reginienė,

2011), maximum soil freezing depth is 80 cm (Juknevičiūtė, Laurinavičius, 2008). All research places belong to the same climatic sub-region and are located to each other in a relatively small distance (the distance from the research place Saušilis I to Saušilis II is about 700 m, the distance from the research place Užminijai I to the research place Saušilis I and Saušilis II is about 1.5 km, the research place Lauko Soda is located in the distance of 6 – 7,5 km from other three research areas), thus the influence of climate on the distribution of plant species in differently managed grassland areas was not evaluated.

Soil. Sod-moderately-podzolic (Jv2) (according to classification until 1999) or *Eutric Albeluvisols* (JIb) (according to classification from 1999) (Grybauskas et al., 2011) soils prevail in the research places. Considering soil acidity, moderate acid (pH 5.6 – 6.0) and slightly acid (pH 6.1 – 6.5) soils (Mažvila, Bugorevičiene, 2011) are characteristic to the research places. According to granulometric composition, the research places can be characterised as sandy soils (data of soil spatial variability collection Dirv_DR10LT).

According to P. Kavaliauskas (2011), various characteristics of landscape structure, such as morphogenesis, type of surface (soil making) rocks, nature of relief, features of hydrographic network, climate peculiarities, culturisation level, become differently important due to territorial factors in different landscape analysis stages (regional and local levels). For example, in a local level, climate does not influence the distribution of plants at such a large extend as the type of soil and technogenicity does (Kavaliauskas, 2011). Since the research was performed in a local level, the soils of the researched grassland were similar, thus their plants were similar too (Katutis et al., 2011). Therefore, as the main factor influencing the differences of plant species' composition in plant communities of the research places, the anthropogenic influence was analysed.

The dissertation delivers the information about the areas of grassland habitats of all 4 research places, map references of the model plots, neighbourhoods of the grassland researched, and the methods of grassland usage.

Grassland plant communities research

Data collection time. Research material was collected in stationary plots once per year, in vegetation season, from June 10 till June 15, 2011 and 2012. The research time was chosen taking into account the requirements of the activity "Natural and semi-natural grassland management" that set the beginning of possible farming activities in grassland areas. The research was performed in a period of two years aiming to eliminate possible mistakes of the identification of plant species and definition of their dominance in the research samples (handfuls of plants) during the first year.

Methods of research data collection and analysis. The grassland plant species' composition was identified using handful (De Vries) method (Peeters, 1989; Skuodienė, 2004.). Handful (De Vries) method is based on ecological indicators, used by H. Ellenberg, E. Klapp, and D. M. De Vries, and adapted for the recalculation of data with a computer. The method requires relatively small labour and energy resources and delivers the information necessary for a comprehensive, i.e. ecological, biological, and agronomical, evaluation of grassland plant communities, since plant species composition is considered as a reflexion of conditions in growing sites. It also sets quantitative and qualitative indicators of forage production. The usage of handful (De Vries) method allows taking decisions on soil acidity, water and nutrition facts, and the intensity of using grassland (Skuodienė, 2004).

Using handful (De Vries) method, preciseness of the indicators obtained depends on the number of samples (handfuls of plants) (Peeters, 1989; Skuodienė, 2004) taken. In the grassland researched 30 samples (handfuls of plants) were taken from each model plot of 100 m^2. The research samples were collected by three researchers, who went in a straight line of 10 m length and collected 10 handfuls of grass going.

Each handful from the model plots was analysed separately. The sequence of analysing the handfuls from one model plot does not make any difference on the research results. The plants were grouped according to their weight in each handful. Three dominant species were identified in each handful. The dissertation delivers precise descriptions of each research place. Three dominant species of plants are marked by numbers 1, 2, and 3; respectively the most common species is marked 1, etc. All other plant species found in a handful are marked as +. All plant species identified within a

handful are listed. Data obtained during a field trial were processed with a computer, using a prepared formula package. After the calculation, the indicators general to the research place (grassland) and separate to each identified species were obtained (Peeters, 1989; Skuodienė, 2004).

The indicators calculated by a method of handfuls (De Vries):

NES – number of species estimated;

CDD – coefficient of dominance, which is inversely proportional to the number of species estimated. This coefficient is higher when the grassland has one or two dominant species;

F% – frequency of the occurrence of each species. It is obtained dividing the sum of samples (handfuls of plants), where the plant species were found, by total number of samples (30) and multiplying by 100;

P% – index of relative abundance, which is calculated by formula:

$$P\% = (F_i\% \times 100) / \sum_{n=1}^{n} F_i\% \quad (1)$$

i – plant species found in a model plot; F% – frequency of the occurrence of each species.

InH – index of hydrotolerance:

$$InH = \sum_{n=1}^{n} (P_i\% \times H_i) / 100 \quad (2)$$

i – plant species found in a model plot; H – plant species adaptation to damp conditions index (Ellenberg, 1992).

Table 1. The index of hydrotolerance of plant species, which shows grassland plant species adaptation to damp conditions (Peeters, 1989; Ellenberg, 1992).

Plant species groups	Points
Species tolerating drought	1 – 2
Species adapted to drier conditions	3 – 4
Species adapted to moderate dampness conditions	5 – 6
Species that prefer dampness	7 – 8
Species that extremely like dampness	9 – 10

InR – soil acidity index:

$$\mathrm{InR} = \sum_{n=1}^{n} (\mathrm{P_i}\% \times \mathrm{R_i}) \,/100 \qquad (3)$$

i – plant species found in a model plot; R – plant species adaptation to soil acidity index (Ellenberg scale is adapted to 5 point scale taking into account calculation principles of handful (De Vries) method) (Peeters, 1989).

Table 2. The index of plant species adaptation to soil acidity (Peeters, 1989; Ellenberg, 1992).

Plant species groups	Points
Species adapted to extremely acid soil	1
Species adapted to acid soil	2
Species adapted to moderate acidity soil	3
Species that prefer neutral soil	4
Species that like alkaline soil	5

InN – index of plant species adaptation to the nutrition of soil:

$$\mathrm{InN} = \sum_{n=1}^{n} (\mathrm{P_i}\% \times \mathrm{N_i}) \,/100 \qquad (4)$$

i – plant species found in a model plot; N – index of plant species adaptation to the nutrition of soil, first of all, nitrogen (Ellenberg scale is adapted to 5 point scale taking into account calculation principles of handful (De Vries) method) (Peeters, 1989).

Table 3. The index of plant species adaptation to the nutrition of soil (Peeters, 1989; Ellenberg, 1992).

Plant species groups	Points
Species adapted to extremely low nitrogen content soil	1
Species adapted to low nitrogen content soil	2
Species adapted to moderate nitrogen content soil	3
Species that prefer nitrogen rich soil	4
Species that like enough nitrogen rich soil	5

Ecological conditions of the growing sites were evaluated using Ellenberg's scale. In this way, the researchers set indicative values of plant species found in model plots according to such ecological criteria as soil dampness (H), soil acidity (R), and soil nutrition (N). The evaluation of ecological factors was taken from the internet database

of Federal Environmental Protection Agency of Germany (Bundesamt für Naturschutz) www.floraweb.de, where numerical values of the indictors are delivered according H. Ellenberg et al. (1992).

Inc – index of resistance to harvest:

$$\mathrm{Inc} = \sum_{n=1}^{n} (\mathrm{P_i}\% \times \mathrm{c_i}) \,/100 \qquad (5)$$

i – plant species found in a model plot; c – index of resistance to harvest, which is identified in a prepared package of formulas of handful (De Vries) method.

Inp – index of tolerance to trampling:

$$\mathrm{Inp} = \sum_{n=1}^{n} (\mathrm{P_i}\% \times \mathrm{p_i}) \,/100 \qquad (6)$$

i – plant species found in a model plot; p – index of tolerance to trampling, which is identified in a prepared package of formulas of handful (De Vries) method.

InP – index of pasturage:

$$\mathrm{InP} = \sum_{n=1}^{n} (\mathrm{P_i}\% \times \mathrm{P_i}) \,/100 \qquad (7)$$

i – plant species found in a model plot; P – index of pasturage, which is identified in a prepared package of formulas of handful (De Vries) method.

Table 4. The index of resistance to harvest, trampling, and pasturage used in handful (De Vries) method (Peeters, 1989).

Plant species groups	Points
Species intolerant to harvest and trampling	1
Species hardly tolerant to harvest and trampling	2
Species moderately tolerant to harvest and trampling	3
Species tolerant to harvest and trampling	4
Species extremely tolerant to harvest and trampling	5

The species that are indifferent to the abovementioned factors, i.e. characterised by high environmental plasticity, are identified as 0 (Peeters, 1989; Skuodienė, 2004).

Description of grassland plant communities and habitats. Plant species found in each handful were identified according to the guidelines of A. Lekavičius (1989) "Vadovas augalams pažinti" (Plant Recognition Guidelines) and K. K. Vilkonis (2008) "Lietuvos žaliasis rūbas" (Green Robe of Lithuania). Names of plant species were delivered according to Z. Gudzinskas (1999) "Lietuvos induočiai augalai" (Vascular Plants of Lithuania), K. K. Vilkonis (2008) "Lietuvos žaliasis rūbas" (Green Robe of Lithuania), and Jankevičiene (1998) "Botanikos vardų žodynas" (Vocabulary of Botanical Names). The researcher also paid attention to the latest nomenclature changes of the last years. Plant species non-identified during the collection of the material were herbarized aiming to identify them later. In each handful, 2-3 plant species remained unrecognised, however they were not dominant and did not influence the research of plant communities. After the identification of plant species growing in model plots, taxonomic analysis of plants was made. The system of plant taxons of the taxonomic analysis: *Phyllium* – section; *Classis* – class; S*ubclassis* – subclass; *Familia* – family; *Species* – species. The beginning of blooming period of plants found in grassland was estimated according to the atlas of K. K. Vilkonis (2008) "Lietuvos žaliasis rūbas" (Green Robe of Lithuania). Summarising the research results the abbreviations of plant names are used, for example, *Aegopodium podagraria* – AEPO.

Plant species identification. Plant species identified in grassland researched were grouped into ecological groups. On a basis of soil dampness: xerophytes (1-2 point group), xeromesophytes (3-4 point group), mesophytes (5-6 point group), hygromesophytes (7-8 point group), hygrophytes (9-10 point group). On the adaptation to soil acidity: species adapted to extremely acid soil (1 point), acid soil (2 points), moderately acid soil (3 points), slightly acid soil (4 points), and alkaline soil (5 points). On the basis of the need for nutrition materials: oligotrophic (1 point), mesooligotrophic (2 points), mesotrophic (3 points), mesoeutrophic (4 points), and eutrophic (5 points) plants.

Identification of the similarity of plant species' composition in plant communities. The similarity of plant species' composition was identified using the Jaccard coefficient (K_J) and Sörensen coefficient (Cs).

Jaccard coefficient (K_J) is expressed in percentage according to the following formula (Durau, 2012):

$$K_J = \left(\frac{c}{a + b - c}\right) \times 100 \quad (8)$$

a – number of species in one plant community, b – number of species in another plant community, c – number of species common for both plant communities (i.e. repeating in one and another plant community).

The greater amount of plant species common for both plant communities, the more similar communities are. Plant communities are considered similar, when their similarity coefficient exceeds 50 percent (Rimkus, 2003).

Sörensen similarity coefficient (Cs) is expressed in decimals according the following formula (Magurran, 1992):

$$Cs = \frac{2j}{a + b} \quad (9)$$

a – number of species in one plant community, b – number of species in another plant community, j – number of identified species common for both communities of grassland researched.

When the value of the coefficient is 0, the species' composition is completely different in grassland areas researched; when it is 1, the grassland areas researched are completely similar (Tuomisto, Ruokolainen, 2006).

Evaluation of plant prevalence. In order to characterise plant communities as the unit of prevailing species, secondary and subdominant plant species were identified. The identification was performed using the scale of Liubarski (Table 5) (Bakanov, 1987).

Table 5. The scale of the prevailing plant species according to their relative abundance (Bakanov, 1987).

Class boundaries according to relative abundance	Prevalence level
0 < N =< 4	Rear
4 < N =< 16	Secondary
16 < N =< 36	Subdominant
36 < N =< 64	Dominant
64 < N =< 100	Absolute dominant
N – a part from general relative abundance, %	

Identification of the economic value of grassland. For the identification of the economic value of plants, the methodology of K. Rimkus, A. Petkevičius, and A. Stancevičius was used (Rimkus, 2003). The methodology was prepared amending grassland nutrition value score identified by A. Petkevičius and A. Stancevičius (1982). The methodology delivers the scale of evaluating grassland plants consisting of 12 points. All well or worse eat plants get 1-10 points, while not eat or poisonous plants get 0-1 points. The state of a plant is estimated in accordance with general economic value (Table 6). The economic value of grassland was also estimated using a method of handful (De Vries). Using this method and comparing the grasslands with each other, the economic value of grassland is better expressed in percentage of relative abundance (P%) (Peeters, 1989).

Table 6. Scores of the economic value of grassland.

Economic value of grassland	Total score of the economic value (Rimkus, 2003)	Total score of the economic value (Peeters, 1989)
Extremely high	8.6–10	-
Very high	7.1–8.5	100–81
High	5.6–7.0	80–61
Medium	4.1–5.5	60–41
Satisfactory	3.1 –4.0	-
Low	below 3.0	40–21
Very low	-	20–0

Total score of the economic value is estimated using the following formula:

$$VP = \sum_{n=1}^{n} (A_i\% \times I_i) / 100 \qquad (10)$$

A_i% – P% of each plant species, P% – relative abundance, I_i – score of the economic value of each plant species (the researchers use the scores delivered in Rimkus "Pievotyra" (2003) Annex 1). Note: in the calculation of the economic value using handful (De Vries) method, the sum of the products of relative abundance and the economic value scores of each plant species is delivered by 10.

Research data statistical analysis

Data is statistically processed using Microsoft Office Excel 2003 and Statistica 10.0. The analysis (for checking the significance of differences in values obtained) was

made using a nonparametric statistical method – Mann-Whitney U test (Čekanavičius, Murauskas, 2004). The data on the plant species composition was processed using the prepared formula package in accordance with handful (De Vries) method in Microsoft Office Excel datasheet (Peeters, 1989).

RESULTS AND DISCUSSION

Evaluation of plant species' composition in grassland communities

Aiming to reach the research objective, the researcher evaluated plant species' diversity and compared botanical composition of grassland areas managed in different methods. The comparison of total number of plant species found in research places on 2011-2012 identified the greater number of plant species in grassland areas managed according to the requirements of activity "Natural and semi-natural grassland management" in Saušilis II and Lauko Soda, while traditionally managed grassland areas had greater number of plant species in Saušilis I and Užminijai (Fig. 2). In all grassland areas researched the difference in plant species (comparing two plant communities found in one research place) varied from 6 to 11 percent. The analysis of the number of plant species as one of the indicators of biological diversity disclosed that plant communities of the grassland areas researched were similar. Plant species' diversity is considered as minor when the grassland has 5-20 (25) plant species (Rašomavičius, 2012). Summarising the research results, it might be maintained that grassland areas researched had high variety of plant species (from 25 to 33). Similar data was obtained by other Lithuanian researchers too. It was identified that the riverside grassland of Minija and Veiviržas had 23-35 plant species (Nekrošienė, Skuodienė, 2012). The research performed disclosed that the number of plant species differed only slightly in grassland areas harvested and pastured in accordance with specific requirements, aiming to obtain agri-environmental payments, and traditionally, and not always it was higher in grassland areas managed in biological diversity friendly methods.

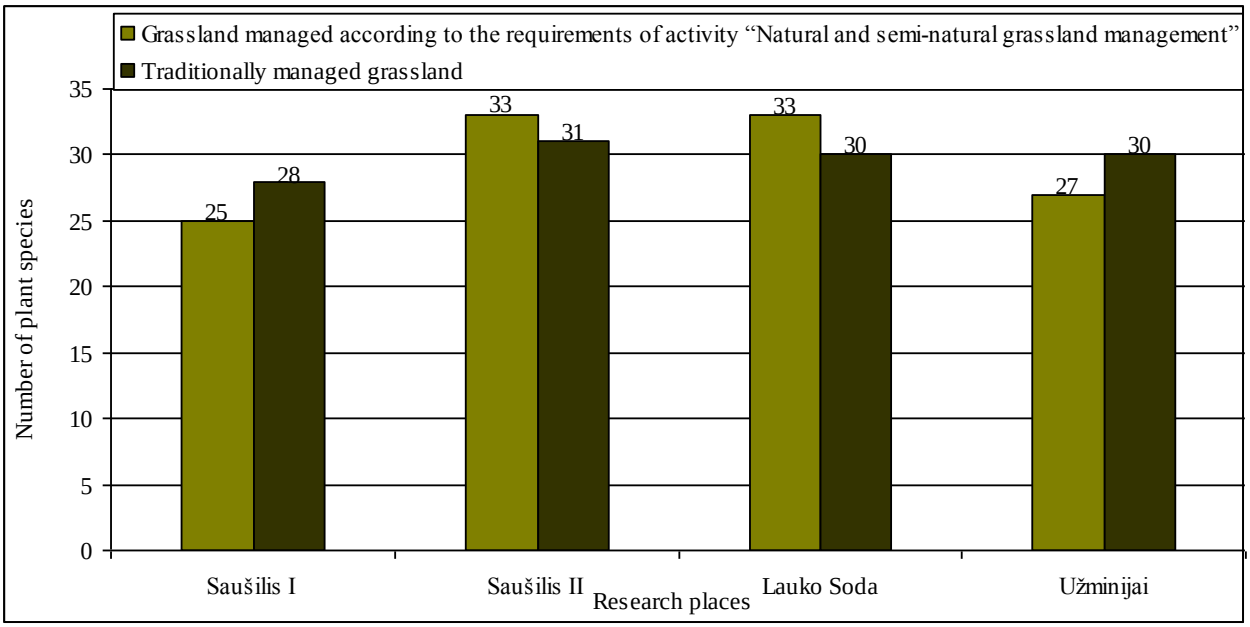

Fig. 2. The number of plant species found in grassland areas (data of 2011-2012).

Evaluating the diversity of grassland plant in family level, the researcher has estimated different distribution of plant families in four research places (Fig. 3). The comparison of total number of plant families in both grasslands disclosed the same number of plant families in Saušilis I grassland areas (10) in 2011-2012. In the research place Saušilis II, greater number of plant families was found in grassland managed on agri-environmental basis, i.e. 13 families, while traditionally managed grassland had 12 families. In Lauko Soda, both research places had the same number of plant families – 13. In Uzminijai, greater number of plant families was found in traditionally managed grassland. This grassland had 12 plant families, while that of managed according to the principles of the preservation of biological diversity had 9 plant families in 2011-2012. In conclusion it might be maintained that grassland managed according to the requirements of the activity "Natural and semi-natural grassland management" and that of traditional farming methods had the same number of plant families or the difference was not significant.

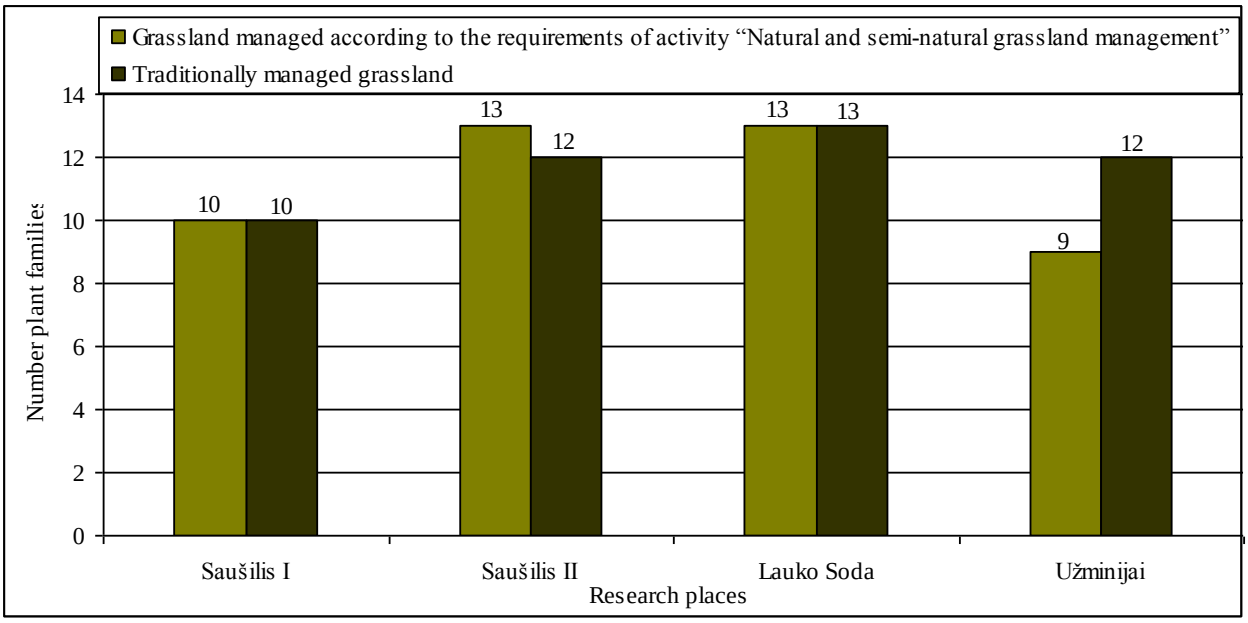

Fig. 3. Number plant families estimated in grassland areas (data of 2011-2012).

The analysis of plant families found in research places showed that *Poaceae*, *Asteraceae*, *Fabaceae* plant families prevailed in all eight grassland areas researched (Fig. 4).

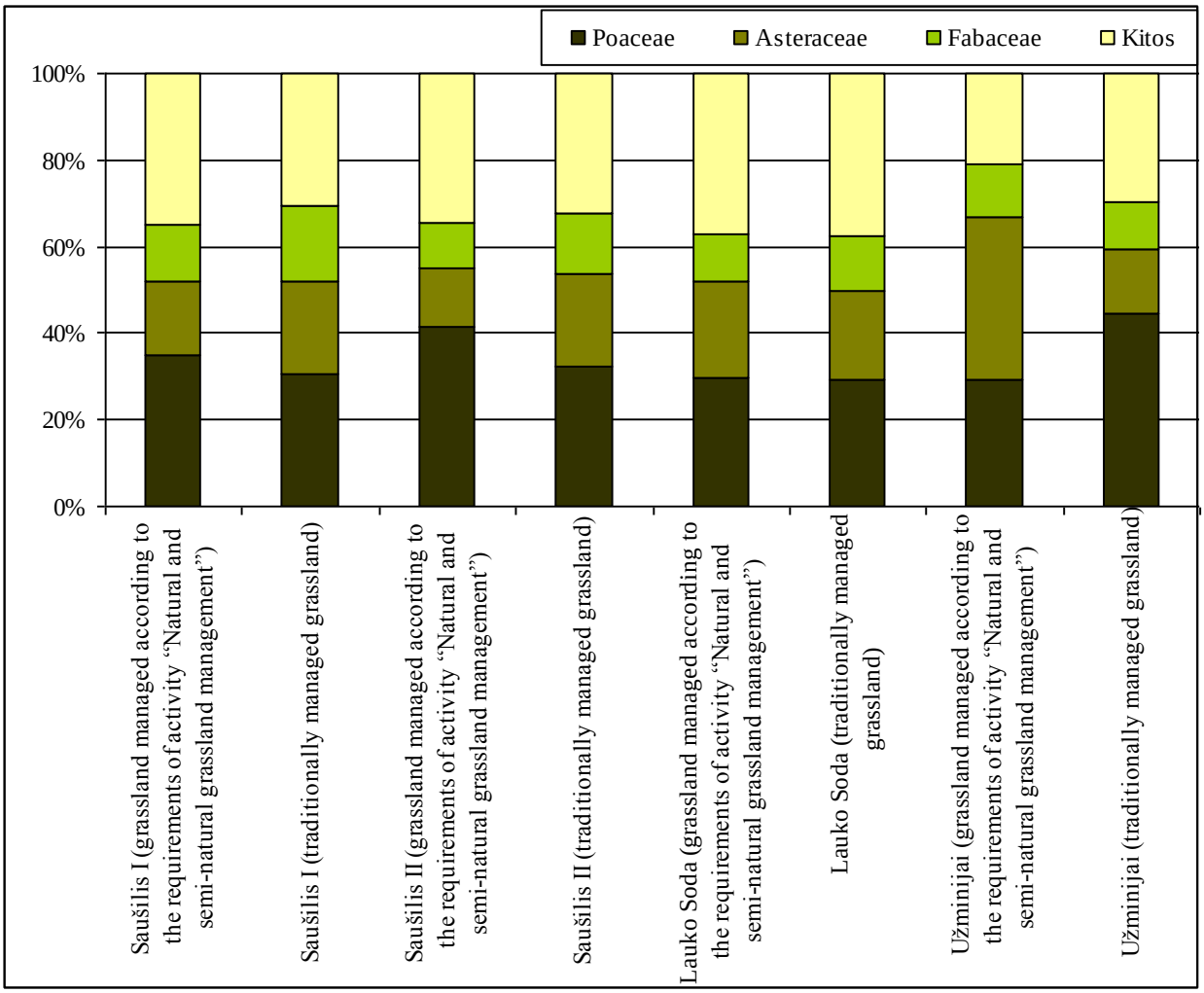

Fig. 4. Plant species' composition of plant communities (average data of 2011-2012).

Using handful (De Vries) method, coefficients of dominance (CDD) were estimated for all research places. In 2011-2012, the average CDD was higher in traditionally managed grassland areas. The difference between the CDD of traditionally managed grassland areas and that of managed according to the requirements of the activity "Natural and semi-natural grassland management" was not significant; it reached 6 percent in Saušilis I, 10 percent in Saušilis II, 4 percent in Lauko Soda, and 5 percent in Užminijai (Fig. 5). Low CDD shows that the grassland is rich in plant species and it was used extensively. Other researchers indicate that, for example, in Minija riverside grassland areas the average CDDs were 0.8, 0.9, and 1.29; in Nemunas Delta flooded grassland areas – 1.34, 1.6, 3.59; while in resown grassland areas – 2,5 (Skuodienė, Simonavičiutė, 2004; Simonavičiutė, Ulevičius, 2007).

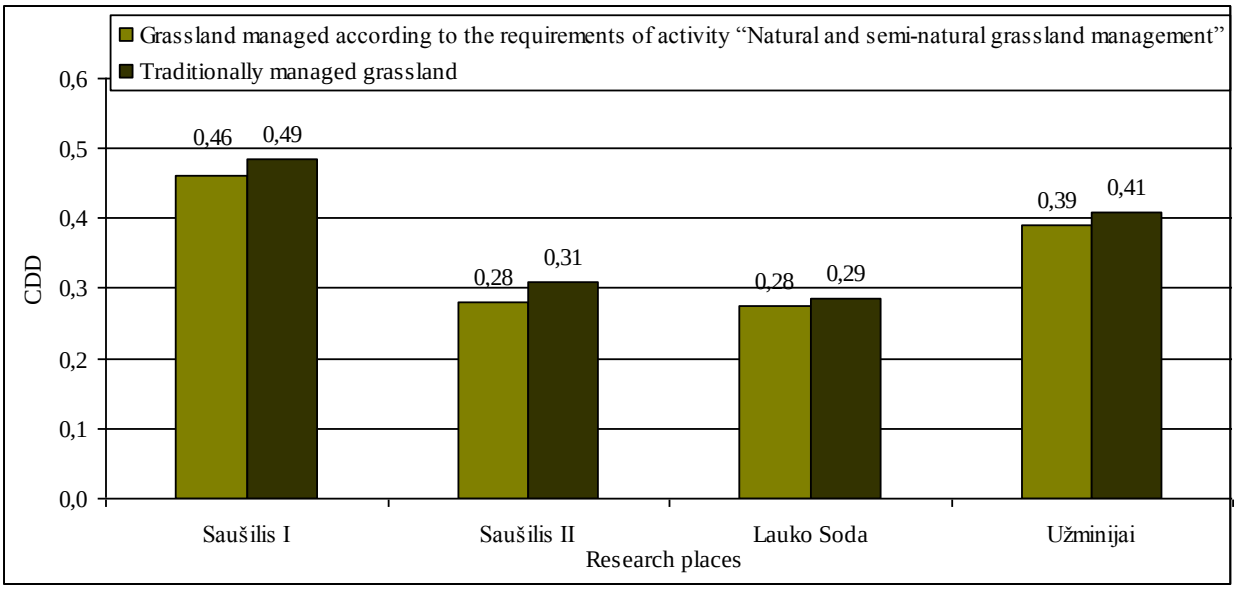

Fig. 5. The coefficients of dominance (CDDs) of species in plant communities (average data of 2011-2012).

The diversity of species depends not only on the number of species, but also on relative abundance of certain species in plant community. Aiming to evaluate the differences of botanical composition in grasslands using Mann-Whitney U test, the distribution of plant species relative abundance values of differently managed grassland areas were compared. The data did not show any significant differences of this indicator in all research places.

Using Liubarski scale, the plant species were grouped into the classes of dominance according to their relative abundance. The results showed that none of plant communities had absolute dominant or dominant species. Subdominant species were found only in grasslands of Saušilis I. Only one subdominant – common dandelion (*Taraxacum oficinale*) – was identified in grassland hayed and pastured according to agri-environmental management requirements set in the legal acts (P% 16.2). Subdominants of traditionally managed grassland areas were common dandelion (*T. oficinale*) (P% 16.3) and orchard grass (*Dactylis glomerata*) (P% 16.3). Secondary species made less than a half of plant species found in grassland areas. Similar results were obtained by Simonavičiute L. and Ulevičius A. (2007): the researchers did not find dominants and subdominants in Minija riverside grassland areas and found only three subdominants in Nemunas Delta grassland areas.

The similarity of plant communities was estimated using Jaccard (K_J) and Sörensen (Cs) coefficients. Comparing plant communities according to species'

composition found, the average Jaccard (K_J) coefficients were calculated. In 2011-2012, K_J was equal to 50 percent in one research place, while in three research places it exceeded 50 percent. The average values of Sörensen coefficients were close to 1 (from 0.68 to 0.79) in grassland of all research places (Fig. 6). Summarising the results, it is obvious that grassland of all research places have similar composition of vascular plant species (comparing two plant communities of the same research place).

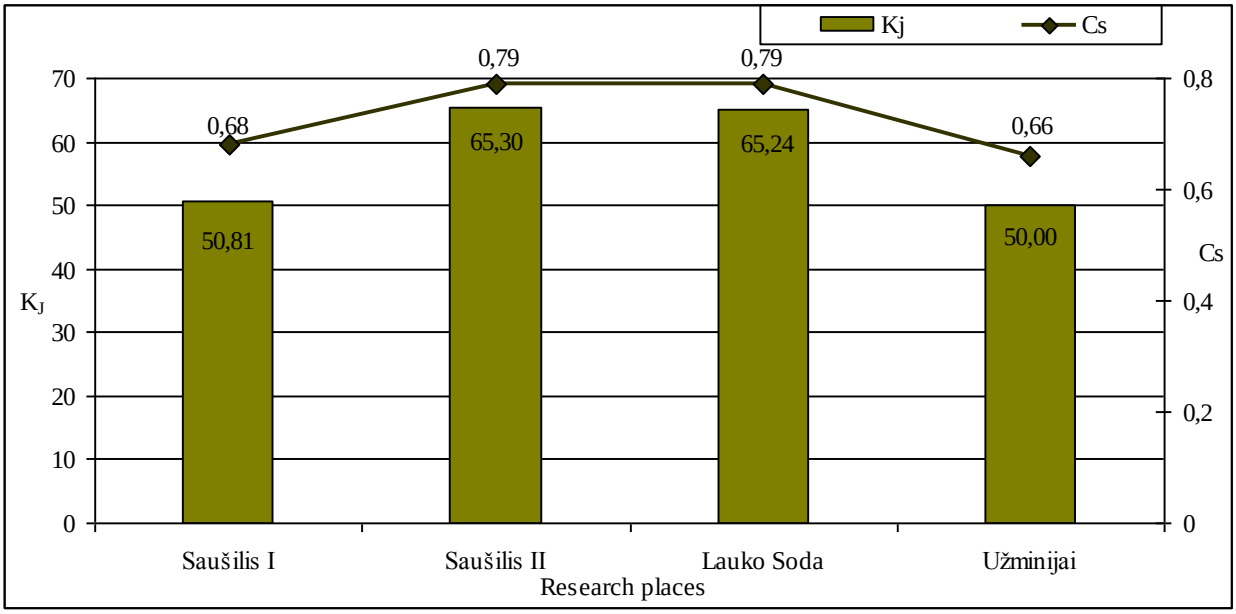

Fig. 6. The evaluation of the similarity of plant communities (average data of 2011-2012).

Analysis of the ecological groups of plant species

Ecological analysis of plant species found in researched grasslands disclosed similar hydrotolerance indicators of differently managed grasslands in 2011-2012. The difference in InH values of grassland managed according to the requirements of activity "Natural and semi-natural grassland management" and that of traditionally managed grassland varied from 2 to 4 percent, depending on the research place (Fig. 7). From the environmental perspective, mesophytes prevailed in the grassland areas researched. Plant communities were similar according to this indicator. Mann-Whitney U test confirmed that hydrotolerance indicators of differently managed grasslands did not had significant differences.

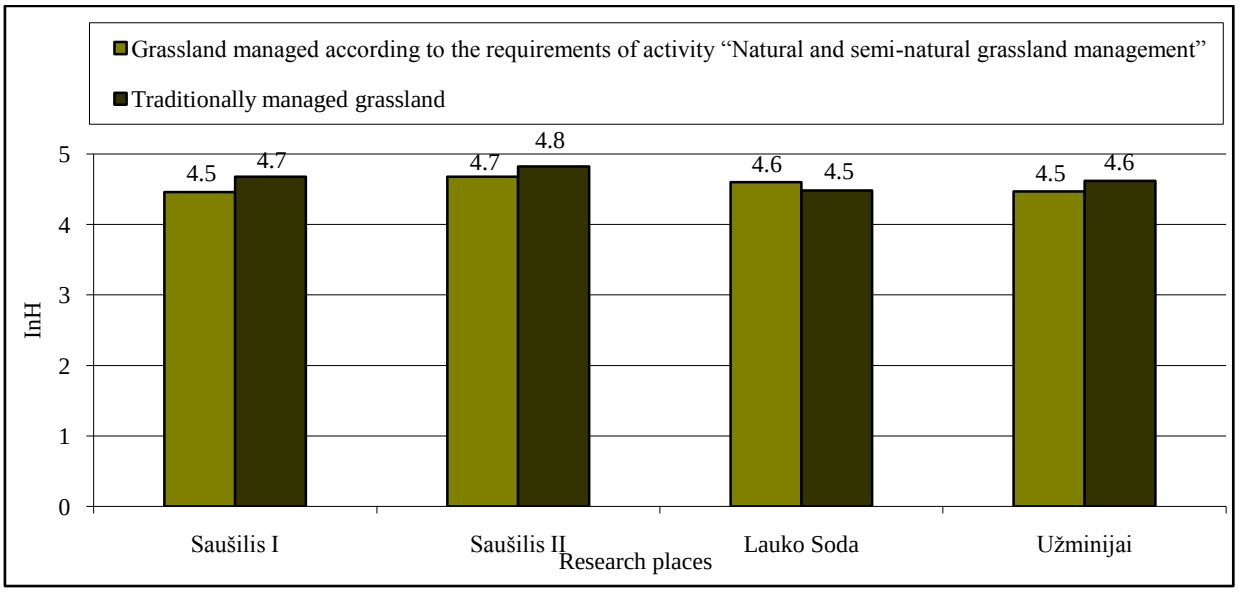

Fig. 7. Hydrotolence indicators of grassland areas (average data of 2011-2012).

The evaluation of plant communities according to their adaptation to pH of soil disclosed that soil acidity was not a determining factor for the most of plant species in grassland researched. Similar results were obtained by other researchers too (Skuodienė, Simonavičiutė, 2004). The most of grassland plants can successfully grow in soil with quite different pH level, however maximum quantity of units of each species can be found in an optimal pH level only. Since 5.0-7.5 pH is suitable for the most of grassland plants, their uneven distribution may be explained by indirect influence of soil acidity, i.e. by changed other conditions of growth, first of all – nutrition (Rimkus, 2003). In conclusion in might be maintained that grassland plant communities were similar according to this indicator.

Ecological analysis of plant species found in grassland researched also showed similar average soil nutrition indicators of differently managed areas in 2011-2012. The difference in InN values of grassland managed according to the requirements of activity "Natural and semi-natural grassland management" and traditionally managed grassland varied from 7 to 17 percent depending on the research place (Fig. 8). Mesotrophic plants prevailed in research places Saušilis I and Užminijai. Mesooligotrophic plant communities, adapted to less nutrient soils, were common in research places Saušilis II and Lauko Soda. It should be noted, that greater amount of plant species, indifferent to nitrogen content of soil, could influence the InN values of grassland researched. The comparison of plant communities of grassland researched showed their similarity

according to the indicator evaluated. Mann-Whitney U test has not revealed statistically significant differences in nutrition indicators of plant species in differently managed grassland.

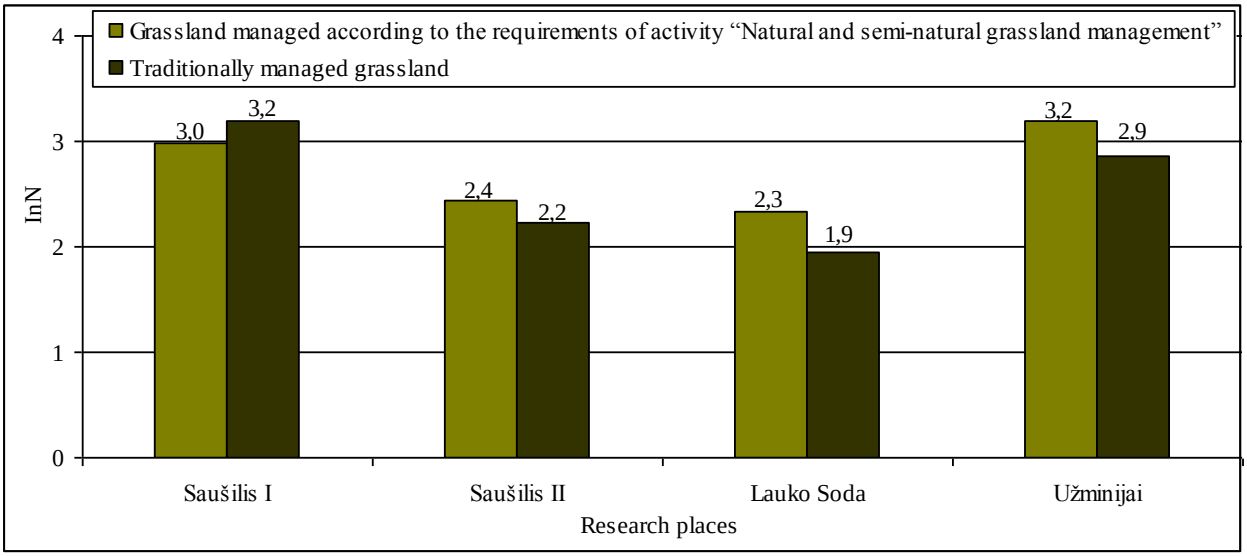

Fig. 8. Grassland nutrition indicators (average data of 2011-2012).

The distribution of plant species in community depends on characteristics of soil. Plants grow in places where they find suitable soil conditions (pH, dampness, nutrition). Summarising the research results, it might be maintained that, taking into consideration plant communities present, soil conditions were similar in all research places, thus similar soils attracted similar plants (Katutis et al., 2011). The research data did not show significant differences of species' composition between traditionally managed grassland and that of managed according to the requirements of biological diversity favourable farming; and, taking into account the distribution of plant species among the ecological groups, their plant communities were considered as similar.

Evaluation of the economic value of grassland

The improvement or at least maintenance of the feed value of grassland is important economic indicator to farmers taking decisions on participation in the implementation of agri-environmental measures; thus the economic value of grassland was calculated during the research. Evaluating data obtained during the research, it has been identified that the average economic value of grassland in three research places (Saušilis I, Saušilis II, and Lauko Soda), managed according to agri-environmental

requirements, were lower than that of traditionally managed grassland in 2011-2012 (Table 7). In the research place Užminijai, lower economic value was identified in traditionally managed grassland. In all research places, the difference of economic values varied from 3.08 to 8.15 percent. Mann-Whitney U test also disclosed the absence of differences in the distribution of the product of relative abundance and economic value between grassland managed according to the requirements of the activity "Natural and semi-natural grassland management" and traditionally managed grassland.

Table 7. Grassland economic value scores (average data of 2011-2012).

Economic activity	Grasslands			
	Saušilis I	Saušilis II	Lauko Soda	Užminijai
Grassland managed according to the requirements of activity "Natural and semi-natural grassland management"	5.97	5.19	4.17	5.69
Traditionally managed grassland	6.33	5.52	4.54	5.52

After evaluating economic values according to Rimkus (2003) and handful (De Vries) methods, the research data showed that in Saušilis I the economic value of grassland, managed according to the requirements of preserving biological diversity, was in high state (medium), while that of traditionally managed grassland was only high. In Saušilis II and Lauko Soda, economic values of grassland were medium. In Užminijai, economic value of grassland managed according to the requirements of agri-environmental measures, was high (medium), while traditionally managed grassland economic value was medium. In Saušilis I and Užminijai, the level of economic values of grassland managed according to the requirements of the preservation of biological diversity, was different due to the differences in calculation methods.

Average economic value scores were lower in three research places of four in grassland managed according to the requirements of the activity "Natural and semi-natural grassland management" compared to traditionally managed grassland, but the differences were not significant and grassland of both types belonged in the same category of economic value. It is believed that the application of agri-environmental requirements reduces the quality of feed and the economic value of grassland, thus farmers, who think about the development of their farms, do not show extreme interest in such payments (Kontautas, 2008) although the data of National Paying Agency under the

Ministry of Agriculture show that the number of applications for payments according to the activity "Natural and semi-natural grassland management" increased from more than 2 thousand in 2007 to more than 8 thousand in 2013. One of factors influencing the accumulation of nutritional substances in grass is plant species' composition in grassland (Zableckienė, Butkutė, 2006). Since the research results show that plant communities of differently managed grassland were similar and their economic values were the same, it can be maintained that biological diversity favourable farming does not reduce the economic value of grassland and thus farmers and other owners of grassland shall not avoid the application of agri-environmental measures in their grassland.

Evaluation of efficiency of agri-environmental measures

One of the activities supported by rural development programme measure "Agri-environmental payments" is natural and semi-natural grassland management. Agri-environmental payments are paid if grassland is managed according to specific requirements, for example, they are not fertilised, pesticides and liming agents are not used. A part of abovementioned requirements are restriction to haying and pasturing, i.e. grassland shall be hayed every year starting July 15 or it shall be pastured not earlier than June 15 and less intensively than 1 animal unit per hectare. Lately pesticides, fertilisers, and liming agents are little used in small farms. In latest decades, haying becomes the main way of using and maintaining natural grassland (Rašomavicius, 2012), thus aiming to evaluate the efficiency of currently applied agri-environmental measures, oriented towards the preservation of plant diversity in grassland, the main attention is paid to haying and pasturing activities.

Aiming to evaluate the efficiency of agri-environmental measures, it was identified what plant species were adapted to grow in grasslands according to their resistance to the frequency and timing of haying during the research. The research results showed that average indicators of grassland resistance to haying in grasslands hayed at different intensity and timing were similar in 2011-2012. The difference of Inc values varied from 4 to 8 percent in grassland managed according to the requirements of the activity "Natural and semi-natural grassland management" and traditionally managed grassland. Plant communities' resistance to haying was average in the grassland researched (Fig. 9). Mann-Whitney U test also showed that grassland managed according to specific

agri-environmental requirements and hayed traditionally were not different according to their indicators of resistance to haying.

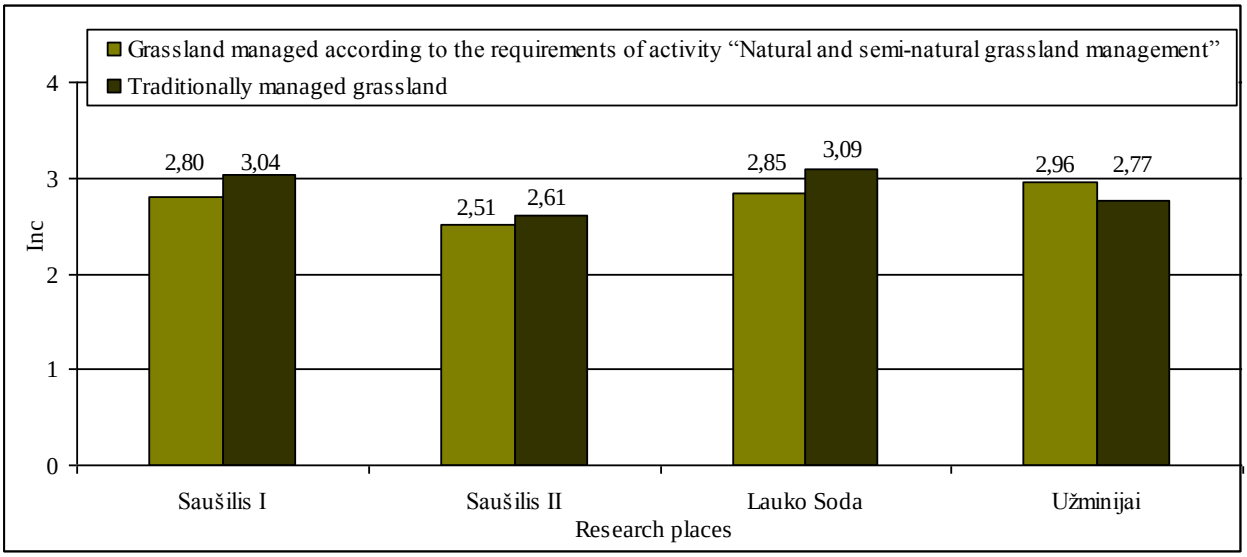

Fig. 9. Indicators of resistance to haying of grassland areas (average data of 2011-2012).

In addition, the grassland researched was hayed one or two times per season, and, according to the information found in the scientific literature, the diversity of plant species is greater in grassland hayed in such frequency than that of hayed three or more times per season (Vasiliauskienė et al., 2007; Zechmeister et al., 2003).

Regulated the beginning of haying (July 15) is of the requirements of rural development programme measure "Agri-environmental payments" related to natural and semi-natural grassland management supported by agri-environmental payments. Evaluating the efficiency of agri-environmental measures from the perspective of possible effect of the beginning of haying on plant communities, the beginning of blooming of plants found in grassland researched was estimated. During the research, it was identified that more than 80 percent of plant species found in grassland researched start blooming in May and June. The requirement of the activity "Natural and semi-natural grassland management" to perform the first haying only after July 15 ensures that plants will finish their blooming, produce and sow their seeds before haying, and this is important aiming to preserve plant species rich communities. Since the results showed similar botanical composition between grassland managed according to agri-environmental protection requirements and traditionally managed grasslands, it might be

maintained that traditionally managed grassland was not exploited too intensively; in addition, most of the plants of the grassland were perennial thus haying in June did not influenced the diversity of species.

The grassland of the research place Saušilis I, managed according to the requirements of the activity "Natural and semi-natural grassland management", was not only hayed, but also pastured, in both research cases; thus the indicators of plant tolerance to trampling and pasturing were evaluated too. The results of the research showed that the plant species of both grassland areas were tolerant to trampling and pasturing. The average of Inp of grassland managed according to the requirements of the activity "Natural and semi-natural grassland management" was 3.31, while InP was 2.74 (2011-2012). The average Inp of traditionally managed grassland reached 3.14, while InP was equal to 2.99. Mann-Whitney U test showed that both grassland areas researched were similar comparing the index of tolerance to trampling and pasturing, thus it might be maintained that low intensity pasturing did not influence species diversity in plant communities since traditionally managed grassland was not pastured during the research year.

Currently applied agri-environmental measures, aimed at the preservation of biological diversity of grassland, are not efficient enough taking into account the amount of allocated financial resources and the result of plant diversity obtained, since botanical composition of traditionally managed grassland in small farms is the rather similar; thus the targeted utilisation of agri-environmental payments is under the question. Aiming to more efficient use of agri-environmental payments, oriented towards the preservation of plant diversity in a period of 2014-2020, financial resources shall be allocated to the preservation of plant species or plant communities described by clear criteria, i.e. "result oriented" agri-environmental payment allocation methodology should be applied.

CONCLUSIONS AND RECOMMENDATIONS

1. The evaluation of differences of plant species' composition in plant communities of grassland managed traditionally and according to the requirements of agri-environmental farming disclosed: grassland of both types had abundance of plant species (25-33); the difference in the number of species was not significant (6-11 percent), and not always the grassland managed according to the requirements of the preservation of biological diversity had higher number of plant species; the distribution of the relative abundance of plant species was not significantly different; the number of plant families (10 and 13) or their difference (8 percent) was not significant; in 2011-2012, the average coefficients of dominance were higher in traditionally managed grassland, however the difference in CDD values was not significant (4-10 percent); the average values of Jaccard (50-65 percent) and Sörensen similarity (0.7-0.8) coefficients showed the similarity of the grassland of both types according to the plant species' composition found in 2011-2012.

2. The analysis of the ecological groups of plant species and the comparison of such indicators as the adaptation to soil dampness, acidity, and nutritional content in traditionally managed grassland and that of agri-environmental farming has not disclosed statistically significant differences. From the ecological perspective, most of the plants in grassland researched were mesophytes (InH 4.5–4.8); soil acidity was not a determining factor to the most of plants; mesooligotrophic and mesotrophic (InN 1.9–3.2) plant communities prevailed in the grassland researched.

3. Biological diversity favourable farming does not reduce economic value of grassland. In 2011-2012, the average economic value scores of grassland managed according to the agri-environmental requirements were lower (from 4.17 to 5.97) compared to the scores of traditionally managed grassland (from 4.54 to 6.33). However, in all research places the differences of the economic values scores of differently managed grassland were not statistically significant (the difference varied from 3.08 to 8.15 percent), and, in addition, grassland of both types belonged to the same category of the economic value scale and was of average high or high economic value.

4. The evaluation of specific requirements related to haying and pasturing activities, aimed at the preservation of biological diversity, disclosed that this measure is

not efficient enough taking into consideration the amount of financial resources allocated and the result of the preservation of biological diversity obtained, since plant communities of grassland managed traditionally and in biological diversity favourable methods were similar. It is obvious that such use of the EU funds, dedicated for the preservation of grassland plant diversity, is not efficient.

5. In 2014-2020, agri-environmental payments should be paid according to "result oriented" methods, aiming to preserve the diversity of grassland plants. Financial support of the EU, oriented towards the preservation of biological diversity of grassland plants in Lithuania, should be allocated upon certain, legally identified, criteria, for example, the result of the preservation of certain plant species.

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Pranešimai darbo tema pateikti Lietuvos mokslinėse konferencijose: „13-joje Lietuvos jaunųjų mokslininkų konferencijoje „Mokslas – Lietuvos ateitis“ (Vilnius, 2010), „Mokslas gamtos mokslų fakultete“ (Vilnius, 2010), „Mokslas gamtos mokslų fakultete“ (Vilnius, 2012).

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REZIUME

Pievų augalų įvairovė yra labai svarbi siekiant palaikyti agrarinio kraštovaizdžio atsparumą antropogeniniam poveikiui. Pievose aptinkama retų, saugomų rūšių, taip pat šiose buveinėse yra susitelkę svarbūs genetiniai ištekliai. Pievos saugo dirvožemį nuo erozijos, vaidina svarbų vaidmenį mažinant šiltnamio efektą sukeliančių dujų kiekį, pievų augalų biomasė gali būti naudojama kaip energijos šaltinis, taip pat mažina dirvožemio taršą sunkiais metalais, saugo paviršinius vandens telkinius nuo taršos biogeninėmis medžiagomis. Natūralus potvynių reguliavimas yra viena iš svarbių ekologinių funkcijų, kurias atlieka užliejamos pievos. Pievose susikaupusi augalų įvairovė yra svarbi ūkine ir estetine prasme. Siekiant sėkmingai įgyvendinti Europos Sąjungos biologinės įvairovės išsaugojimo politiką, sukurtos finansinės paramos priemonės, padedančios spręsti biologinės įvairovės nykimo problemas. Lietuvos kaimo plėtros 2007–2013 metų programoje numatyta agrarinės aplinkosauginės priemonė, kurios tikslas mažinti neigiamą antropogeninį poveikį pievų biologinei įvairovei, ūkininkavimą derinant su aplinkos apsaugos poreikiais. Agrarinės aplinkosaugos priemonių įgyvendinimui skiriamos didžiulės lėšos, todėl svarbu įvertinti šių priemonių poveikį pievų augalų bendrijoms. Šiame darbe ištyrus pievų augalijos įvairovės ir ūkinės vertės skirtumus, sąlygotus skirtingos ūkinės veiklos intensyvumo, siekta įvertinti reglamentuotų, ES agrarinės aplinkosaugos priemonėmis paremtų, pievų tvarkymo metodų efektyvumą smulkiuose Lietuvos ūkiuose. Pievų augalų bendrijos buvo vertintos keturiose tyrimo vietose, kurių kiekvieną sudarė dvi skirtingai tvarkomos pievos, t. y. pieva, kurioje taikomi agrarinės aplinkosaugos principais pagrįsti ūkininkavimo metodai, ir pieva, kurioje taikomos tradicinės ūkininkavimo veiklos. Tyrimo metu vertinti kiekvienos tyrimo vietos dviejų skirtingai tvarkomų pievų augalų bendrijų panašumai ir skirtumai. Tyrimo duomenys parodė, kad pievos pasižymėjo didele (nuo 25 iki 33) augalų rūšių gausa, o augalų rūšių skaičiaus skirtumas varijavo nuo 6 iki 11 proc., ir ne visais atvejais buvo didesnis pievose, kuriose ūkininkaujant siekiama išsaugoti biologinę įvairovę. Apibendrinant tyrimo duomenis matyti, kad pievose (lyginant dvi vienoje tyrimo vietoje buvusias pievų augalų bendrijas) inventorizuotas vienodas augalų šeimų skaičius (10 ir 13), arba jų skirtumas buvo nežymus (7,7 proc.). Tyrimo vietose rastų augalų šeimų analizė parodė, kad visose aštuoniose tirtose pievose daugiausia buvo rasta

Poaceae, Asteraceae, Fabaceae šeimų augalų rūšių. Vertinant pievas kokybiniu požiūriu nustatyti 2011-2012 m. vidutiniai dominavimo koeficientai buvo didesni įprastais ūkininkavimo būdais naudojamose pievose, tačiau CDD reikšmių skirtumai palyginus skirtingai tvarkomas vienoje tyrimo vietoje buvusias pievas, buvo nežymūs (nuo 4 iki 5 proc.). Augalų rūšių įvairovę lemia ne tik rūšių skaičius, bet ir atitinkamos rūšies santykinis gausumas augalų bendrijoje. Naudojant Mano-Witnio U testą (*Mann-Whitney U test*) nustatyta, kad augalų rūšių santykinio gausumo pasiskirstymas, skirtingai tvarkomose pievose, statistiškai reikšmingai nesiskyrė. Analizuojant augalų rūšių, šeimų skaičių, dominavimo koeficientų reikšmes, kaip biologinės įvairovės vertinimo rodiklius, nustatyta, kad tirtų pievų augalų bendrijos buvo panašios. 2011-2012 m. vidutinės Žakaro (nuo 50 iki 65 proc.) ir Sörensen bendrumo (nuo 0,7 iki 0,8) koeficientų reikšmės taip pat parodė pievų augalų bendrijų panašumą pagal jose rastų augalų rūšių sudėtį. Atlikus pievų augalų rūšių ekologinių grupių analizę ir palyginus tradiciniais bei agrarinės aplinkosaugos principais pagrįstais ūkininkavimo metodais tvarkomose pievose rastų augalų rūšių prisitaikymo prie dirvožemio drėgmės, rūgštingumo, turtingumo maisto medžiagomis rodiklių reikšmes, visose tyrimo vietose nenustatyti statistiškai reikšmingi jų skirtumai. Ekologiniu požiūriu pievose vyravo mezofitai (InH nuo 4,5 iki 4,8), daugumai augalų rūšių dirvožemio rūgštingumas buvo neįtakojantis veiksnys, pievoms buvo būdingi mezooligotrofiniai ir mezotrofiniai žolynai (InN nuo 1,9 iki 3,2). Pievų pašarinės vertės pagerinimas arba bent esamos būklės išlaikymas yra svarbus ekonominis rodiklis ūkininkams apsisprendžiant dalyvauti agrarinės aplinkosaugos priemonių įgyvendinime, todėl tyrimo metu buvo apskaičiuota kiekvienos pievos ūkinė vertė. Biologinės įvairovės apsaugai palankus ūkininkavimas pievų ūkinės vertės nemažina. 75 proc. tirtų pievų, tvarkomų vadovaujantis agrarinės aplinkosaugos priemonėmis paremtais metodais, 2011-2012 m. ūkinės vertės balų vidurkiai buvo mažesni (nuo 4,17 iki 5,97), lyginant su tradiciniais ūkininkavimo metodais tvarkomų pievų ūkinės vertės balais (nuo 4,54 iki 6,33). Tačiau visose tyrimo vietose skirtingai tvarkomų pievų ūkinės vertės balų skirtumai buvo statistiškai nereikšmingi (skirtumas nuo 3,08 iki 8,15 proc.), o žolynų ūkinės vertės nustatymo skalėje abiejų tipų pievos priklausė toms pačioms kategorijoms, ir buvo vidutinio gerumo arba geros ūkinės vertės. Tyrimo rezultatai parodė, kad įvertinus pievų biologinės įvairovės išsaugojimui skirtos agrarinės aplinkosaugos priemonės specialiuosius reikalavimus, susijusius su šienavimo

ir ganymo veiklomis, nustatyta, kad priemonė nėra pakankamai efektyvi vertinant skiriamų lėšų dydį ir turimą pievų augalų įvairovės išsaugojimo rezultatą, nes įprastais ir biologinės įvairovės apsaugai palankiais ūkininkavimo metodais tvarkomų pievų bendrijos yra panašios. Matoma, kad ES lėšos įgyvendinant Lietuvos kaimo plėtros 2007–2013 metų programos priemonę, skirtą pievų augalų įvairovės išsaugojimui, naudojamos neefektyviai. Todėl svarbu, kad saugant pievų augalų įvairovę, naujame 2014–2020 m. finansavimo laikotarpyje, agrarinės aplinkosaugos išmokos būtų mokamos taikant „orientuotą į rezultatą“ agrarinės aplinkosaugos išmokų skyrimo metodiką. Taikant minėtą metodiką kompensacinės išmokos mokamos už pasiektą rezultatą, susijusį su pievų augalų bendrijų išsaugojimu, o ne už tam tikrų veiklų, pavyzdžiui, šienauti ne anksčiau kaip liepos 15 d., vykdymą. ES parama, kurios panaudojimo tikslas išsaugoti pievų augalų įvairovę Lietuvoje, turėtų būti skiriama tik už paramos gavimą reglamentuojančiuose teisės aktuose nurodytų kriterijų, pavyzdžiui, tikslinių augalų rūšių išsaugojimas, pasiekimą.

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